DOES THE PROCESSING OF HYPNOTIC ANALGESIA REQUIRE ATTENTION-DEMANDING RESOURCES?

A dual-task analysis of hypnotic-susceptibility-mediated differences in executive attentional processing between hypnotic and nonhypnotic analgesia

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DEDICATION

This thesis is dedicated to the memory of Ernest R. Hilgard, Kenneth S. Bowers and Nicolas P. Spanos, who all sadly passed away in recent years. Their research efforts spanning several decades have contributed immensely to our understanding of clinical hypnosis in general and hypnotic analgesia in particular, and have inspired many others, myself including, to pursue further research in these areas.

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PREFACE

For most people, myself included, the first contact with hypnosis is through watching a demonstration of hypnosis either on television or as part of a live audience. Such performances can be quite spectacular and are certainly entertaining. However, to me they remained interesting stage phenomena, much like those performed by a skilled magician, and did not arouse any scientific interest into hypnosis. Being interested in pain management thought, one sooner or later comes across accounts of hypnotic analgesia, that is the use of hypnotic suggestions to achieve relief of pain and distress. Whatever ones opinion about hypnosis, it has been thoroughly proven, both in clinical and experimental settings, that some people do achieve significant and clinically important benefits when using hypnotic suggestions over and above those available to the average person using nonhypnotic coping methods. The interesting question, which has been debated by some researchers for decades, is what are the processes whereby hypnotic analgesia is achieved, and are these fundamentally different from those involved in the execution of nonhypnotic coping strategies.

More recently, pain research has increasingly emphasised the role of attention in pain processing and in particular the ability of pain to have priority access to processing resources and dominate conscious processing at the expense of other activity. This interference with other ongoing activity is one of the major pain-related handicaps experienced by people with chronic pain. The concept of attention, and in particular the distinction between controlled and automatic processing, is crucial to an understanding of both pain processing and hypnosis and provides an important and fascinating approach for studying the two.

This thesis was written as part of a study investigating differences in attentional interference effects between hypnotic and nonhypnotic analgesia. The main hypothesis tested is whether: "Hypnotic analgesia, unlike nonhypnotic pain-coping strategies, can be achieved without reliance on high-order (executive) attentional resources and therefore results in no or only minimal interference with other ongoing and attention-demanding activities.

A proper understanding of this topic and the wider context wherein it occurs requires some knowledge of the following key aspects: (1) pain and pain management; (2) pain coping strategies; (3) attention, and in particular access to, and interference with, attentional resources in multiple task environments; (4) consciousness; and (5) hypnosis. The introduction to this thesis follows this outline.

Chapters one to six form the introduction. Some sections of the introduction provide additional and more in-depth information (particularly on the neurophysiology of pain, attention, and hypnosis) that are useful for a fuller appreciation of these topics and can assist the reader in understanding how these main aspects are linked together. However, strictly seen these are not necessary for a direct understanding of the main research question. For the convenience of the reader, these sections are marked with a red asterisk (⊛) following the section heading. They include sections 1.4, 3.6, 5.2, 5.5, 5.6.2.2., 5.7, and all of chapter 4.

Chapter 1 provides an overview of the main aspects of our current understanding of pain processing and the control mechanisms involved. Particular reference is given to inhibitory control processes descending from cortical and subcortical brain structures. As Chapter 6 will show, there is evidence for hypnosis-related differences in the effectiveness of such inhibitory control mechanisms. The final section briefly covers how the advances in pain research have influenced pain management practices.

Section 1.4 ⊛ provides more in-depth information on the affective-emotional dimension of pain, on the changes that take place when a pain condition becomes chronic, and on the neurophysiology of cortical and subcortical brain structures involved in pain processing and responding. It is in the management of chronic pain where hypnotic analgesia may have its greatest advantage. The specific question of the current study is part of an underlying research effort to enhance our understanding of pain mechanisms and derive at more effective methods for the control of particularly chronic pain. Developments in the area of neurophysiology are leading to a more specific understanding of the theoretical mechanisms of pain, which in turn contributes to the development of more specific and effective pain management practices. It is for this reason that these areas are given substantial coverage in the introduction of this thesis.

Chapter 2 "Psychological methods of pain control" consists of two main parts. The first part introduces behavioural and cognitive pain coping strategies, highlights factors that may influence their utility, and evaluates evidence for the effectiveness of such strategies. It then describes some of the influences of anxiety on pain responding, outlines the cognitive costs of using attention diversion and pain suppression strategies, and contrasts the effectiveness of attention diversion versus sensation monitoring strategies. The second part describes the main characteristics of hypnotic analgesia, looks at both clinical and experimental evidence for its effectiveness, and outlines proposed mechanisms whereby hypnotic analgesia may reduce pain.

Chapter 3 "Attention, multi-task performance, and task interference." This chapter briefly describes the main characteristics of information processing: competition for limited capacity processing resources, and the selection of information for further processing. It continues with a description of how this latter process is influenced by both bottom-up stimulus-driven biases and by top-down control. It then highlights the development of models of attention with particular reference to Shiffren and Schneider's (1977) distinction between controlled and automatic processing, and outlines the main components of Norman and Shallice's (1986) hierarchical model of supervisory attentional control. This is followed by a description of how interference and the demands of concurrent task performance are treated by traditional limited-capacity models of attention, and by models based on multiple resource theory. The next section describes the interruptive quality of pain, its specific (hard-wired) capacity to capture attention, and factors that may moderate the interruption of ongoing activity. This is followed by a brief section on biases in the processing of emotion-arousing information and preliminary findings regarding the efficacy of distraction tasks with an emotional theme.

Section 3.6 ⊛ deals with the neurophysiology of attention. This section reviews the different dimensions of attentional processing and their anatomical correlates, including arousal and targeted readiness which are also important aspects in pain processing, and novelty which is important for attentional capture and effective distraction strategies.

Particular attention is given to the mechanisms involved in the control of attention and findings supporting the existence of anterior and posterior attentional systems. This section provides a summary of the background knowledge that has led to the development of the neuropsychophysiological model of hypnosis described in section 5.7.3.2.

Chapter 4 briefly introduces the topic of consciousness and relates conscious and unconscious processes with respectively controlled and automatic attention. It does so with particular reference to Bernard Baars' Global Workspace theory of consciousness and briefly describes how this conceptualisation can be used to explain such phenomena as hypnosis, absorption, dissociation and involuntariness. Many actions and processes are either well established (learned and familiarised) or may be programmed (hard-wired) as is the case with pain so that they, once activated, can be executed on an automatic and subconscious level. As will be covered in section 5.6, some researchers and theorists argued that hypnosis is one of these processes.

Chaper 5 "Hypnosis" starts with a description of the nature and characteristics of hypnotic phenomena, and the factors that may contribute to the experience of hypnosis. The next three sections deal more in-depth with the three main factors: hypnotic susceptibility, absorption, and dissociation respectively.

Section 5.6 compares and critically evaluates the main models of hypnosis: the dissociated experience and dissociated control models and the social-psychological model of hypnosis, and the predictions they make regarding the involvement of attention. The next part highlights some more recent findings that indicate that the opposing views of social psychological and special process (i.e. dissociation) explanations both appear to apply, but at different ends of the continuum of hypnotic responding.

Section 5.2 ⊛ covers the assessment and measurement of hypnotic susceptibility. Experimental studies of hypnosis phenomena commonly use scores on standard hypnotic susceptibility scales as the criterion for allocating subjects to experimental conditions on the basis of their hypnotic ability. This section explores the argument as to how well such measures capture the important components of hypnotic responding.

This is relevant because there is increasing support for the notion that (1) individual differences in hypnotic responding reflect differences in kind (i.e., underlying mechanisms) rather than in dimension (i.e., position along the continuum of a single trait), and (2) there exist subsamples of highly hypnotisables exhibiting distinct patterns of responding and brain activity that are not differentiated by the standard hypnotic susceptibility tests which treat highly hypnotisables as a homogeneous group.

Section 5.5 "Unconscious influences in hypnosis" indicates how human behaviour in general, and hypnotic responding in particular, can be influenced by information that is perceived and processed outside of normal conscious awareness. It highlights how the social psychological explanation of hypnosis emphasises the importance of Type I unconscious influences such as demand characteristics, expectancies, and social compliance; but, unlike the dissociation model of hypnosis, denies the influence of Type II unconscious influences involving genuine alterations in the way information is processed such as the down-regulation of nonessential functions and a shift towards increased primary process thinking. This section also reviews experimental research into the relative efficacy of direct and indirect hypnotic suggestions, and highlights how a type of control experiment called the real-simulator design can be used to assess the influence of demand characteristics.

Section 5.7 It is the area of neurophysiological research that provides important new insights in the, otherwise largely stagnated, debate about the mechanisms underlying hypnotic responding in general and hypnotic analgesia in particular. This section reviews neurophysiological evidence for fundamental changes in brain activity that: (1) can distinguish the hypnotic from the nonhypnotic state, and (2) can distinguish between individuals with low and high hypnotic susceptibility in each of these states. It concludes with a summary of a neuropsychophysiological model of hypnosis that is based on the result of these studies.

Chapter 6 "The current study" starts with a description of the two studies by Miller and Bowers (1986; 1993) that form the basis for the current experiment.

This is followed by a description of the main aim of the current study and the ways in which the methodology was changed in an effort to increase the sensitivity of the design and allow for greater specificity when analysing the effects of the experimental manipulation. The last section outlines the specific hypotheses of the current study.

Chapters 7 and 8 make up the method section for respectively the hypnotic susceptibility screening stage and the experimental part of the study.

Chapters 9, 10, and 11 comprise the results section. Chapter 9 covers the results of analysis of tracking performance data relating to the main research question. Chapter 10 lists the results of the assessment of pain intensity and pain unpleasantness ratings as well as data on subjects' level of absorption, strategy use, and hypnotic depth. Chapter 11 briefly summarises the results of hypnotic susceptibility measurements during the screening part of the study. The data in Chapters 10 and 11 does not directly relate to the main research question, but does provide additional information used in interpreting the results and supports the arguments made and conclusions reached in the discussion section.

Chapter 12 starts with a discussion of results relating to the main research question (hypotheses 1 and 2) and evaluates possible reasons for the absence of hypothesised differences in interference effects. The effectiveness of the tracking task is examined with reference to the characteristics of attentional capture of visual motion, and recommendations are made for future research and improvements to the current design. This is followed by a discussion of the analyses of pain ratings (hypotheses 3 and 4). Finally, recent research of attentional processing during hypnosis is evaluated with particular emphasis on neuroimaging studies providing direct measures of localised cortical activation during hypnosis and performance of attention-demanding tasks.

ABSTRACT

There is substantial evidence that hypnotic analgesia can be effective in reducing pain and distress in both experimental and clinical settings in at least a sizeable portion of the population. However, the mechanism whereby hypnosis achieves this are not well-understood and various explanations have been proposed. These offer fundamentally different predictions about the attentional involvement of hypnotic analgesia, which are highly relevant to pain research as the disruption of ongoing activity is one of the more debilitating aspects of pain. While cognitive-behavioural coping strategies may attenuate pain of short duration, their effortful deployment further interferes with ongoing activity, and there are strong indications that their effectiveness rather rapidly decreases as pain perseveres. If, as dissociated-control theory proposes, hypnotic analgesia does not require attentional effort for its execution, it would provide significant advantages for individuals who can effectively achieve it (i.e., those who are highly susceptible to hypnotic suggestions). This hypothesis was further tested in an experimental study using a dual-task scenario and repeated-measures design. One hundred and ninety student volunteers were first screened for hypnotic susceptibility using the Hardvard Group Scale of Hypnotic Susceptibility: Form A, and seventy-eight also completed a more demanding follow-up assessment using the Waterloo-Stanford Group C scale. This resulted in fifty individuals who qualified for participation in the experimental part of the study by scoring as either high or low hypnotisable on both these measures. Of these, 12 lows and 14 highs went on to take part in an experimental study that had high and low hypnotisables performed a cognitively demanding tracking task while using either hypnotic analgesia or cognitive-behavioural strategies to cope with iontophoretically administered pain. Interruption of tracking performance during each coping method was used as a measure of central attentional resources needed to execute that coping strategy. Results did not find evidence for the hypothesised absence of interference effects among high hypnotisables using hypnotic analgesia. Possible reasons are examined and exploration of data indicates that the tracking task was not difficult enough to require significant and continuous attention, and lacked sensitivity to distinguish interference effects between treatment conditions.

Findings do not allow a conclusion of support for either explanation of the mechanisms underlying effective hypnotic analgesia. Highly hypnotisable subjects using hypnotic analgesia did achieve significantly greater reductions in both the intensity and unpleasantness of the pain than low hypnotisables using hypnotic analgesia or high and low hypnotisables using cognitive-behavioural coping strategies. Characteristics of the attentional capture of visual motion are discussed and suggestions made for future research and improvements to the design of the current study. Considerable attention is given to findings of a large body of neurophysiological studies of brain activity and a proposed neuropsychophysiological model of hypnosis. When combined, results of these studies indicate that: the mechanisms of attentional control involved in the process of hypnosis are fundamentally different from those involved in the use of standard cognitive-behavioural strategies, but that both processes do require central attentional effort and resources.

INTRODUCTION

CHAPTER ONE

PAIN MECHANISMS AND MANAGEMENT

1.1. *Development of Pain Theories and Treatments*

Our understanding of pain and the mechanisms that influence the experience of pain has increased enormously, specially during the second half of this century. Till then, pain was seen to result from a straight-through sensory projection system (Melzack, 1993; Melzack & Wall, 1965). Specificity theory proposed that pain perception resulted from activation of receptors that only responded to intense noxious stimulation and transmitted impulses in a direct line to an exclusive pain centre in the brain. The amount of pain experienced was seen to be directly proportional to the amount of noxious stimulation or tissue damage. Pain was solely a function of sensory input and varied according to the quality and intensity of the sensory stimulus.

Accordingly, the majority of clinicians adhered largely to a medical model that treated pain as a disease. As a result, pain treatment approaches consisted mainly of attempts to remove the pain stimulus, either pharmaceutically (e.g., by administering analgesics, narcotics, or nerve blocks) or through reparative or destructive surgical procedures. Yet, such medical and surgical interventions proved to be effective in no more than 50% of chronic pain patients (Weisenberg, 1977). Psychological factors were dismissed as merely reactions to pain, and comorbidities were generally ignored (Long, 1994). Patients who reported pain for which there was no apparent organic cause were frequently told it was all in their head, and were dismissed as "frauds" or send to psychiatrists (Merskey & Chandarana, 1992). Observant clinicians, however, noticed that this conceptualisation of pain did not account for some phenomena they frequently observed in practice.

Surgical lesions made at almost every level of the central and peripheral nervous system had proven unsuccessful in abolishing the severe pain that frequently follows trauma or lesions to peripheral or central nerve fibres (e.g., neuralgia, phantom limb pain, causalgia; Melzack & Wall, 1965). These factors argued strongly against a strict direct-line, stimulus-response model of pain perception. A new theory was needed that could account for, among others, such phenomena as: individual differences in pain responding; pain that occurred or persisted long after the stimulus was removed or the injury had healed; pain referred to unrelated areas where no pathology existed; and the observation that low-threshold non-nociceptive stimuli, such as light touch, did at times trigger severe pain.

Several versions of pattern theory emerged out of this quest. All included some form of central summation of stimuli, which was proposed to take place in the dorsal horns of the spinal cord. Levingstone (1943) suggested that continued stimulation set up reverberating circuits in the dorsal horns. Activity evoked in such structures could then be triggered by normally non-nociceptive stimuli and generate the abnormal firing patterns that are interpreted centrally as pain. Noordenbos (1959) proposed that large-diameter fibres inhibit small-diameter fibres and that the substantia gelatinosa in the superficial dorsal horn plays an important role in this central summation and input control. These theories were still rather vague and none included an explicit role for the brain other than as a passive receiver of messages. Nevertheless, they moved the theoretical conception of pain in the right direction and introduced the idea that nociceptive transmission can be modulated and is influence by both nociceptive (slow) and non-nociceptive (fast) fibre systems.

1.2. *Advances in the Understanding of Nociceptive Transmission*

It is useful at this stage to distinguish between nociception and pain, as the two are not synonymous. Nociception refers to neural activity in the pain-mediating nervous system that is evoked by activation of nociceptors. Nociceptors are free nerve endings that are preferentially sensitive to stimuli that are damaging (noxious) to normal tissues or to stimuli that would become noxious if prolonged (International Association for the Study of Pain, 1986, p. S220).

Pain is a subjective experience based on cognitive mechanisms that are influenced by the level of arousal in this nociceptive system (Bromm, 1995). Pain, like other sensations, can be modulated by a wide range of behavioural experiences. Not all nociception is experienced as pain, and nociception itself is neither a necessary nor a sufficient condition for the conscious experience of pain. It is not until the brain interprets the noxious stimulation, and provides it with an affective evaluation, that nociception becomes pain.

The two main types of nociceptors in humans and other mammals are: (1) *mechanical and thermal nociceptors,* which are activated by high intensity mechanical stimuli (e.g., pinprick or cut) or noxious heat or cold (> 45^0C or < 5^0C); and (2) *polymodal nociceptors*, which react to chemical events activated by tissue damage resulting from high-intensity mechanical, thermal, or chemical means (Bowsher, 1989). Nerve fibres can be classified from A to D according to the speed at which they conduct nerve impulses (Tyrer, 1992). Nociceptors transmit impulses along *small-diameter* axons. In the case of mechanical and thermal nociceptors, these are thinly myelinated, relatively fast-conducting $A\delta$ fibres; whereas for the polymodal nociceptors they are unmyelinated, slow-conducting C fibres. *Mechanoreceptors* form another type of receptors. These are activated by low-threshold non-nociceptive stimuli (e.g., touch or light pressure) and transmit stimuli along *large-diameter*, myelinated, fast-conducting $A\alpha$ and $A\beta$ fibres. Thus, the small-diameter nociceptive ($A\delta$ and C) fibres convey high-threshold pain and thermal sensations whereas the large-diameter non-nociceptive ($A\alpha$ and $A\beta$) fibres convey low-threshold mechanical sensations. Together they are referred to as primary afferents. There is a fourth category of nociceptors called *silent receptors* who are not normally activated by noxious stimulation, but whose firing threshold can be dramatically reduced by inflammation or various chemical insults.

The dorsal (posterior) horn of the spinal cord (see Figure 1) can be divided into several layers, called the laminae of Rexed, based on structural differences and their function in the transmission and modulation of afferent information. These laminae are interconnected and exhibit a high degree of interaction. For an in-depth description of nociceptive transmission and dorsal-horn organisation see, for example, Brown (1981), Willis (1985) or Willis and Coggeshal (1978).

Both nociceptive and non-nociceptive primary afferents enter the spinal cord via de ventrolateral division of the dorsal (posterior) horn. Within the spinal cord they ascend for one or two segments and then terminate on to neurons in several laminae in the dorsal horn. From here they projection to *second-order projection neurons* also referred to as *transmission or tract (T) cells* which relay the incoming sensory information along five major pathways or tracts to higher centres in the brain.

The lateral spinothalamic tract is concerned with the transmission of well-localised discriminative pain and temperature sensations. The anterior spinothalamic tract mainly carries light touch stimuli. Recent evidence suggests that some of its fibres ascend ipsilaterally all the way to the midbrain, where they cross in the posterior commissure and project primarily on intralaminar neurons in the thalamus, with some fibres reaching the periaqueductal gray matter of the midbrain. This tract is suggested to convey aversive and motivational nondiscriminative pain sensations, although some question its existence as a separate entity (Afifi & Bergman, 1998). The spinoreticular and spinomesencephalic tracts are also important in pain transmission. The latter, consisting of axons of neurons in laminae I and V, is thought to contribute to the affective component of pain (Basbaum & Jessell, 2000). The spinothalamic tract ascends throughout the spinal cord and brainstem to project on neurons in the ventral posterior lateral (VPL) nucleus of the thalamus. Axons of the VPL neurons further project to the somatosensory cortex.

Various neurotransmitters and neuromodulators are involved in the transmission and modulation of nociceptive stimulation. The majority of primary sensory neurons in the dorsal horn release glutamate, an amino acid that functions as a rapidly acting excitatory neurotransmitter. In addition, many dorsal-horn neurons reacting to small-diameter (Aδ and C) fibres also release neuropeptide neurotransmitters, notably substance P (SP), somastatin (SOM), and vasoactive intestinal peptide (VIP), which are believed to mediate slow synaptic transmission (Afifi & Bergman, 1998). Substance P and glutamate are released from the intraspinal terminals of nociceptors following noxious stimulation and have an excitatory action on dorsal-horn neurons and facilitate pain transmission (Dickenson, 1996a). Excitatory neuropeptides such as SP enhance and prolong the actions of glutamate.

Nociceptive activity can be inhibited by *descending* pathways containing serotonergic fibres from the nucleus raphe magnus and nucleus gigantocellularis of the medulla oblongata, noradrenergic fibres from the nucleus locus coerulus in the rostral pons and caudal midbrain, and enkephalinergic fibres from the periaqueductal gray matter in the midbrain (Afifi and Bergman, 1998). They transport, among others, endogenous opiate peptides that are released following activation of various brain structures. The main families of endogenous opiates are endorphins, enkepkalins, and dynorphins. They are potent inhibitors of pain receptors. Met-enkephalin and SOM inhibit the release of SP from primary afferents thereby inhibiting activity in dorsal horn neurons. A number of other neuropeptides are also involved in the modulation of pain transmission including neurokinins, galanin, and calcitonin gene-related peptide (CGRP). While know to modulate pain mechanisms, the exact functions of many of these neurotransmitters/modulators are still largely uncertain (Dray, 1996). For a more thorough description of the function and distribution of neurotransmittters and neuropeptides see, for example, Strand (1999).

Glutamate is likely to be the main neurotransmitter of the projection neurons (Dickenson, 1996a). Some of the projection neurons are nociceptive specific (i.e., they are only excited by Aδ or C fibres). Other projection neurons in the deeper laminae (particularly lamina V), called *wide-dynamic-range* (WDR) or *convergent* neurons, receive input from both high-threshold nociceptors that facilitate pain perception and low-threshold mechanoreceptors that normally inhibit pain transmission. Noxious stimulation of Aδ and C fibres results in the high-frequency discharge of WDR neurons associated with the perception of pain, whereas tactile stimulation of Aα and Aβ fibres normally results in only low-frequency activation (Abram, 1990). The WDR neurons have receptors for both SP and glutamate and the interplay of these receptors determines the excitatory component of spinal pain transmission. One of the subtypes of glutamate receptors is the N-methyl-D-aspartate (NMDA) receptor. Low-frequency stimulation of C fibres produces an acute constant response of the WDR neurons. The NMDA receptor does not appear to participate in this normal baseline response. However, repeated (i.e., high-frequency) noxious stimulation sensitises the WDR neurons and lowers their threshold so that they then also respond to low-threshold stimulation.

This results in a dramatic increase in both magnitude and duration of the neuronal response, a phenomenon referred to as *'wind-up'* (Diamond & Coniam, 1997; Dickenson, 1996a). The wind-up of WDR neurons is NMDA receptor dependent. Ion channels of NMDA receptors are normally closed by voltage-dependent magnesium (Mg^{2+}) blocks, but the release of peptides and glutamate, combined with a postsynaptic depolarisation, opens the positively charged ion channels and allows for an influx of calcium ions (Ca^{2+}). This sets off several intracellular actions that lead to a persistent increase in the excitability of the WDR neuron (see Carstens, 1996; Dickenson, 1996b). Under these conditions, even gentle non-noxious stimulation of normal skin (e.g., the rubbing of clothes against the skin), which produces only a low-level afferent barrage, can result in the high-level spinal output that is experienced as pain. This pain condition is known as allodynia, and is one example of the plasticity in the behaviour of central nervous system (CNS) neurons. There are indications that such NMDA events play a crucial role in the maintenance of prolonged pain, which is frequently accompanied by hyperalgesia (i.e., increased sensitivity to noxious stimulation) and allodynia (Dickenson, 1996a). There is clear evidence for the effectiveness of NMDA antagonists in inflammatory pain, neuropathic pain, and experimental models of allodynia (e.g., Yaksh, 1989). NMDA antagonists (anti-hyperalgesics) differ from conventional analgesics in that they prevent or block the hypersensitivity, but leave baseline responses unaffected.

1.3. *The Gate-Control Theory of Pain*

In the early 1960's, neurophysiological studies started to provide evidence for modulation of dorsal-horn neurons (Jessel & Kelly, 1991). Melzack and Wall (1965) integrated the earlier work by Noordenbos and others with the new evidence for neural modulation at the spinal level and developed it into a theory that could account for many of the previously confusing clinical observations. They called this the *gate-control theory*. Although a lot of detail has been added to the initial formulation of this theory, its original propositions remain largely intact today. However, rather than seeing this as an empirically proven theory, it is more helpful to view it as a conceptual model that provides a useful representation of the vastly complex and only partially understood neural interactions that take place at the spinal level.

When entering the dorsal root, the fast conducting Aδ fibres excite synapses of dorsal-horn neurons in laminae II and IV, while some also terminate on laminae I, III, and V. The slow-conducting C fibres terminate on and excite neurons in particularly laminae II, but some also project to laminae I and III. The substantia gelatinosa (lamina II) is made up almost exclusively of inhibitory and excitatory interneurons. The more inner laminae (particularly lamina V) are increasingly excitable by non-noxious, low-threshold, stimulation from Aα and Aβ fibres. The majority of neurons in laminae V are WDR neurons which receive low-threshold input from large-diameter Aβ fibres as well as, both direct and indirect, input from the small-diameter nociceptive afferents (Aδ and C fibres). Some of the Aδ fibres provide direct input to projection neurons in the marginal layer (lamina I) which also receive indirect input from C fibres via stalk-cell interneurons in lamina II.

There exists a cascading interaction (inhibition and excitation) between neurons in these progressively deeper layers within the dorsal horn which, with the exception of lamina II, all send fibres to the brain (Diamond & Coniam, 1997). Lamina V contains primarily second-order projection neurons that send information up the spinal cord to the brainstem and thalamus for further processing. What will be transmitted upwards depends on the summation of informatioin received from the more dorsal laminae, direct input from periheral stimulation, and central inhibition descending from higher up in the nervous system. The combined interaction of all these factors determines the integrated firing pattern of the projection neurons. When this exceeds a critical preset level, it triggers a sequence of responses in what Melzack and Wall (1965) referred to as the *Action System*. This involves many areas of the brain including specialised systems that are involved in the sensory-discriminative, affective-motivational, and cognitive-evaluative dimensions of pain. It also directs motor pathways that facilitate motor responses including somatic and autonomic activity. The entire system operates through complex feedforward and feedback mechanisms (see Figure 3, p. 13). Furthermore, nociceptive signals can also be modulated at successive synaptic relays along the central spinal pathway up the dorsal columns. The entire nervous system exhibits a high level of integrity, particularly with regard to pain sensation.

The gate-control theory of pain transmission proposes a control system, located in the substantia gelatinosa (lamina II) of the superficial dorsal horns, that modulates the flow of nerve impulses from peripheral fibres to higher centres in the CNS. This gate-control mechanism is sensitive to the level of activity in both nociceptive and non-nociceptive fibres, and is modulated by the interaction of excitatory and inhibitory interneurons plus inhibitory control pathways that descent from higher centers.

The following is a brief description of the updated version of the gate-control mechanism. Both small- and large-diameter fibres project into the substantia gelatinosa (SG) which is suggested to be the modular center for pain. The small-diameter, nociceptive Aδ and C fibres directly (postsynaptically) inhibit SG neurons, whereas the large-diameter Aα and Aβ fibres directly facilitate (excite) these SG neurons. The large-diameter, non-nociceptive fibres and small-diameter, nociceptive Aδ fibres also provide postsynaptic excitatory input to the T cells (see Figures 1 and 2).

Neural connections in the substantia gelatinosa can modulate the transmission of primary sensory afferents unto the second-order projection cells by regulating (closing) the gate in two basic ways.

Normally there is always some ongoing stimulation carried by tonic, slowly adapting fibres which keeps the gate open. The discharge of these large-diameters fibres initially will fire the T cells through the direct route and then partially close the gate through their activation of SG neurons which provide presynaptic inhibition of T cells. Substance P, the probable neurotransmitter of the C fibres (Bowsher, 1989, Tyrer, 1992), is found abundantly in dorsal-root ganglion neurons of C fibres and in the areas of the dorsal horn where they terminate. It facilitates transmission in second-order projection neurons (T cells), opens the gate, and increases the perception of pain. Nociceptive Aδ fibres directly activate projection neurons, and C and Aδ fibres also inhibit activity of the SG cells. In the case of the latter, this occurs both directly and by some segmental collaterals that activate enkephalin-releasing interneurons (I_E, see Figure 3).

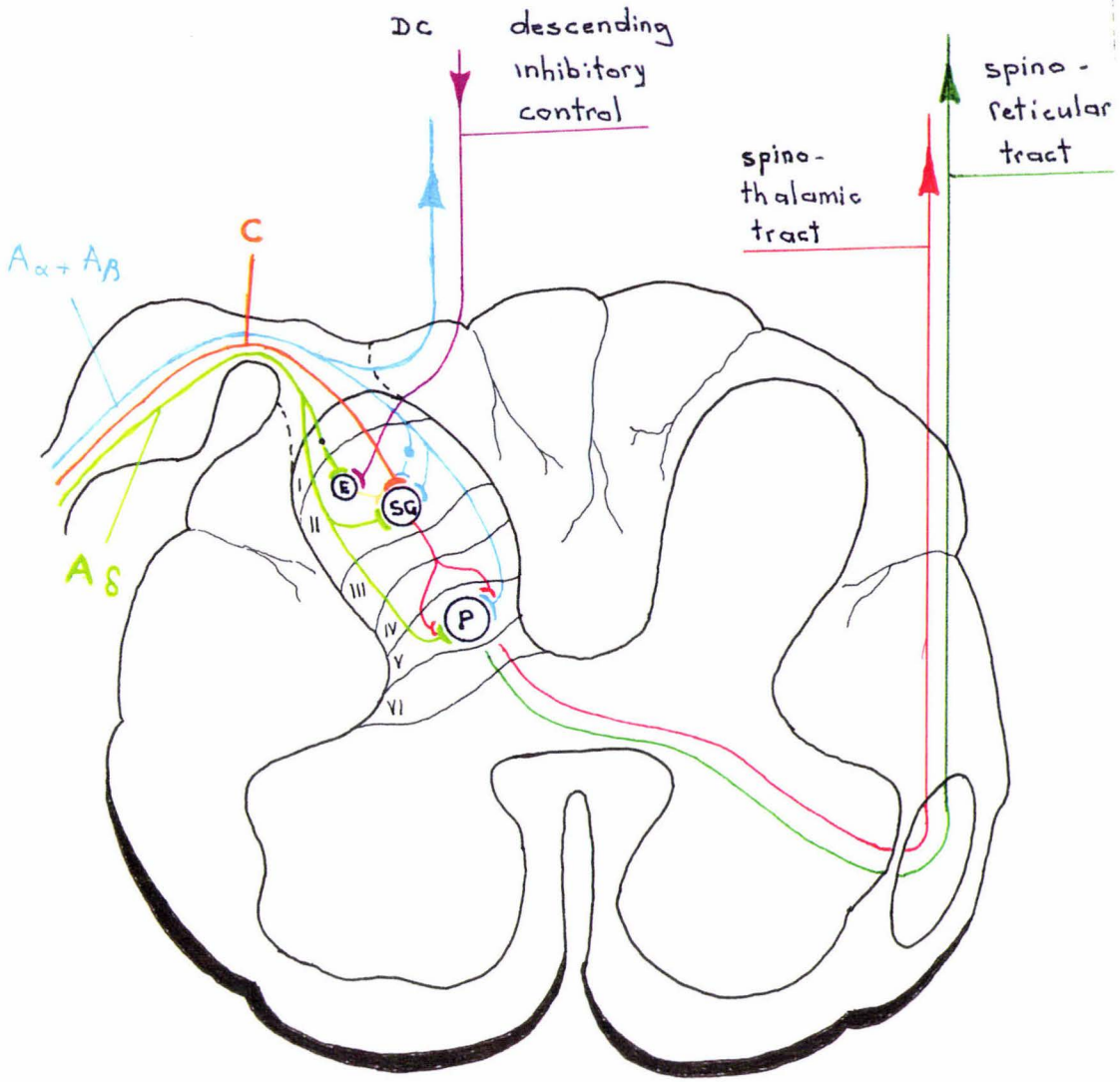

Figure 1. Superficial layers of the dorsal horn receiving postsynaptic facilitation from tactile fibres and inhibition from nociceptive fibres. Deeper layers receiving postsynaptic facilitation from both noxious Aδ and non-noxious fibres. Substantia gelatinosa neurons presynaptically inhibit projection neurons. Descending control and some Aβ collaterals activate inhibitory interneurons. Output of projection neurons crosses to the other side of the cord and ascends up the spinal column.

However, collaterals of the large-diameter, non-nociceptive Aβ fibres, whose main axons ascend the dorsal columns, can activate GABA-energic interneurons that presynaptically inhibit the central terminals of nociceptive C fibres, thereby reducing their capacity to secrete the SP that would normally inhibit the SG cells.

Thus, one way of closing the gate is through non-nociceptive (low-threshold high-frequency) input from large-diameter tactile fibres. Therefore, rubbing the skin or applying gentle heat to the area around a painful spot can alleviate the pain. This process is used therapeutically by techniques such as massage, transcutaneous electrical nerve stimulation (TENS), or vibratory stimulation (Wall & Sweet, 1967; Woolf, 1989).

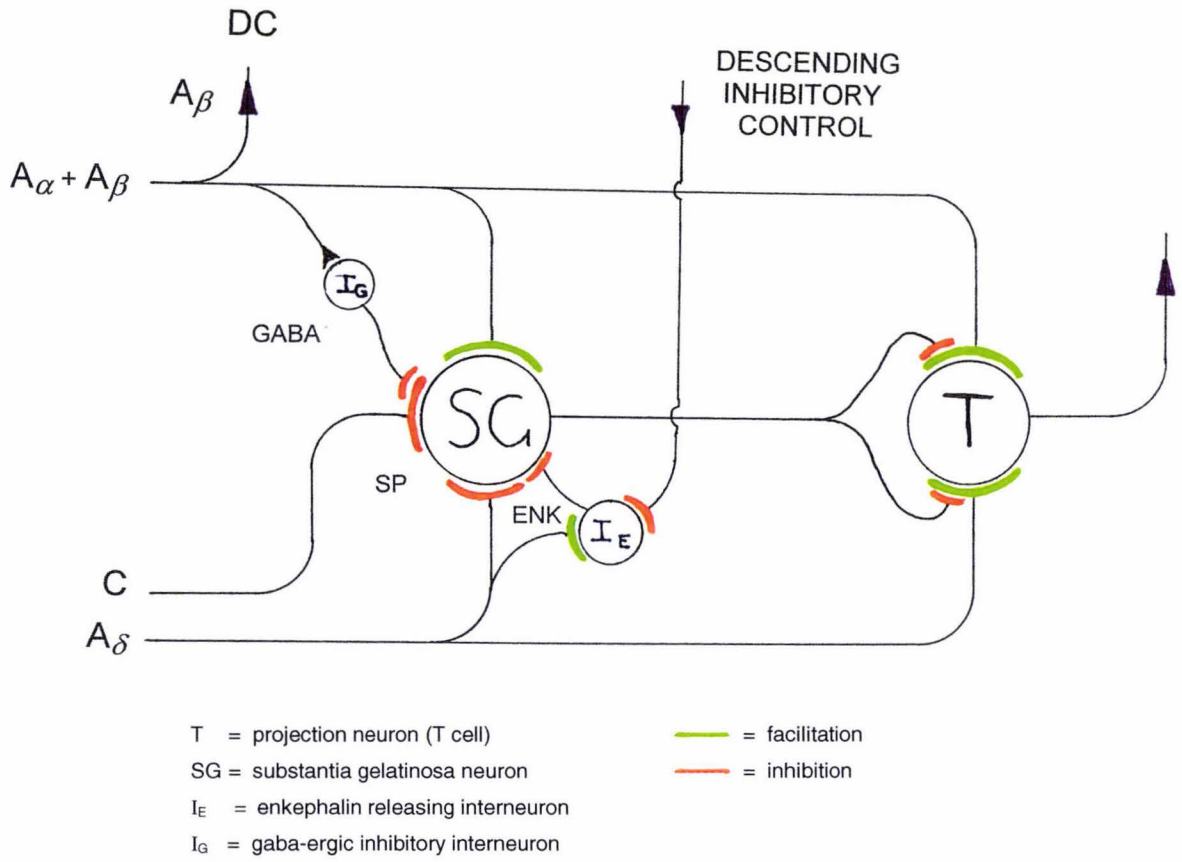

Figure 2. Simplified schematic representation of the gate-control theory of pain transmission.

A second and much more powerful way involves closing the gate from the inside through descending inhibitory control. Prior to reaching the SG, the main axons of some of the very fast conducting Aβ fibres branch off and travel up the dorsal columns and connect with certain structures in the medulla, pons, and periaqueductal grey matter of the brainstem (see Figure 3). Neurons in these brainstem structures have ascending projections to the thalamus, which modulates pain responding (Lenz, 1992). When activated either directly or by low-threshold high-frequency peripheral stimulation, they release endogenous opioids that activate descending inhibitory pathways (see Dickenson, 1994). Descending inhibition can reduce or prevent nociceptive signals from being transmitted upwards to conscious levels of the brain (see Basbaum & Fields, 1984; Fields & Basbaum, 1978, 1989; Willis, 1985, 1995). This feed-forward loop enables these central control centres to activate descending inhibitory control (feedback loop) before activity in the projection neurons has triggered the action system (Bullingham, 1985, Melzack & Wall, 1965).

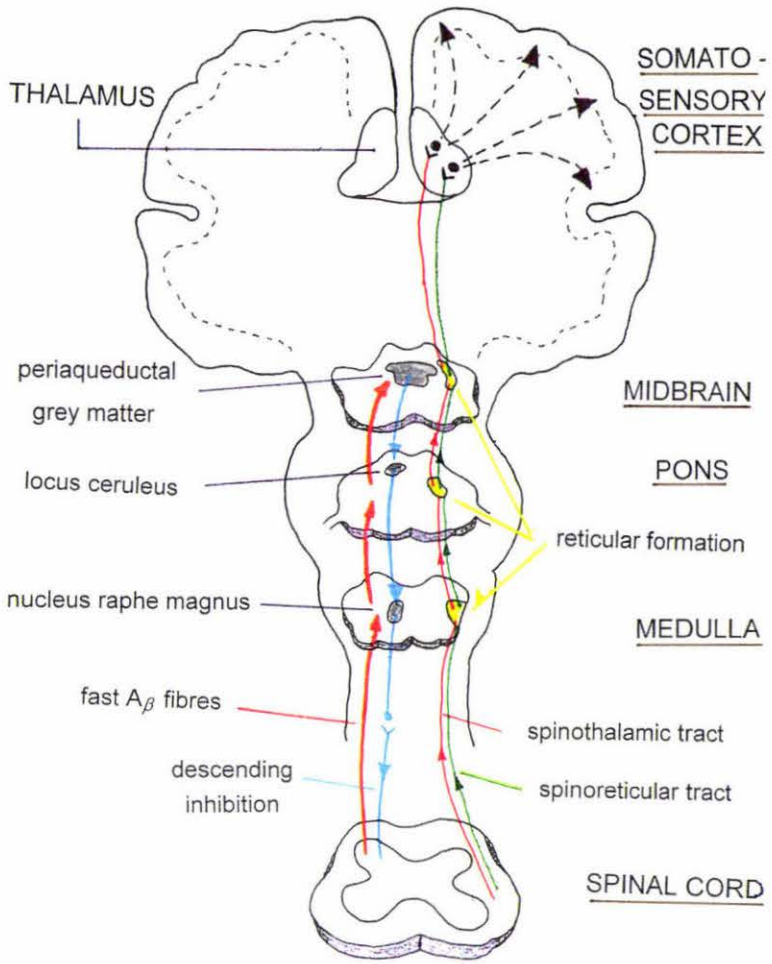

Figure 3. Major ascending and descending pathways in the central nervous system related to nociception.

The superficial dorsal horn contains a high density of enkephalin- and dynorphin-containing inhibitory interneurons. Enkephalins have similar properties to morphine, they modulate the effect of SP and consequently tend to close the gate and reduce pain (Tyrer, 1992). Descending neurotransmitters and some collaterals from Aδ fibres excite these inhibitory interneurons, whose enkephalin-releasing terminals inhibit activity of the C fibres (see Figure 1). This occurs both presynaptically, by decreasing their ability to release SP, and postsynaptically, by hyperpolarising the membrane of the dorsal-horn neurons and increasing membrane permeability thereby reducing the size of the excitatory postsynaptic potential (see Netter, 1983, p. 160). Descending axons of serotonergic, noradrenergic, and enkephalinergic fibres also exert direct inhibitory control through contacts with the dendrites of projection neurons.

There is another way that descending control can reduce the activity of the WDR projection neurons, namely through noxious stimulation elsewhere in the body at sites that are distant from the excitatory receptive fields of these WDR neurons. This is referred to as diffuse noxious inhibitory control (DNIC). It operates through a control loop that is independent from the descending inhibitory control that originates from structures in the midbrain and medulla that are part of the endogenous pain-inhibition system mentioned above (LeBars, Bouhassira, & Villaneuva, 1995). The DNIC loop involves the subnucleus reticulus dolaris, which contains neurons that are exclusively responsive to nociceptive stimuli and have "whole-body" receptive fields. These send descending projections that are relayed through the dorso-lateral funiculus and terminate in the dorsal horn at all levels of the spinal cord.

1.4. *Current Understanding of Pain*

1.4.1. **Lateral and medial pain systems - phasic and tonic pain**

The two types of nociceptive afferents (Aδ and C) are not only activated by distinct types of stimuli, but transmit impulses along separate pathways and facilitate distinct types of pain responses. These are referred to as phasic or first pain and tonic or second (slow) pain.

Phasic or first pain is activated by stimulation of mechanical or thermal nociceptors. These are located in the skin, subcutaneous tissues, and around muscles and joints and respond to pinprick or phasic heat stimuli (> 45^0C or < 5^0C). They transmit impulses along Aδ fibres that have a conduct velocity of approx. 5–25 m/s (Adriaensen, Gybels, Handwerker, & van Hees, 1983; Holmes, 1990). Phasic pain, which occurs immediately following an injury, has a mean latency of 240 msec (Bromm, 1995). It is brief, has a sharp stinging or pricking quality, and can rapidly rise and fall in intensity. It causes phasic withdrawal reflexes designed to quickly withdraw from the emergency and avoid further damage.

Melzack (1990) suggest that the lateral pain-signalling system is most active during such phasic pain. The tracts of the lateral system travel upward along both sides of the brainstem's central core and project onto the sensory cortex. Thus, activation of the lateral system can give rise to rapid, sudden, sharp pain in clearly identified sites. Phasic or first pain provides information about the sensory qualities of the pain including the location, duration, and intensity of the noxious stimulus (Price, 1976).

Following injury, the body's own opioids activate the descending control system, which quickly dampens activity in the lateral system. This rapid inhibition is necessary from an evolutionary and biological standpoint. In situations where other demands are particularly urgent and dominant (e.g., life threatening), powerful stress-induced analgesia is activated (Bolles & Fanselow, 1980). This enables an animal to defend itself or escape from danger, rather than become overwhelmed by fear or the pain of the injury and, therefore, an easy prey. In humans it manifests itself, for example, in the fact that people often report little or no pain immediately following a serious injury, or can rescue somebody else while being apparently oblivious of their own injuries. Only in such exceptional circumstances of extreme environmental stress can severe pain be relegated and momentarily lose its attention demanding character. As the imminent danger diminishes, pain will again demand attention.

Tonic pain is activated by tissue damage relayed by polymodal nociceptors that are distributed in tissues throughout the body with the exception of the CNS. Stimuli are transmitted along small-diameter, unmyelinated, C fibres that have a slower conduction velocity of about 0.5-2 m/s (Adriaensen et al., 1983; Holmes, 1990). Tonic or second pain, therefore, has a mean latency of approx. 1.200 msec (Bromm, 1995). It has a burning or throbbing quality, and causes tonic muscle contractions that strongly motivate us to recuperate and refrain from activities that could further aggravate the injury. They promote natural healing and limit the spread of infection.

The medial pain signalling system is thought to be largely responsible for tonic pain that can linger long after the initial injury has occurred, and is seen to control the affective-motivational component of pain (Melzack, 1990). Its tracts ascend through the central core of the brainstem and send impulses to structures in the limbic system which influences emotions.

Because of its slow conduction velocity, the medial pain signalling system is not well-suited for immediate responses. Rather, activation of the medial system results in the emotional responses that influence actions taken following the initial threat. Tonic or second pain can in many cases be completely or significantly suppressed by psychological factors or peripheral skin stimulation (Price, 1976).

In summary: The lateral pain system is proposed to include the primary (S_I) and secondary (S_{II}) somatosensory cortex, and be involved in the processing of sensory-discriminative aspects of pain. The medial pain system is proposed to include limbic structures such as the anterior cingulate cortex and the mid and anterior insula, and be involved in the processing of the affective-motivational aspect of pain.

1.4.2. **The affective–emotional component of pain experience**

So far, I have mainly dealt with nociception; however, this by itself is neither necessary nor sufficient for the experience of pain. The neural activity is only the initiator that opens the door to the conscious experience of pain. Emotional distress is a fundamental part of the pain experience. It can be a cause of pain, a consequence of pain, and a state concurrent with pain (Craig, 1993). The International Association for the Study of Pain (IASP) clearly acknowledged the importance of affective distress in pain by defining pain as: "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (IASP, 1986, p. S217).

The sensory perception of pain (nociception) would not be experienced as pain without the evaluation of emotional distress. It is not so much the sensory intensity of pain, but rather its negative emotional quality and disruption of normal ongoing activity that lead to suffering. Although it is useful to distinguish between nociception and pain (Fields, 1987), this should not lead to dualistic thinking as the two are highly interrelated and are not amenable to a tidy separation (Fernandez & Turk, 1992). The sensory experience may give rise to the emotional distress of pain, but emotional distress can amplify the sensory experience. Emotions are seen as adaptive and motivating organisers of experience and behaviour (Chapman, 1996).

Emotions compel action and expression, and have an important role in memory and learning processes. What is stored in long-term memory depends heavily on its emotional value. Memories of emotional events have a powerful influence on current and future behaviour and expectations. Associated cues can bring them back to immediate and heightened attention. Emotional events are also highly effective reinforcers (positive or negative) that influence operant learning (Fordyce, 1990).

The emotional reaction to pain is related to the perceived threat of the situation. Perceived threat to our biological integrity results in heightened arousal and a generalised stress response that prepares us for immediate and effective actions needed to safeguard our wellbeing (e.g., the fight or flight response, withdrawing from injurious behaviour, and/or efforts to seek help). Fear conditioning supports survival by fostering avoidance of potentially dangerous situations. However, the fear accompanying pain can become associated with non-noxious stimuli through classical conditioning and lead to avoidance of activities that are not painful in themselves, but have become associated with pain. Furthermore, environmental stimuli, including the behaviour of others, can become reinforcers or punishers that either directly or indirectly reward pain behaviour (e.g., attention from others, possibility of financial compensation) or punish it (e.g., loss of mobility and possibly loss of job and/or status). These influences can become powerful shapers of coping behaviour that either enhance recuperation or lead to maladaptive coping styles and produce chronicity of the pain condition.

Emotional experiences are not simply universal (i.e., inherent and immutable), but are to an important extent determined by societal and cultural influences (Mesquita and Frijda (1992). There is reasonable evidence to suggest that the experience of pain is at least partially a social construction (Craig, 1986). The complex interactions of emotions, previous pain experiences, cultural and societal influences, and subjective expectations and interpretations influence whether and how a particular person experiences pain (see e.g., Craig, 1995; Crawford Clark & Bennett Clark, 1980; Levine & De Simone, 1991; Otto & Dougher, 1985; Zatzick & Dinsdale, 1990).

There is both clinical and experimental evidence for the interaction of emotions and pain. Romano and Turner (1985), for example, observed a bidirectional relationship between pain and depression. Depression can provoke pain by increasing pain sensitivity and reducing pain tolerance, and pain can serve as a stressor that evokes subsequent depression. Zelman, Howland, Nichols, and Cleeland (1991) found that tolerance to cold-pressor pain was reduced by viewing depressive statements and enhanced by viewing reduced elation statements.

Thus the affective-emotional response to injury or tissue trauma is a complex interaction of the perceived threat of the situation; the level of physical arousal and resulting stress response; and the combination of learned behaviours, memories of previous experiences, expectations, and social influences.

The discrimination between sensory and affective pain processing first arises at the dorsal horn of the spinal cord. From here sensory information is transmitted along the spinothalamic tracts, while information destined for affective processing ascends the spinal cord along the spinoreticular tract (Chapman, 1995). The afferent pathways of the spinoreticular tract arrive at different levels of the brain stem from where they project along four major pathways to various areas in the neocortex. These reticulocortical pathways use various neurotransmitters, all of which play a role in the complex experience of emotion during pain. The noradrenergic pathway, consisting of a dorsal and a ventral noradrenergic bundle, is most closely linked to negative emotional states (Gray, 1987).

The *dorsal noradrenergic bundle* (DNB) is the ascending projection from the locus coeruleus (LC). The DNB has widespread projections throughout the limbic system and neocortex. Through these; the LC, which accounts for about 70% of all noradrenaline in the brain, may exert an almost global influence on brain activity (see Chapman, 1995). The LC reacts to stimuli that threaten or signal damage to the biological integrity of the individual. These do not have to be nociceptive specific, but nociception inevitably increases activity in LC neurons. Enhanced activity in the LC and DNB results in negative emotional arousal and hypervigilance that can even progress into panic.

The DNB is the mechanism for vigilance and orientation to affectively relevant and novel stimuli. It also regulates attentional processes and facilitates motor responses (Foote & Morrison, 1987; Gray, 1987). This enables the individual to exercise global vigilance for harmful or threatening stimuli and to respond quickly and effectively when needed. Excitation of the LC is also evident in anaesthetised animals and does not appear to require cognitively mediated attention (Chapman, 1996). The emotional experience of pain is thus linked with the awareness of immediate biological threat and shares central mechanisms with vigilance.

The *ventral noradrenergic bundle* (VNB) innervates the hypothalamus. The medullary reticular formation projects through the ventral noradrenergic bundle (VNB) to the hypothalamus (Bonica, 1990b). These projections supply up to 90% of all the catecholaminergic innervation to the hypothalamus and provide the major neurophysiological link between tissue trauma and the hypothalamic response (Chapman, 1996). The hypothalamus plays an important role in the affective response to pain. The medial and lateral hypothalamus receive input from nociceptive projection neurons at all levels of the spinal cord (Burstein, Cliffer, & Geisler, 1988).

The paraventricular nucleus (PVN) of the hypothalamus is an important coordinating centre that links nociceptive input with autonomic arousal and hormone release in the hypothalamus, pituitary and adrenal cortex also referred to as the HPA axis (see Chapman, 1995). The PVN evokes autonomic arousal through neural as well as hormonal pathways, and neural activation and hormone release in HPA structures is regulated by intricate feedback mechanisms. The HPA axis takes executive responsibility for coordinating behavioural readiness with physiological capability, awareness, and cognitive function (Chapman, 1996). The PVN receives afferent information from other nuclei in the hypothalamus, several nuclei in the reticular system including the LC, and from the hippocampus and amygdala. The PVN synthesises corticotrophin-releasing hormone (CRH), and in response to afferent input that signals threat or injury (e.g., noxious stimulation) secrets CRH into the portal circulation. This, in turn, stimulates the anterior pituitary, which leads to the release of several neuropeptides including adrenocorticothrophic hormone (ACTH) into the systemic circulation (see Chapman, 1996, p. 71; Strand, 1999, pp. 170-174).

ACTH stimulates the adrenal medulla to release adrenaline and noradrenaline and corticosteroids such as hydrocortisone and corticosterone. Corticosteroids inhibit the inflammatory response and provide inhibitory feedback to regulatory processes that can return immune system disturbances to normal, preventing excessive responses to stress that could produce self-injury, that is, autoimmune disease (Strand, 1999). The widespread activation of excitatory and inhibitory processes produce a complex adaptive stress response that involves both neural and endocrinologic changes.

Activation of structures in the HPA axis can alter the normal balance in endocrine function to help ready the organism for the extraordinary behaviours that will maximise its chances to cope with the threat at hand (Selye, 1978). Intricate feedback mechanisms help to regulate hormone activity and re-establish normal homeostasis again. If the spinoreticular activation is particularly strong, these processes can lead to powerful stress-induced analgesia that minimises peripheral sensitisation and attenuates nociceptive signalling, thereby helping the organism to cope with the threat without the distraction of severe pain. When the activation persists after the immediate threat is gone and is not, or cannot be, controlled with medication, the stress response will reduce, but some low to moderate level of stress response action is likely to remain. When this persists for days, weeks, or longer, the prolonged dysrhythmia of the HPA axis may become counterproductive and, in particular, disrupt circadian rhythms. This is evident in the frequent reports of sleep disturbances, fatigue, general lethargy, poor concentration, loss of appetite, and diminished sexual interest by chronic pain patients, although some may undoubtedly also result from side effects of medication taken. These consequences of HPA axis dysrhythmia contribute to the development and maintenance of depression that is a frequent comorbidity of chronic pain (Chapman, 1996).

In summary, tissue trauma results in: (1) activation of both spinothalamic and spinoreticular pathways, (2) the concurrent generation of sensory and affective processes that subserve adaptive functions, (3) activation of predominantly noradrenergic structures in the limbic system to produce the affective dimension of pain, and (4) in a hypothalamically mediated stress response that plays a role in pain chronicity (Chapman, 1996).

Thus, pain is not synonymous with nociception, and cognitive and affective factors play a crucial role in the experience of pain. Accordingly, interventions for the management of pain should target both emotional and sensory processes (Chapman, 1995). Exactly how the nociceptive activity becomes conscious and induces feelings of pain (the mind-body problem) remains still largely unresolved (Crick & Koch, 1992). For further reading on the particular utility of hypnosis in integrating mind and body aspects of pain and healing, see Rossi and Cheek (1988).

1.4.3. **Plasticity in the CNS and the development of acute and chronic pain**

1.4.3.1. *Different pain states, changes in response patterns, and underlying neurophysiological mechanisms*

There are many different pain conditions or syndromes, each with their own specific physiological and psychological characteristics (e.g., low back pain, neuralgia, migraine, visceral pain, deafferentation pain, cancer pain, fibromyalgia etc). An understanding of their underlying mechanisms, combined with psychosocial information, is invaluable in determining the most effective pain-management program for each pain patient or patient group.

There are different criteria along which the various pain conditions can be grouped into broader categories, for example: (i) acute and chronic pain; (ii) nociceptive and nocigenic pain; or (iii) Phase 1, Phase 2, and Phase 3 type pain, which combines the previous two classifications.

Acute pain sensations are usually related to a specific and locally definable injury. They evoke a generalised pain response that involves various characteristic physiological and behavioural changes such as elevation of blood pressure, peripheral vasoconstriction, inhibition of gastrointestinal activity, glycogen release by the liver to increase blood sugar, and extreme anxiety or hostility. These are intended to alert the organism to impending damage and prepare it for rapid response.

Acute pain normally subsides gradually. It responds well to analgesics and usually does not develop tolerance to them (Bullock, 1996; Swonger & Matejski, 1988).

Chronic pain is prolonged, defined by persistence, and often progresses in severity as pathology increases. It is generally less clearly localised and described (Swonger & Matejski, 1988). It is now well-understood that chronic pain is not simply acute pain that lingers on, but involves distinct characteristics, neural changes, and pain behaviours that require different treatment approaches.

Nocigenic or nociceptive pain results from direct activation of nociceptors due to tissue damage caused by trauma, inflammation, or disease, while *neurogenic or neuropathic* pain is due to lesions of nerves in the peripheral or central nervous system and can occurs in the absence of nociceptor stimulation. Neurogenic pain includes pain conditions such as deafferentation and central pain syndromes (e.g., reflex sympathetic dystrophy, phantom limb pain, postherpic neuralgia, thalamic pain) and often has a burning or electric sensation (Basbaum & Jessell, 2000).

Cervero and Laird (1996) have proposed a conceptual framework that can be used to understand the changes in neurophysiological mechanisms that occur along the transition from acute to chronic pain states. They have identified three major stages or phases of pain, which they refer to as Phase 1, Phase 2, and Phase 3 pain. This classification is based on the changes in the nature and time course of the originating stimuli and the subsequent fundamental changes in response properties of various components of the nociceptive system. The three pain phases range from nociceptive pain in a stable, intact, and normally functioning nociceptive system to more abnormal, neuropathic, pain states. Although each phase has its own distinct underlying neurophysiological mechanisms, these are not mutually exclusive and several mechanisms may coexist in the same individual.

Phase 1 pain: Phase 1 pain is of short duration and relates to the processing of brief noxious stimuli (i.e., acute pain of nociceptive origin). It is characterised by a close relationship between the level of activity in peripheral nociceptors and the subjective experience of pain. Experimental pain research has predominantly studied Phase 1 pain.

The features of Phase 1 pain can best be explained by models based on specificity, that is a direct transmission along neural circuits that specifically process simple noxious events with possible modulation occurring at synaptic relays along the way. Localised, brief, noxious stimulation does not result in the extrasynaptic spread of neuropeptides (volume transmission) in dorsal-horn neurons that is evident following inflammation or prolonged noxious stimulation (Sandkühler, 1996).

Phase 2 pain: Phase 2 pain is persistent and relates to intense and prolonged noxious stimulation resulting from tissue damage or inflammation (i.e., chronic pain of nociceptive origin). Repeated, high-frequency stimulation not only greatly increases afferent inflow, but also changes the sensitivity of nociceptive neurons both peripherally and centrally. Phase 2 pain is characterised by this shift in stimulus-response function that is triggered and maintained by repeated, high-frequency input and results in increased excitability. Prolonged noxious stimulation and inflammation also activate the release of various neuropeptides that modulate postsynaptic transmission. Sandkühler and colleagues have observed a synchronisation of discharges in multireceptive neurons following inflammation that was not present following acute, noxious stimulation. (Sandkühler, 1996). Synchronisation of converging neurons is a powerful mechanism whereby information transfer may be strengthened. While, SP superfusion significantly enhanced background activity, by itself it did not result in synchronisation of discharges in converging neurons.

Peripherally, there are two main changes in the response pattern of nociceptors that contribute to Phase 2 pain. First, a lowering in threshold to the extent that stimulation in the area of injury that would normally only be mildly painful results in an excessive response and becomes much more painful (*primary hyperalgesia;* LaMotte, Shain, Simone, & Tsai, 1991). Mildly painful stimulation to normal skin surrounding the injured area may also become more painful (*secondary hyperalgesia;* Cervero, Meyer, & Campbell, 1994; LaMotte et al., 1991; Torebjörk, Lundberg, & LaMotte, 1992). This sensitasation of nociceptors after injury or inflammation results from the release of a variety of chemicals including bradykinin, histamine, prostoglandins, leukotrines, acetylcholine, serotonin and SP by the damaged cells and tissue in the vicinity of the injury (see Basbaum & Jessell, 2000).

Second, this increased responsivity is further enhanced by the appearance of spontaneous activity. Together they result in a continuous barrage of nociceptive afferent input that is likely to contribute to the development of spontaneous pain (Cervero & Laird, 1996). There is evidence that certain noxious stimuli can evoke not only an acute excitation of nociceptors, but also cause prolonged sensitisation of both "normal" and "silent" nociceptors (for a review see Cervero, 1994).

Central sensitisation also plays a role in the development of Phase 2 pain. Repeated, high-frequency, peripheral stimulation also sensitises nociceptive neurons in the spinal cord so that they become more easily excited. Activity in low-threshold mechanoreceptors (e.g., by light touch) is now able to evoked not only tactile sensations, but also the high-frequency output that is associated with pain. This condition is known as allodynia. While allodynia only occurs in responds to a stimulus (i.e., patients with allodynia feel no constant pain), patients with hyperalgesia often perceive pain spontaneously (Basbaum & Jessell, 2000).

This development of spontaneous pain, allodynia, and hyperalgesia is dependent on ongoing afferent input from the site of injury and can be abolished by the injection of a local anaesthetic into the site of peripheral nociceptive activity (Gracely, Lynch, & Bennett, 1992). The knowledge that certain pain states activate subsequent hyperalgesia triggered the idea of using pre-emptive analgesia (i.e., analgesia administered **before** a painful procedure) to reduce, for example, postoperative pain (Wall, 1988). This is an interesting concept, particularly if it would also apply to neuropathic pain. So far, outcome studies have revealed no significant advantage for the pre-emptive use of non-steroidal anti-inflammatory drugs or local anaesthetics, but some tentative positive results have been reported for the pre-emptive use of opioids (for a review see McQuay, 1994). More research is needed using improved designs and larger sample sizes that provide greater statistical power.

Phase 3 pain: Whereas nocigenic pain (i.e., Phase 1 and Phase 2 pain) results from peripheral injury, Phase 3 pain, also called neurogenic or neuropathic pain, results from loss of sensory input due to lesions of peripheral nerves or damage to the CNS itself. A characteristic feature of Phase 3 pain states is the lack of correlation between injury and pain.

There are a number of Phase 3 pain states and their particular features and underlying mechanisms depend not only on the location and nature of the nerve damage, but also on genetic, developmental, emotional, and psychological influences, as well as the influence of instrumental learning, conditioning, and the development of pain memories. Therefore, even seemingly similar injuries might result in greatly different expressions of pain and disability.

There are three main groups of mechanisms that account for the abnormal sensory symptoms that typically accompany most Phase 3 pain states: (1) reactive changes in response to nociceptive afferent input, (2) pathological changes in damaged neurons, and (3) altered response patterns resulting from a functional reorganisation in the CNS following the loss of normal afferent input. Reactive changes in response to nociceptive input are a normal consequence of injury or inflammation. This process also operates in neuropathic pain and is likely to account for the allodynia and secondary hyperalgesia frequently seen in neuropathic pain patients. The pathological changes in damaged neurons and the functional reorganisation in the CNS, however, are largely unique to Phase 3 pain (see e.g., Devor, 1988). Pathological activity in nociceptors and abnormal ongoing activity in damaged, large-diameter, non-nociceptive afferents can results in the particularly prolonged and intense, secondary, hyperalgesia-like and allodynia-like changes observed in neuropathic pain patients following loss of afferent input (Willis, 1994).

We have already seen that the level of ascending spinal nociceptive transmission is determined by the balance between excitatory and inhibitory systems. Differences in this interaction help to explain why Phase 3 pain is often much harder to attenuate than Phase 2 pain, and why, for example, NMDA receptor antagonists are much more effective in the control of inflammation than in the control of neuropathic pain. Tissue damage and inflammation cause activation of nociceptive afferents that excite dorsal-horn neurons. In neuropathic pain this peripheral nociceptive input either is reduced or absent (e.g., following complete transection of the spinal cord). Remaining peripheral input and abnormal firing of damaged neurons may aggravate the condition. Additional excitation can arise from descending excitatory tracts that can be activated by stimulation of the motor cortex, stimulation in the reticular activation system, or emotional responses (Willis, 1991).

Preliminary findings indicate that changes in descending excitation may be involved in the expression of Phase 2 and Phase 3 pain (Cervero & Penderleith, 1985; Cervero & Wolstencroft, 1984).

Even more important than the differences in excitatory input are the very significant changes in inhibitory input. Neuropathic damage result in the reduction of a number of key inhibitory controls, including: (i) loss of afferent input resulting in loss of large-diameter non-nociceptive inhibition; (ii) a reduction in the number of, particularly pre-synaptic, inhibitory opioid receptors; (iii) a reduced ability of morphine to produce analgesia at the spinal level; and (iv) a reduction in the transmitter levels of GABA and glycine, leading to malfunctioning of inhibitory interneurons (Dickenson, 1996a). In contrast, inflammation results in increased activity in inhibitory mechanisms once a certain level of excitation is produced. This might represent physiological attempts to counter the increased peripheral drive. Neurons with low excitability become more excitable, but, within one to three hours of inflammation, neurons with a high degree of peptide or NMDA-receptor-mediated excitation (wind-up) become less active (Stanfa, Sullivan, & Dickenson, 1992). Inflammation increases the ability of morphine to inhibit nociception as it rapidly induces a novel peripheral site of opioid action and enhances the spinal effect of morphine (Dickenson, 1994). Thus, whereas neuropathic damage results in reduced inhibition that helps to maintain a prolonged and constant level of high excitation, inflammation results in a brief period of high excitation followed by an increase in inhibition and a gradual decline in excitation. The effectiveness of morphine analgesia is enhanced after inflammation, yet reduced in neuropathic states.

The magnitude of supraspinal descending inhibition over spinal nociceptive neurons is directly related to the amount of afferent input they receive (Brinkhus & Zimmermann, 1983; Cervero & Plenderleith, 1985). Thus, loss of afferent input not only causes changes at the spinal level, but also leads to reduced descending inhibition from supraspinal mechanisms. This disinhibition may be an important factor in the high spontaneous discharges and exaggerated afterdischarges in dorsal-horn neurons recorded in animals with peripheral or central nerve damage (Brinkhus & Zimmermann, 1983). It may also be responsible for the abnormally enhanced pain perception (hyperpathia) in some patients with neuropathy (Cervero & Laird, 1996).

1.4.3.2. *Changes in neurotransmitter systems*

The different pain phases not only involve different neurophysiological mechanisms, but also changes in pharmacology as different transmitter systems become involved. Opiates, for example, are extremely effective in inhibiting both Phase 1 and Phase 2 pain states. Although there is no obvious theoretical reason why they should not be effective in treating Phase 3 pain, their usefulness in neuropathic pain is subject to some debate (see e.g., Arnér & Meyerson, 1988; Portenoy, Foley, & Inturrisi, 1990). The opioid inhibitory system appears to be less sensitive following deafferentation than following inflammation (Lombard & Besson, 1989; Mao, Price, & Mayer, 1995; Mayer, Mao, & Price, 1995). Neuropathic pain can be very severe and, for extraneous opioids to be effective, their dosage may need to be so high that side effects become intolerable. The extent of changes in the opiate system following nerve damage may also depend on the time elapsed after injury.

Phase 2 pain resulting from tissue damage secondary to inflammation is activated by the increased formation and release of prostaglandins due to the de novo synthesis of the cyclo-oxygenase (COX-2) enzyme (Cervero & Laird, 1996). Cyclo-oxygenase enzymes produce and release prostaglandins, which sensitise nociceptors and stimulate the production of other substances that activate nociceptors such as bradykinins, SP, histamines, and acetylcholine (Stimmel, 1997). This facilitative effect is cumulative and may persist for relatively long periods. The COX-1 enzyme is present in most tissues were it produces prostaglandins as part of normal healthy tissue regulation. The COX-2 enzyme is absent from healthy tissues, but is rapidly induced under conditions of inflammation, resulting in an accumulation of prostaglandins at the injury site (Cervero & Laird, 1996). The effectiveness of non-steroidal anti-inflammatory drugs (NSAIDs) results from their ability to inhibit the activity of, in particular, the COX-2 enzyme. Although NSAIDs can inhibit Phase-1-type pain, they are more effective in conditions of inflammation.

As noted earlier (p. 7), glutamate is a major transmitter in the spinal cord, and the NMDA glutamate receptor subtype is suggested to have an important role in mediating persistent pain and hyperalgesia (Dickenson, 1996a,b).

NMDA receptors are thought to be responsible for the hyperexcitability seen in chronic pain states through their ability to increase the discharge frequency of dorsal-horn neurons (Stimmel, 1997; Woolf, 1983). Severe and persistent injury results in the repetitive firing of C fibres and a progressivly increasing response of dorsal horn neurons referred to as wind-up. This wind-up phenomenon is dependent on the release of glutamate from C fibres and the consequent opening of postsynaptic ion channels by the NMDA-type glutamate receptor. These long-term changes in the excitability of dorsal horn neurons constitute a memory of the C-fibre input that has an important influence on chronic pain states.

NMDA receptor antagonist are not very effective in Phase 1 type pain, but can reverse hyperalgesia evoked by local inflammation and some, but not all, types of abnormal pain behaviours. There is some indication that NMDA receptor antagonists can reduce abnormal neurogenic "wind-up" pain in humans (Kristensen, Svensson, & Gordh, 1992). The development of new NMDA antagonists that are active at the glycine modulatory site of NMDA receptors, thereby greatly reducing the potential for adverse CNS side-effects present in currently available agents, could provide an alternative therapy for Phase 2 and Phase 3 type pain (Cervero & Laird, 1996).

Substance P is another intermediary that is important in the transmission and modulation of neural activity in the peripheral and central nervous system. It binds at the NK1 tachykinin receptor, to which it has the highest chemical attraction of all endogenous molecules. Recently discovered selective NK1-receptor antagonists do not affect responses of dorsal-horn neurons or spinal reflexes to brief noxious stimuli (De Konick & Henry, 1991). This suggests that NK1 receptors are not involved in the transmission of Phase-1-type pain. They do, however, appear to play a role in the processing of Phase 2 pain as they inhibit responses in dorsal-horn neurons to prolonged or intense stimulation and enhanced responding evoked by inflammation (De Konick & Henry, 1991). Furthermore, peripheral inflammation increases the expression of both SP and NK1 receptors in the spinal cord (Cervero & Laird, 1996). Preliminary evidence from animal studies indicates that NK1-receptor antagonists may be effective in Phase 3 pain states (Yamamoto & Yaksh, 1992). These compounds have only been developed quite recently and little published information is available on their effects in experimental or clinical pain in humans.

Substance P has been found to differentially influence the discharge behaviour of the various types of nerve endings (Mense, Hoheisel, & Reinert, 1996). In the peripheral nerve endings of primary afferents, SP did increase background activity in nociceptors and simultaneously decreased responsiveness in low-threshold mechanoreceptors, but had little or no effect on the sensitivity of nociceptors. Increased background activity has been associated with the occurrence of spontaneous pain. The above pattern was reversed at the spinal level. Here, the release of SP resulted in a heightened sensitivity and an increase in the receptive-field size of dorsal-horn neurons, but had no influence on the level of background activity. Thus, SP may contribute to spontaneous pain at the primary afferent level without producing tenderness, while at the spinal level it may be involved in the development of allodynia and hyperalgesia, but has no effect on spontaneous pain. These findings indicate that spontaneous pain and increased sensitivity (hyperalgesia and allodynia) are controlled by different mechanisms and can occur independently. Activation of C fibres resulted in increased responsiveness of dorsal-horn neurons that, before SP release, were only responsive to large-diameter Aβ fibre input. Mense et al. (1996) propose that a proportion of dorsal-horn neurons may have afferent connections that normally are ineffective in driving the cell. The release of SP from spinal terminals of nociceptive afferents may strengthen synaptic connections in these otherwise silent neurons, thereby unmasking additional input and changing dorsal horn connectivity.

1.4.3.3. *Functional plasticity in the CNS*

Although sprouting and the formation of new synapses may occur following nerve injury, damaged neurons in adult mammals have little capacity for successful regeneration (Bullitt, 1991) and, even if this occurs, regenerated receptors generally exhibit significantly lower response thresholds and chemical responsiveness (Zimmermann & Herdegen, 1996). However, parts of the CNS can exhibit considerable plasticity in other forms, both at a functional level and a genetic level (see e.g., Carli & Zimmermann, 1996).

Deafferentation (i.e., loss of sensory input) results in substantial synaptic alterations in normal nociceptive function and a reduction in the immunoreactivity of dorsal-horn neurons to a number of neurotransmitters or modulators (Bullitt, 1991). These include the amino acid glutamate (fast transmitter) and various neuropeptides (slow transmitters and/or modulators) such as SP, neurokinins, galanin, calcitonin gene-related peptide (CGRP), vasoactive intestinal peptide (VIP), and somastatin (SOM). Peripheral nerve section in primary afferents can initiate dramatic and long-lasting changes in the expression of neurotransmitters/modulators and their receptors (see e.g., Dray, 1996; Wiesenfeld-Hallin & Xu, 1996). Glutamate has an important role in the sensitisation and wind-up of WDR neurons. The involvement of NMDA receptors in mediating this activity-dependent hyperexcitability is substantially reduced following peripheral nerve lesions. This is possibly a reflection of the reduced release of glutamate by primary sensory neurons (Wiesenfeld-Hallin, & Xu, 1996). The NMDA receptor appears to play a particularly important role in the development and maintenance of neural plasticity in the spinal cord following tissue damage and inflammation (Coderre, Katz, Vaccarino, & Melzack, 1993).

Indications are that protein kinase C may be involved in the regulation of postsynaptic NMDA and NK1 receptors and is a crucial mediator in the intracellular processes, including protein phosphorylation, that lead to enhanced excitability of central neurons following noxious stimulation (Chen & Huang, 1992; Coderre et al., 1993). Protein kinase C has been found to be particularly abundant in the substantia gelatinosa of the dorsal horn (Mori, Kose, Tsujino, & Tanaka, 1989; Worley, Baraban, & Snyder, 1996, both cited in Tölle, Berthele, Schadrack, & Zieglgänsberger, 1996).

Glutamate and the neuropeptides SP, CGRP, and galanin all coexist in dorsal root ganglion cells (De Biasi, & Rustioni, 1988; Weihe, 1990). There are strong indications that peptides that coexist in the same cells have a functional interaction that can be substantially altered following loss of normal afferent input (Weisenfeld-Hallin & Xu, 1996). Galanin functions as an antagonist to the excitatory effects of SP and CGRP when nerves are intact. A number of changes take place following peripheral nerve section. These include a downregulation in the reactivity of SP, CGRP, and SOM, while that of galanin is intensely upregulated, thereby enhancing its inhibitory role.

In addition, there is a switch in the role of excitatory peptides. This involves a gradual decline of SP in the dorsal root ganglion cells. At the same time, VIP, which normally has no excitatory or facilitatory role, is upregulated and becomes a major excitatory mediator (see Weisenfeld-Hallin & Xu, 1996). On the other hand, galanin now no longer inhibits the excitatory effect of SP, has a greatly reduced inhibitory effect on CGRP, and becomes an antagonist of VIP.

Inflammation can also result in substantial synaptic alterations in normal nociceptive function, but its effects on neurotransmitters or modulators differ from those following deafferentation. Prolonged immunogenic inflammation results in an upregulation of SP and CGRP synthesis in the dorsal-root ganglion neurons of C fibres and an enhanced release of SP and CGRP at the peripheral and central axonal endings. At the central (spinal) synapses, SP and CGRP act as excitatory transmitters or modulators and facilitate nociceptive transmission. At peripheral terminals (e.g., in an inflamed joint) the enhanced release of SP and CGRP induces neurogenic inflammation that contributes to the maintenance of total joint inflammation. When prolonged, this may initiate a viscious circle of inflammation – nociceptor excitation - neuropeptide upregulation – prolonged neurogenic inflammation – nociceptor excitation and sensitisation -- and so on (see Zimmermann and Herdegen, 1996). This mechanism of prolonged inflammation and Phase 2-type pain is another example of long-term changes in nociceptive function due to plasticity of the peripheral and central nervous system. Initial findings indicate that the increased production of CGRP may result at least in part from the synthesis of CGRP in neurons that under normal conditions do not produce CGRP in detectable quantities (see Schaible & Schmidt, 1996). The development, maintenance, and decline of inflammation is a reflection of the changes in the balance between excitatory influences (e.g., SP and CGRP) and inhibitory influences (e.g., dynorphin and enkephalin) on spinal-cord neurons.

1.4.3.4. *Plasticity at the gene-expression level*

Neuropeptides are expressed through gene duplication and there is also evidence for plasticity at the gene-expression level. For a more detailed account of the neuropeptides see Strand, 1999).

Stimulation of nociceptive C fibres releases neurotransmitters/modulators (e.g., glutamate and various neuropeptides) that activate postsynaptic receptors (e.g., NMDA and NK1) which release second-order messengers (e.g., protein kinases) that in turn trigger a multi-enzymatic cascade of intracellular events in the nucleus of the postsynaptic cell. These may induce the phosphorylation (i.e., enzyme-activated catalysis) of genetranscription factors that then bind to promoter elements of immediate–early genes (IEGs). The proteins produced by these IEGs in turn divide and bind to promoter or enhancer elements of target genes that include genes for various peptides, hormones, receptors or enzymes (see Zimmermann & Herdegen, 1996). Any stimulation-induced long-lasting phenotypic changes in nerve cells require de novo protein synthesis that is initiated by some IEGs (Zimmermann, 1991). Such induced expression of IEGs has been observed following loss of afferent input and following noxious stimulation resulting from tissue damage or inflammation.

Gene transcription is the rewriting of the genetic message of DNA into RNA. A gene contains the information required to synthesise a protein, and messenger RNA serves as the template for this protein synthesis (Eigen, 1992; Kolb & Wishaw, 1990). Immediate-early genes are the master switches of this transcription process, and inducible transcription factors (e.g., CREB, ATF-2, Fos, Jun) are enzymes (i.e., transcription proteins) that, when activated by second-order messengers, can act as catalysts for the transcription of IEGs. The ability to change the rate of gene transcription is important during the development of the nervous system, but adult nerve cells do not normally grow and undergo mitosis.

Hunt, Pini, and Evan (1987) were able to show that expression of the c-Fos protein in the nuclei of dorsal-horn neurons followed noxious stimulation of spinal neurons. Subsequent studies have reliably and repeatedly observed the pronounced expression of not only c-Fos, but also several other IEGs following either strong noxious stimulation, inflammation of peripheral tissues, nerve-fibre transection, or experimental superfusion with SP or neurokinin A (e.g., Herdegen, Leah, Walker, Bassler, Bravo, & Zimmermann, 1991; see also Sandkühler, 1996). The ability to change gene expression in adult nerve cells might be an essential part of the mechanisms that enable cells to modify their working range at the molecular level in response to the requirements of changing conditions.

Induced gene transcription may be involved in the long-term plasticity seen in Phase 2 and particularly Phase 3 pain. Zimmermann and Herdegen (1996) suggest that it is conceivable that virtually all long-term changes in CNS function involve modified gene expression in nerve cells.

Stimulation of nociceptice C fibres has been found to evoke a dramatic expression of IEG-encoded proteins in the superficial and deeper layers of the dorsal horn except lamina III, while stimulation of large-diameter non-nociceptive Aβ fibres was not effective in inducing IEG expression (e.g., Hunt et al., 1987; Molander, Hongpaisan, & Grant, 1992, cited in Zimmermann & Herdegen, 1996). Two experimental animal studies, however, found a strong expression of c-Fos in lamina III following subsequent electrical stimulation of the transected nerve stump or when the animal (rat) was allowed to walk freely or run in a running wheel (Jasmin, Cogas Ahlgren, Levine, & Basbaum, 1994; Molander et al., 1992, both cited in Zimmermann & Herdegen, 1996). This suggests that the quality of synaptic transmission can be substantially altered and may result in induction of otherwise nonresponsive genes.

Changes in IEG expression are an example of plasticity at the gene-transcription level. Zimmerman and Herdegen (1996) suggest that they are interrelated with plasticity at the functional level and together result in the enhanced sensitivity of the pain system. This plasticity at the genetic level may enable the organism to alter protein synthesis in an effort to adapt to changing conditions evoked by extra- and intra-cellular stimulation, toxins, and tissue or nerve damage in the peripheral and central nervous system, including the brain. However, this plasticity at the genetic level has to be balanced with the organism's need for stability.

Inducible transcription factors such as the Fos and Jun proteins are potent modifiers of cellular functions and their capacity for synaptic re-arrangement and reactive gene expression should, for example, not be able to result in alterations of the body map. This is relatively fixed for life and the plasticity at the genetic level, therefore, needs to be carefully controlled, most likely by some intraneural mechanisms.

The induction of transcription-factor encoding genes depends in part on intracellular elevation of calcium levels (Ghosh & Greenberg, 1995). There are indications that the control of transcription-factor induced gene expression might involve calcium-binding proteins that absorb (scavenge) calcium ions. Neural stimulation would then only result in transcription-factor induced gene expression when the scavenger system had been saturated. Such a mechanism would protect neurons from large alterations in gene expression that might shift the balance between stability and plasticity at the level of gene expression (Zimmermann & Herdegen, 1996).

The number of c-Fos expressing neurons in the spinal cord and medulla varies with stimulation intensity and their distribution in the various dorsal horn laminae is in part related to the modality (mechanical or thermal) of the noxious stimulus. The protein products of elevated levels of induced IEG expression have been found in the nuclei of dorsal-horn neurons, medulla, limbic system, hypothalamus, and certain thalamic nuclei, but not in areas that are excited by acute noxious stimulation such as the cerebellum and hippocampus or in the ventrobasal complex of the thalamus or in dorsal-column nuclei. Thus, the expression of IEGs appears to label selective neural populations which alter their neural program and their initial protein synthesis in response to a prolonged noxious stimulation (Zimmermann & Herdegen, 1996).

The expression of IEGs is subject to both potentation from co-occurring painful events and habituation over time. The potentation of IEG expression in dorsal-horn neurons parallels the increased sensitivity (hyperalgesia) following noxious stimulation and is likely to have some mechanism in common with long-term potentation of synaptic transmission in the hippocampus. Continuous C-fibre stimulation leads to spontaneous activity and hypersensitivity in dorsal-horn neurons and a strong expression of IEGs. After a period of several days to a few weeks, depending on whether the injury is localised to one site or more diffuse (e.g., monoarthritus or polyarthritus), the IEG expression disappears. This occurs while spinal neurons remain hyperexcitable and continue to show spontaneous firing and while there is an increased release of glutamate and excitatory neuropeptides from the affected C-fibre afferents. All of these influences excite dorsal-horn neurons and would be expected to maintain the level of IEG expression.

The reason for this dissociation of nociceptive activity and IEG expression is not clearly known, but the desensitisation at the transcriptional and genetic level might be related to the loss of novelty of the stimuli that induce IEG expression (Zimmermann & Herdegen, 1996). Prolonged and repeated noxious stimulation might generate lasting, genetically fixed, memory traces (engrams) for pain memories. Thus, chronic events can result in loss of responsiveness and plasticity on a genetic level that could possibly contribute to the progression of the condition and a reduced access for therapeutic interventions (Zimmermann & Herdegen, 1996).

Transection of primary afferent neurons, motoneurons, or preganglionic nerve fibres results in the selective expression of c-Jun when the axotomy is proximal to the cell body and evokes a cell-body response (Zimmermann & Herdegen, 1996). The expression of the c-Jun protein is an early (possibly first) indicator of genetic alteration following axonal injury and is closely related to synaptic remodelling and to the increased regenerative propensity of injured neurons. This has led to the hypothesis that the expression of c-Jun might be an intrinsic molecular-genetic prerequisite for the induction of regeneration-associated genes (Zimmermann & Herdegen, 1996). A greater capacity for axon sprouting and elongation carries with it a higher vulnerability for dysfunctional regeneration and an increased rate of cell death. The level of expression of c-Jun remains elevated until regeneration has established a new target connection, whereupon it gradually returns to basal levels again. A subsequent transection re-induces a dramatic upregulation of c-Jun, indicating that the slow decrease following successful regeneration is not due to neural cell death or a reduced neural capacity for protein synthesis (see Zimmermann & Herdegen, 1996).

The c-Jun IEG has the capacity to associate with a variety of transcription-factor proteins, which gives it a wide operative range to modulate gene transcription. The expression of c-Jun has been found to precede and covary with the expression of nitric oxide synthase (NOS) and the peptides galanin in dorsal-root ganglion neurons and CGRP in motoneurons (see Zimmermann & Herdegen, 1996). Following axotomy, both galanin and NOS are upregulated in the same selective neural populations that include dorsal-root ganglion neurons, but not motoneurons.

Here they act at presynaptic terminals and produce long lasting changes of transsynaptic impulse transfer to second-order spinal neurons. Galanin inhibits the excitation of deafferentated spinal neurons and counteracts the hyperalgesia following peripheral nerve-fibre lesion. It may also have neurotropic effects that could be beneficial to axotomised neurons. The expression of c-Jun and NOS are very closely related in both quantity and time course. Enhanced NOS levels result in an increase of released nitric oxide (NO, the product of enzymatic catalysis of NOS), which facilitates the excitatory input and hyperalgesia of dorsal-horn neurons (Anbar & Gratt, 1997). Furthermore, NO is also involved in the expression of c-Fos in spinal-cord neurons following peripheral noxious stimulation and is colocalised with AP-1 transcription-factor proteins (see Zimmermann & Herdegen, 1996). The synthesis of CGRP triggers the reformation of acetylcholine receptors in muscle fibres resulting in functional re-establishment of neuromuscular transmission (New & Mudge, 1986).

Only some of the major mechanisms involved in long-term changes in nociceptive function have been described above. Many other, in general not fully understood, factors are either known to be or likely to be involved. The combined evidence indicates that the following phenomena and mechanisms may be involved in the development and maintenance of chronic (neuropathic) pain: (1) a decrease in the strength of descending inhibition, (2) a decrease in the efficacy of monoaminergic inhibitory systems, (3) a decrease in responsiveness of the opioid antinociceptive system, (4) an increase in excitatory synaptic transmission within the ascending nociceptive system due to an increasing involvement of NMDA receptors, and (5) complex processes at the level of nuclear gene transcription as indicated by induced IEG expression (Zimmermann, 1991). A thorough understanding of the molecular and genetic processes in the nervous system will have much to contribute to our current understanding of the mechanisms involved in the chronification of pain.

Research findings so far suggest that the structural changes following induced gene expression have the potential to result in functional changes in the circuitry of dorsal-horn neurons. They also suggest the potential for the development of new therapeutic interventions that prevent or reduce the long-term alterations that underlie, currently often hard to treat, chronic pain conditions.

Further research might also clarify whether some kinds of chronic pain can best be understood and treated as diseases of acquired gene-transcription failures, which could result in new therapies (Zimmermann & Herdegen, 1996). The possibility for the development of new NMDA antagonists with reduced side effects that could provide an alternative therapy for Phase 2 and Phase 3-type pain has already been mentioned (Cevero & Laird, 1996). The fact that the moderate galaninergic control of nociceptive input is greatly enhanced following nerve injury suggests that galanin agonists may be useful analgesics for the treatment of neuropathic pain. The observed changes in induced gene expression and protein synthesis also suggest the potential for possible interventions aimed at the level of second-order messenger systems. However, second-order messenger systems have many and diverse effects, and pharmacological attempts to block these interactions are likely to result in unexpected side effects (Willis, Sluka, Rees, & Westlund, 1996).

A few cautionary comments are appropriate here. It is not known what happens beyond the few transcription factors that have been observed so far, and many new processes and modulators of nervous system function might still be discovered. The initial observation by Hunt et al. (1987) that expression of IEGs followed noxious stimulation of the nervous system led to the hypothesis that the induced expression of IEGs may play a role in the long-term changes in nociceptive function observed in Phase 2 and Phase 3 pain states. However, despite the many studies that have supported and extended this observation, no evidence of a direct causal relationship between altered gene expression and changes in nociception has as yet emerged (Sandkühler, 1996). Furthermore, the same transcription processes can activate a variety of target genes and the final outcome of these processes is still largely unknown. Finally, virtually all of these experimental studies have been conducted on animals and it is known that there are considerable interspecies differences in the reaction of nervous cells to injury.

In summary, it can be concluded that: (i) the three major pain phases have different underlying neurophysiological mechanisms and involve differences in the action of neurotransmitter/modulator systems; (ii) prolonged high-frequency stimulation can result in long-term changes in the CNS including spontaneous activity and increased sensitivity of nociceptive neurons; (iii) nerve damage and loss of afferent input can result in functional reorganisation at both the spinal and cortical level; (iv) there is evidence of considerable plasticity in the CNS at the systemic, cellular, and molecular levels; (v) the effects of this plasticity and reorganisation are important factors in the development and maintenance of chronic pain and the abnormal pain features that are characteristic of neuropathic pain; and (vi) nociceptive stimulation of spinal neurons is accompanied by changes in the expression of IEGs, which, at the moment only speculatively, have been linked to long-term changes in nociception and the rewiring of the dorsal horn.

1.4.4. **The diathesis-stress model of chronic pain**

Pain responding involves three interacting response systems: the physiologic-organic, the motor-behavioural, and the psychologic-cognitive (see Birbaumer, Flor, Lutzenberger, & Elbert, 1995). The resulting pattern of interaction plays a decisive role in the development, maintenance, and extinction of chronic pain. The specific response pattern can vary over time and between individuals, as well as between different pain syndromes. Flor, Birbaumer, and Turk (1990) have proposed a diathesis-stress model of chronic pain. Flor and colleagues (see Birbaumer et al., 1995) found that, at the physiological-organic level, pain patients develop excessive muscular tension when exposed to personally relevant stressful situations and episodes of pain. The increased muscle responsivity was localised to those muscle-fibre groups in which the patient subjectively experienced the pain and resulted in either a local sensitisation of nociceptors or the direct activation of nociceptors in contracted muscle fibres. Furthermore, pain patients exhibited a reduced capacity to consciously perceive and voluntarily regulate their levels of muscle tension (Flor, Birbaumer, Schugens, & Lutzenberger, 1992).

Birbaumer et al. (1995) proposed that chronic pain involves a response pattern (both peripheral and central) that is learned through classical and instrumental (operant) conditioning The muscular response is contingently preceded by physical, motor, or psychological stimuli. When these are perceived as pain cues, their originally pain-neutral characteristics elicits the pain response with which they are associated (classical conditioning). The pain response is typically followed by various actions to achieve pain relief (e.g., assuming certain body positions, avoiding certain activities) and other forms of positive reinforcement (e.g., attention from significant others, time of work, injury compensation). These constitute the instrumental learning element in the maintenance of the classically conditioned pain response (Fordyce, 1976; 1990).

Chronic pain seems to change fundamentally the way in which the cortex processes painful stimulation. It results in learned changes in cortical brain activity. These are apparent in changes in the amplitude and localisation of electroencephalographic (EEG) and magnetoencephalographic (MEG) recordings of pain-evoked brain potentials. Chronic pain patients have been found to exhibit both an early (pre-conscious) site-specific and a late, nonspecific, overactivation of cortical areas involved in the processing of painful stimuli (see Birbaumer et al., 1995). Central cortical processes are clearly involved in the development and maintenance of pain. Birbaumer et al. (1995) regard the early, site-specific, increase in pain response as a learned increase in the facilitation of pain related information by the projection areas in the primary somatosensory cortex (S_I). Late (slow) potentials indicate a nonspecific increase in responsivity for conscious evaluative-cognitive processing in chronic pain patients. Memory forms a crucial component of perception (Adolphs & Damasio, 1995), and the mental representation of an experience engages the vast knowledge accumulated in distributed neural networks. The learned response patterns described above can become habituated and develop into stable pain memories that are independent of actual tissue damage and form the basis for patients' continued suffering. Birbaumer et al. (1995) found that patients who continued to avoid anticipated, but no longer existing, pain exhibited a change in the dynamics of widespread cortical cell assemblies responsible for the storage and retrieval of pain memories. This involved a characteristic sequence of depolarisation (negative potential) before the conditioned avoidance response, followed by a repolarisation by a reinforcing (positive) inhibitory potential after the response.

Thus, chronic pain causes changes in the pattern of physiological and psychological responses. Sympathetic nervous-system responses may become habituated and nerve damage may cause sensitisation and reorganisation of other, including central, parts of the nervous system. Pain tolerance is frequently lowered, and pain may be evoked not only by actual stimuli, but also by expected (i.e., conditioned) stimuli. Comorbidities (e.g., depression, anxiety, sleep disturbances, irritability, and changes in eating habits) are frequently manifested and can play an important role in the manifestation of pain. Pain behaviours may include maladaptive responses such as catastrophising and avoidance of a wide range of activities. Fear relevant stimuli (e.g., certain activities or movements) are particularly likely to become associated with aversive events (e.g., pain) and produce long-lasting conditioned automatic responses (Öhman, 1993). Such fear-conditioned learning may lead to severe malfunction in home and work situations. Real or perceived secondary gain can also become powerful motivators of avoidance behaviours (Eisendrath, 1995). For a review of scientific evidence for secondary gains, see Fishbain, Rosomoff, Cutler, and Steele-Rosomoff (1995).

Unlike acute pain, chronic pain serves no biologically useful purpose. It is less responsive to analgesic mediation and tolerance usually develops. As Bonica has stated: "... chronic pain rarely, if ever, has a biological function, but is a malefic force which imposes severe physiological, emotional, economic and social stresses on the patient, on his family, and on society as a whole." (Bonica, 1979, p. 206).

1.4.5. **Pain in absence of nociceptive input - the neurosignature**

Certain phenomena such as phantom-limb pain could not be explained by the gate-control theory as it was and clearly indicated that additional mechanisms had to be involved. Observations in people with total spinal sections did reveal that the brain, despite being completely disconnected from the spinal cord, may still perceive the presence of, and sensations in, extremities that are no longer, or never were, part of the body. This suggests that the brain itself, without sensory input, can generate every quality of experience normally triggered by sensory input (Melzack, 1989). Apparently, "you don't need a body to feel a body".

Therefore, to arrive at a more complete understanding of pain mechanisms, it was necessary to include cortical structures above the level of the medulla oblongata and the midbrain. While these are normally triggered by sensory stimuli, they do not rely on them.

The body is normally perceived as a unity and is identified as the self, distinct from other people and its surroundings. Melzack (1991) has proposed that the neural substrate for this body-self consists of a widespread network of neural circuits (loops) that include structures in the thalamus, cortex, and limbic system. He has called this network the neuromatrix. The particular structure of the neuromatrix (i.e., the pattern of synaptic connections) is genetically programmed and subsequently modified by sensory input and experiences including e.g., pain memories (Katz & Melzack, 1990).

All input from the body undergoes repeated cyclical processing and synthesis through the circuits of synaptic connections in the neuromatrix. This transformation imparts a characteristic pattern, or neurosignature, on all input flowing through it (Melzack, 1991, 1993). Parts of the neuromatrix are specialised to process input related to major sensory events (e.g., injury, temperature change, and erogenous stimulation), and such neuromodules may impress subsignatures on the larger neurosignature. Thus, the neuromatrix acts like a template for the whole body that generates a continuous representation of the body and includes patterns for the myriad qualities we experience (Melzack, 1995).

The constantly varying nerve-impulse patterns resulting from this cyclical processing and synthesis are superimposed on the main signature pattern. The resulting continuous stream of neurosignature output is diverted into two systems (Melzack, 1993, 1995). In one, the neurosignature is projected to areas in the brain known as the sentient neural hub. Here the stream of nerve impulses is converted into a continually changing stream of awareness (e.g., the experience of movement). A similar neurosignature pattern proceeds through an action neuromatrix that produces activation of neurons in the spinal cord resulting in several possible patterns of muscle activity for complex actions (e.g., riding a bicycle).

Continued feedback ensures that possible action patterns are successively eliminated until the pattern emerges that is most appropriate for the existing circumstances. In this way, input and output are synthesised simultaneously and in parallel, thereby ensuring a smooth and continuous stream of action patterns. The split in neurosignature output can account for the fact that impulses originating in the brain may generate the awareness of movement of a phantom limb even though there is no limb to move and no proprioceptive feedback.

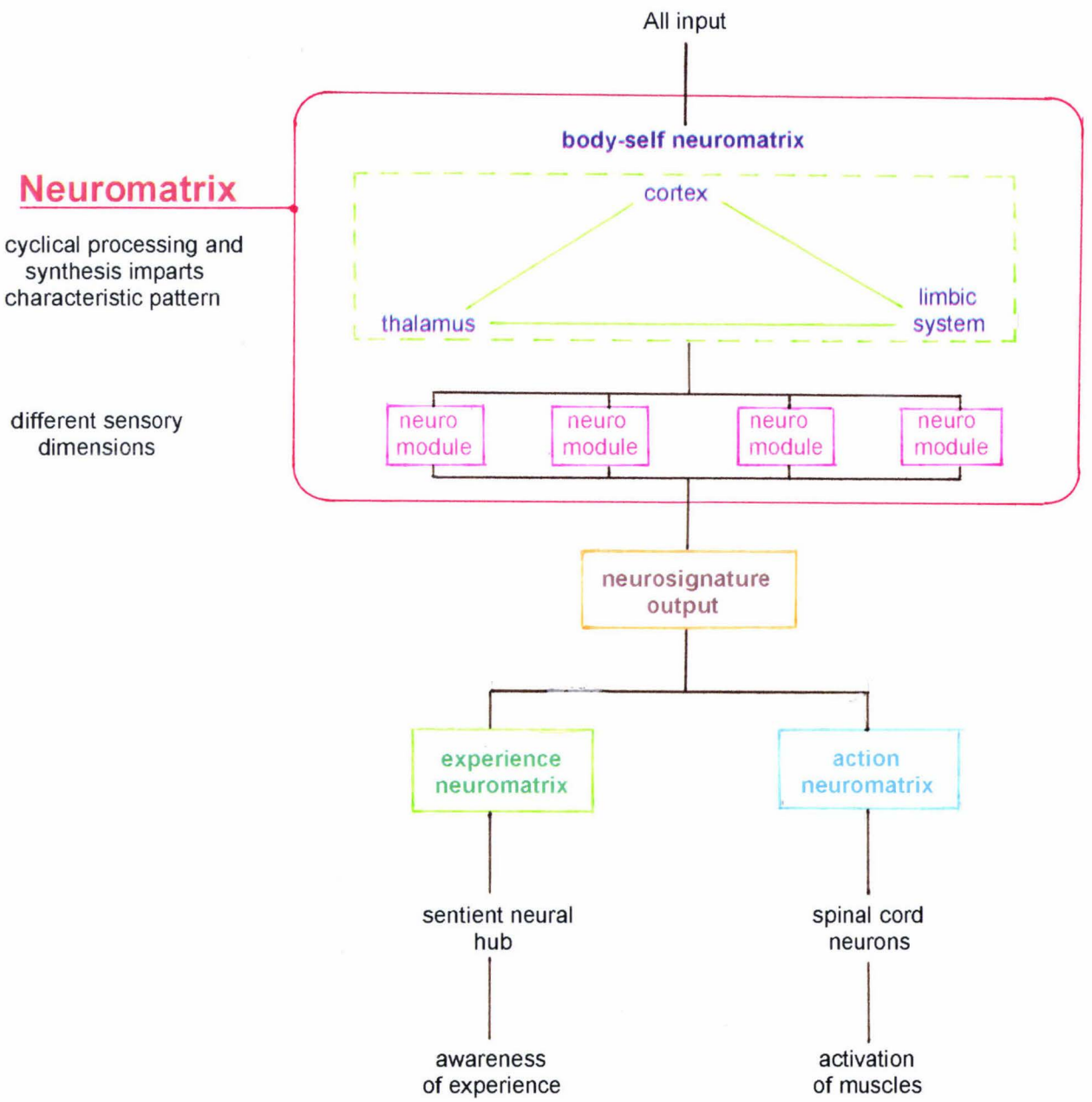

Figure 4. Schematic representation of information processing in the neuromatrix.

It has become obvious that the qualities of the experience of sensations are generated in the brain and are not inherent in the peripheral nerve stimulation as suggested by classical specificity theory. Furthermore, we do not learn the qualities of experience; our brains are built to produce them. The experience of the body-self involves sensory, affective, evaluative, postural and many other dimensions. The sensory dimensions are subserved, at least in part, by neuromodules in the sensory projection areas of the brain. The affective dimensions are subserved by neuromodules in areas in the brain stem and limbic system. Other neuromodules are responsible for particular action patterns. Each of these works together, a bit like the different sections of musical instruments in a symphony orchestra that together produce the single unitary experience we recognise as the particular musical symphony. The stream of neurosignature output, with constantly varying patterns riding on the main signature pattern, produces the sensations of the whole body with their constantly changing qualities.

Ramachandran, Stewart, and Rogers-Ramachandran (1992, cited in Birbaumer et al., 1995) found that somatosensory neurons representing a deafferentated body area (e.g., amputated limb) develop an increased responsivity to activation by input from other body areas. This cortical reorganisation or remapping may be the basis for the altered neuromatrix in phantom-limb patients. The neurosignature is produced by the pattern of synaptic connections in the entire neuromatrix. Because the neuromatrix extends throughout selective areas of the entire brain, its destruction is not a viable option for terminating the neurosignature of pain in, for example, a paralysed or amputated limb. However, if, as suggested, the neurosignature for pain is generated by the cyclical processing and synthesis that occurs within the neuromatrix, then blocking activity in these areas could produce relief of experienced pain. A number of studies have examined the analgesic effects caused by injection of the local anaesthetic lidocaine into several brain structures. Results suggest that several particular structures are involved in generating the neurosignature for pain. These include the lateral hypothalamus, the cingulum bundle and other reticular areas, the dentate nucleus with its major connections to the hippocampus, and the medial and interlaminar thalamus (McKenna & Melzack, 1992; Tasker, Choiniere, Libman, & Melzack, 1987; Vaccarino & Melzack, 1992).

1.4.6. **The neurophysiology of pain - Pain and the brain**

Advances in neurophysiological techniques for the imaging and recording of brain function have provided much new information about the role played by cortical structures in, among others, processes such as attention, pain perception and responding, consciousness, and hypnosis. Results have shed important new light on the observed individual differences in these attributes and have provided new direction for research efforts. Such techniques include: analysis of event-related potentials obtained by electroencephalography (EEG) or magnetoencephalography (MEG), positron-emission tomography (PET) images of regional cerebral blood flow (rCBF), and functional magnetic resonance imaging (fMRI).

Event-related electrical brain potentials provide a unique "window" to brain activity during perceptual and attentional processes, including pain processing (Bromm, 1985; Pribram & McGuinness, 1992; Treede, Lorenz, Kunze, & Bromm, 1995). Repeated stimulation and sophisticated averaging techniques can be used to better identify the small electrophysiological changes and separate them from the spontaneous background noise. For a review of EEG recording of event-related brain potentials see, for example, Birbaumer, Elbert, Canavan, and Rockstroh (1990) or Raichle (1994).

Studies recording brain activity have clearly shown that awareness of pain does not stem from neural activity in a single brain centre, but involves the participation of several functionally distinct, but interacting and interrelated, brain areas (Casey, Minoshima, Morrow, Koeppe, & Frey, 1995; Porro & Cavazzuti, 1996; for a review see Chen, 1993a, 1993b), These include in particular: the limbic system, the anterior cingulate cortex, the primary and secondary somatosensory cortex, and the orbital frontal cortex (Jones, Brown, Friston, Qi, & Frackowiak, 1991; Kenshalo & Douglas, 1995; Roland, 1992; Talbot, Marrett, Evans, Meyer, Bushnell, & Duncan, 1991). The sensory cortex is involved in the discrimination of the nature and location of the stimulus, the motor cortex is responsible for the movements initiated by the action system, the limbic system and frontal lobes are the source of the emotional response, the hypothalamus coordinates the autonomic arousal and stress response that initiates behavioural readiness, and so on.

Positron emission tomography studies of rCBF in normal volunteers during noxious heat to the forearm indicate pain related increases in CBF in the contralateral anterior cingulate cortex, lentiform nucleus, insula and prefrontal cortex; and bilaterally in the thalamus and primary and secondary somatosensory cortex (Casey, Minoshima, Gerger, Koeppe, Morrow, & Frey, 1994; Coghill, Talbot, Evans, Meyer, Gjedde, Bushnell, & Duncan, 1994, both cited in Chapman, 1996; Jones et al., 1991; Talbot et al., 1991). The lentiform nucleus is part of the basal ganglia and consists of the putamen and globus pallidus. The insula is the only part of the limbic cortex in which cells respond directly to somatic stimulation (MacLean, 1990). It is located just lateral from the lentiform nucleus and in close proximity to the primary and secondary somatosensory cortex. Non-noxious (vibrotactile) stimulation also activates primary and secondary somatosensory cortical areas, but painful stimuli has a significantly greater effect on the insula and produces in general a more widely dispersed effect. The insular cortex receives direct projections from the ventral and posterior medial thalamic nuclei. Neurons in the insular cortex process information on the internal state of the body and contribute to the autonomic component of the overall pain response (Basbaum & Jessell, 2000). The close anatomical connections between these areas suggest that they are highly interactive in the encoding of different aspects of pain.

The thalamus appears to be especially important for the experience of pain. Not only is it a crucial relay system between cortical structures and spinal cord mechanisms, but the activity of certain thalamic structures is critical for the experience of the affective (i.e., distress) component of pain. Furthermore, the thalamus appears to have the capacity to generate the experience of pain without input from ascending or descending spinothalamic tracts. If the thalamus is totally ablated, the experience of pain ceases (Gonzalez, 1995). Damage to the CNS (e.g., following spinal cord injury, peripheral deafferentation, amputation, or stroke) frequently results in central pain syndromes. There is evidence that such conditions are accompanied by abnormal firing (burst-firing) and somatotopographic reorganisation of certain neurons in the thalamus (Flor, Elbert, Knecht, Weinbach, Pantev, Birbaumer, Larbig, & Taub, 1995; see also Tasker, 1995).

The spinothalamic tract terminates predominately in the ventral caudal part of the ventrobasal (VB) complex of the thalamus. The ventrobasal complex consist of the ventral posterior lateral (VPL) nucleus and the ventral posterior medial nucleus (VPM) The caudal portions of the VPL receive somatosensory information from dorsal-horn nuclei via the spinothalamic tract and dorsal-column medial lemniscus, while the caudal area of the VPM receives somatosensory information from the trigeminal nuclei in the head via the spinal trigeminal tract (see Netter, 1983). Cells in the posterior and ventral portion of the VB complex are somatotopically organised so that they provide a somatosensory representation (homunculus) of the body map. In actual fact, Tasker and colleagues report a dual representation of this somatosensory body map; a horizontally oriented and strictly contralaterally representing homunculus and immediately posterior from it a vertically oriented, bilaterally organised, representing homunculus (Emmers & Tasker, 1975, cited in Gybels & Kupers, 1995). Deafferentation, spinal-cord injury, and stroke have been shown to result in somatotopic reorganisation (Tasker, 1995).

Stimulation of certain subcortical brain structures can both provoke and suppress pain. The response to such stimulation has repeatedly been found to differ between patients with and without pain (for a review see Gybels & Kupers, 1995; Gybels & Sweet, 1989). Cells in the VPL and VPM of the thalamus are clustered according to the somatosensory dimension to which they predominantly respond. Electrical stimulation of the ventrocaudal nucleus of the thalamus (in particularly the posterior and inferior located parvocellular portion) often provokes localised sensations of cramplike burning pain in patients with central pain, but rarely in patients with (nonpainful) movement disorders (e.g., Lenz, Tasker, Dostrovsky, Kwan, Gorecki, Hirayama, & Murphy, 1988). A similar difference has been observed for stimulation of the intralaminar nuclei of the thalamus (for review see Gybels & Kupers, 1995). Following intralaminar stimulation, pain patients experienced burning pain and central allodynia, but none of the natural unpleasant sensations (e.g., dizziness, difficulty in breathing, movement) experienced by pain-free patients. The intralaminar parts of the thalamus do not exhibit the strict somatosensory representation of the posterior parts of the VB complex; therefore, any sensations evoked tended to be rather diffuse and poorly localised.

This suggest that ventrocaudal and interlaminar thalamic nuclei may be functionally altered in patients with central neuropathic pain, and that this alteration might be related to the sensation of pain in these patients.

There are indications that the occurrence of pain following intralaminar stimulation is dependent on the presence of allodynia or hyperpathia. Tasker and coworkers observed that a large proportion (62%) of patients with deafferentation pain, who also exhibited allodynia or hyperpathia, showed a peculiar sensitivity to electrical stimulation of the medial thalamus and medial tegmentum. Such stimulation induced a contralateral, poorly localised, burning pain that frequently resembled the deafferentation pain, patients suffered from. This effect was only present in 8% of pain patients who did not exhibit these sensory abnormalities. Thus, in central pain patients, stimulation of the ventrocaudal nucleus results in burning sensations that are referred topographically to the deafferented area; while stimulation of the medial thalamus results in burning pain that is referred to large, poorly defined areas of the contralateral body, but predominantly only in central pain patients who also exhibit allodynia and hyperpathia (Tasker, et al., 1983, cited in Gybels & Kupers, 1995).

Lenz and colleagues (see Lenz, 1991; Lenz & Dougherty, 1995) observed that, in patients with chronic pain following spinal-cord transection, neurons with receptive fields adjacent to the area of sensory loss occupied an increased area of the thalamic homunculus compared to the area normally representing that part of the body. Somatotopic reorganisation was also suggested by a mismatch between receptive fields and projected fields. After loss of sensory input to a portion of the ventrocaudal thalamus, the lost receptive fields from the deafferented part may be replaced by receptive fields from body parts from which input is still intact (Tasker, 1995). This is supported by clinical observations that patients with nervous system injury frequently mislocate sensations in the border area of sensory loss to the anaesthetic parts of the body (Leijon, Boivie, & Johansson, 1989). The central representation of a deafferented part of the body persists long after the loss of sensory input from that body part. This may be the physiological basis of phantom sensations, and changes in the central representation may be responsible for alterations in size and shape of phantoms (Jensen & Rasmussen, 1989).

Lenz and colleagues also observed significant abnormalities in the spontaneous activity of cells in the ventrolateral thalamus representing the border zone between anaesthetised and normal body areas. Such cells exhibited a significantly higher likelihood of having a burst-firing pattern, a lower rate of action potentials outside bursts, and a longer pre-burst interval. Burst firing was most intense in cells located in the ventrocaudal areas where spinothalamic terminals are most dense. Findings suggest that the neural reactivity of deafferented cells in the border zone is fundamentally different from that in control areas (Lenz & Dougherty, 1995).

Loss of afferent input from the spinothalamic tract results in an interruption of excitatory input and tonic facilitation, as well as a change in inhibitory processes in the thalamus. These changes in the balance between excitatory and inhibitory inputs can lead to a hyperpolarisation of thalamic projection neurons that induces an oscillatory mode of functioning resulting in calcium-spike activated burst firing (see Lenz, 1992; Steriade & Llinas, 1988). This burst-firing activity may be related to the paroxysmal component of deafferentation pain that may be experienced following loss of sensory input. However, both burst firing and somatotopic reorganisation also occur in deafferentation patients who do not have pain and their exact role in central pain is not clear yet (Tasker, 1995). McCormick and Pape (1990) have demonstrated, in animals, that burst-firing activity associated with calcium spikes can be modulated by noradrenergic, serotonergic, and cholinergic agents. The adrenergic and anticholenergic effects of some antidepressants may explain the effectiveness of these agents in the treatment of central pain (Feinmann, 1985).

Stimulation of selective subcortical brain structures has been used successfully to suppress certain pathological conditions of persistent pain in humans, particularly when opioids provide insufficient pain relief or produce unmanageable side effects (see Gybels & Sweet, 1989). Deep brain stimulation appears to be more or less equally effective in neuropathic and nociceptive pain. Stimulation of the periventricular and periaqueductal gray matter is used mainly for nociceptive pain (e.g., cancer pain and low-back pain), whereas VPL - VPM thalamic stimulation is used predominantly for neuropathic pain.

Somatosensory thalamic stimulation is most effective for pain due to peripheral nerve lesions and postcordotomy pain, while conditions involving atrophy at the dorsal horn and somatosensory thalamic level (e.g., pain following spinal-cord lesions, thalamic pain, and anaesthesia dolerosa) respond only poorly (Gybels & Kupers, 1995). There is some clinical evidence that stimulation of the motor cortex may be useful in relieving neuropathic pain of central or trigeminal origin (Meyerson et al., 1992; Tsubakawa et al., 1991, both cited in Gybels & Kupers, 1995). Overall therapeutic success rates are around 30%, for studies that included patients with an unfavourable responses to trial stimulation and in whom no stimulator was internalised as treatment failures, and around 50% for studies that excluded such cases (see Gybels & Kupers, 1995).

Anatomically, the medial and the lateral pain systems divide at the level of the thalamus. Nociceptive neurons in the lateral nuclei project to the primary and secondary areas of the somatosensory cortex, while nociceptive neurons from the medial and interlaminar thalamic nuclei project to structures in the limbic system including the anterior cingulate cortex. The medial pain system also involves connections to the periaqueductal grey, orbitofrontal and precentral agranular cortices, and the amygdala (see Kenshalo & Douglas, 1995).

There is data to suggest that the primary somatosensory cortex (S_I) and secondary somatosensory cortex (S_{II}) may receive and process nociceptive information in a parallel fashion. Both areas receive nociceptive information from the spinothalemic tract (Roland, 1992). This appears to arrive at S_I through a major nociceptive pathway involving the ventroposterior lateral (VPL) nucleus and a smaller pathway through the ventroposterior inferior (VPI) nucleus and the centrolateral nucleus. The major pathway whereby S_{II} receives nociceptive information is through the VPL, VPI, and posterior nuclei (Roland, 1992; see also Kenshalo & Douglas, 1995).

The primary somatosensory cortex (S_I) appears to play primarily a role in the sensory-discriminative characteristics of pain (Jones & Derbyshire, 1995). Neurons in S_I are capable of encoding the location and intensity of the noxious stimulation. This area seems to be more concerned with the specific features of the stimulus, rather than its noxious nature (Jones et al., 1991; Kenshalo & Douglas, 1995).

The secondary somatosensory cortex includes neurons located in S_{II}, area 7b, and the retroinsular cortex. Only a small number of neurons in S_{II} respond to nociception (< 3% in S_{II}, approx. 9% in area 7b) They are clustered in localised regions, particularly in area 7b involved with whole body representation. These neurons have large receptive fields, and whereas some have a slowly adapting discharge that is graded with the intensity of the noxious stimulus, others do not encode intensity. In addition, a cluster of high-threshold nociceptor-specific neurons with small receptive fields has been located on the border between S_{II} and area 7b. These neurons did not encode the intensity of noxious stimuli, but did provide information about the duration of the stimulus (see Kenshalo & Douglas, 1995). Area 7b appears to be an important area for integration of visual and somatosensory (particularly nociceptive) information that is necessary for spatially directed attention. Thus, nociceptive neurons found in S_{II} and area 7b do not appear to be involved in the sensory-discriminative dimension of pain, but the visiosensory cortex may play an important part in spatially directed attention to noxious thermal stimuli.

The anterior cingulate cortex also participates in the perception of pain (Jones et al., 1991; Talbot et al., 1991) and there are some indications that this part of the cortex is involved in the affective-motivational aspects of pain sensation (Roland, 1992). The anterior cingulate cortex is particularly rich in opiate receptors and enkephalin immunoreactivity (Kuhar, Pert, & Snyder, 1973). Cingulotomies (i.e., surgical lesions of the cingulate cortex) have been reported to alleviate chronic pain (e.g., Gybels & Sweet, 1989). Furthermore, Vaccarino and Melzack (1989) found that lidocaine injections into the cingulate bundle could block behavioural measures of pain responses in rats to tonic (formalin injection in the forepaw), but not phasic (hot water foot-flick test) pain. The formalin pain has a significantly longer duration than the brief phasic pain and may, therefore, have a greater affective component. Vaccarino and Melzack, therefore, suggest that this blocking of observable pain behaviours might reflect a role of the cingulate bundle in the affective-motivational component of pain.

Sikes and Vogt (1992, cited in Kenshalo & Douglas, 1995) found that neurons in the anterior cingulate cortex responded primarily to noxious mechanical and thermal stimuli and had broad receptive fields with little or no somatotopic organisation.

Nociceptive responses in the anterior cingulate cortex were transmitted through the medial and intralaminar thalamic nuclei and were not effected by surgical lesions removing input from other cortical areas, including the somatosensory, insula, parietal and posterior cingulate cortices. This further supports suggestions that the anterior cingulate cortex is directly involved in affective and/or autonomic responses to nociceptive stimuli.

A PET study by Rainville, Duncan, Price, and Bushnell (1997), established direct evidence that the anterior cingulate cortex is involved in the specific encoding of pain unpleasantness. These researchers used hypnotic suggestions to selectively manipulate the unpleasantness of noxious stimuli without changing the perceived pain intensity. Results revealed significant changes in metabolic activity (rCBF) in the anterior cingulate cortex during manipulation of the unpleasantness of induced pain (i.e., immersion in neutral or painfully hot water). Activity in S_I and S_{II} was unaffected by manipulation of the affective component of pain. This study also demonstrated that hypnotic suggestions can effectively and selectively alter aspects of pain processing.

The ventrolateral orbital cortex (VLO) also participates in the processing of nociceptive information. This area receives major afferent input from the nucleus submedius, which contains a large number of neurons that are responsive to noxious stimulation of the skin, the large internal organs, and the joints (Snow, Lumb, & Cervero, 1992). These neurons have large receptive fields that may cover the entire body. This lack of somatotopic organisation and the convergence of cutaneous, visceral, and joint information suggest that VLO neurons are more likely to play a role in the affective-motivational component of pain. Activation of the VLO may be responsible for the unpleasant experience that causes the organism to attempt to escape from prolonged painful stimulation (Kenshalo & Douglas, 1995).

However, PET recording techniques have some limitations. They may lack the spatial resolution to differentiate between closely adjacent structures, particularly when these are coactivated during task performance (Goldman-Rakic, 1995; Jones & Derbyshire, 1995).

Jones and Derbyshire, for example, caution that PET lacks the spatial resolution to distinguish between S_I, S_{II}, and the insular cortex, and suggest that careful repeated individual fMRI studies are needed as these permit control of the attentional and sensory-discriminative components of pain between experiments. Furthermore, although currently available PET procedures can indicate activity levels, they are not able to determine whether the recorded activity is excitatory or inhibitory. The same applies for fMRI studies. The valance of the synaptic activity needs to be determined by other methods such as EEG or MEG recorded potentials (Casey et al., 1995).

Areas of neural activity in the brain can be localised by measuring the induced electrical potentials on the scalp (EEG) or the magnetic fields outside the skull (MEG). The appearance of an evoked electrical or magnetic potential gives evidence that a peripheral sensory impulse pattern has been transmitted to the brain via activation of the specific afferent system. Some more recently conducted studies have used laser technology to deliver brief, radiant-heat stimuli. Individual stimulus durations can be as small as a few milliseconds, and the applied heat is completely absorbed in the most superficial skin layer. Such stimuli, therefore, selectively evoke nociceptive neural activity that is transmitted along $A\delta$ or C fibres and projected within the spinothalamic tract. Experimental pain research investigates the late components of cortical evoked responses to these phasic pain specific stimuli.

The late components of laser evoked potentials (LEPs) are related to $A\delta$ fibre activation and ultra-late components are related to C-fibre activation (Treede et al., 1995). Experimental studies using electrodes implanted in the thalami of patients with persistent pain have provided direct evidence that conscious sensory awareness requires stimuli to be presented for a substantial duration of time (> 500 msec.). Stimuli presented for durations shorter than this can be detected, but do not enter awareness (see Libet, 1993). Late and in particular ultra-late components of somatosensory evoked potentials can thus be influenced by nonspecific conscious mechanisms such as attention, distraction, habituation, vigilance, and expectation (Treede et al., 1995). Experimental methodologies are, therefore, designed to control for these influences, for example, by stabilising attentional requirements, randomising stimulus intervals, and ensuring that different stimulus properties have an equal probability and task relevance.

Procedures for the recording and analysis of EEG and MEG data continue to be improved. Earlier studies were limited by analyses that assumed that the potential at each sampled time point is generated by only a single dipole. However, newer procedures (e.g. brain electrical source analysis or BESA) recognise that brain potentials are generated by multiple, simultaneously active, cortical regions that produce electrical fields that overlap in time and space and allow for multiple spatiotemporal dipole modelling (Chen & Bromm, 1995). Information obtained from PET or MRI scans can provide the parameters for further investigation through multiple-dipole measures of evoked potentials.

A study by Chen and Bromm (1995) using LEPs and both single and multiple dipole analyses distinguished three major components at different scalp sites at about 100, 150, and 220 msec for all ten subjects tested. Multiple, spatio-temporal, dipole modelling revealed four clearly identifiable generators: dipole I, with maximum negativity at about 100 msec in the contralateral secondary somatosensory cortex; dipole II, with maximum negativity 6 msec later in the corresponding ipsilateral area; dipole III, with maximal positivity at 130 msec in the frontal cortex (35 mm beneath the cortical surface); and dipole IV, describing both the late negativity at 150 msec near the crown of the head and the consecutive positivity at 220 msec under the crown in deep (33.1 mm) brain structures. The spatial head model of the BESA program located dipole IV as the rostral part of the anterior cingulate gyrus. All of the dipoles, except dipole III, showed a very constant behaviour over repeated sessions and between different subjects. Dipole III exhibited marked interindividual variability even when frontal activity from motor-related artefacts (e.g., eye movements or blinks) was eliminated from further analysis. Activity in the frontal cortex is not only involved in pain experience, but is also related to mechanisms of attention and arousal, and to other nonspecific reactions in the ascending reticular activation system (Guilbaud, Peschanski, & Bession, 1984). The distribution pattern of the late negativity generated by dipole IV showed a very broad lateral extension. Further analysis indicated that this consisted of two dipoles with similar activities, localised symmetrically in the left and right hemisphere.

Another EEG study of LEPs by Treede et al. (1995) obtained quite similar results. These authors observed that the pattern of LEPs in healthy subjects revealed a distinct negativity at about 170 msec that was clearly distinguishable from a later negative component at 240 msec and a positive component around 380 msecs. The distribution of N_{170} potentials covered an area close to the region of SI contralateral to the stimulated hand, but with maximum density over temporal sites. This topography suggests that S_{II} or the insular cortex may be involved in the generation of the initial LEP negativity (Kunde & Treede, 1993; cited in Treede et al., 1995). These findings are also consistent with observation of MEG investigations. Laudahn, Kohlhoff, and Bromm (1995) recording evoked magnetic-field potentials following laser-induced phasic heat stimuli and observed a similar biphasic waveform with a negative component peaking around 135 msec and a positive component with peak latency around 195 msec.

In summary, there is clear evidence that pain perception involves various cortical areas. This, however, does not mean that pain is sensed exclusively in these areas. Coherent activation of other parts of the central nervous system; including spinal, rhomboencephalic, mesencephalic, and diencephalic pain circuits may be just as capable of inducing the perception of pain, although without the discrimination of finer intensity differences or the precise location of the stimulus (Freeman, 1991). The thalamus is an important relay station between spinal and cortical mechanisms involved in pain perception.

The spinothalamic tracts ascend the spinal cord to activate neurons in the ventral caudal portions of the ventrobasal complex of the thalamus. From here, the lateral pain system projects predominately to the primary and secondary somatosensory cortex, which are concerned with identifying the sensory discriminative features of the pain stimulus and its exact location. Pribram (1991) refers to this as the epicritic or sensory pain system. Within this system, stimuli can be clearly defined because certain neurons in the somatosensory cortex and the posterior part of the ventrobasal complex of the thalamus are somatotopically organised so that they provide a somatosensory map (homunculus) of the body.

The spinoreticular tract ascends the spinal cord to activate neurons in the brainstem reticular formation which in turn project to the intralaminar (medial) nuclei of the thalamus. From here, the medial pain system projects to various structures in the limbic system, the anterior cingulate cortex, and the orbital frontal cortex. Neurons in these structures have broad receptive fields with little or no somatotopic organisation. These structures are mainly involved in determining the aversiveness of the stimulus and the emotional response to it. They make up the affective-motivational component of the pain response that involves among others autonomic arousal, behavioural readiness, and vigilance. Pribram (1991) calls this the protocritic, distress, or comfort-discomfort pain system.

The thalamus also appears to have the capacity to generate the experience of pain without input from ascending or descending spinal thalamic tracts. Loss of afferent sensory input results in a change in the balance between excitatory and inhibitory inputs. This can lead to both abnormal burst-firing activity and somatotopic reorganisation that fundamentally change the neural reactivity of thalamic projection neurons. However, their exact role in central pain is not clear yet as both phenomena also occur in pain-free deafferentation patients.

1.5. *Influence on Pain Management*

The recognition of the importance of CNS modulation at the spinal level, and the importance of brain systems in facilitating descending control and interpreting the experience of pain, has had a major impact on pain management approaches. Factors such as attention, emotions, expectancies, and memories of prior experiences are now all considered. Prior to the understanding of the important role that cognitive processes play in evaluating and modulating nociceptive input, pain treatment followed largely a medical model that treated pain as a disease. Consequently the main treatment approaches were pharmaceutical (e.g., analgesics, narcotics, nerve blocks) or surgical (reparative or destructive) and aimed at achieving pain relief. Psychological factors were dismissed as merely reactions to pain, and comorbidities were generally ignored (Long, 1994).

Increased knowledge about the physiology of pain, combined with results of a large body of experimental pain research, has supported clinical observations that psychological, emotional, and behavioural factors play an important role in the perception and maintenance of pain.

Assessment of patients with chronic pain was frequently based on the unfortunate practice of diagnosis by exclusion, which presumed psychological dysfunction if no adequate pathophysiological basis for a complaint could be found. This led to the problematic distinction between organic and psychological pain (Dworkin, 1992). In a move away from this distinction, some recent studies examining similarities and differences among patients with chronic back pain have preferred to classify patients as being either "medically congruent" or "medically incongruent" (Hadjistavropoulos & Craig, 1994; Reesor & Craig, 1988; Waddell, Pilowsky, & Bond, 1989). Patients in the medically incongruent group expressed their pain more emotionally, were more likely to use passive coping strategies, and more frequently used negative interpretations and dysfunctional catastrophising cognitions than did those in those in the medically congruent group. Such findings attest to the emotional, evaluative, and behavioural complexity of both acute and chronic pain (Craig, 1995).

A number of factors, including advances in the theoretical understanding of pain, increased recognition that pain is a complex, multifaceted, subjective experience that is not solely determined by pathology, and the concurrent growth of cognitive-behavioural psychology have jointly contributed to the development of specific pain management programs for both acute and in particular chronic pain (see e.g., Chapman & Turner, 1986, Loeser & Egan, 1989; Loeser, Seres, & Newman, 1990; Long, 1994). Pain management is slowly becoming a field of expertise in itself and this is reflected in the development of pain clinics. It is now largely accepted that, although it is not always possible to achieve full or even adequate pain relief, pain and its accompanying distress can and should be managed.

While working as an anaesthetist in a military hospital during World War II, Bonica recognised as early as 1945 that the effective treatment of complex chronic pain problems needed a multimodal approach combining the specific knowledge and skills of practitioners from various disciplines (Bonica, 1990a).

Pain management clinics may combine the skills of neurologists, anaesthetists, neurosurgeons, clinical psychologists, social workers, physiotherapists, and occupational therapists. In a truly interdisciplinary setting, these jointly take care of the medical, psychological, and physical management of pain complaints. The multidisciplinary approach to pain management was largely ignored by health professionals until the 1970's and true interdisciplinary pain-management centres are still relatively rare. Pain management is increasingly incorporated in the wider field of rehabilitation and pain clinics are frequently an integral part of rehabilitation clinics or departments. In New Zealand, it is only recently that we have seen the establishment of some pain management programs outside the four main centres, and as yet there are few if any that offer fully multi or interdisciplinary pain-management programs.

Comprehensive pain-management programs start with a thorough physical examination and an extensive psychosocial assessment including pretreatment screening (see e.g., Loeser & Egan, 1989). The assessment covers among others the history of the complaint, the significance the pain has for the patient, its emotional and behavioural consequences for both the patient and the family or caregivers, the patterns of pain behaviour and their likely motivating forces, and the existence of comorbidities (see Stimmel, 1997). Based on information from this in-depth assessment, the team can than develop the treatment approach that is most appropriate for the particular patient or patient group. In planning a treatment program, consideration is given to why treatment might fail and what steps are needed to address these issues. The psychologist can play an important role in this process by identifying those patients who are not likely to benefit from the treatment program at this stage, for example, because of adverse attitudes towards treatment or the existence of significant comorbidities. These might have to be addressed first.

Any chronic illness, pain including, will effect the emotions and behaviour of the patient. Some chronic pain patients exhibit abnormal pain behaviours and an over identification with illness. Part of the role of the psychologist is to educate patients and their family so that they can recognise the connection between pain and emotions and how these might lead to maladaptive pain behaviours. The experience of chronic pain often causes marked changes and role adjustments in marital, family, social, and employment relations.

Both patients and carers may be motivated either deliberately or unconsciously to reinforce maladaptive coping behaviours because of actual or perceived secondary gains (see Fishbain et al., 1995; Turk, Flor, & Rudy, 1987). Waddell, Bircher, Finlayson, and Main (1984) determined that, the amount of treatment received by patients with back pain bore more relationship to the distress and illness behaviour they exhibited than to the amount of physical damage. However, the successful outcome of the treatment was only related to the latter. The same frequently applies to financial and social support. By identifying such patterns of excessive emotional distress and maladaptive coping during the assessment stages of the management program, appropriate interventions can be initiated. This can prevent the development or persistence of the medically incongruent pain patterns and related dysfunctional behaviours described above (Linton, Bradley, Jensen, Sprangfort, & Sundell, 1989).

Pain management programs typically incorporate a variety of approaches in conjunction with some of the various pharmacological agents now used in the management of chronic and acute pain such as antidepressants, anticonvulsants, antiarrhythmics, opioids, sympatholytics and topical agents (Fernandez, 1986; Galer, 1995; Rowbotham, 1995). These may include behavioural and cognitive-behavioural strategies, relaxation techniques, biofeedback, hypnosis, and physical exercises (for a review of pain management strategies see e.g., Bonica 1990b; Barber & Adrian 1984; Diamond & Coniam, 1997; Loeser & Egan, 1989; Turk & Feldman, 1992). Cognitive-behavioural strategies address patients' attitudes, beliefs, and expectations. They can help patients to identify negative beliefs and substitute them with positive thoughts and actions. By counteracting feelings of helplessness and hopelessness, which can result in avoidance and illness behaviours, patients can gain an increased sense of control and self-efficacy. Relaxation techniques help to reduce the physical and emotional tension, which frequently accompany pain. Relaxation also contributes to the effectiveness and likelihood of success of other cognitive strategies including hypnosis. Patients are also taught to be more aware of events that increase or decrease the pain. Biofeedback techniques can teach the patient how to exercise some conscious control over what are normally unconscious functions. All these measures increase the locus of control of the patient, which is an important factor in the long-term success of pain management.

Imagery can be used to relabel and reinterpret the sensation of pain. Attention-diversion strategies can be used to direct attention away from the pain. Imagery can again be useful by directing attention to images that are incompatible with the experience of pain.

Another technique that can be used is hypnosis (see e.g., Barber, 1996a, 1982; Chaves, 1994; Hilgard & Hilgard, 1994; Hilgard & LeBaron, 1984; Sacerdote, 1982; Spira & Spiegel, 1992). A substantial proportion of patients has been found able to use hypnotic techniques to reduce the level of pain and distress. Hypnosis and self-hypnosis techniques can reduce the level of pain and distress and produce an increase in personal locus of control and a shift in self-concept away from illness identification (e.g., James, Large, & Beale, 1989; Large & James, 1988). A very useful approach can be the addition of posthypnotic suggestions that continue to have an effect after the patient has regained normal waking consciousness. An example might be: "Whenever you need to feel relief from the pain, you will suddenly notice that, in fact, you *are* beginning to feel better. And you will feel better throughout the day" (Barber, 1996b, p. 93).

Self-hypnosis can be particularly effective in creating both long-lasting pain relief and independence for the patient. When possible initial resistance is overcome, the majority of patients appear to be able to learn self-hypnosis quire readily and achieve analgesia over increasingly greater lengths of time (Barber, 1982; Sachs, Feuerstein, & Vitale, 1977). The development of less time consuming hypnotic-susceptibility assessments (e.g., Spiegel, 1977; Stern, Spiegel, & Nee, 1979), rapid-induction procedures (e.g., Barber, 1977), and methods to enhance hypnotic responding (see e.g., Barabasz, 1982; Barabasz & Barabasz, 1989; Crasilneck, 1995; Gfeller, 1994; Spanos, Robertson, Menary, & Brett, 1986) may further increase the utility of hypnotic analgesia as a viable option in pain-management programs. For a comprehensive review of hypnotic pain-management strategies and assessment measures see Eimer and Freeman (1998).

Reviews suggest that, despite its proven utility in many situations, hypnosis is used infrequently for pain management compared to other behavioural interventions (Malone & Strube, 1988; Trijsberg, van Knippenberg, & Rijpma, 1992).

Apart from time constraints and simple lack of familiarity, part of the reason might be that some clinicians might not be comfortable with the use of imaginal techniques and the high level of interpersonal contact involved. Furthermore, training in the clinical use of hypnotic techniques is generally not part of the curriculum of medical, dental, or psychological training (Barber, 1996b).

A number of outcome studies of multidisciplinary pain-management programs are now available, including several controlled studies using a nontreatment comparison group. Results have provided empirical support for the utility of, in particular, multidisciplinary pain-management programs. Patients attending such pain clinics in general displayed a significantly higher level of general, outdoor, and social activities; a decrease in medication use; a reduced need for sick leave; and a significantly higher proportion that returned to work or vocational rehabilitation (Deardorff, Rubin, & Scott, 1991; Johansson, Dahl, Jannert, Mehlin, & Andersson; 1998; Vlaeyen, Haazen, Shuerman, Kole-Snijders, & Eek, 1995). These gains were generally maintained at a one-year follow-up. There are some indications that these gains are greater for patients attending inpatient clinics than for outpatients (Williams, Richardson, Nicholas, Pither, Harding, Ridout, Ralphs, Richardson, Justins, & Chamberlain, 1996), but Peters, Large, and Elkind (1992) found no differences between their in and outpatients other than a superior return to work rate for inpatients. For meta-analyses of outcome studies see Cutler, Fishbain, Rosomoff, Abdel-Moty, Khalil, and Steele-Rosomoff (1994) and Flor, Fydrich, and Turk (1992).

The major advances in the understanding of pain mechanisms have led to improved and more specific pain management approaches including the novel use of new and existing analgesics (see e.g., Sawynok, & Cowan). However, despite all these developments, the majority of patients in pain are treated inadequately or inappropriately and many types of pain are poorly managed, resulting in needless suffering (Macrae, Davies, & Crombie, 1992; Melzack, 1990). Many doctors are not sufficiently aware of recent advances in pain research, and widespread disagreement about the effectiveness of various treatments has been observed (Davies, Crombie, Lonsdale, & Macrae, 1991). Loeser (1990) commented that many doctors still consider neuroablative surgery as appropriate when there is evidence to suggest that these techniques are often counterproductive.

Although this mindset is slowly changing, it remains evident even in current practice. At the same time other treatment options remain under used.

Furthermore, a substantial number of pain treatment centres still utilise only the medical model in one form or another (IASP, 1986). Despite the increased knowledge available, chronic pain continues, in many settings, to be attributed to learned or emotional or even neurotic reactions when there is no observable pathology or nociception (Fordyce, 1988). As Macrae et al. (1992, p. 290) conclude "Today's major challenge is changing doctor's perceptions of pain and methods of treatment, not just among pain clinicians but in the wider medical community." This would also apply to health funding providers, which tend to regard the management of pain as a rather low priority.

CHAPTER TWO

PSYCHOLOGICAL STRATEGIES FOR COPING WITH PAIN

2.1. *Behavioural and Cognitive Coping Strategies*

Some of the commonest approaches to pain management from a psychological viewpoint are the behavioural and cognitive perspectives. In current treatment, these are commonly combined into the cognitive-behavioural approach.

2.1.1. **Behavioural strategies**

Pain behaviours are the end stage of the process of nociception. They are sensitive to environmental contingencies and are not solely based on nociception. From the behavioural perspective, an important distinction can be made between acute and chronic pain. Because of its short duration, acute pain is more strongly tied to its nociceptive stimulus and is less subject to learning and conditioning. Chronic pain not only involves respondent pain behaviours that occur as a direct consequence of nociceptive stimuli, but also operant pain behaviours that develop as pain behaviours become contingent upon environmental reinforcement (Fordyce, 1976). Such reinforcement can be direct, through such things as positive consequences of pain medication or attention of others; or indirect, through the effective avoidance of unpleasant activities. Avoidant coping strategies are influence by such factors as the level of experienced discomfort, perceived coping inefficacy, and anticipated anxiety, which often operate in a vicious circle.

Operant techniques are used to reduce or eliminate inappropriate pain behaviours such as catastrophising, avoidance of nonpain behaviours, identification with illness behaviour, and reliance on external influences. Patients and family members are made aware of how their actions may reinforce pain behaviours and are trained in using positive reinforcers of wellness behaviours.

Emphasis is placed on teaching self-control. New behaviours and goals are established, which the patient can use in their home environment and at work (see e.g., Keefe, Dunsmore, & Burnett, 1992).

2.1.2. **Cognitive strategies**

Whereas behavioural techniques are designed to modify overt behaviours, cognitive strategies aim to influence covert behaviours (e.g., thought processes and mental representations). A whole range of cognitive coping strategies has been developed for the control of pain and distress. In regard to direct pain control, these can be divided into two categories: those focusing on the cognitive interpretation of the experience and using suggestions to alter its appraisal, and those relying on some form of attention diversion (passive or active distraction) (Kongstvedt, 1987; Turk, Meichenbaum, & Genest, 1983; Tan, 1982; Weisenberg, 1987).

2.1.2.1. *Focusing*

The first category involves self-instructional training aimed at teaching techniques to reinterpret the painful sensation and alter negative beliefs about one's ability to cope with the situation. Self-instructional training teaches a person to monitor the painful situation and detect negative thoughts and self-statements. These are then used as cues to generate coping strategies that enhance outcome expectancies (i.e., beliefs about the effectiveness of particular coping strategies), enhance self-efficacy expectations (i.e., beliefs in our own capability to effectively use these strategies), or reinterpret the experience in ways that reduce its aversiveness.

2.1.2.2. *Distraction*

The utility of attention-diversion (distraction) strategies is argued to stem from the limited capacity of the executive part of the human information-processing system (McCaul & Mallott, 1984).

Attention determines access to this executive control system and pain has high priority on attentional resources. Unless we actively direct attention away from a painful stimulus, that stimulus will dominate our attention (Miron, Duncan, & Bushnell, 1989). Focal attention is selective by filtering out other inputs competing for attentional resources. For pain to remain in conscious awareness it needs to dominate access to attentional resources and displace other competing inputs. Attention-diversion strategies can interfere with this process by displacing attentional resources otherwise available for pain processing, thereby ameliorating the experience of pain (e.g., reducing its perceived intensity and unpleasantness, and/or raising pain threshold and pain tolerance levels). Melzack and Wall (1982) propose that, attention exerts its modulating effect on pain through descending inhibitory control on the gate-control mechanism in the dorsal horns of the spinal cord.

This rationale for the utility of attention diversion is dependent on three basic assumptions: (1) pain perception is an effortful nonautomatic process and attention demanding processing is needed for noxious stimulation to achieve its affective (distressing) character, (2) the capacity for conscious, attention-demanding processing is limited, and (3) pain processing and the deliberate performance of the distraction task rely on the same pool of limited-capacity attentional resources (McCaul & Malott, 1984). There appears to be general consensus about the accuracy of the first two assumptions. The extent to which the third assumption is correct can be debated and will depend on the particular features of the distraction task (see notes on multiple-resource theory p. 93).

If correct, this interpretation would suggest that an individual's conscious awareness of pain can be reduced to the extent that he or she directs attention to other internal or external stimuli, and that the more attention demanding a particular distraction task is, the greater the level of analgesia that can be achieved. This could account for the differential efficacy of various attention-diversion strategies. However, support for this notion is equivocal at best. While some have concluded that more demanding distraction tasks do produce greater analgesia (e.g., McCaul & Haughtvedt, 1982; Williams & Kinney, 1991), others have failed to find that the difficulty of distraction tasks has a differential influence on pain perceptions (e.g., McCaul, Monson, & Maki, 1992; Hodes, Howland, Lightfoot, & Cleeland, 1990).

Comparisons between studies are hindered by the plethora of distraction tasks used; differences in the affective content of distraction tasks; differences in the instructions given, which may effect expectancies; different types of painful stimulation used; and differences in the measures taken (Eccleston, 1995a).

2.1.3. Factors affecting the efficacy of cognitive-behavioural pain-coping strategies

Studies have identified a number of factors that may mediate or moderate the efficacy of cognitive-behavioural coping strategies. These include: (a) *self-efficacy* (e.g., Bandura, Cioffi, Barr Taylor, & Brouillard, 1988; Litt, 1988; Williams & Kinney, 1991), (b) *the level and locus of perceived control* (e.g., Rokke, Al Absi, Lall, & Oswald, 1991; Toomey, Mann, Abashian, Carnrike, & Hernandez, 1993), (c) *expectancies* (e.g., Baker & Kirsch, 1991; Kirsch, 1985; Marino, Gwynn, & Spanos, 1989; Murphy, Lindsay, & de C Williams, 1997), (d) *negative affectivity and catastrophising* (e.g., Gil, Williams, Keefe, & Beckham, 1990; Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990; Williams, & Keefe, 1991), (e) *information about the predictability of pain* (e.g., Crombez, Baeyens, & Eelen, 1994), and (f) *the level of absorption in the coping strategy* (e.g., Devine & Spanos, 1990). These factors do not operate in isolation. Although they are frequently related, they are not identical and often are most effective when several are operating in conjunction (e.g., Litt, 1988; Marino et al., 1989; Rokke et al., 1991). Several studies have shown that expectancies alone do not account for all the reduction in pain (e.g., Beers & Karoly, 1979; Chaves & Barber, 1974; Crombez, Vervaet, Bayens, Lysens, & Eelen, 1996).

Multiple-resource theories would argue that the main factor that determines the efficacy of any attention-diversion strategy is the degree to which it uses the same resources as pain processing (see section 3.2, p. 92). Only when pain processing and performance of the coping strategy use similar resources does the level of absorption in the coping strategy become important. Thus, the differential effectiveness of pain coping strategies would mainly reflect differences in the extent to which particular coping strategies share stimulus modality, processing stage, and processing modality with pain processing.

2.1.4. **Evidence for effectiveness**

Both distraction and suggestions for reappraisal of the experience may involve the use of imagery. Some outcome studies indicate that imagery strategies are generally superior to nonimaginative coping strategies (e.g., sensation monitoring or sensory detection distraction), presumably because they produce greater attention diversion (Fernandez & Turk, 1989). Others, however, have found that visual and somatic detection tasks produced greater changes in pain responding than an imagery distraction task (Johnson, Breakwell, Douglas, & Humphries, 1998).

Three separate outcome reviews found that, in between 50% and 85% of studies examined, cognitive coping strategies reduced pain ratings, increased pain threshold and/or enhanced pain tolerance compared to nontreatment (Fernandez & Turk, 1989; Tan, 1982; Turk, et al., 1983). The meta-analysis by Fernandez and Turk (1989) classified cognitive coping strategies into five categories. The categories with their respective weighted mean effect size in brackets were: neutral imaginings (0.74), pleasant imaginings (0.64), external focus of attention (0.49), rhythmic cognitive activity (0.44), and pain acknowledging (0.34). Each class of coping strategies attenuated pain significantly. The imagery strategies tended to be most effective while sensation monitoring was least effective. However, none of the differences in effectiveness between strategies were significant. Fernandez and Turk (1989) suggested that the important factor in the effectiveness of various strategies is not so much the type of strategy used, but rather the person's own sense of self-efficacy, attitudes, and expectancies about the usefulness of the selected strategy.

Most studies evaluated in these meta-analyses were experimental studies involving volunteers that were exposed to acute, experimentally induced pain of limited duration to a small area of the body. While such studies have discovered important characteristics of pain responding, caution, and replication in clinical settings, is required before results can be generalised to the treatment of chronic pain (Kongstvedt, 1987, McCaul & Malott, 1984). Although much fewer studies are available that evaluated the effectiveness of cognitive coping strategies for chronic pain in clinical settings, there are some clear indications that cognitive strategies can be beneficial in clinical settings and for chronic pain.

Jay and colleagues found that a combination of cognitive-behavioural strategies, based on a stress-inoculation model, was effective in reducing pain and distress in children during a variety of painful medical procedures (e.g., Jay, Elliott, Katz, & Siegel, 1987; Jay, Elliott, Ozolins, Ohlson, & Pruitt, 1985; Jay, Elliott, & Woody, 1991). This approach was most effective in reducing anticipatory anxiety and pain and anxiety during the recovery phase, but had less impact on the intense sensory experience (e.g., during the actual moment of bone marrow aspiration or lumbar puncture). Several well-controlled studies have also found that cognitive-behavioural strategies were significantly more effective than a placebo treatment (involving attention but no strategy training) or a routine care control condition in the relief of pain and distress in patients with chronic rheumatoid arthritis (e.g., Bradley, Young, Anderson, Turner, Agudelo, McDaniel, Pisko, Semble, & Morgan, 1987; Keefe, Caldwell, Queen, Gil, Martinez, Crisson, Ogden, & Nunley, 1987). However, the study by Bradley et al. (1987) found that, except for reductions in trait anxiety, the rheumatoid arthritis patients failed to maintain their treatment gains at six-month follow-up. The above studies all involved multicomponent treatment packages, and it is, therefore, difficult to determine the effectiveness of individual strategies. Some studies that specifically examined distraction strategies have found these to be effective in reducing pain and distress in acute clinic (e.g., Vessey, Carlson, & McGill, 1994) and chronic pain settings (e.g., Johnson & Petrie, 1997).

2.1.5. **Anxiety**

Murphy et al. (1997) suggest that chronic pain patients frequently underpredict pain, which then can lead them to experience painful episodes as extremely aversive and anxiety provoking. This typically results in avoidant behaviours, which limit the opportunity for corrective feedback (Rachman & Arntz, 1991). Heyneman et al. (1990) found that catastrophisers trained in modifying their self-statements showed greater improvement in pain tolerance than those using attention diversion, whereas noncatastrophisers improved their tolerance scores significantly more when using attention diversion rather than positive self-statements.

Stress-inoculation training is frequently part of cognitive-behavioural pain management approaches in clinical settings. It involves educating pain patients about the pain experience, teaching and exposing them to a variety of cognitive and behavioural coping strategies, and practising and testing newly acquired skills. This approach is aimed at reducing both the pain and the frequently associated anxiety.

Clinical studies have also indicated that chronic and pre-chronic pain patients selectively attend to, process, and recall pain-related information (Asmundson, Kuperos, & Norton, 1997; Knost, Flor, Braun, & Birbaumer, 1997; Pincus, Pearce, McClelland, & Turner-Stokes, 1993). Results suggest that chronic and prechronic pain patients tend to facilitate pain associated stimuli and that this is not limited to somatosensory input, but may also involve verbal information (i.e., pain related words). This appears to be a learned response that is influenced by established pain memories and may serve an instrumental function in the development of chronicity. The enhanced emotional processing in relation to neutral or nonpain-related stimulation was reflected in enhanced early event-related potentials in frontal areas of the cerebral cortex (Knost et al., 1997).

The direct influence of anxiety on pain is somewhat less clear. In this context, an important distinction can be made between pain-relevant anxiety (i.e., anxiety that has pain as its focus) and pain-irrelevant anxiety. Both attribution theory and attentional theory predict that pain-relevant anxiety increases pain responses and pain-irrelevant anxiety decreases pain ratings. According to attribution theory, this is mediated through attributional processes (i.e., when arousal is experienced as pain-relevant, the emotion is labelled as pain, whereas arousal experienced as pain-irrelevant is labelled as anxiety). Pain relevance is, therefore, a crucial factor. Attentional theory argues that this effect is mediated by attentional processes (i.e., pain-relevant anxiety tends to draw attention towards the pain, whereas pain-irrelevant anxiety tends to draw attention away from the pain and towards the anxiety-provoking stimulus). Thus, according to attentional theory the crucial factor is not the focus of anxiety but the focus of attention.

A few studies have found some support for the influence of the focus of anxiety (e.g., Al Absi, & Rokke, 1991; Dougher, Goldstein, & Leight, 1987; Weisenberg, Aviram, Wolf, & Raphaeli, 1984). However, a study by Cornwall and Donderi (1988) found that both pain-relevant and pain-irrelevant anxiety had a pain-increasing effect. This result does not support the mediating role of attributional processes and is arguably better accounted for by attention disruption. Anxiety involves focused attention and competes with nociception for attentional resources. This makes it harder to evaluate either experience, and the person is likely to focus his or her attention on the most salient aspect of the experience. Unless anxiety is very strong, this tends to be on the pain, thereby increasing pain reports. A set of studies that controlled for attentional effects found that pain relevance had no additional influence on subjective pain ratings besides that of attentional focus. Results provided clear support for the role of attentional focus as a psychological mediator of the influence of anxiety on pain (Arntz, Dreessen, & De Jong, 1994; Arntz, Dreessen, & Merckelbach, 1991, Janssen & Arntz, 1996; see also Mogg & Bradley, 1998, for an in-depth analysis of attentional influences and biases in the processing of threat).

2.1.6. **The cognitive cost of attention diversion and pain suppression**

Although there is substantial support for the efficacy of attention diversion from experimental studies and a relatively small number of clinical studies, other findings suggest that this support is qualified. Both experimental and clinical studies have generally involved pain stimulation of short duration (typically no more than few minutes). There are indications that the effectiveness of distraction strategies diminishes rather quickly as pain persists (Ahles, Blanchard, & Leventhal, 1983; Hodes et al., 1990; McCaul & Haughtvedt, 1982; Suls & Fletcher, 1985). Furthermore, many studies found that the attenuation of pain, as indicated by pain reports, was mainly evident through increases in pain tolerance, rather than decreases in pain intensity. Several clinical studies indicate that cognitive-behavioural strategies are most effective in reducing the anxiety that commonly accompanies pain, but less effective in reducing the intensity of pain, particularly when present for extended periods of time (e.g., Bradley et al., 1987; Jay et al., 1985, 1987, 1991; Keefe et al., 1987).

As noted earlier, it is a natural function of pain to grab our attention. Attempting to divert attention away from such a strong habitual, reflex-like, response is difficult and requires substantial executive effort. When the pain is too severe or prolonged it may simply become too hard to suppress it or divert our attention away from it (McCaul & Malott, 1984). A set of four studies by McCaul et al. (1992) established that distraction by itself lacked analgesic properties. Increasing the attentional demand of an affectively neutral (i.e., reaction time) task did not result in greater reductions in physiological, self-report, or behavioural responses to a cold-pressor task. Similar results were found by Hodes et al. (1990).

Studies of cognitive coping strategies have almost exclusively been concerned with the imagery load of the various strategies and the *direction* and *degree* of the attentional engagement (e.g., attention on the pain as in sensation monitoring, or away from the pain as in distraction), while paying little attention to the *content* or somatic interpretation of the strategy (Cioffi, 1991). Consequently, coping strategies grouped in the same category may differ substantially in content, varying from being affectively neutral to having a high level of emotional arousal. A study by Devine and Spanos (1990), which examined four cognitive coping strategies that were maximally different on the sensation monitoring (reinterpretation vs. distraction) and imaginary involvement (imaginal vs. nonimaginal) dimensions, found no significant differences between tasks in both expected and reported pain reductions at either low or high pain intensities. The reductions in reported pain were not dependent on expectancies.

2.1.7. **Distraction versus sensation monitoring**

Painful sensations can be processed for their discrete sensory aspects, which Leventhal refers to as sensory monitoring, and for their emotional or threatening value (Ahlens et al., 1983; see also Melzack & Wall, 1982). Most people strongly believe that distraction is an effective way to achieve pain relief and select it as their preferred cognitive coping strategy. Monitoring of somatic sensations appears to be counter-intuitive and is generally not regarded as being useful (Leventhal, Leventhal, Shachman, & Easterling, 1989; McCaul & Haughtvedt, 1982).

However, several studies have found that sensory monitoring can be an effective strategy to increase pain threshold and tolerance, and that its efficacy is not dependent on expectancy effects (Ahlens et al., 1983; Leventhal, Brown, Shachmam, & Engquist, 1979; Blitz & Dinnerstein, 1977). These results are supported by findings of clinical field studies, which established that attending to the sensory aspects of a variety of stressful medical procedures (e.g., childbirth, chemotherapy) produced greater reductions in distress than attending to a distraction task or to one's emotional reaction (see Cioffi, 1991). Notwithstanding this, most subjects intuitively preferred distraction tasks and needed considerable practice plus the actual experience of successful pain relief before they accepted sensation monitoring as a viable strategy. Meta-analyses by Mullen and Suls (1982) and Suls and Fletcher (1985) did conclude that, although distraction may work better in the early stages of distress, sensory monitoring frequently proves to be more beneficial when pain is more prolonged.

Cioffi and Holloway (1993) found that subjects using sensation monitoring recovered more rapidly from cold-pressor pain than those using distraction. Subjects who suppressed somatic sensations had the slowest recovery and also rated a subsequent vibration stimulus as more unpleasant. Sensation monitoring and distraction might be more effective than suppression because they provide specific strategies for positive action, whereas suppression simply states what not to do. The particular effectiveness of sensation monitoring is likely to result from a number of factors. Focusing and monitoring the objective qualities of a physical stimulus acts itself as a distraction from attending to the high-order interpretation of the distressing interpretations and emotions associated with the stimulus. Thus, the painful stimulus is likely perceived as less distressing. In addition, attending to the somatic qualities of the stimulus is likely to provide information that can enhance self-regulation (e.g., by being able to discriminate between painfulness and other qualities of the experience that are merely associated with it) and increase preparedness (Leventhal et al., 1989). Furthermore, being wilfully aware of a stimulus, even when unpleasant, is likely to result in greater perceived control and self-efficacy, which can enhance reductions in pain tolerance (Bandura et al., 1988; Litt, 1988).

We normally always consciously attend to something and just performing concurrent attention-demanding tasks does not necessarily have to lead to rapid "fatigue" and cognitive failure. What is 'special' in situations of painful stimulation is that we have to try to maintain attentional capture against very strong competition (i.e., assuming that pain and any other tasks require the same attentional processes). This can only happen if the salience of the stimulus or thought attended to is so dominant that it can displace attentional resources needed for pain processing, which normally has priority access. To do so, a distraction task would have to be novel and complex enough. Many distraction techniques (e.g., picturing yourself on a sunny beach) may rather quickly loose effectiveness as their initial novelty wears off and further imaginative elaboration can not be maintained in the presence of high-level cognitive competition for shared resources. Being involved in, for instance, a physical activity that provides novel stimuli on a continuous basis may prove to be more successful, until the pain becomes so severe that it dominates even the novel stimuli. Thus, novelty of input may be a crucial element in the effectiveness of distraction techniques.

Distraction tasks do not have to be affectively neutral and can be designed so that they include pleasant imagery. This can be beneficial and prolong the usefulness of distraction strategies. However, if the pain is severe, it is unlikely that the pleasant imagery will completely ameliorate the distress. Information processing is then faced with the simultaneous contradictory messages of pleasant imagery and painful distress. Dealing with contradictory (incongruent) inputs is particularly attention demanding and would thus be expected to reduce the effectiveness of the distraction strategy. By directing attention to the distinct qualities of the sensation, rather than its emotional interpretation, sensory monitoring can utilise the novelty of the changing stimulus qualities as an effective distractor while avoiding the contradiction in stimulus interpretation inherent in pleasant-imagery-based distraction tasks. Sensory monitoring might, therefore, be more effective in situations where pain is more prolonged and subject to fluctuations.

Thus, the effectiveness of a cognitive coping strategy is also influenced by the level of somatic awareness of a stimulus and the meaning (i.e., affective interpretation) attributed to it.

2.2. *Hypnotic Analgesia*

2.2.1. **Characteristics**

Hypnotic analgesia procedures involve a hypnotic induction followed by suggestions for analgesia. Such suggestions typically involve the use of thoughts and images that are incompatible with pain and direct attention away from the pain. Hypnotic suggestions can be used in a variety of ways, either individually or jointly, to: evoke to perception of anaesthesia, suggest imaginative strategies to diminish the distressing quality of the sensation, to substitute or reinterpret the sensation, to displace the sensation to another area of the body, or to evoke dissociation from the pain (see Barber, 1996b).

High and low hypnotisables do not differ in their ability to use attention-diversion strategies. However, only highly hypnotisable individuals appear to be able to achieve significant reductions in pain sensations when using hypnotic suggestions for analgesia (e.g., Spanos, McNeil, Gwynn, & Stam, 1984; Tenenbaum, Kurtz, & Bienias, 1990). Highly susceptible individuals have also been shown to achieve significant reductions in pain sensations following analgesia suggestions in a normal waking (i.e., nonhypnotic) state (e.g., Farthing, Venturino, & Brown, 1984; Spanos et al., 1984). This suggests that both high and low hypnotisables can effectively divert attention to external stimuli, but only high hypnotisables can successfully direct attention inward, particularly on imagery, to control pain. This is supported by findings that high hypnotisables score higher on measures of imagery vividness (e.g., Perry, 1973; Crawford, 1982) and absorption in imaginary activities (e.g., Tellegen & Atkinson, 1974).

Although many factors might enhance the ease with which individuals enter a hypnotic state and the effectiveness of the suggestions, few have been found essential for the achievement of effective analgesia. Hypnotic inductions typically involve both specific and nonspecific instructions for relaxation (e.g., to close the eyes, to be comfortable and relaxed in a sleep-like state).

These can help hypnotic subjects to set aside their ties with ordinary activities and problems so that they can more fully attend to the hypnotic suggestions. Subsequent hypnotic suggestions for analgesia are also frequently accompanied by specific suggestions for relaxation. Some psychologists go so far as to see relaxation as the central core of the hypnotic state (Edmonston, 1981). However, relaxation is not essential for a hypnotic induction (Banyai & Hilgard, 1976) and neither is the addition of relaxation suggestions necessary to achieve hypnotic analgesia (Miller, Barabasz, & Barabasz, 1990; Malone, Kurtz, & Strube, 1989). Furthermore, although a prior induction may enhance responsiveness to suggestion in highly susceptible subjects (Malone et al., 1989), a formal hypnotic induction is not necessary for successful hypnotic responding (Barber, 1969; Hilgard, 1965; Spanos, Perlini, & Roberts, 1989; Tenenbaum et al., 1990; Wadden & Anderson, 1982). A high correlation (about .85) has been observed between responsiveness to suggestions made in the nonhypnotic (waking) state and suggestions administered following a hypnotic induction (Barber & Glass, 1962; Hilgard & Tart, 1966). The magnitude of this correlation suggests that common mechanisms are involved in both types of responses, which argues against an altered state interpretation of hypnotic responding. Although relaxation, distraction of attention, and imagery may be of importance, experimental results indicate that none of these factors is the primary mechanism behind hypnotic analgesia (Zacharaia & Bjerring, 1994). Studies have also demonstrated that hypnotic analgesia is not simply the result of cognitive coping strategy use (Miller & Bowers, 1993), placebo responding (McGlashan, Evans, & Orne, 1969: Spanos, Perlini, & Robertson, 1989), or compliance (Reed, Kirsch, Wickless, Moffitt, & Taren, 1996).

2.2.2. **Evidence for effectiveness.**

Hypnotic analgesia is used in a variety of clinical areas. These include, in particular, the treatment of cancer pain, relief of pain and anticipatory anxiety in certain medical procedures (e.g., spinal aspirations or wound debridement for burn patients), dentistry, headaches, and obstetrics (see Barber, 1996a; Hilgard & Hilgard, 1994; Hilgard & LeBaron, 1984). Hypnosis has also been used in surgical settings. When used preoperatively, it can reduce apprehension and anxiety about the anticipated anaesthesia and surgery.

Postoperatively it can be used for pain relief, thereby reducing the need for postoperative narcotics, and hypnotic suggestion can also help reduce nausea, stimulate more adequate breathing, and make the patient more comfortable in general. Hypnotic analgesia has also been used as additional or sole anaesthesia in many operations, particularly when chemical anaesthesia is not appropriate for medical reasons or the patient is terrified of, and refuses to undergo, chemical anaesthesia (see Hilgard & Hilgard, 1994; Bejenke, 1996). Hypnotherapy has proven to be effective as an adjunct to chemical analgesia and a variety of cognitive-behavioural approaches (Kirsch, Montgomery, & Sapirstein, 1995; Patterson, Questad, & de Lateur, 1989). Several controlled clinical studies have found that, at least for hypnotisable subjects, hypnosis can be significantly more effective than comprehensive cognitive-behavioural training (e.g., Smith, Barabasz, & Barabasz, 1996; Syrjala, Cummings, & Donaldson, 1992; Zeltzer & LeBaron, 1982).

There is general agreement that hypnotic analgesia can be effective in achieving relief of pain and distress in at least a sizeable proportion of responsive individuals. Support for this notion has been well-documented by a vast body of experimental (e.g. Farthing et al., 1984; Orne, 1974; Price & Barber, 1987; Spanos et al., 1989; Tenenbaum et al., 1990) and clinical studies (e.g., Barber & Mayer, 1977; Ellis & Spanos, 1994; Patterson & Ptacak, 1997; Patterson, Everett, Burns & Marvin, 1992; Schaffer, 1975; see also Barber, 1996a; Holroyd, 1996). Differences in opinion between researchers are mainly concerned with the proportion of individuals who can make effective use of hypnotic suggestions and the particular mechanisms that underlie the effectiveness of hypnosis (for a review see Spanos, Carmanico, & Ellis, 1994). Explanations of hypnotic analgesia have centred around those that emphasise the importance of psychological processes (e.g., Coe & Sarbin, 1977; Spanos, 1991; Spanos & Chaves, 1989; Spanos & Coe, 1992; Kirsch, 1991) and those who argue that distinct physiological differences also play an important part (e.g., Crawford, 1994b, Crawford & Gruzelier, 1992; Hilgard, 1994). Psychological and physiological processes need not be mutually exclusive, and it is likely that both contribute to the complex mechanisms that determine hypnotic behaviour. Chapter 5 will deal more in depth with differences between these two major explanations and the more recent support for neurophysiological differences between hypnotic and nonhypnotic or waking analgesia.

The term "waking" is often used for what better would be described as nonhypnotic. Throughout this thesis the term nonhypnotic will, therefore, be used where appropriate, e.g., nonhypnotic state and nonhypnotic analgesia rather than normal "waking state and "waking" analgesia.

Studies of hypnotic analgesia have laboured under a double burden in that both the independent variables of hypnotic treatments and the dependent variables of the pain experience have typically been subjective measures. (Price, 1996). Most studies that have investigated the effectiveness of hypnotic analgesia have used patients' pain reports as the index of pain relief. However, the use of such subjective measures is complicated by the fact that hypnotic interventions are typically structured to motivate the person to inhibit overt signs of pain and deny pain experiences. As Barber (1963) has stated 'caution is necessary in accepting the hypnotic patient's verbal report or lack of overt behavioural reactions as valid indexes that the patient did not suffer.' Therefore, some researchers have looked for physiological correlates of pain that are difficult or impossible to affect voluntarily. Early experimental pain studies established that hypnotically induced analgesia did not result in changes in autonomic responses such as blood pressure, heart and respiratory rate, and skin conductance (for review see Barber, 1963; Hilgard & Hilgard, 1994). Some recent studies have used nociceptive reflexes and somatosensory evoked potentials as objective measures of pain responding. Their findings are discussed in section 2.2.3.

2.2.3. **Mechanisms**

Some theorists propose that hypnotic analgesia is achieved through the same mechanisms as cognitive stategies (e.g., Spanos, 1991; Spanos & Coe, 1992). Others propose that those who are highly hypnotisable are able to achieve effective hypnotic analgesia through a process called dissociation and that this involves a mechanism that is fundamentally different from the use of cognitive strategies (e.g., Hilgard, 1973; Hilgard & Hilgard, 1994; Miller & Bowers, 1986, 1993). All individuals appear to be able to achieve some level of relief through the imaginative use of analgesia suggestions administered in the nonhypnotic state. However, only high hypnotisables appear to be able to benefit effectively from the additional relief provided by mechanisms engendered by the hypnotic procedure.

Two general mechanisms have been proposed whereby hypnosis in particular can reduce pain sensations. Hilgard (1973) observed that hypnotic suggestions for analgesia did produce an additional reduction in overtly, but not covertly, reported pain over that achieved by nonhypnotic suggestions for analgesia. This additional reduction in overtly reported pain was seen to reflect the actions of a dissociative mechanism (amnesia-like barrier) that divided streams of consciousness and diverted pain sensations from entering conscious awareness.

Part of the phenomenon of effective hypnotic analgesia is that, while at the conscious level there is no or very little awareness of pain and discomfort, reactivity at the physiological level (e.g., increases in galvanic skin response and elevated heart rate or blood pressure) is largely similar to that in the nonhypnotic situation and indicates arousal of the autonomic nervous system (Crawford, 1994a; Hilgard & Hilgard, 1994). This suggests that the noxious stimulation had been registered, at least at some level, but that for those who were highly susceptible to hypnosis it was not perceived as painful and distressing. Hilgard, Morgan and MacDonald (1975) did demonstrate through automatic writing and key-pressing that subjects were covertly aware of cold-pressor pain although their overt pain reports indicated no pain or greatly reduced levels of pain intensity and unpleasantness (see also Hilgard & Hilgard, 1994, pp.166-177). The part that is aware of the pain hidden from conscious awareness has been called the "*hidden observer*" (Hilgard, 1973). Thus, one mechanism of hypnotic analgesia appears to involve the dissociation of pain sensations from conscious awareness.

It could be argued that pain sensations that are perceived, but dissociated from conscious awareness, might still adversely effect the person's wellbeing. If so, this could severely reduce the clinical usefulness of hypnotic analgesia. However, the physiological signs observed during hypnotic analgesia procedures are only minimal and no more intense than those aroused by the mild excitement of knowing that a stressful stimulus is going to occur (Hilgard, Macdonald, Morgan, & Johnson, 1978). Clinical studies and observations of hypnotic analgesia have found no reports of spontaneously returning hidden pain or indications of noticeable adverse effects resulting from unconsciously registered distress (Hilgard & Hilgard, 1994).

A second general mechanism whereby hypnotic analgesia might reduce pain is through descending inhibitory control, which prevents the transmission of pain-related information to the brain. The best known system of descending inhibitory control is that activated by endogenous opioids, which is responsible for closing the "gate" from the inside (see Chapter 1, p. 12). However, hypnotic analgesia does not appear to depend on endogenous opiate mechanisms. Several independent studies have established that hypnotic analgesia is not reversed by naloxone hydrochloride, an opiate antagonist (e.g., Barber & Mayer, 1977; Goldstein & Hilgard, 1975; Spiegel & Albert, 1983). Furthermore, hypnotic analgesia, once repeatedly established in highly hypnotisable individuals, can be induced and terminated very rapidly, whereas endogenous opiate mechanisms typically have a delayed onset and their effects are slow to dissipate (Price, 1996). Although these findings argue against the involvement of endogenous opiate mechanisms in the production of hypnotic analgesia, they do not exclude the possibility that nonopiate descending control mechanisms might be involved, particularly since nonopiate control mechanisms descending from the brain to the spinal cord are known to exist (Price, 1988).

Several studies have identified physiological changes in brain function during hypnotic analgesia, but the ability to draw clear conclusions is severely curtailed by the difficulty of identifying the neuroanatomical sites at which relevant modulatory mechanisms take place (e.g., Barber & Hahn, 1962; Crawford & Gruzelier, 1992; Mayer, Price, Barber, & Rafii, 1976). Painful stimulation is known to cause nociception specific reflexes in the spinal cord (Dowman, 1991; Willer, 1977). The most straightforward way of establishing the involvement of descending inhibitory control during hypnotic analgesia would, therefore, be through evidence of simultaneous reductions in spinal nociceptive reflex function and pain perception. A recent set of studies have examined activity of the R–III reflex, a polysynaptic spinally mediated nociceptive reflex, in order to understand a variety of analgesic mechanisms (Danziger, Fournier, Bouhassira, Michaud, De Broucker, Santarcangelo, Carli, Chertock, & Willer, 1998; Kiernan, Dane, & Philips, & Price, 1995). The latency of the R-III reflex is consistent with the conduction velocity of Aδ nociceptive afferents, and its magnitude is linearly related to subjective reports of pain intensity (Chan & Dallaire, 1989; Dowman, 1991; Willer, 1977, 1984). This makes the R-III reflex ideally suited for the above purpose.

Kiernan et al. (1995) found that during hypnotic analgesia, subjects with high hypnotic susceptibility exhibited significant mean reductions in R-III reflex amplitude and in the sensory (intensity) and affective (unpleasantness) components of pain perception. Specific suggestions for hypnotic analgesia did not result in greater reductions in R-III than did nonspecific suggestions for comfort and wellbeing. This study provided strict controls for expectancy and compliance, and subjects were blind to the physiological index being measured. When, later, informed that measurements were being made on the R-III flexion reflex, they failed to intentionally reduce the magnitude of this reflex. During hypnosis, pain intensity was reduced by approx. 30%, pain unpleasantness by approx. 40%, and the R-III reflex was reduced on average by about 20%.

It needs to be noted though that there were marked individual differences in the amount of change in R-III reflex activity, ranging from a 75% reduction to an 18% increase. The percentage reduction in R-III accounting for 51% of the variance in the reduction in pain intensity (r = .71, p = .003) and for 26% of the variance in the reduction in pain unpleasantness. This latter relationship was not quite statistically significant (r = .51, p = .053). The reduction in pain intensity accounted for 77% of the variance in the reduction in pain unpleasantness (r = .88, p = .0001). Some other researchers also found greater reductions in pain unpleasantness than in pain intensity following hypnotic analgesia (e.g., Price & Barber, 1987), but this finding has not been observed consistantly. Research indicates that differences between the relative reduction in the intensity and unpleasantness of pain depend on the content of the hypnotic instructions used and is not a characteristic of hypnosis itself (Malone et al., 1989; Rainville, Carrier, Hofbauer, Bushnell, & Duncan, 1999). For example, Malone et al. (1989) found that hypnotic-analgesia suggestions reduced pain intensity but not unpleasantness, whereas the opposite pattern was found following hypnotic suggestions for relaxation (i.e., reductions in unpleasantness but not intensity). Many procedures for hypnotic analgesia also include instructions for relaxation, both during the induction process and as explicit hypnotic suggestions delivered in conjunction with suggestions for analgesia. Differences in the make-up of hypnotic instructions may, therefore account for some, if not a large part, of the difference between studies in the reported efficacy of hypnosis to reduce either dimension of pain.

The above results suggest that hypnotic analgesia is only partly accounted for by a reduction in spinal nociceptive activity and that other (non-nociceptive) inhibitory mechanisms are likely to play an important role in hypnotic analgesia. Based on their findings, Kieran et al. (1995) proposed that at least three general mechanisms might be involved in hypnotic analgesia. First, the reductions in R-III indicate the involvement of antinociceptive mechanisms in the spinal cord that prevent the transmission of nociceptive information. Second, the reduction in sensory pain over and beyond the reductions in R-III may relate to brain mechanisms that serve to prevent awareness of pain once nociceptive input has reached higher centres, as predicted by Hilgard's neodissociation model (Hilgard, 1991; 1994; see also section 5.6.1). The fact that the percentage reduction in pain intensity was greater than that of the R-III is consistent with findings that autonomic responses to pain remain even under conditions of profound hypnotic analgesia (Barber & Hahn, 1962; Hilgard, 1994; Sutcliffe, 1961). Third, the reductions in pain unpleasantness over and beyond the reductions in pain intensity may be related to selective reduction in the affective dimension of pain, possibly as a consequence of a reinterpretation of the meaning attributed to the pain sensation as suggested by Price and Barber (1987). Such mechanisms might also be involved in other psychologically mediated forms of analgesia.

The study by Kiernan et al. (1995) is important for a number of reasons: (1) it provides crucial confirmation that hypnotic analgesia is a measurable psychophysiological phenomenon that has measurable effects on spinal reflexes; (2) it not only shows that a single hypnotic intervention can effect multiple components of pain reduction, but also provides a strategy for the independent evaluation of multiple stages of pain processing; and (3) it demonstrates that the hypnotic experience has some measurable effect beyond those suggested by social-psychological and role-enactment theory (Price, 1996).

Hypnotic susceptibility was only moderately associated with reductions in pain sensation and not significantly related to reduction in R-III. Further studies are needed to clarify which components in hypnotic analgesia are specifically related to hypnotic susceptibility and suggestion.

Some nonhypnotic psychological interventions are also able to effect pain sensation and nociceptive reflexes. For example, Willer, Boureau, & Albe-Fessard (1979) found that sustained attention on a mental task decreased both pain sensation and R-III reflex produced by stimulation over the sural nerve. The reduction in pain sensation was about twice the size of the percentage reduction in R-III, similar to the reduction achieved by hypnotic analgesia in Kiernan et al. (1995). A stress condition resulted in the facilitation of both R-III and pain sensation. Simultaneous noxious stimulation of the contralateral ulnar nerve left the R-III reflex unchanged while inhibiting the pain sensation. Intense noxious stimulation of the sural nerve itself resulted in an increase of pain sensation and a marked and immediate increase of R-III, which returned to its control value after 28-30 seconds. These results show the possibility of a dissociation between afferent ascending nociceptive messages and nociceptive motor activity. Willer et al. (1979) suggest that supraspinal descending influences can act differently on spinal dorsal-horn neurons in the case of pain ascending volleys, and in the case of spinal nociceptive motor activity

Both Kiernan et al. (1995) and Danziger et al. (1998) also measured the R-II (H) reflex, a tactile monosynaptic flexion reflex associated with group I afferent fibres, which provides an index of alpha-motoneuron activity. Alpha-motoneurons are involved in the R-III pathway and R-II reflex measures were used to control for the effect of reduced motoneuron excitability. Results showed that reductions in R-III activity were not linked to a generalised decrease in alpha-motoneuron excitability.

Focused attention has been shown to decrease the R-III and increase the R-II reflex, and Kiernan et al. (1995) found a similar inverted relationship (r = -.55, $p < .05$) in response to hypnotic suggestions. This inverse pattern of reflex responses is consistent with descending reticular modulation of spinal nociception (Hagberth & Kerr, 1954; Fields & Basbaum, 1989). Reticular modulation of spinal nociception has been associated with a significant increase in autonomic activity (Batthien & Hugelin, 1969, cited in Kiernan et al., 1995), which may be consistent with earlier cited persistence of autonomic responses during hypnotic analgesia.

Like Kiernan et al. (1995), Danziger et al. (1998) found that, during hypnotic analgesia, subjects with high hypnotic susceptibility displayed significant reductions in both sensory and affective measures of pain. Although the magnitude of the change in R-III amplitude between hypnotic analgesia and control conditions was similar for all subjects (being 20% or more), it represented two distinct, and opposing, patterns of R-III modulation. Whereas one subgroup (11 out of 18 subjects) displayed a strong inhibition of the reflex, a second subgroup (n = 7) displayed a strong facilitation of the R-III reflex. This suggests that at least two different mechanisms of spinal modulation may be at work during effective hypnotic analgesia, depending on the individual and causing either inhibition or facilitation of the spinal nociceptive withdrawal reflex. Furthermore, the striking changes in pain threshold and R-III amplitude were only observed following hypnotic suggestions for analgesia, and not following suggestions for relaxation.

There were a number of differences between the studies by Kiernan et al. and Danziger et al. that might explain this difference. Danziger et al. Deliberately selected subjects who were both highly susceptible to hypnotic suggestions (as in Kiernan et al.) and had demonstrated that they could effectively use the hypnotic suggestions for analgesia (i.e., they reported a pronounced increase in pain threshold during pre-trial assessment). Furthermore, the study by Danziger et al. recorded the reflex amplitude continuously whereas Kiernan et al. made only four recordings per phase. There were also important differences in the content of the suggestions.

The study by Kiernan et al. included suggestions for reinterpretation of the sensation and the use of dissociative imagery that may have generated different mechanisms of spinal modulation. An interesting finding in the study by Danziger et al. (1998) was that only some subjects (n = 8) exhibited the R-II tactile flexion reflex and that all of those who did also showed inhibition of their R-III reflex during hypnotic analgesia. The reason why only, but not all of, those who displayed nociceptive reflex inhibition exhibited an R-II reflex was not clear (Danziger et al., 1998).

EEG recordings of late somatosensory-evoked potentials may provide another method of obtaining an objective measure of pain responding.

An important distinction can be made between early and late components of these scalp-recorded measures of brain activity. The amplitudes of early components of event-related potentials (100-200 msec after stimulus presentation) reflect exogenous factors such as the intensity of the stimulus and the process of selecting the perceptual channel (e.g., visual versus auditory) that is used (Ford, Roth, & Dirk, 1978; Sutton, Braten, & Zubin, 1965). The amplitude of late components (200-500 msec after stimulus presentation) are influenced by: endogenous factors such as the response to the perception of the stimuli, stimulus infrequency, task relevance, attention (Baribeau-Braun, Picton, & Gosselin, 1983; Pritchard, 1981; Sutton et al., 1965); the novelty of the stimuli (Squires, Squires, & Hillyard, 1975); and the extent to which the stimuli are consciously perceived (Posner, 1978). The magnitude of long-latency laser-evoked potentials has been found to be closely related to pain sensations, with late potential components related to Aδ–fibre activation and ultra late components related to C-fibre activation (Treede et al., 1995).

Danziger et al. (1998) also recorded the amplitude of late somatosensory potentials (P_{150} - N_{220}) and found that these decreased by 40% during hypnotic analgesia, but remained unchanged during relaxation. Roughly similar results (31% reduction during hypnotic analgesia) were obtained for a sample of high hypnotisables following laser-induced pain stimulation (Arendt-Nielsen, Zachariae, & Bjerring, 1990). Meier, Klucken, Soyka, and Bromm (1993) did not find any changes in these potentials during hypnotic analgesia, but their sample consisted only of subjects with moderate hypnotic susceptibility (SHSS:C mean score 5.6). Furthermore, the intensity of painful stimulation was much higher in the Meier et al. (1993) study, being two to three times the pain threshold compared to 1.2 times the pain threshold in Danziger et al. (1998).

There are striking similarities between the effects of hypnotic analgesia and those of attention diversion. An important factor they have in common is that they both change the direction of attention. Attending to another stimulus modality can influence the perception of pain intensity and unpleasantness (Miron et al., 1989).

Furthermore, the degree to which one pays attention to a painful stimulus has a strong influence on late somatosensory-evoked potentials (Miltner, Johnson, Braun, & Larbig, 1989). Absorption is also suggested to be an important factor in hypnotic analgesia (see section 5.3, p. 143).

Willer et al. (1979) did observe a similar inhibition of the R-III reflex during sustained attention, and reduction of pain perception and reflex modulation have also been observed following placebo analgesia (Hashish, Feinman, & Harvey, 1988). These results indicate that the mechanism of spinal reflex inhibition does not depend specifically on hypnosis.

CHAPTER THREE

ATTENTION, MULTIPLE-TASK PERFORMANCE, AND CONCURRENT TASK INTERFERENCE.

3.1. *Attentional Processing*

A basic tenet examined by this study is that attentional processes play an important role in understanding both pain processing and hypnotic processes. As Karlin (1979) has argued attentional processes may well be critical in understanding the function and meaning of hypnotic behaviour. Differences in attentional processes may be what sets hypnosis and hypnotic analgesia apart from other cognitive behaviours and pain coping strategies. I will, therefore, briefly explain current knowledge on attention and then give a brief summary of some of the major developments that have led to the conceptualisation of the attentional system that is currently used by most cognitive scientists. Most research on the mechanisms of attention involves visual attention because this modality is best known and easiest to study experimentally.

Two important characteristics of information processing are competition for limited-capacity processing resources, and selectivity of input processing. At some point (or several points) between input and response, stimuli compete for representation, analysis, or control. This competition is biased towards information that is relevant to current behaviour. To attend to relevant stimuli, the attentional system needs to be selective and screen out unwanted stimuli (Desimone & Duncan, 1995). The following is a brief summary of information processing.

The detection of a stimulus is followed by several stages of information processing. The information initially arrives in sensory memory, which has a large storage capacity, but only a short holding time. After the particular stimulus pattern is recognised by specific neurons that react to activation by this type of stimuli, some of its features are coded for short-term memory, also called working memory (Birbaumer, et al., 1990).

Normally, there are always several stimuli that are presented concurrently (e.g., all the different visual stimuli that make up the total picture we see in front of us), but at any one time we can, and often want to, attend to only one or some of these. We, therefore, need to screen out the unwanted stimuli (nontargets) from the target stimuli that are selected for further processing. One of the functions of the attentional system is to modulate this selection so that those types of stimuli are selected that are most important for the current behaviour sequence (Desimone & Duncan, 1995; Posner & Petersen, 1990).

3.1.1. **Control of stimulus selection - bottom-up biases and top-down control**

The modulation of the selection process is influenced by bottom-up stimulus-driven biases as well as top-down goal-directed control. Bottom-up biases stem from the properties of incoming stimuli that make them stand out in both space and time from other surrounding stimuli. Examples are for instance the sudden appearance of a new object in the visual field (Jonides & Yantis, 1988) or an object that is larger, brighter, or faster moving than others in its surroundings (Treisman & Gormican, 1988). The properties of incoming stimuli are compared with a short-term representation of information stored in long-term memory that is associated with the incoming stimuli. This short-term description specifies any stimulus properties needed to match the stored program. This stored mental representation has variously been referred to as a *neural model,* an *attentional template* (Duncan and Humphries, 1989), or a *competence* (Pribram & McGuinness, 1992). The evaluation process is one of the aspects of short-term or working memory (Baddeley, 1992). Mismatches between stored and incoming information elicit an orienting response (i.e., a nonspecific first preparatory response), or a defence response (e.g., a nociceptive reflex such as the R-III) if the stimulus is potentially harmful (Birbaumer et al., 1990). Novel situations are one type of condition that results in a mismatch between stored and incoming data. Either the incoming stimulus fails to match with an associated template or no related template can be found at all. Up to this point the stages of information processing are normally outside of conscious awareness (i.e., they happen more or less automatically).

However, the stimuli that stand out from their background because of bottom-up biases are not necessarily stimuli that are relevant to information we selectively want to attend to. Therefore, to bias competition towards whatever information is relevant to current behaviour, top-down control is needed in addition to the bottom-up stimulus-driven biases.

Top-down control derives from the requirements of the task at hand. For example, in object selection we might use the attentional template in working memory to selectively attend to a target's spatial location while ignoring simultaneously presented distractors (i.e., nonmatching stimuli) at other locations, thereby reducing their competition for processing resources (Moran & Desimone, 1985). In a similar way, the attentional template can be used to selectively attend to an object on the basis of one or more of its features (e.g., when certain features are more discriminating than its location, or when the location is not known in advance). The process of top-down control is also assumed to take place in working memory. When a target consists of a combination of attributes (e.g., a large yellow triangle) and appears in a background of nontargets that are similar on one or more of the attributes (e.g., different shapes that also vary in colour and size), the search process becomes slow, attention demanding, and serial (Duncan & Humphries, 1989). Cues about an attribute (e.g., location or timing) of a stimulus presentation can markedly reduce the time required to orient to such stimuli and improve the accuracy of stimulus groupings (Cohen & Ivry, 1989; Treisman & Gormican, 1988).

The next major processing stage involves preparation for sensory and motor activity. If the initial comparison of stimulus properties evokes response choices, further processing and evaluation is involved in selection of the most appropriate response. Sensory and motor preparatory mechanisms may be initiated in parallel. The sensory mechanism allows for further input processing and the motor mechanism is involved in output organisation. It is assumed that the initiation and activation of preparatory mechanisms requires the mobilisation of limited resources. The various processing systems (e.g., visual, auditory, somatosensory, spatial, verbal, and manual) compete for the allocation of resources to their systems (Navon & Gopher, 1979).

The speed of information processing may be enhanced by the grouping of related stimuli into discrete chunks (e.g., those representing an object). Indications are that these units behave as wholes and are treated and preserved as such during competition for representation and control of behaviour (Duncan & Humphries, 1989). Related to grouping is the problem of binding, that is keeping together parts or attributes of the same entity in a distributed representation (e.g., the many features that make up a representation of a face).

If, as is often presumed, different features are represented separately in the cortex, the logical question is how do they bind together to form a united representation? Feature Integration Theory (Treisman & Gelade, 1980, see also Navon, 1990; Treisman, 1990) proposes that attention is the medium that links together different features at the attended location. However, if, as suggested, this occurs in a serial fashion (e.g., like a mental spotlight that scans each item in the visual field), the different features have to be bound together one at a time. The time needed to do this would cause problems for complex objects that have many features or parts which may be arranged according to hierarchical part-whole relationships (e.g., the human body). Binding of such features would require comparable binding hierarchies (e.g., a finger may be seen as part of a hand, a limb, or the entire body) (Desimone & Duncan, 1995). Furthermore, as already discussed, particular features may cause an object to pop out from its surroundings before it has become the focus of attention, and before any attentional binding (Duncan & Humphries, 1989; McLeod, Driver, & Crisp, 1988; Wolfe, Cave, & Franzel, 1989). This suggests that, at least some aspects of, the binding of stimulus features may be operating in parallel.

3.1.2. **Models of attention**

All models of attention propose some type of spatial gating mechanism for situations when targets are selected by spatial location. However, when a target needs to be identified on the basis of particular features (e.g., searching for a face in a crowd) different classes of models (i.e., serial, parallel, or some combination of both) diverge significantly in the mechanisms they propose.

The question as to whether attentional processing is serial or parallel, or to what extend comprises both, is still unresolved and under further investigation. Models of attention that favour serial processing propose that each element is selected in turn by attention whereupon it is evaluated by the recognition process in working memory, a process that continuous til the target is found and the scanning of the array is finished (e.g., Olshausen, Anderson, & Van Essen, 1993; Schneider & Shiffrin, 1977; Treisman and Gelade, 1980).

Parallel processing models, including the previous description, propose that all input elements compete in parallel for further processing (e.g., Bundesen, 1990; Duncan & Humphries, 1989; Desimone and Duncan, 1995). Examples of, more general, models of attentional processing that use a parallel distributed approach have been developed by Christ (1991a,b, 1992) and McClelland, Rummelhart, & PDP Group (1986). Some other recent models include both serial and parallel processing components. The Guided Search model (Wolfe et al., 1989), modified Feature Integration Theory (Treisman & Sato, 1990), and the Spatial and Object Search model of Grossberg, Mingolla and Ross (1994), for instance, all incorporate parallel top-down processes for the grouping and recognition of elements across the visual field that share target features.

Whether attention is a serial or a parallel process also has some implications for task interference. Interference occurs when the time between presentation of the items is shorter than the attentional dwell time on the first item and subsequently presented items compete for processing resources. Typical serial models propose rapid attentional scanning of objects in a scene, whereby objects consume processing capacity for only a few milliseconds. Thus, the attentional dwell time is short and interference would only occur if items were presented very rapidly. The attentional dwell time can be much larger in parallel models, particularly when many items are presented. Thus, interference may last for much longer periods of time. A study by Duncan, Ward, and Shapiro (1994) found that interference following sequential target presentation lasted for several hundred milliseconds, a result that is consistent with parallel models. Note of course that this relates to interference during object selection, which is only one aspect of the total interference that can occur.

Over the years several theories have evolved that increasingly provide a fuller representation and understanding of attentional processing. The following is a brief outline of this process. Broadbent (1958) proposed a limited-capacity system through which inputs must pass to acquire control over behaviour. To capture selectivity, the limited-capacity system was preceded by a 'filter' accepting those inputs that were relevant to current behaviour and rejecting others. Based on examination of the visual attention system, Treisman (1969) proposed that the attentional system could be divided into a number of special purpose analysers that operate in parallel. Rather than being completely blocked by a single filter ("bottleneck") as was initially suggested by Broadbent, Treisman suggested that unselected messages are attenuated so that a stimulus of higher intensity is needed for them to be processed.

Subsequent theories have proposed that the allocation of limited-capacity resources is coordinated by a central processor (Kahneman, 1973) or general executive controller (Broadbent, 1977a). Shiffren and Schneider proposed that human information processing could be divided into two theoretical processes: controlled and automatic processing (Schneider & Shiffren, 1977; Shiffren & Schneider, 1977). *Controlled processing* represents a temporal sequence of operations that are under the control of the individual, require active attention, utilise short-term memory, and are capacity limited. It occurs in situations for which automatic processes have not yet been developed, such as responses to novel or highly complex situations that involve changing stimulus-response relations. *Automatic processing* relates to early processing. It can develop as a result of extensive practice of tasks that involve consistent stimulus-response relations. Automatic processing is activated by a particular, recognised, stimulus. It is a fast, parallel process that is not limited by short-term memory and requires minimal processing effort (Posner & Snyder, 1975). Automatic processing is unavailable to conscious awareness, occurs even when the appropriate stimulus is outside of attention, and is difficult to modify once initiated.

Cognitive theories of planned and unplanned behaviour now generally assume that our actions are controlled by the activation of sensorimotor schemata (Mandler, 1984) or managerial knowledge units as Grafman (1989; 1995) has called them, that interact in a hierarchically organised fashion (e.g., Hilgard, 1986; Miller, Galanter, & Pribram, 1960, Norman, 1981; Norman & Shallice, 1986).

These schemata are like a program, that is a representation of an established competence or goal (e.g., how to drive to a particular location). Such a source schema can be made up of several component schemata (e.g., how to make a left hand turn), which in turn can act as source schemata for even lower-level subordinate schemata (e.g., adjusting speed or indicating a turn). Each of these component schemata is capable of being triggered by environmental stimuli.

At the top of the hierarchy is an executive controller whose function it is to bias the selection of schemata to ensure that those schemata are selected that are relevant to, and coherent with, current behaviour or goals. This process of inhibiting distracting and task-irrelevant information is thought to require limited attentional resources (Engle, 1996). It is this highest level of hierarchical control that is identified with consciousness and intentionallity. Many activities are well-established (learned) and when triggered can be performed automatically without the need for high-level intentional activation or control. The performance of such acts takes little or no conscious awareness.

Norman and Shallice (1986) have used the distinction between automatic and controlled (or willed) actions and the proposed hierarchical organisation of action schemata and have developed it into what has now become one of the most widely used models of attentional processing. They proposed that the attentional system contains two complementary control systems for the initiation and control of action. A lower-level control system, referred to as "contention-scheduling" that is decentralised and takes care of routine acts that do not require conscious or attentional control. Contention scheduling operates through the competitive and cooperative activation of action or thought schemata. The activation level of a particular schema is influenced partly by environmental triggers and partly by other supporting or conflicting schemata. Once it exceeds a threshold, the particular schema is selected and the corresponding action activated. This mechanism is well-equipped to deal with routine and automatic tasks. In the absence of complications, even relatively complex acts can be performed largely automatically and with little or no awareness. This automaticity clearly has an adaptive function in that it frees attentional resources and increases our capacity to engage in simultaneous tasks.

There is a cost to automaticity in that the quality of information is lower, which results in an increased probability of errors and action slips (Norman, 1981; Reason, 1984).

However, when a task is novel, not well-established, or when it needs to overcome a strong habitual response, contention scheduling may fail to make the appropriate schemata available. Such situations rely on the activity of a higher-level control system, which Norman and Shallice (1986) have called the *"supervisory attentional system"* or *(SAS)*. The SAS provides centralised control that is qualitatively different from that obtained through contention scheduling. It not only monitors the lower-level control system, but also has access to its own relatively unique information, including the individual's goals and intentions (Woody & Bowers, 1994). Rather than directly controlling behaviour itself, the SAS exerts its control indirectly through modulation of the lower-level system. By providing extra activation or inhibition it changes the activation values of source schemata and biases their selection by the contention-scheduling system. For a review of supervisory system and anterior attentional functions see also Stuss, Shallice, Alexander, and Picton (1995). The nature of the involvement of the supervisory system has an important influence on how an action is experienced (e.g., as a wilful act or as being nonvolitional, or as only partly wilful). This is particularly relevant to the topics examined in the current study and will be examined further in section 5. 6.1.2.

3.2. *Multiple-Task Performance*

Traditional resource models of attention postulate that there is a limited capacity of resources available for information processing. In line with this notion, it is often suggested, or simply just assumed, that the performance on two or more concurrent tasks depends on graded sharing of a *single* pool of cognitive resources (Pashler, 1992). The frequent failure to find that the level of difficulty of one task does affect the performance on another, simultaneously performed, task has raised important questions about the validity of the limited-capacity model of attention (Israel, Chesney, Wickens, & Donchin, 1980; Wickens, 1984). Although the metaphor of a limited pool of resources is still widely used, this model has come under increasing criticism (e.g., Allport, 1992; Allport, Styles, & Hsieh, 1994; Navon, 1985; Pribram & McGuinness, 1992).

Absence of interference could mean that the combined attentional demands did not exceed the available capacity, or that both tasks did rely only partly or not at all on the same pool of attentional resources. Lack of interference has also been observed between concurrent tasks known to require considerable attentional resources for their successful performance, which has sparked interest in multiple-resource theories of information processing.

Multiple resource theories argue that performance of a task typically involes many processes which in turn depend on a multiplicity of resources (modules). The modules that make up processing pathways can be thought of as a set of resources within the system. According to multiple resource theory, two or more simultaneous activities will compete for processing capacity and may interfere with one another to the extent that their processing pathways intersect, or in other words to the extent that they rely on the *same* resources for different purposes (Cohen, Dunbar, & McClelland, 1990). This suggests that the more similar activities are, the more likely they are to interfere with each other. This model allows that there be may be more than one attentional resource (module) within the system and that different processes may rely on different modules. The extent to which limitations in atttentional capacity will affect performance will depend on: the particular processes involved in the task or set of tasks, the extent to which these processes rely on attentional resources, and wheter the attentional resources are the same or different for the various processes involved.

Wickens (1984, 1991) has suggested three main resource dimensions along which activities can differ. The attentional processing of activities can vary: (1) in input modality (e.g., visual versus auditory), (2) the stage of processing (perceptual or central processing versus response activation (i.e., attentional versus para-attentional), and (3) the particular codes of perceptual and central processing (e.g., verbal versus spatial). Johnson et al. (1998) have proposed that pain is an example of a third (i.e., somatic) category of input modality.

Meyer and Kieras have recently introduced a theoretical framework of executive cognitive processes and multiple-task performance, which they have called "executive-process interactive control" or EPIC.

The computational models that can be formulated using this framework can be used to explain and predict the characteristics of multiple-task performance across a variety of contexts. For a detailed description of the EPIC architecture see Meyer and Kieras (1997a,b).

People have flexible strategies for scheduling various stages of processing to satisfy instructions about task priorities. Meyer and Kieras (1997a) proposed that this scheduling can take place along alternative response-transmission modes through which selected responses are either stored temporarily in working memory (deferred mode) or sent directly to their motor processors (immediate mode). This notion further highlights the role that working memory might play as part of executive mental control. Results obtained using a "strategic response deferment" model based on the EPIC architecture highlight the fact that limitations of perceptual-motor mechanisms strongly shape human multiple-task performance. To cope with such limits and to satisfy competing task priorities, flexible scheduling strategies are used. These strategies are mediated by executive cognitive processes that coordinate concurrent tasks adaptively. This flexibility in the scheduling of concurrent tasks might be greater in people with high hypnotic ability as has been suggested by some of the neurophysiological research (see Crawford, 1994b).

3.3. *Task Interference*

Interference with concurrent task performance can provide important insights into the human information-processing system. Controlled, conscious performance of two or more concurrent tasks frequently results in interference with the performance of either one or all of the tasks. Which task will be interfered with most will depend on the relative dominance of their goal contexts. Tasks need to be within conscious awareness to be able to interfere with each other. Completely automatic actions do not require conscious attention for their successful execution and do not interfere with each other beyond the initial limits of perceptual capabilities.

The extent of any possible interference between tasks is influenced by a number of factors including task similarity, task difficulty, and amount of practice (Eysenck, & Keane, 1995). Interference between concurrent tasks is greatest if they have the same stimulus modality (e.g., visual or auditory), make use of the same stages of information processing (input, internal processing, output), or rely on related memory codes (e.g., verbal or visual). Response similarity is another important factor. Task interference is greater when the responses required by each task are highly simular (e.g., both manual rather than one manual and the other vocal). However, measuring such similarities between tasks is far from straightforward. With sufficient practice, tasks can become largely automatic and less reliant on executive control, thereby reducing the need for attentional resources and the likelihood of interference. Finally, interference between non-automatic tasks that are sufficiently similar will be larger the more difficult the tasks are.

It is important to note that the combined resources demanded by two simultaneously performed tasks are not necessarily equal to the sum of their individual demands. The necessity to perform two or more tasks together introduces additional demands of coordination and avoidance of interference. Along this line, Navon (1985) has proposed an alternative explanation for task interference that is not dependent on a limited capacity of resources. Rather than stemming from a competition for scarce resources, Navon argues that task interference results from an outcome conflict between tasks that are performed concurrently. Tasks do not withhold resources from each other (i.e., they split the amount of available resources), but they generate something that degrades performance on one or all tasks (i.e., they suffer the consequences of sharing the same processes). Thus, according to the resource perspective, any tasks that require significant attentional resources, whether they involve the same processes or stage of processing or not, compete for access to a limited capacity (pool) of overall available resources. Navon's outcome conflict perspective, on the other hand, proposes that two or more tasks only compete for resources to the extend that they share the same resources.

3.4. *Pain and Attentional Interference*

3.4.1. **Direct access to awareness**

Attention can be seen as an active process that controls the selection of information into awareness (Baddely, 1993). Attentional engagement is needed to select, coordinate, and monitor the processes needed to perform a particular action or thought in a fashion that ensures coherence of goal-directed behaviour in an environment that provides multiple and often conflicting demands (Allport, 1989).

High-intensity pain has high processing priority and seems to afford direct access to awareness (Eccleston, 1995a). For pain to maintain attentional focus, it needs to dominate access to these resources at a cost to either any other tasks requiring attentional processing (resource perspective),or only to those tasks that share the same resources (outcome conflict perspective). Thus, pain can interrupt focal awareness of ongoing activity; which is part of controlled attentional processing.

Pain has some specific characteristics that set it aside from most other cognitive tasks that compete for shared resources. When practised sufficiently, other tasks become habituated and can be activated and monitored more or less automatically through their own internal controls (Shiffren & Schneider, 1977; Logan, 1988, 1989). They no longer rely on conscious, attention-demanding, executive control., this would means that much of the resources required prehabituation are now available for the executive processing of other tasks that are more difficult, novel, or ill learned. Only when the environment introduces an unexpected change that interferes with the normal performance of the habituated task is conscious executive effort required again. Pain, on the other hand, is seen as the ultimate controlled task and by definition a conscious process that can not be automated or dropped from consciousness (Jaynes, 1985; Marcel, 1988). The very function of pain is to make us *aware* of impending danger and prepare us for required action. What is automatic about pain is its access to consciousness (Cioffi, 1991) and its demand for central attentional resources (Shallice & Burgess, 1993).

The automatic, attention-demanding characteristics of a stimulus (trigger) such as pain give it the capacity to interrupt ongoing deliberate activity and supervisory control and influence schema selection on a broadly distributed level (Normal and Shallice, 1986). Many of the disturbing aspects of pain result from its ability to interrupt ongoing activity. For a task to displace pain from access to conscious awareness (e.g., through pain suppression or attention diversion) it must demand a high level of attention. The attention-demanding execution of such tasks itself results in the interruption of ongoing activity. Hypnosis, on the other hand, has been argued to reduce the sensitivity of the supervisory system to such interrupts (Woody and Bowers, 1994). As we will see later, some researchers suggest that hypnosis, through a process of dissociation, is not only able to attenuate pain and its accompanying distress which eliminates any outcome conflict and inhibits its interrupt function, but can do so in a way that does not require attention-demanding effort itself.

3.4.2. **The interruptive quality of pain**

Disruptions of normal daily activities at home, in the workplace, and in social situations are a frequent complaint of chronic pain sufferers. These reports are supported by clinical evidence that cognitive impairments such as increased distractibility and problems with memory and concentration are common in chronic pain patients (Dufton, 1989; Jamison, Sbrocco, & Parris, 1988, Kewman, Vaishampayan, Zald, & Han, 1991).

Both Dufton (1989) and Jamison et al. (1988) found that patients with either high or low levels of reported cognitive difficulties did not differ significantly on ratings of pain intensity or chronicity, amount of medication taken, number of specialists seen, or their ability to carry out various activities. However, patients who endorsed having (more) memory and concentration problems did report a higher incidence of anger and disharmony at home and less desire for, and satisfaction with, social and sexual activities. Furthermore, patients in the high cognitive difficulties group showed significantly higher levels of emotional distress including mild depression, increased anxiety, and a low tolerance for frustration.

In contrast, the study by Kewman et al. (1991) did not find any significant group differences for either anxiety or depression between patients reporting low or high levels of cognitive difficulties. This may be, at least in part, a result of differences in methodology, sample composition, screening criteria, and in assessment measures used. For example, the study by Kewman et al. (1991) excluded all prospective participants who had previously been diagnosed as having cognitive impairments or had used narcotic analgesics during the previous twenty-four hours. In addition, their patients (students attending a university outpatient clinic) were more highly educated than the normative sample for the cognitive impairment measure used. The fact that chronic pain patients who experience cognitive difficulties also frequently report family conflicts suggests that these patients may also benefit from family therapy interventions and the inclusion of family members in their treatment programs (Jamison et al., 1988).

Although the above studies found that pain, emotional problems, and cognitive failure were correlated, results cannot be taken as evidence of a direct relationship between pain and cognitive failure, as a number of factors may be able to explain the observed relationship. For example, measures of emotional distress, particularly depression, share considerable item content with measures of cognitive inefficiency, but not with pain. Pain-induced distress, cognitive difficulties, and emotional problems might well interact in a circular relationship. As we have seen, pain consists of both a perceptual and an affective-motivational component. Although the above studies did not separately assess the sensory and affective components of pain, it would be consistent with other findings if cognitive difficulties were related to the affective (i.e., distress) component of pain, but not to the intensity and duration of the pain.

Overall, results indicate that: (1) cognitive impairment is common among chronic pain patients, and (2) cognitive inefficiencies appear to be significantly related to emotional distress, but not to sensory qualities of pain per se, such as its intensity and duration. As Rachlin (1985, p. 44) has stated: "it is by its aversiveness, not by its sensory quality, that pain causes disability."

3.4.2.1. *Alternative research methodologies: The task paradigm*

Research investigating the role of attention in pain control has typically examined the impact of various instructions or interventions (e.g., attention-diversion strategies) on subjects' pain reports. Eccleston (1995b) refers to this as the "instruction paradigm." More recently, an increasing number of pain researchers have begun to employ a different methodology (i.e., a "task paradigm") designed to investigate the interruptive quality of pain on other ongoing activity (e.g., Crombez et al., 1994; Eccleston, 1994, 1995b; Lorenz & Bromm, 1997). Most often, participants are instructed to direct their attention to the accurate performance of a task that is demanding of central attentional resources while using a coping strategy to deal with painful stimulation. The level of pain is treated as an independent variable and the disruption of a simultaneously performed attention-demanding task as the dependent variable. By measuring the difference in interference with task performance following painful stimulation, both before and after the introduction of a coping strategy, we can obtain a more objective measure of the effects of pain and subjects' attentional engagement in the particular coping strategy. This method has considerable practical utility, as interference with ongoing activity is one of the more debilitating aspects of pain.

3.4.2.2. *Factors that may moderate the interruptive function of pain*

Research has shown that the interruptive function of pain can be moderated by sensory, affective, and cognitive factors. These include pain-related factors such as the intensity, novelty, predictability, and perceived threat of the stimulus as well as factors more related to environmental demands such as task difficulty and emotional arousal (Eccleston & Crombez, 1999).

Intensity. A number of experimental studies have found that pain can result in significant cognitive impairment on other tasks, but only if the intensity of the pain is high and the task is complex and demanding of central attention (e.g., Eccleston, 1994, 1995b; Kewman et al., 1991; Morton, 1969). High levels of reported pain predicted impaired performance, even when controlled for differences in medication use and affective distress.

However, this intrusion cannot be fully explained by the sensory characteristics (e.g., intensity) of pain (Eccleston & Crombez, 1999).

Novelty. Pain that occurs within a novel (i.e., unfamiliar and unexpected) context resulted in greater interference on other attention-demanding tasks, despite instructions to ignore the pain (Crombez et al., 1994; Crombez, Eccleston, Baeyens, & Eelen, 1996). Furthermore, the interference following novel pain was greatest immediately following the onset of the pain and did diminish, but not disappear with repeated experience of the stimulus (Crombez, Eccleston et al., 1996; Crombez, Eccleston, Baeyens, & Eelen, 1997).

Experimental studies further found that task interference was less when the onset of a noxious stimulus was cued or signalled (Beers & Karoly, 1979; Crombez et al., 1994; Dawson, Schell, Beers, & Kelly, 1982). Signalling the onset of a noxious stimulus reduces its novelty and provides an opportunity to engage in preparatory responses. Some of these might be largely automatic while others involve deliberate coping strategies. The nature of the preparatory responses is determined by the affective evaluation of the anticipated stimulus. The person may simply decide that, although unpleasant, the stimulus is not likely to seriously hurt them and no deliberate coping strategies are needed. They may also conclude that they want and are able to attenuate the averseness of the stimulus in which case they are likely to engage in some deliberate coping strategy they have learned. On the other hand, when the person interprets the anticipated event more negatively and concludes that they lack the self-efficacy to influence the stimulus, they are more likely to become fearful and engage in catastrophic thinking. This may be accompanied by an increase in vigilance and heightened somatic awareness (Crombez, Eccleston, Baeyens, & Eelen, 1998b; Heyneman et al., 1990).

The above findings are not surprising when the effects of novelty are examined in more detail. The sudden onset of an intense stimulus, whether novel or not, tends to elicit a startle reaction which is a form of defensive reflex. Novel stimuli are unexpected and have previously not or only rarely been encountered in that particular context or configuration (O'Keefe & Nadel, 1978).

They elicit curiosity and/or fear. Curiosity results in orienting and exploration, while fear results in defensive reflexes and either withdrawal or immobility (Sokolov, 1963). When generalised fear is not dominant, curiosity results. When a current stimulus does not match a stored representation, orienting and further exploration follows. This explorative behaviour is a specific response to novelty that competes with, and can reduce, fear (Russell, 1973). When not intense enough to elicit a defensive reflex, novel stimulation elicits curiosity and may result in an arrest reaction. This brief reaction results in the cessation of ongoing activities and the maintenance of the posture exhibited at the onset of the stimulation. This is rapidly followed by a complex of reactions including changes in autonomic responses referred to as the orienting response (Sokolov, 1963). Repeated presentation of a stimuli typically results in a brief initial sensitisation that is followed by rapid familiarity and habituation. The exploration of novelty, however, is very different and follows a much longer time course requiring attention-demanding executive engagement.

Contextual factors. Experimental pain research has typically utilised designs that controlled or held constant any environmental factors (Eccleston, 1995a). Pain, however, does not occur in isolation and when pain interrupts, it is always at the expense of some other prior attentional engagement. This frequently results in a rapid switching of attention between attempts to coping with the pain and efforts to maintain the coherence of other environmental demands.

A few recent studies have started to systematically explore and manipulate the context wherein the pain occurs. Preliminary indications are that the difficulty of a distraction task by itself does not significantly influence pain tolerance and pain related distress (McCaul et al. 1992). For example, Johnson and Petrie (1997) found that patients with chronic low back pain were able to successfully perform an automatic physical task that was normally interrupted by pain when in an environment that provided multiple competing demands for attentional engagement. Performing an additional attention-demanding task did not affect ratings of pain intensity and distress, but did increase exercise tolerance.

Fear. Leventhal (1992) has suggested that the emotional significance of competing demands for attention is a particularly important aspect of the context of pain. Emotional arousal also initiates a readiness to respond and, like pain, emotions can place powerful demands on attention (Bradley, Cuthbert, & Lang, 1996; Frijda, 1986; Mandler, 1964).

The attentional interruption of pain is thus best understood within a hierarchical system of motivations to act (Bolles & Fanselow, 1980). These authors have proposed a perceptual-defensive-recuperative model of fear and pain that is based on this notion of hierarchical motivation. Injury or the expectation of injury is seen to activate a fear motivational system and a pain motivational system. The fear motivational system activates defensive behaviour (remaining immobile, fight, or flight) and facilitates the interpretation of environmental events towards the perception of danger or safety. The pain motivational system facilitates the perception of nociceptive stimulation and activates recuperative behaviours (resting and body-care responses) that promote the recovery from injury.

These two motivational mechanisms interact through mutual inhibition that is mediated by an endogenous analgesic mechanism involving endorphins. The organism's response depends on the relative strength of these two systems. During immediate danger (e.g., a severe injury or an attack by a predator) fear motivation is dominant and triggers the endorphin mechanism, thereby inhibiting pain motivation and recuperative behaviours that might compete with effective defensive behaviour. When immediate danger is over a relative safety has returned, pain becomes dominant and promotes recuperative behaviours (Bolles & Fanselow, 1980).

The emotional significance of a stimulus also has a strong influence on the level of disruption of ongoing activity. The expectation of pain is rarely affectively neutral. Pain is generally experienced as a threat to the organism and its anticipation initiates various preparatory responses (Crombez et al., 1994; Crombez, Vervaet et al., 1996; Grillon, Ameli, Woods, Merikangas, & Davis, 1993). These preparatory responses, among others, facilitate priority access into awareness for stimuli that may signal threat and injury (Allport, 1989; Dawson et al., 1982; Öhman, 1979).

Studies have shown that attentional interference is enhanced by the threat of pain (Crombez, Eccleston, Baeyens, & Eelen, 1998a) particularly when combined with an overly emotional (catastrophic thinking) reaction to the threatening information (Crombez, Eccleston, Baeyens, & Eelen, 1998b; Heyneman et al., 1990). High levels of fear and fear related thinking are accompanied by a vigilance or increased awareness of the possible sources of threat (Eysenck, 1992). Such increased vigilance (i.e., hypervigilance) to behaviours thought to initiate or exacerbate pain is frequently observed in certain chronic pain syndromes (McDermid, Rollman, & McCain, 1996; Rollman, & Lautenbacher, 1993). Furthermore, Eccleston, Crombez, Aldrich, and Stannard (1997) observed that, only patients with high intensity pain who also had a high awareness of bodily sensations (i.e., somatic awareness) exhibited significant impairment in attentional performance.

Just like pain itself, coping strategies do not have to be affectively neutral and can utilise the powerful attentional demands of emotional arousal by including either pleasure- or anger-based cognitions. Based on the above findings, it would appear that coping strategies should be most effective when they are both novel and emotionally arousing. In experimental settings, it is quite easy to design a distractor so that it is unexpected and unpredictable, but in daily life this is less practically feasible. Although, for example, the modality of a transcutaneous electrical nerve stimulation (TENS) device can be adjusted so that it follows a varying pattern of stimulation, cognitive strategies are typically learned and practiced and, therefore, no longer novel. However, emotion-arousing imagery can easily be included in cognitive strategies (see Martin, 1990, for a review of mood inducing strategies).

3.5. *Processing of emotion-arousing information and efficacy of emotion-arousing distractors*

There is substantial evidence for attentional biases in the processing of emotional information and for the notion that memory retrieval is (mood) state-dependent (e.g., Bower, 1981; Mathews, 1993). Results suggest that responses congruent with the current emotional state are facilitated, whereas emotions incongruent with the emotional state are inhibited.

This is supported by findings that a defensive startle reflex (elicited by to acoustic probes) is potentated during the imagination of aversive affective states (e.g., fear, anger, or sadness scripts), but is inhibited during the imagination of pleasant scenes such as joy and pleasant relaxation scripts (Cook, Hawk, Davis, & Stevenson, 1991; Vrana & Lang, 1990). This suggests the possibility that tasks which strategically control such biasing of emotional information may exhibit superior utility. A distraction task that arouses pleasant imagery may thus achieve greater reductions in particularly pain unpleasantness than an affectively neutral distractor. However, if the pain is severe it might not be possible to displace it from attention. It this situation, the person is still faced with having to deal with incongruent responses, which is particularly attention demanding. Thus, although a distractor involving pleasant imagery may have a greater capacity to reduce pain it might not result in less task interference than an affectively neutral distractor.

As Eccleston and Crombez (1999) point out, there is some preliminary evidence that distraction with an emotional theme is effective in altering pain perception (Berntzen, 1987; Stevens, Heise, & Pfost, 1989). While these studies all show that emotion-arousing distractors can be effective, evidence for a differential effectiveness between anger- and pleasure-based cognitions is so far inconclusive. Stevens et al. (1989) found that anger-based cognitions produced a higher pain tolerance than pleasure-based cognitions. Self-reports suggested that this differential effectiveness was not moderated by the intensity of affect. Westcott and Horan (1977, cited in Stevens et al., 1989) found that anger-based cognitions produced a higher pain tolerance than pleasant or neutral cognitions relative to a no instruction control condition. Berntzen (1987), however, found that both a single pleasant-imagery strategy and multiple affectively neutral cognitive strategies did significantly increase pain tolerance, but there was no significant difference in effectiveness between them. Although it would be expected that emotion-arousing distractors are more attention demanding than neutral distractors, the preliminary findings of the above studies do not warrant that conclusion. It appears that, although emotions may place powerful demands on attention, these may result in selective rather than universal interference with other ongoing cognitive processes. More studies will be needed that compare emotional (anger and pleasure) based distraction and neutral distraction in otherwise comparable conditions.

3.6. *Neurophysiology of Attentional Processes*

3.6.1. **The posterior and anterior (fronto-limbic) attentional systems**

Initial observations in brain injured people made it possible to identify the general brain regions that are important in attentional processing. New developments in neuroscience have facilitated the physiological study of higher cognitive functioning (see e.g., Birbaumer et al., 1990; Hillyard & Picton, 1987; Raichle, 1983, 1994). Advances in neuroimaging techniques have made it possible to record changes in brain activity at specific cortical locations following various types or phases of attentional processing. It has become clear that attention involves a network of interacting brain areas and is neither the property of a single brain area nor a general function of the brain operating as a whole (Rizolatti, Gentilucci, & Matelli, 1985, Mirsky, 1989). Posner and Petersen (1990) propose that the attentional system is anatomically separate from the data processing system and, like sensory and motor systems, interacts with other parts of the brain while maintaining its own identity. Although, we now know the major anatomical areas that appear to be basic for the selection of information for conscious processing, much remains unknown about the particular pathways and interactions that connect the various anatomical structures involved in the neurophysiology of attention in humans (Arendt-Nielsen et al., 1990).

Researchers interested in the localisation of attention have conducted a large number of neuropsychological studies of brain activity in both humans and animals following performance of specific cognitive tasks and data of neglect or impairment following lesions in clearly identified brain areas. Individual differences have been observed for four major dimensions of attentional processing: (1) *focussed and sustained attention:* the ability to focus and sustain attention over time without distraction; (2) *selective attention:* the ability to select and discriminate between stimuli; (3) *divided or dual attention:* the ability to divide attention between two tasks, often one primary and the other secondary; and (4) *ambient attention:* the ability to attend to one task, but also to have diffuse attention in preparation to respond to other stimuli, e.g. the cocktail-party phenomenon (e.g., Crawford, Brown, & Moon, 1993; Davis, Jones, & Taylor, 1984; Sack & Rice, 1974).

Based on the results of these studies, various researchers have proposed that there are at least two major attentional systems: (1) a *posterior attentional system* involved in the processing and encoding of incoming information and the engaging and disengaging of attention (i.e., selective attention); and (2) an *anterior or fronto-limbic attentional system* that is involved in maintaining effortful attention over time (i.e., focused and sustained attention), inhibition and resistance to distraction, and the modulation of emotionality and comfort-discomfort (Luria, 1980; Posner & Petersen, 1990; Posner, Petersen, Fox, & Raichle, 1988; Pribram, 1973; Pribram & McGuinness, 1975, 1992; Stuss & Benson, 1986). Damage to the prefrontal area of the brain frequently leads to a sensitivity to interference (distractibility) and major problems in maintaining attentional focus (for reviews see Grafman, 1989; Stuss & Benson, 1986). Damage to the posterior area of the brain, on the other hand, causes no such problems, but results in deficits in selective attention such as the ability to engage and disengage attention (Posner et al., 1988; Stuss & Benson, 1986).

3.6.2. **Major functions of attention and their anatomical substrates**

A review by Posner and Petersen (1990) indicated three major functions of attention that appeared prominently in the literature: (1) orienting to sensory stimuli, (2) selecting signals for focal (conscious) processing, and (3) maintaining a vigilant or alert state.

3.6.2.1. *Orienting*

The orienting phase first involves the disengagement of attention from its present focus. This is reflected in activity in the posterior parietal lobe. Activity in the midbrain area (superior colliculus) then acts to move the index of attention to the area of the target. This is followed by activity in the pulvinar nucleus of the thalamus which is involved in reading out data from the indexed locations (see Posner & Petersen, 1990). In this generally alert but disengaged state, the monitoring of even multiple stimulus modalities or locations produces only small amounts of interference. This, however, changes with the introduction of a target.

3.6.2.1. *Selection*

Detecting and selecting a target results in widespread interference with most other cognitive operations (Posner, 1978). PET measures of cerebral blood flow indicate that the anterior cingulate gyrus plays an important function in target detection and selection (Petersen, Fox, Posner, Mintun, & Raichle, 1988; Posner et al., 1988). The cingulate gyrus is part of the limbic association cortex. It receives input from the anterior nucleus of the thalamus and in turn projects through the cingulum to the entorhinal cortex (Brodmann's area 28), which provides the bulk of extrinsic input to the hippocampal formation (Afifi & Bergman, 1998). The hippocampal formation, which has widespread connections including to the prefrontal and orbitofrontal cortex (Martin, 1996) has been implicated in attention and alertness and has a generalised role in memory. The anterior cingulate gyrus has close anatomical links with the posterior parietal lobe and the dorsolateral prefrontal cortex (Goldman-Rakic, 1988).

Studies of interference between monitoring an auditory message and orienting toward a visual cue indicate that visual orienting and language processing involve separate but interconnected attentional systems (Posner et al., 1988). This fits well with the observation that association aspects of language are located in the lateral frontal cortex (Petersen et al., 1988). It appears that the anterior cingulate cortex is important in tasks requiring the posterior attentional system as well as in language tasks. Results suggest a possible hierarchy of attention systems in which the anterior system can pass control to the posterior system when it is not occupied with processing other material (Posner & Petersen, 1990).

3.6.2.3. *Vigilance*

The ability to develop and maintain alertness has consistently been found to depend heavily on the integrity of the right cerebral hemisphere. Right-hemisphere lesions result in more frequent signs of neglect and greater impairment in vigilance tasks then left-hemisphere lesions (see Heilman, Watson, & Valenstein, 1993). The areas of the posterior attentional system (i.e., posterior parietal lobe, pulvinar, and superior colliculus) of the right hemisphere appear to provide the basis for maintaining alertness.

These areas are innervated by noradrenergic pathways that arise in the locus coeruleus and are more strongly lateralised in the right hemisphere. Activation of these noradrenergic pathways can, via the posterior attentional system, increase the rate at which targeted (i.e., high priority) information can be selected for further processing.

3.6.3. Controlled and automatic processing: Event-related brain potentials studies of the different phases of attentional control with evidence for brain structures and neurotransmitter systems involved

Pribram and McGuinness (1992) have collated information of studies using event-related brain potentials to arrive at a model of attentional (controlled) and para-attentional (automatic) processing. Event-related brain potentials are ideal for tracking the rapid sequence of brain responses that make up the orienting reaction (i.e., the immediate processing following the presentation of a sensory input). Those aspects of the input that are attended to become accessible to awareness and form the attentional component; whereas the remaining, unattended aspects, form what Pribram and McGuinness (1992) have called the para-attentional component.

Analysis of electrical event-related brain potentials has identified the following components of attentional control: (1) an early component at approx. 50 msec reflecting activity in the extrinsic systems, (2) a positivity at roughly 60 msec indicating the beginning of the selection process followed by a negativity around 80-100 msec indicating the selection of sensory channels on the basis of sensory features, (3) a new processing face representing within-channel selection indicated by an initial positivity around 200 msec followed by a negativity that may extend beyond the 400 msec range, (4) the updating of this within-channel processing, which is signalled by a subsequent positive deflection.

This positive deflection has two sources: a P3a component around 300 msec that is related to generalised orienting and mainly frontal in location, and a somewhat later P3b component that is influenced by within-channel selection variables and reflects the initiation of a new phase in which the consequences of earlier targeting are processed.

The P3b component often, but not always, reflects a rebound from a prolonged negativity, the so-called contingent negative variation or CNV. The CNV itself consists of a frontal component related to generalised orienting and arousal, and a set of expectancy waves that are modality specific and include a potential for motor readiness. See also Stuss, Shallice, Alexander, and Picton (1995) for a review of supervisory system and anterior attentional functions.

Indications are that readiness and effort reflect the operations of two distinct neural systems (Pribram & McGuinness, 1992). The event-related processing negativity around 100 msec reflects the rapid, efficient, between-channel selection of inputs based on their physical features (Hillyard, Squires, Bauer, & Lindsay, 1971). This is what Broadbent (1977b) refers to as the stimulus filtering process. The smaller the channel separation between attended and unattended stimuli the longer and larger this initial negativity becomes. This between-channel selection is followed by a second, slower, serial process that involves the comparison of the selected input against memory representations prior to classification (Näätänen, 1982, 1990; Näätänen, Alho, & Sams, 1985). Broadbent calls this pigeon holing. The distinction between these two processes is also referred to as between-channel versus within-channel selection. Both stimulus filtering and pigeon holing can proceed simultaneously, but the pigeon holing process takes longer (up to 400 msec or more) to complete (Hillyard, Hink, Schwent, & Picton, 1973).

Pribram and McGuinness (1992) propose that there are three separate dimensions of attentional control that are initiated by the orienting reaction: (1) arousal and familiarisation, (2) activation and readiness, (3) comfort and discomfort (effort).

3.6.3.1. *Arousal and familiarisation to novel input: the habituation of the orienting reaction.*

The arousal component of the orienting reaction occurs when an input produces a brief measurable (i.e., phasic) change in the activity of a physiological indicator over its baseline (e.g., a sudden change in the intensity or timing of the input, or in the context wherein it appears). The sensory input is matched against a representation (a neural model or competence) of a relevant past experience stored in memory.

This match-mismatch process, which is reflected in evoked-potential negativity, is likely to be a necessary, but not sufficient, condition for stimulus discrimination (Sams, Alho, & Näätänen, 1985). Arousal results if the input is novel in the history of the organism's experience. With repeated stimulus presentation, the input becomes familiarised and a residual neural model of the event is established in memory. The arousal response wanes and the input pattern becomes habituated. The processing changes from being attentional, and consciously controlled, to being para-attentional and automatic. A change in the input pattern (novel configuration of input parameters or change in context wherein they occur) will again initiate an arousal response and orienting reaction (dishabituation). Furthermore, certain stimuli that have special relevance (e.g., one's name) can produce dishabituation in an appropriate context. In summary, arousal results in a visceroautonomic reaction that, with repeated stimulus presentation, becomes habituated.

Anatomy: Studies relating brain function to this visceroautomatic component of the orienting reaction have identified a core system of neurons, which is involved in the familiarisation of novel input (see Groves & Thompson, 1970). This system extends from the medial portions of the spinal cord to the reticular formation in the brainstem and on to the ventromedial nucleus of the hypothalamus. It lies in close proximity to the neurons responsible for the initiation of visceroautomatic responses to novelty. The limbic forebrain exerts control over this arousal system by reciprocal facilitatory and inhibitory circuits that are centred on the amygdala. The facilitatory circuit involves the ventrolateral frontal cortex and the inhibitory circuit is associated with the orbitofrontal cortex (Pribram, 1987; Sauerland & Clemente, 1973; Skinner & Lindsley, 1973; Wall & Davies, 1951; see also Pribram & McGuinness, 1975). This opposing reciprocity allows for sensitive modulation (fine-tuning) of the arousal mechanisms (Solomon, 1980). By controlling the onset and duration of the visceroautomatic responses, these circuits also exert control over the onset and duration of arousal. Lesions of the amygdala and the ventromedial hypothalamus produce a failure to habituate to familiar and unrewarded stimuli and thus a continuation of generalised orienting during continued stimulation (Rolls, 1992, see also Rolls, 1995).

The amygdala not only plays an important role in emotions, fear conditioning, and the stress response, but is also involved in stimulus-reinforcement learning. Rolls (1992) suggests that certain neurons in the amygdala act as filters that provide an output if a stimulus is associated with a (positive or negative) reinforcer or is reinforcing because of its novelty, but provide no output when the stimulus is familiar and has not been associated with a primary reinforcer. The amygdala may thus be involved in determining whether, on the basis of previous reinforcement history, representations of the stimuli should be made or retained, attention should be paid to the stimuli, and whether an affective response occurs.

There appear to be distinct subgroups of neurons in the amygdala that preferentially respond to certain types of stimuli. One of these has been found to respond maximally to novel stimuli and significantly less to the same stimuli when they were familiar. In these neurons, responding was determined by the novelty of stimuli rather than their differential reinforcement value (Wilson & Rolls, 1991, cited in Rolls, 1992). There are also indications that a small group of neurons in the amygdala provides information about the recency with which a stimulus has been observed. These neurons have a memory span of up to 10 intervening stimulus presentations. Another group of neurons has been found to respond selectively to faces (Rolls, 1992). Observations following lesions in the amygdala have prompted some researchers to suggest that these neurons play a role in recognition memory (Mishkin, 1978; see also Rolls, 1992). However, others suggest that the observed effects result from concomitant damage to surrounding cortex and that the entorhinal and perirhinal cortices, rather than certain amygdala nuclei, contribute to recognition memory (see Murray, 1992).

Most of these findings stem from neurophysiological studies of responding to visual stimuli in the amygdala of monkeys. However, there are many important similarities between amygdala damage in man and other primates. Amygdala lesions in humans result in loss of emotional responsiveness, but generally do not affect learning and memory other than some reports of significant impairment on immediate recognition of visiospatial (but not verbal) information and of face recognition (Anderson, 1978, Tranel & Hayman, 1990, both cited in Aggleton, 1992).

Conclusions are hindered by differences in the extent and location of the lesions and by the fact that many of the patients received amygdala surgery for epilepsy or severe behavioural disorders and already exhibited abnormal brain functioning. Furthermore, reports frequently group patients with different aetiology together, often fail to specify any objective tests, and almost never include comparison data on unoperated subjects.

Neuropharmacology: Noradrenaline is involved in the regulation of arousal through its ability to regulate serotonergic mechanisms which facilitate behaviourally relevant events such as orienting, reinforcement, and paradoxical sleep; and enable them to interrupt an ongoing state, be it activity or inactivity (see Pribram & McGuinness, 1992). Substance P and endorphins are both found in abundance in the amygdala (Amaral, Price, Pitkänen, & Carmichael, 1992; Roberts, 1992) and the reciprocal activity of these neuropeptides may provide a third level of modulation (Pibram & McGuinness, 1992). There is extensive evidence that the amygdala can selectively modulate memory storage in other brain areas and that this modulation is influenced by the effects of adrenergic activation and GABAergic and opioid peptidergic inhibition of noradrenaline receptors within the amygdala (see McGaugh, Introini-Collison, Cahill, Kim, & Liang, 1992).

3.6.3.2. *Activation and readiness: the maintenance of targeted orienting.*

Behaving organisms are spontaneously active and constantly interact with and change their environment, often through highly programmed, serially ordered, responses (Miller et al., 1960). This activity requires control of the somatomotor system, which effects the responses and feedback from the outcome (reinforcing consequences) of the behaviours. Once an activity is selected, the necessary behaviour needs to be continued and monitored. This requires readiness and includes the selective targeting of possible outcomes of behaviour. While the arousal and familiarisation component of orienting addressed the "what is it?" reaction, readiness signals "what needs to be done?"

Generalised orienting and targeted readiness (behaviourally targeted orienting) are two closely related but reciprocally acting processes. Generalised orienting and arousal result in an interruption of ongoing activity and the familiarisation process stops further behavioural reactions to the input due to habituation or satiety. Targeted readiness (focused attention), on the other hand, is designed to maintain active attentional engagement.

Anatomy: Behaviourally targeted orienting has been associated with activity in the basal ganglia and the superior-temporal and inferior-parietal cortices (Mirsky, 1989). Lesions of the basal ganglia system (caudate nucleus, putamen, and globus pallidus) result in an inability to retain targeted attention and a neglect of the stimulus (Bowen, 1976; Heilman et al., 1993). The basal ganglia activate the preparation for activity that precedes the motor response to a targeted stimulus. The function of the basal ganglia has been compared to that of a "clearing house" that accumulates samples of ongoing activity and, on a competitive basis, facilitates one and suppresses the others by transferring attention to the targeted stimulus and maintaining that attentional set (see Pribram & McGuinness, 1992).

Neuropharmacology: The maintenance of this targeted readiness requires activation of a cholinergic mechanism that is likely to be regulated by a dopaminergic system, both of which project to the basal ganglia from where they innervate areas of the cortex (see Pribram & McGuinness, 1992).

3.6.3.3. *Comfort and effort: innovative attention*

Two distinct systems are thus responsible for arousal and familiarisation of input and the activation required for targeted readiness. Under many circumstances, these two reactions are linked together; coupling input to output - stimulus to response. However, if this was always the case, the behaviour of humans and other behaving organisms would be restricted to the constant arousal of enviromental stimuli and the activity motivated by them. Certain circumstances, though, require either an innovative change of attention or the maintaining of an attentional state in the face of changes in external parameters.

Therefore, some sustained control process is needed that involves both generalised arousal and active selection and allows for the uncoupling and recoupling of these systems. This coordinating process requires effort (energy in the form of metabolic output) to control attention and motor activity.

Anatomy: The hippocampal circuit functions to coordinate familiarisation with targeted readiness to make such innovative change possible (Pribram & McGuinness, 1992). Lesions in the hippocampal circuit result in a change from the more effort demanding relationships between perception (noticing a stimulus) and action (the instrumental response) to the more primitive relationship in which aspects of behaviour are captured by either input or output without the coordinating intervention of central control (Pribram & McGuinness, 1992). Animal studies have revealed that lesions in the hippocampus do not affect the autonomic aspects of orienting and their habituation in a noncompetitive situation. In competitive environments, the animals again oriented and habituated to an unexpected distractor, but oriented for a shorter period and in a weaker fashion. More importantly though, they failed to explore the novel stimulus and engage in so called hypothesis behaviour and displayed a strong tendency to persevere with the ongoing behavioural sequence. Reactions to aversive stimuli are largely unaltered in animals with hippocampal lesions (for a review see O'Keefe & Nadel, 1978, and Isaacson, 1974).

Findings of event-related potential studies in the theta range (4-8 Hz), reviewed by Pribram and McGuinness (1992), indicate the existence of two dissociated systems of neurons that influence hippocampal synchronisation and desynchronisation. One system originates in the anterior portion of the medial raphé and associated midline structures of the midbrain and courses through the medial portion of the hypothalamus. Stimulation of this medial system results in synchronised theta activity in the hippocampus and in targeted orienting and exploration. The other system originates more laterally in the medial forebrain bundle and courses through the lateral hypothalamus. Electrical stimulation of this lateral system produces hippocampal desynchronisation and a momentary "locking on" to a specific aspect of the environment. Synchronisation of theta range activity in the hypothalamus is accompanied by desynchronisation in the cortical convexity and vice versa.

These findings indicate that the hippocampus can operate in at least two modes to regulate orienting. Firstly, through tonic inhibitory discharge of hippocampal neurons that leads to targeted exploration of more or less familiar territory and the updating of processing competence. Secondly, by shutting of the inhibitory neurons when something relevant has been encountered during generalised orienting. This causes hippocampal rhythms to become desynchronised, while those of the cortical convexity become synchronised. Attention becomes focussed and the organism is, to a considerable extent, insulated from distracting explorations.

Neuropharmacology: Activity of the hippocampal system is influenced by the interaction of cholinergic and both serotonergic and noradrenergic mechanisms. The cholinergic hippocampal neurons interact independently with the serotonergic and adrenergic mechanisms and, therefore, another "higher" level of neurochemical interaction is needed to integrate both processes. This integration is provided by activity in the thalamic-pituitary-adrenal cortex (HPA) axis (see Chapter 1, pp. 19-20). Input from the hippocampal and amygdala systems is intimately connected with activity in the HPA-axis, and the cholinergic and aminergic mechanisms act upon and within the matrix of steroids and peptides released by this HPA system.

Stress and fear, in particular mild fear, are known to mobilise the HPA system, but there is also evidence that first-experience situations, unmet expectancies, and the novelty detection-mismatch function of the hippocampus are particularly effective triggers of endocrine responses (see O'Keefe & Nadel, 1978). As part of its output in mismatch situations, the hippocampus will activate the release of adrenocorticotrophic hormone (ACTH). The superior region of the hippocampus is the brain area that has most corticosterone binding cells. O'Keefe and Nadel (1978) suggest that the hippocampus may be part of a feedback loop designed to maintains basal levels of these hormones whilst enabling the HPA system to respond to novelty. The endogenous hormones ACTH and ACTH–related peptides (e.g., enkephalins) have been shown to operate on just this aspect of the discrimination-reversal experiment (see Pribram & McGuinness, 1992). It is highly likely that the central morphine-like effect of these endogenous hormones or endorphins, and the hippocampal circuit on which they operate, function to modulate a comfort-effort dimension of experience and behaviour.

3.6.3.4. *Summary*

It is possible to distinguish between controlled attention and the para-attentional (i.e., pre- and post-attentive) processes upon which the former controls operate. Para-attentional processing is automatic and largely parallel in nature. It has been associated with activity in the extrinsic lemniscal primary sensory projection systems (Posner, 1973). The lemniscus is a band of nerve fibres in the brain (medulla, pons, and midbrain) through which sensory information is projected to the thalamus. Processing activity in the extrinsic lemniscal primary sensory projection system is reflected in the early components of event-related potentials. These extrinsic lemniscal projection systems are responsible for the rapid efficient selection of inputs by virtue of their physical attributes (i.e., bottom-up biases). This process is referred to as between-channel selection or stimulus filtering.

Activity in the extrinsic systems is sensitive to the history of reinforcement that has been experienced, which has implications for the traditional concept of "limited atentional capacity". Studies have show that with extensive practice a formerly limited "capacity" can become less and less restricted (Logan, 1979; Hirst, Spelke, Reaves, Caharack, & Neisser, 1980). Pribram and McGuinness (1992) propose that the concept of limited channel capacity needs to be modified to incorporate this ability of organisms to improve, through practice, their competence and thereby enable a great deal of information to be processed in parallel. According Pribram and McGuinness (1992, p. 85) it is "competence, not capacity that limits central processing span." Competencies can be multiple, both at the input and output sides, and these authors therefore argue that ultimate capability, rather than being conceived as the capacity of a box of finite limits, can be better construed as a flexible matrix of interlocking competencies.

A set of slow acting, serial, intrinsic extralemniscal processes provide top-down attentional control to the automatic lemniscal systems. The attention requiring activity in the intrinsic extralemniscal systems, and those that control them, is reflected by the late components of event-related potentials and indicate targeted conscious awareness. The slower serial activity in these systems represents within-channel selection (pigeon holing) that involves input matching.

Pribram and McGuinness (1992) propose that these top-down influences result from three distinct extralemniscal control systems: (1) an orbitofrontal amygdala system responsible for familiarisation, (2) a basal-ganglia (nigrostriatal) system responsible for targeted readiness, and (3) a hippocampal system that operates to enhance processing efficiency by modulating the functions of the orbitofrontal-amygdala and nigrostriatal systems. As yet, there is only indirect evidence for the relationship between the basal ganglia and targeted readiness.

Processing in the lemniscal sensory systems is modulated by a reciprocal mechanism of extralemniscal inputs that converge on the reticular nucleus of the thalamus. Inhibition by tecto-tegmental inputs opens the gate for further sensory processing, whereas excitation by orbitofrontal activity that is centred on the amygdala closes those gates. A third set of controls converges on the hippocampal system, which exerts its influence on familiarisation rostally through its connections with the thalamus and frontal cortex, and on readiness posteriorly by way of its connections with the brain stem.

CHAPTER FOUR

CONSCIOUSNESS

4.1. *The Search for a Model of Consciousness*

Consciousness is a trait that has evolved over many millennia. Conscious awareness allows for greater flexibility in behaviour, which offers distinct evolutionary advantages. However, this also brings about the need for control over the selection of processing needs and actions. Consciousness is fairly continuous and unified in the normal waking state and includes at any time various items that can be either within the focus or at the periphery of attention (Searle, 1994). Although consciousness and attention are intimately related, we cannot be consciously aware of something without at least in some way attending to it, the two should not be confused as being the same (Baars, 1993; Searle, 1994). Attention can be seen as the control of access to consciousness (Baars, 1988).

Many researchers consider consciousness to be an intrinsic feature of biological processes in multiple integrated areas of the brain (e.g., Desmedt & Tomberg, 1995; Searle, 1994). Desmedt and Tomberg (1994, cited in Desmedt & Tomberg, 1995) found direct evidence for reciprocal and re-entrant feedback interactions between detailed real-time representations in the primary projection area in the parietal cortex and the stored representations called upon by the working-memory mechanism in the prefrontal cortex. They concluded that the observed linkage (locking) of transient 40-Hz phase EEG oscillations between these areas in humans subserves a conscious brain mechanism that is directly involved in the perceptual and behavioural decisions relating to a sensory object or event.

Consciousness is an intriguing concept for philosophers, cognitive psychologist, and the rapidly expanding domain of cognitive neuroscience. Consciousness is by definition subjective and private to the organism involved and as such cannot be dealt with as a third-person objective phenomenon (Searle, 1994).

Until recently most psychologists and neuroscientists believed that the study of consciousness was conceptually confusing at best and that any attempt to construct a theory of consciousness was hopelessly premature (Baars, 1994). Findings of brain imaging studies have been particularly useful in clarifying the otherwise rather vague and diffuse boundary between conscious and unconscious processes. They have provided support for many phenomena already observed in psychological studies of cognition. Some models and theories of consciousness have since been proposed, and these have greatly advanced the systematic study of the nature and distribution of conscious (see e.g., Baars, 1988, Crick, 1994; Edelman, 1989; John, 1976, Gazziniga, 1988; Kinsbourne, 1988,1993; Tononi, & Edelman, 1998; for a review of theoretical explanations of alterations of consciousness see Pendleton Jones, 1997).

Experimental studies of consciousness frequently examine the distribution of consciousness by contrasting two mental representations of the same event, one of which is clearly conscious and the other not. These have provided some important differences between conscious and unconscious processes (see Table 1). Scientists have particularly used aspects of visual awareness to study the nature of consciousness in general (e.g., Crick, 1994; Posner & Petersen, 1990; Young, 1994).

Table 1. *Contrasting capabilities of conscious and unconscious processes*

Conscious Processes	*Unconscious Processes*
1. Computationally inefficient: many errors, relatively low speed, and mutual interference between conscious processes.	1. Very efficient in routine tasks: few errors, high speed, and little mutual interference.
2. Great range of contents.	2. Each routine process has a limited range of contents.
Great ability to relate different conscious contents to each other	Each routine process is relatively context-free.
Great ability to relate conscious events to their unconscious contexts.	Each routine process is relatively context-free.
3. High internal consistency at any single moment, seriality over time, and limited processing capacity.	3. The set of routine, unconscious processes is diverse, can sometimes operate in parallel, and together has great processing capacity.

From Baars (1994, p. 153)

The mind-body problem has been one of the basic theoretical issues in science that has occupied scholars over the ages. Some consider consciousness to be separate from, but interacting with, the brain. Others, the current author including, consider conscious and unconscious processes as functional manifestations of the same complex system of neural networks, but at different levels of hierarchical organisation. Both types of processes can take place in the same neural system and do not require the existence of any special mediating interface (Radil, Radilová, Bohdanecký, & Bozkov, 1985). Conscious processes are related to controlled attention, explicit memory, and declarative learning. Unconscious processes are associated with automatic attention, implicit memory, and procedural (habit) learning (Birbaumer, Lutzenberger, Elbert, Flor, & Rockstroh, 1993).

For the purpose of the current study, the treatment of how information may enter conscious awareness will be limited to highlighting the major concepts of the Global Workspace theory put forward by Baars (1988). Additional reviews of consciousness and its relation to human information processing can be found elsewhere (e.g., Bock & Marsh, 1993; Dennett, 1991; Flanagan, 1992; Revonsuo & Kamppinnen, 1994; Shallice, 1991; Underwood, 1996; Velmans, 1991). Baars (1993, p. 282) posed the question "How does a serial, integrated and very limited stream of consciousness emerge from a nervous system that is mostly unconscious, distributed, parallel and of enormous capacity?" There is considerable evidence for both parts of this notion. Most scientists agree that large parts of the central nervous system, including our brain, can be viewed as arrangements of separable, very specialised, unconscious subsystems (Dennett & Kinsbourne, 1992; Kinsbourne, 1988, 1993; Marcel, 1993). Such specialised processors can work in parallel and process very large amounts of information simultaneously (Christ, 1991a,b, 1992; McClelland et al., 1986). This notion is supported by neurophysiological evidence (e.g., Mountcastle, 1978); physiological experiments and studies of brain damage (e.g., Gazzaniga, 1988; Geschwind, 1979; Luria, 1980); and psychological studies of automaticity (Schneider, Dumais, & Shiffrin, 1984), memory, and errors and slips in attention (e.g., Marcel, 1993, Norman, 1981; Reason, 1979, 1983). Although a collection of specialised unconscious processors can handle routine tasks efficiently by assigning them to the appropriate processor, it has great difficulty in adapting to novel situations that require integration of several specialities (Baars, 1994).

Our daily environments are full of repetitive stimuli that have become habituated and now form well-developed skilled behaviours that can be performed in an automatic 'unconscious' fashion. However, a sudden change in any of these stimuli can bring it immediately to our conscious awareness and attention. This suggests that the nervous system must maintain a rather accurate unconscious representation of the repetitive (habituated) stimulus. The ability of being absorbed in one train of conscious events, while simultaneously processing and maintaining a representation of unconscious stimuli is one aspect of selective attention.

There is also strong and reliable support for a mechanism that is serial, internally consistent at any single moment, very limited in capacity, and strongly associated with consciousness. Studies of selective attention show that humans can attend to only one coherent flow of information at any one time; any other streams of information are unconscious. Furthermore, studies of dual-task performance show that tasks that are consciously performed and require mental effort interfere with each other and cause performance degradation on one or both when performed simultaneously (Norman & Shallice, 1986). Also, short-term memory has been shown to be severely limited in capacity, being roughly in the range of seven plus or minus two separate and unrelated items (Baddely, 1992, 1993).

The problem was how could these two aspects be integrated into a functional system of awareness and consciousness. Baars (1988) has proposed a Global Workspace theory of conscious experience, which provides a structure that aims to do exactly that. It proposes, based on many lines of converging evidence, that consciousness is a reflection of a basic architectural aspect of our nervous systems and is functionally equivalent to a global workspace were distributed sets of neural processors work in parallel.

4.2. *Globel Workspace Theory*

The Global Workspace (GW) theory suggests that conscious experience emerges from a nervous system in which multiple input processors compete for access to a broadcasting capability. The processor that achieves dominance can then disseminate its information globally throughout the brain (Baars, 1993).

The theory proposes a number of global workspace architectures, which have been developed into a series of models that can progressively account for more complex aspects of consciousness. These models, and the architectures they suggest, can be used to form further hypotheses and test specific processes and attributes of information processing. Global Workspace theory accounts for both distributed and limited-capacity aspects of consciousness and addresses the main critiques of limited-capacity resource models of attention (see Navon, 1984). It is consistent with, but not reducible to, other models of consciousness and limited-capacity processing (e.g., Baddeley, 1992; Kinsbourne, 1988; Norman & Shallice, 1986).

The Global Workspace model has only three main constructs: (1) a set of unconscious goal contexts, (2) a global workspace (GW), and (3) a set of specialised unconscious processors. These correspond to a variety of differently named, but roughly equivalent, constructs proposed by other researchers (see Figure 5).

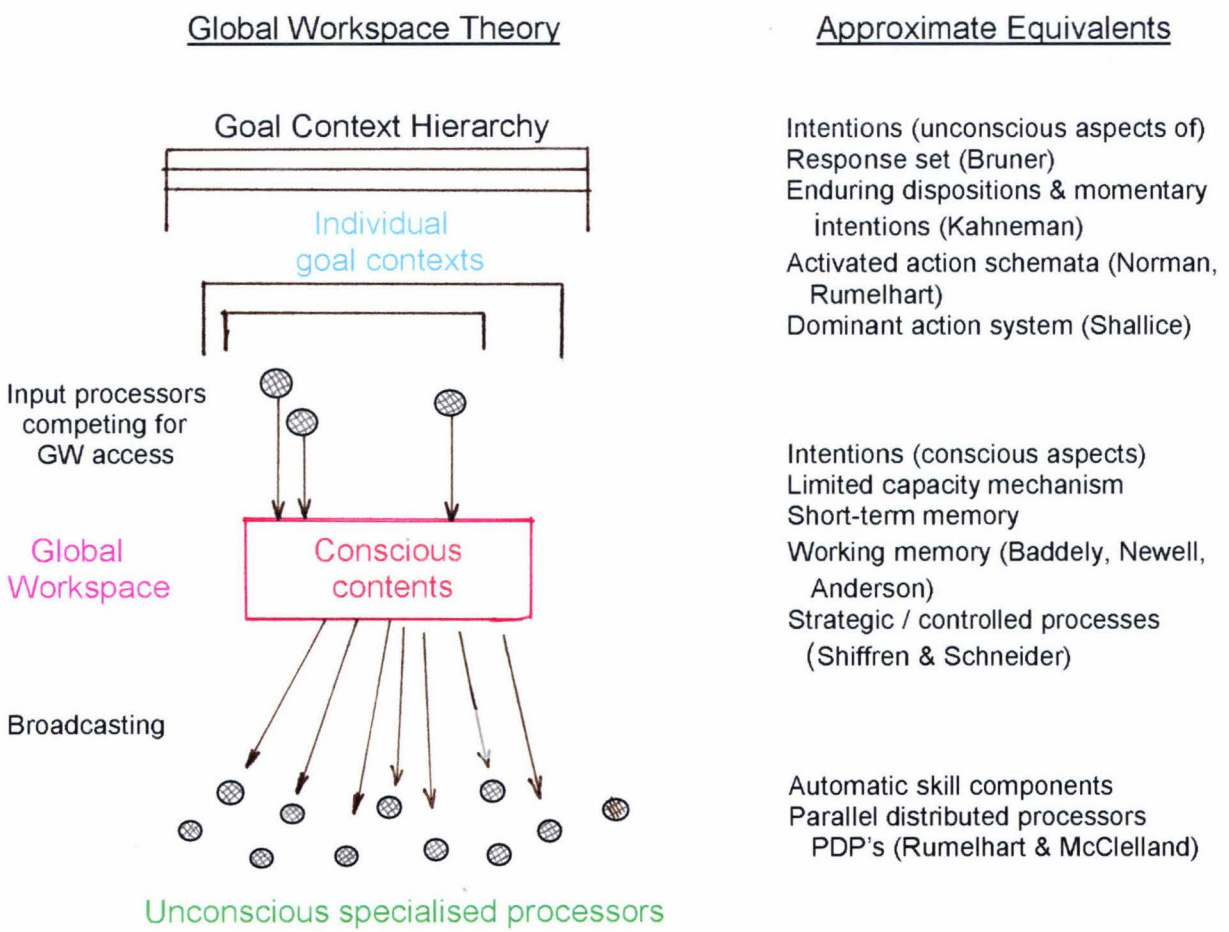

Figure 5. Relationship between basic constructs of Global Workspace theory, with widely used equivalent terms. Adapted from Baars (1994, p. 159)

Conscious contents are shaped and evoked by unconscious contexts that can be either conceptual (i.e., presupposed knowledge needed to use abstract concepts) or motivated by specific goals (i.e., future-directed mental representations of one's own proposed actions). Contexts compete or cooperate jointly to constrain conscious contents. A set of contexts can organise together into a context hierarchy and conscious events are always constraint by the multiple layers of context hierarchies.

The dominant context hierarchy dominates the global workspace and thereby controls access to the limited-capacity system. This system decides in a serial fashion which conscious content is broadcasted globally so that it can recruit and trigger the specialised processors needed to carry out the required action. It also allows for editing if the unconscious systems detects an error in the goal image (i.e., if it does not meet required criteria). This may trigger other unconscious goal contexts that can then compete to edit and correct the conscious goal image. Obviously, the most effective competition comes from other goal contexts in the dominant goal hierarchy, since these already have access to the GW during the preparation and execution of the action. The editing system, however, is open to any 'onlooking' processor as long as it can compete for access to the GW. Once a single goal wins out long enough it will be executed. In this way, a single conscious goal image, if it does not meet with competition, may be sufficient to set off a complex, highly coordinated, largely unconscious action.

The dominant goal hierarchy shapes normal voluntary action. Any goal content that is conscious long enough to succeed in recruiting and executing an action has been implicitly edited by multiple criteria. Voluntary action is, in essence, action whose conscious components have been edited before being carried out. Most components of voluntary action are formulated unconsciously. However, they must have been conscious at some point in the past when they were implicitly edited and became a consistent part of a dominant goal hierarchy. Although they cannot be controlled in detail, they are perceived to be consistent with the current goal.

Consciousness and context are two inseparable issues. The stream of consciousness can be seen as a complex interplay between conscious events and their goal contexts. Before input becomes conscious, it interacts with numerous unconscious contextual influences to produce a single coherent conscious experience. Melzack's hypothesised neurosignature (Melzack, 1991, see also section 1.4.5., p. 40) could be seen as a special, genetically programmed and experientially modified, context that provides a representation of our body-self image that, on an unconscious level, continuously operates in the background and interacts with current experiences to form a conscious and coherent body image.

Contexts are mental representations or schemata that shape conscious experience without them being conscious at the time (e.g., currently unconscious intentions and expectations). Conscious processes are context sensitive and have a great capacity for relating conscious events to each other, whereas unconscious processes are relatively isolated and automatic (Baars, 1988). Input specialists can compete, either singularly or in coalition, for access to the GW. These specialised unconscious systems are limited to one particular function. A set of input processors can become organised into a processor coalition and be deconstructed again depending on the current function that needs to be served. Over time, they may also form into a new, larger, superordinate processor. When a set of specialised processors provides routine control of GW contents it begins to act as a context. The conscious contents are only processed serially like a stream following one after the other. Once processed in the GW, the message is broadcasted to the system as a whole, where many specialised semiautonomous processors, distributed throughout the system, operate in parallel and with enormous collective capacity to initiate the actions needed. This global dissimilation is seen as a necessary but not sufficient condition for conscious experience.

This is only a brief overview of the main constructs of the GW architecture. Baars (1988) has provided a more complete account of conscious experience that specifies additional conditions needed for conscious experience. Following will be some additional details concerning those conditions that are most relevant to the topic of the current study (i.e., competition for conscious processing resources, hypnosis, absorption, and dissociation).

4.2.1. **Why need for competition for access to the Global Workspace?**

To deal with novel problems that do not already have a known algorithm for their solution, the recruitment of a number of specialised processors is needed. The GW allows all these specialists to communicate with each other. Through the GW they cooperate and compete with each other to arrive jointly at the best solution. To do so they must be able to dominate the GW long enough to organise the recruitment of the appropriate specialists and allow for the required editing. Access to the GW is the key element for implementing any new configuration of systems. The GW allows for the resolution of ambiguity between new and unpredictable knowledge sources and enables specialised processors to be updated over time by changes in conscious experience. Without such a system these new information sources would immediately run into powerful competition and never be attended to long enough to develop into solutions or new skills. For a global message to be internally consistent, it must be able to exclude irrelevant or contradictory messages. By having a limited-capacity system that allows the most dominant context to be attended to serially, such other inconsistent messages can be driven from the 'operational blackboard'.

4.2.2. **States of absorption**

An absorbed state can be defined as a state in which only one coherent stream of events dominates consciousness (e.g., Tellegen & Atkinson, 1974). Thus, being absorbed in a certain stream of events should decrease access to other conscious processes. In GW terminology, there is a low level of effective competition between dominant goal contexts and an absence of voluntary effort to change contexts.

In a deeply absorbed state, access to other conscious goal options (including self-monitoring) may be competed out of consciousness. In such states, normal reality monitoring and disbelief may be suspended, allowing the person to identify with attractive suggestions free from the normal inhibition and contradiction. In principle, such a state could be reached in two ways: (1) by a reduction in the number of competing contexts, or (2) by allowing one context to become extremely dominant and thereby exclude alternatives (Baars, 1988).

In fact, most actual absorbed states combine both of these features (e.g., hypnotic suggestions instil a dominant goal image while the hypnotic induction procedure and relaxation suggestions reduce the chance of competition from other elements). Thus, an absorbed state can result from an uninterrupted dominant context. When absorbed in one mental image to the exclusion of others, the others must go on automatic.

4.2.3. **Hypnosis**

In GW theory, hypnosis as experienced by highly hypnotisable individuals is interpreted as an absorbed state in which the dominant context hierarchy allows very little outside competition for consciousness (Baars, 1988). Hypnosis seems to create a new, imaginative context that dominates experience for some time to the exclusion of other events (Singer, 1984). As a result, the dominant conscious goal images can exert great ideomotor control over thought and action. Hypnosis may simply be ideomotor control in a state of high absorption and low competition for access to consciousness. There are several different ways (contexts) that can jointly or separately facilitate a state of low competition e.g., relaxation, trust in the hypnotist, the presence and nature of a hypnotic induction etc. It is, therefore, not surprising that few if any conditions have been reported that are essential for successful hypnotic performance and results vary as to what are clear contributing factors.

Absorbed states are quite normal. Our topmost goals and belief systems are quite stable over time and are much harder to change than lower level goals. Belief system may serve as a dominant context for many thoughts, feelings, and actions (e.g., our survival instinct and lifelong goals such as a desire for social acceptance, the desire to pass on some of our knowledge and experience to others, or a belief in social equality). Once clearly established, such goals are changed only slowly if at all. It could be said that we are always in an absorbed state relative to our own topmost goal context. In a sense all personality types involve absorption, which might explain the difficulty of finding significant personality correlates of hypnosis.

If hypnosis is simply ideomotor control in a state of absorption, and absorbed states are quite normal, why are there such pronounced individual differences in hypnotic ability? A major individual difference seems to be that highly susceptible individuals seem to be quite flexible in the topics wherein they can become absorbed, while most other people are not. Baars (1988) suggests that we maybe should turn the usual question around. Rather then asking what is different about hypnosis we might ask: "why is flexible absorption so difficult for three-quarters of the population?"

4.2.4. **Dissociation**

Dissociations represent a decomposition of normal unitary functioning into its specialised processors, which operate outside conscious awareness. Thus, dissociations can lead, at least for some time, to the loss of conscious awareness over some dissociated function. In the course of the hypnotic procedure, individuals may experience a temporal separation of the prehypnotic context and a spontaneous posthypnotic amnesia for the hypnotic experience as well as a concurrent separations of their own normal experience of self and their, hypnotically controlled, actions.

Spontaneous amnesia after hypnosis stems from a difficulty in voluntarily reconstructing the hypnotic state. The fact that there is quite a difference in content between the absorbed hypnotic context and most of our "normal" contexts makes recall difficult. The same applies to temporal dissociations from the dominant context before hypnosis. As they share relatively few features together, it is easy to feel dissociated from them. In our normal waking state, we tend to forget that we are always unconscious of the details of the actions that carry out our conscious goals and of the contexts that control such goals. As Baars (1988) has put it, the concurrent dissociations of our own self and of our hypnotically controlled actions may just be the act of noticing the truth of ideomotor control. Hypnosis is experienced as unusual because hypnotically controlled actions are often unexpected and violate our usual contextual assumptions about ourselves.

In this light, it is not dissociation that is unusual; rather what is different in hypnosis might be that we realise the existence of ideomotor dissociation between conscious events, their consequent actions, and their antecedental goal contexts (Baars, 1988).

4.2.5. **Compliance and involuntariness**

The compliance observed in highly hypnotisable persons may result from their capacity to be deeply absorbed in the hypnotic context, to the point where no conscious capacity is available to reflect on the situation from an outside perspective. William James's ideomotor theory of conscious control of action fits neatly into the GW framework. According to this view, if conscious goal images do not meet with effective competition, they can organise and trigger automatically controlled actions which then proceed without the need for further conscious involvement. When an activity is practised enough most or all of it may fade from conscious awareness. Such automatisation results in a loss of conscious access to many details of the action and, as a result, we tend to become more vulnerable to misattributions about our performance.

It is important to distinguish between two types of involuntary actions. On the one hand are the nonvoluntary automatisms that are wanted, but not controllable in detail. These include the automatic components of normal actions, reflexes, autonomic functions, spontaneous expressions etc. On the other hand are the unwanted, countervoluntary, automatisms such as slips of speech or action and certain pathological symptoms such as inner speech, delusional thinking, hallucinations, or phobias. Countervoluntary actions are editing failures, that is they would have been edited and changed had there been an opportunity before they were executed. Voluntary actions are always consistent with one's dominant expectations. Conversely, countervoluntary or nonvoluntary automatisms, when resisted, violate the dominant context hierarchy and always surprise the actor.

4.3. *Neurobiological Interpretation of Global Workspace Theory*

Sensory stimulation is followed very rapidly (typically within a few tens of milliseconds) by activity in the somatosensory area of the cortex; however, it may take as long as 500 milliseconds for this cortical activity to become conscious (Libet, 1993). Recordings of cortical event-related potentials seem to indicate that major cognitive events occur in this intermediary period between the arrival of cortical stimulation and the conscious awareness of it.

There is substantial neurophysiological support for the existence of a functional global-workspace architecture or possibly a global set of workspaces. The neural structures most associated with a GW model of consciousness are those comprising the extended reticular-thalamic activating system (ERTAS, Baars & Newman, 1994). These include the brainstem reticular formation, the reticular nucleus of the thalamus, and the neurons that project from the interlaminar thalamus to the entire neocortex. These structures are involved in the regulation of sleep and wakefulness, and lesions in these areas abolish conscious wakefulness and result in coma (Luria, 1973; Magoun, 1963). PET scan studies of tasks involving novel versus automatic perceptual motor skills have revealed very widespread high glucose utilisation in these structures during performance of novel task, followed by a dramatic drop in metabolic activity when the task becomes automatic. This is precisely as would be expected from GW theory. The two general properties of GW systems are: (1) competition for access to the GW, and (2) wide spread distribution of its output.

4.3.1. **Support for access competition**

The reticular formation is believed to modulate the activity of many higher-level neural structures, particularly the neocortex. The nucleus reticularis is believed to control thalamic "gatelets" that can facilitate or inhibit synapses that relay information to sensory tracts that project to the cortex. The nucleus reticularis specifically has been found to show competition between inputs that correspond to the same location in the representation of the body (Hobson & Brazier, 1980).

4.3.2. **Evidence of widespread dissemination of conscious information**

Several phenomena suggest that conscious perceptual information is distributed globally in the nervous system. Studies of hemispheric specialisation using both electrophysiological (EEG) and metabolic (e.g., rCBF) measures of cortical activity have consistently found that the execution of even very specialised tasks, as long as they were novel, results in widespread activation of large parts of both hemispheres of the cortex (Lasse, Ingvar, & Skinhoj, 1978; Springer & Deutsch, 1981). A PET study by Haier, Sieger, MacLachlan, Soderling, Lottenberg, and Buchsbaum (1992) measured the regional glucose metabolic activity of subjects who played a computer game (TETRIS) involving complex visiospatial and motor coordination. When new to the game they showed very widespread metabolic activity, which decreased significantly and became more localised after extensive practice. Those subjects who improved most also had the largest decrease in metabolic activity in several subcortical areas. These changes in glucose metabolic rate with practice may reflect changes in cognitive strategy use that are part of the learning process and result in a reduction of conscious involvement. Haier et al. (1992) conclude that these results suggest that learning may result in decreased use of extraneous or inefficient brain areas. True automaticity and localised activity tend to occur only if tasks are entirely predictable and can be experienced as effortless (Shiffrin & Schneider, 1977).

When we are faced with an extremely surprising or novel event, our nervous system activates a typical set of activities. These have been widely studied and are referred to as the orienting response (see section 3.5). The orienting response involves a very widespread set of reflexes that serve to focus consciousness and prepare us for immediate and decisive action against potentially dangerous stimuli (e.g., the response to phasic or first pain). The fact that these responses are both anatomically and functionally very widespread suggests that they may well be activated by a globally distributed message. Biofeedback training has shown that people can gain, at least temporary, control over a wide range of previously uncontrolled physical activities by arranging for a conscious feedback signal whenever the target system is activated. These may involve large populations of neurons or just a few neurons.

The ability to exercise voluntary control over such a wide range of activities is what we would expect if conscious feedback is made available globally throughout the brain so that those local processors for which the information is pertinent can respond to it. Results from event-related potential studies provide direct evidence that, prior to habituation, conscious perceptual input is widely distributed in the brain. Repeated trains of visual or auditory stimulation (e.g., bright light or loud clicks) result in cortical activity far beyond the specialised visual or auditory pathways. This likely represents an orienting response to the novel stimuli. As the same stimulus is repeated, habituation of the initial response takes place. Event-related potentials never completely disappear, but they become increasingly localised until finally they are limited to the particular visual or auditory pathways only (John, 1976; Thatcher & John, 1977). These findings are strikingly in accord with the GW proposal that stimulus information is conscious and globally distributed prior to habituation. Following habituation it ceases to be conscious and becomes confined to only those specialised unconscious processors needed to execute that particular function.

The reticular formation and the nucleus reticularis of the thalamus appear to be necessary, but not sufficient, for conscious experience. The same seems to apply to the primary sensory projection areas (Weiskrantz, 1986). The simplest hypothesis would be that together both are sufficient for conscious perceptual experience. Examination of visual information processing suggests that this is the case (Baars & Newman, 1994). The primary visual projection area, acting as an input processor, may gain downward-flowing access to the diffuse thalamic projection system and recruit other parts of the cortex via nuclei of the thalamus. This information may then disseminate from the primary projection area via great bundles of neurons flowing to all parts of the cortex. This system could be guided by means of the "gatelets" of the nucleus reticularis discussed by Scheibel (1980) that in turn may be controlled by the attentional system in the parietal and frontal cortex as suggested by Posner and Peterson (1990) and Posner and Dehaene (1994). Thus, access to consciousness may be controlled by attentional systems that may be voluntary, as in frontal control, or involuntary, in the more posterior areas.

CHAPTER FIVE

HYPNOSIS

5.1. *The Nature and Characteristics of Hypnotic Phenomena*

Hypnotic-like experiences are a common and naturally occurring feature of everyday life (Shor, 1960). They are characterised by the focussing of attention on a particular task or event, coupled with a fading of the usual cognitive orientation to a generalised reality perception into a state of reduced awareness and functionality. This notion is conceptually similar to what White (1941) has called "goal-directed striving" and what Sarbin (1950) referred to as role taking. Examples of such phenomena include being so involve in reading a novel that your forget your surroundings and feeling of time, or remembering a past experience so clearly and vividly that it is almost like living it again. The incidence of these naturally occurring phenomena is widely distributed in the population and most people are able to experience at least mild forms of some of these phenomena (Shor, 1960).

Barber (1996b, p. 5) has defined hypnosis as: "an altered condition or state of consciousness characterised by a marked increased receptivity to suggestion, the capacity for modification of perception and memory, and the potential for systematic control of a variety of usually involuntary physiological functions." Despite the frequency of their natural occurrence, such features of reduced awareness are not infrequently seen as somewhat unusual and in their more extreme manifestations are considered as 'abnormal' states. Because of these characteristic features of hypnosis, hypnotic experiences are often referred to as an altered state; however, this term should be seen as a descriptive construct rather than as a causal one meaning a condition that causes things to occur.

Price (1996) has proposed the following model of how a hypnotic state facilitates the suggested behaviour. A hypnotic state begins with an absorbed and sustained focus on something (e.g., a spot referred to as the target in hypnotic inductions).

Relaxation can enhance this absorption and help to modify it from an active form of concentration into a relaxed and passive form of focussed attention. This process is often accompanied by a narrowing in the range of peripheral experiences. The high degree of absorption and focussed attention results in a reduction in the normal monitoring and censoring of the content of one's experience. Contradictory messages that once interfered with attentional focus no longer do so. Thinking and the interpretation of meaning become disconnected from active reflection and reality monitoring. Consequently, behaviour is experienced as occurring more or less automatically. The successfully hypnotised person simply and automatically identifies with the suggested action, sensation, or lack of sensation without experiencing any deliberate action or effort on their part. In this way a hypnotic state facilitates rather than causes the enactment of suggestions, including that of analgesia.

Some important characteristics of hypnosis are: (1) it reflects a striking and unusual alteration of subjective experience, (2) such perceptual alterations are experienced as nonvolitional, (3) some people are far more capable of experiencing hypnosis than others, and (4) the context wherein hypnosis is presented seems to be important in eliciting hypnotic responses (Orne, 1966; Woody, Bowers, & Oakman, 1992). The perceived involuntariness is an important part of hypnotic responding and is the essence of what Weitzenhoffer (1980) has referred to as the "classic suggestion effect." It is this subjective conviction in the reality of the suggested effect, and in particular the experience of involuntariness in response to suggestions, that serves to distinguish hypnosis from behavioural compliance.

Although particular hypnotic procedures may vary considerably, they all appear to involve the focusing of attention and the suggestion of imaginative experiences that involve perceptual alterations. A large number of factors have been suggested as being important to the experience of hypnosis including: hypnotic susceptibility, the level of absorption or imaginative involvement in the suggestions, attitudes towards hypnosis, the interaction with the hypnotist, expectancies, demand characteristics, the content and structure of hypnotic suggestions, the context of the situation, and the ability to experience dissociations. However, few of these have proven to be essential for the experience of effective hypnosis (see pp. 73-74).

Hypnotic induction: The one thing that all hypnotic situations have in common, whether they involve a formal hypnotic induction or not, is that they are labelled as hypnosis (i.e., are presented and/or perceived in a hypnotic context). Hypnotic inductions can enhance hypnotic responsiveness by altering response expectancies (Kirsch, 1985). The language patterns used in hypnotic inductions can be very powerful in shaping and enhancing response expectancies. However, although generally facilitative, an explicit hypnotic induction is neither a necessary nor a sufficient condition for hypnosis (Bowers & Kelly, 1979). The crucial element seems to be that the individual perceives the situation in a hypnotic context (i.e., as being appropriate for the occurrence of hypnotic responses). Simply being highly hypnotisable is not enough, but perceiving the situation in a hypnotic context may be sufficient (Woody et al., 1992).

Adding a hypnotic induction or hypnotic context to other treatments can yield important therapeutic effects independent of a person's hypnotic susceptibility. A meta-analysis of outcome studies found that adding a hypnotic context to cognitive-behavioural treatments improved the treatment outcome for up to 90% of participants, even though in many studies simply labelling the same treatment as hypnosis was the only difference between the hypnotic and nonhypnotic treatment (Kirsch, Montgomery, et al., 1995). Therefore, omitting hypnosis for those who exhibit low hypnotic-susceptibility scores may deprive them unfairly of a potentially beneficial treatment component (Kirsch, 1994).

Response expectancy: Response expectancy is one of the few stable correlates of hypnotic responding, with correlations ranging between approximately .30 and .65 (Kirsch, 1991; Kirsch & Council, 1992; Kirsch, Silva, Comey, & Reed, 1995; Lynn, Snodgrass, Rhue, & Hardaway, 1987). Response expectancies are expectancies about the occurrence of nonvolitional responses (e.g., emotions, pain, sexual arousal, or hypnotic behaviour). There are clear indications that response expectancies can be an important factor in hypnotic responding (Kirsch, 1985). Response expectancies mediate the effect of various other factors that can influence hypnotic behaviour such as imaginative involvement, role perceptions, and rapport (Kirsch & Council, 1989). Hypnosis can be a powerful way to maximise outcome expectancies that does not require deception to be effective.

Kirsch proposes that the best why to decide whether to use hypnosis is to inform the client about the procedure and ask for their opinion. The Chevreul-pendulum illusion can provide a quick and simple way of demonstrating the power of suggestion (see Kirsch, 1993, for a detailed description of this procedure). The willingness of a client to try hypnosis, which is strongly influenced by their response expectancies, is a reasonably good indicator of the therapeutic usefulness of hypnosis. In hypnotic situations, response expectancies are affected by three kinds of cognitions: (1) perception of the situation as hypnosis, (2) perceiving the response as characteristic of the experience and behaviour of good hypnotic subjects, and (3) judging themselves to be good hypnotic subjects (Barber et al., 1974; Sarbin, 1950).

Absorption: Absorption and attitude toward hypnosis have been found to be positively correlated, suggesting that a person's willingness to become hypnotised may be related to their ability to become involved in a subjective experience like hypnosis (Spanos & McPeake; 1975; Yanchar & Johnson, 1981). Positive correlations with hypnotic susceptibility have also been reported for vividness and certain day-dreaming styles have been reported (Perry, 1973; Crawford, 1982)

Imaginative involvement: Imaginative involvement is frequently part of hypnotic suggestions and has been described as an important component of hypnosis. However, recent studies have shown that imaginative involvement, or for that matter any elaborate cognitive strategy, is not necessary for effective hypnotic responding (e.g., Hargadon, Bowers, & Woody, 1995). Furthermore, the introduction of contradictory and incompatible suggestions and images does not measurably reduce responsiveness to hypnotic suggestions in subjects with medium to high hypnotic susceptibility (Zamansky, 1977; Zamansky & Clark, 1986). This suggests that it is not necessary for "good" hypnotic subjects to be fully absorbed or imaginatively involved in the direct suggestions of the hypnotist to perform them successfully. While positive attitudes, expectancies, and imaginative involvement may all be helpful; they, even in combination, do not adequately account for hypnotic behaviour in high hypnotisables (see de Groh, 1989). Proponents of special-process theories of hypnosis argue that dissociation plays a crucial role, particularly in more difficult hypnotic performance (e.g., Bartis & Zamansky, 1990; Bowers, 1992; Hilgard, 1973; Kihlstrom, 1992).

Therefore, it has been suggested that the hypnotic performance of individuals with low to medium hypnotic susceptibility relies on them becoming absorbed (i.e., totally engrossed) in the cognitive strategy they use, whereas those with high hypnotic susceptibility have the ability to dissociate and can achieve effective hypnotic analgesia without the need for absorbed strategy use (Balthazard & Woody, 1992; Bowers, 1992; Woody et al., 1992).

Thus, three of the major individual differences that might play an important role in hypnotic behaviour appear to be hypnotic responsiveness, absorption, and dissociation. These will be discussed in more detail next.

5.2. *Hypnotic susceptibility and its assessment*

5.2.1. **The development and stability of hypnotic susceptibility**

The distribution of hypnotic responsiveness, as assessed by standard hypnotic-susceptibility scales, corresponds largely to the normal curve, with few people being totally unresponsive, the majority in the medium range, and about a third being highly responsive to hypnotic suggestions (Hilgard, 1994). Hypnotic susceptibility is a relatively stable attribute during the late teens and adulthood (Morgan, Johnson, & Hilgard, 1974; Piccione, Hilgard, & Zimbardo, 1989). Stability coefficients of .82 (15 year retest) and .71 (25 year retest) are comparable to those obtained for individual differences on various personality measures such as intelligence (see e.g., Kangas & Bradway, 1971). This long-term stability of average hypnotisability does not mean that the level of a person's hypnotic susceptibility is immutable to changes in the hypnotic situation or to specific interventions aimed at enhancing openness to hypnotic experiences such as the Carlton Skills Training Program (Spanos et al., 1986) or Restricted Environmental Stimulation Therapy (Barabasz, 1982; Barabasz & Barabasz, 1989; see also Barber, 1980; Bowers & Davidson, 1991; Gfeller, 1994).

On average, hypnotic responsiveness tends to increase rapidly during the early childhood years, reaching a maximum between the ages of 8 to 12, and then fall off gradually to become relatively stable during late teens and adulthood. Hilgard and LeBaron (1984) found that, the capacity for absorbing experiences that characterise the hypnotised individual is nurtured by the development of fantasy life during childhood. During the infant stages, the behaviour of children is largely determined by stimulus-aroused experiences. By the time they reach pre-school age they can spontaneously create their own imaginative experiences involving features outside the limited stimulus-response arena. They become involved in sociodramatic play, that is fantasy play involving others in pretend or role playing situations. At this stage, hypnotic responsiveness is still low as the cognitive requirements of hypnotic suggestions are still largely beyond the limits of the cognitive abilities of most children. By the age of eight, children have generally developed the capacity to construct more complex imaginative experiences and involvement in pretend play has become less dominant. These changes follow the development of cognitive processes. Children become less easily distracted and develop an increased capacity for focussed attention and internalised imagination (e.g., day dreaming). They become capable of experiencing the intense concentration, tolerance of logical inconsistencies, and acceptance of reality dissociations asked for in hypnotic suggestions. Consequently, hypnotic responsiveness is generally at its peak during late childhood (Barber & Calverley, 1963; Hilgard & LeBaron, 1984; London & Cooper, 1969). From then on, it tends, on average, to decline slowly over adolescent and adulthood years. This is assumed to be, at least partially, the result of increased pressure for reality orientation and, particularly in Western societies, cultural conventions that discourage adult fantasy.

5.2.2. **Evidence for a genetic contribution**

The relative stability of individual differences in hypnotic susceptibility suggests that there may be predisposing factors that influence the degree to which an individual develops his or her hypnotic ability. A study by Morgan (1973) examined the hypnotic susceptibility of 140 pairs of twins and 132 non-twin sibling pairs.

The combined (male-female) correlation of hypnotic-susceptibility scores was significantly higher for monozygotic twins (r = .52) than for dizygotic twins (r = .17) or for non-twin sibling pairs closest in age (r = .19). When using Holzinger's formula (see Morgan, 1973) this translates into a heritability index of .64. This falls between the heritability indices usually reported for personality measures (around .40, see Lindzey, Loehlin, Manosovitz, & Thiessen, 1971) and those for ability measures such as intelligence (typically ranging from .70 to .90). These results indicate a genetic contribution to hypnotic susceptibility. A low (r = .22), but significant, correlation between hypnotic-susceptibility scores of the parent and child was consistent with this finding. The more a child resembled its same gender parent in personality, the more their hypnotic-susceptibility scores were alike. It appears that environmental factors lead to identification with the parent of the same gender and to subsequent modelling of that parent's behaviour including those characteristics associated with hypnotic susceptibility. Taken together, these results suggest that hypnotisability is the product of both a genetic predisposition and subsequent environmental influences, as well as their interaction.

5.2.3. **Relationship to main personality dimensions**

The knowledge that individual differences in responsiveness to hypnotic phenomena were both measurable and rather stable fuelled the search for personality characteristics that could predict hypnotic susceptibility. Many studies have investigated the relationship between hypnotic susceptibility and main personality characteristics as identified by various personality inventories, but correlations have been small at best and attempted replications with larger samples have generally been unsuccessful (for review see Barber, 1964, see also de Groh, 1989).

The major personality inventories, which mainly reflect the two dimensions of introversion versus extraversion and stability versus neuroticism (Eysenck & Eysenck, 1969), do not appear to adequately sample contents areas that are related to susceptibility (see e.g., Schulman & London, 1963). Hypnotic susceptibility does not appear to be strongly related to either of these dimensions.

The strongest finding of the search for reliable and consistent personality correlates of hypnotic susceptibility has been that individuals who responded well to hypnotic suggestions also had a high capacity for involvement in imaginative activities outside hypnosis (e.g., Hilgard, 1974; Perry, 1973; Tellegen & Atkinson, 1974). Compared to low-hypnotisable individuals, highs tend to be more prone to, and become more absorbed in, fantasy-dominated experiences both spontaneously (e.g., daydreaming) or following directed imagery (e.g., hypnosis). Furthermore, they tend to experience and describe these in more positively vivid images (e.g., Coe, St. Jean & Burger, 1980; Crawford, 1982; Lynn & Rhue, 1988; Spanos & McPeake, 1975; Sutcliffe, Perry, & Sheehan, 1970; Tellegen & Atkinson, 1974).

5.2.4. **Assessment and factor-analytical structure of hypnotic susceptibility**

Hypnotic-susceptibility scales use a criterion-referenced pass/fail approach to measurement, which is based on the notion that the probability of passing an item increases with a person's level of hypnotic ability (Balthazard & Woody, 1985). This assumes the existence of an underlying ability/difficulty continuum on which both a persons hypnotic responsiveness and item difficulty can be located along a so called "performance ladder" (Balthazard, 1993). This continuum has been variously referred to as "depth of hypnosis" or "hypnotic ability" (Coe & Sarbin, 1971).

There has been much debate about what hypnotic-susceptibility scales exactly measure, and whether they provide good measures of individual differences on the construct labelled "hypnotic susceptibility." Initial factor analytical studies using principal component analyses of the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A; Shor & Orne, 1962) and the Stanford Hypnotic Susceptibility Scale: Form A (SHSS:A; Weitzenhoffer & Hilgard, 1959) did differentiate three factors, or item groups, that appear to be related to item difficulty (Hilgard, 1965; Peters, Dhanens, Lundy & Landy, 1974). The first item group involves ideomotor suggestions, direct suggestions of expected behaviour that require will and occur automatically without awareness of volitional effort (e.g., head falling, eye closure, hand lowering, and hands moving).

The second group consists of challenge items, suggestions that the person cannot perform an act that is normally under voluntary control (e.g., arm immobilisation, finger lock, arm rigidity, communication inhibition, and eye catalepsy). A third group covers items that call for some form of cognitive or perceptual alteration (e.g., hallucination, posthypnotic suggestion, and amnesia). However, such factor-analytic approaches are complicated by the dichotomous pass/fail item format, the fact that the scale items vary greatly in difficulty, and the fact that item content is confounded by item difficulty. For a review of psychometric approaches, see Balthazard and Woody (1985).

There are strong indications that hypnotic ability is not an unidimensional quality and that people who differ in hypnotic ability use different processes to generate their responses to hypnotic suggestions. This is consistent with the factorial complexity observed by virtually every factor analytic study of hypnotic ability (e.g., Balthazard & Woody, 1989; Evans, 1991; McConkey, Sheehan, & Law, 1980) and is likely to account, at least in part, for the difficulty in finding reliable and significant personality correlates of hypnotisability (Bowers, 1992). Because factor analytic investigations are confounded by item difficulty, they do not allow one to determine whether the factors reflect different underlying mechanisms or are artefacts of suggestion difficulty. Nevertheless, McConkey et al. (1980) found that, even when item difficulty was taken into account, the item data did not fit the assumptions of a unidimensional model. Results of an alpha (common) factor analysis indicated that items loading on the cognitive factor were factorially complex and had a high degree of unique rather than common variance. Interestingly, it are exactly these items that are seen to represent the essence of hypnosis. This suggests that the standard hypnotic-susceptibility scales would benefit from the inclusion of more, and more difficult, cognitive items (Green, Lynn, & Carlson, 1992; Register & Kihlstrom, 1986). These could then be developed into a special cognitive subscale. An analysis of 5,204 HGSHS:A forms by Oakman and Woody (1996) found that, 31% of participants passed the most difficult item indicating that this measure is not optimally suited for detecting low base-rate response types.

A number of theorists have proposed two-factor models of hypnotic responding (e.g., Balthazard & Woody, 1992; Shor, Orne, & O'Connell, 1962; Tellegen & Atkinson, 1974; Woody et al., 1992). One of these relates to such relatively stable traits as fantasy proneness, absorption, and dissociation. The other factor is tapped by situational-specific personal variables such as compliance, expectancy, attitude, and motivation. These factors have been labelled respectively as "ability – nonability" Shor et al., 1962), "genuine responsiveness – compliance" (Tellegen, 1978/1979), or "absorption/dissociation – social psychological (Woody et al., 1992).

Based on a more recent study of underlying mechanisms of hypnotic performance, Balthazard and Woody (1992) and Balthazard (1993) have described a two-dimensional fan-shaped spectrum, or factor space, of hypnotic performance with respect to absorption (see Figure 6, p. 146). Balthazard and Woody (1992) found that the more difficult the item, the higher its correlation with one of the two underlying dimensions of hypnotic ability and the lower its correlation with the other dimension. Thus, the relative contribution of each latent characteristic would shift gradually, with easier items depending more on one dimension and difficult items more on the other. Items in the middle range of difficulty tend to confound the two characteristics. This conceptualisation of a spectrum of hypnotic performance has received considerable attention and will be discussed in more detail further on.

Kirsch et al. (1995) have criticised the basis of Balthazard and Woody's (1992) support for their proposed two-factor model because their test involved only one measure (absorption) of only the one hypothesised factor (ability factor). They found no support for the two-factor model when examining the relationship between a number of measures (absorption, fantasy proneness, dissociation, attitudes towards hypnosis, and hypnotic response expectancies) and both the proposed ability and non-ability factors. In fact, all significant effects obtained by Kirsch et al. (1995) were directly opposite to those predicted by Balthazard and Woody's two-factor model. Response expectancy was the factor most consistently related to hypnotic susceptibility and accounted for 24% of the variance in hypnotic responsiveness in participants with no prior experience of hypnosis, while absorption and fantasy proneness accounted for less than 5%.

Kirsch et al (1995) argued that the marked differences in correlations between the data sets of these studies might be because they, unlike Balthazard and Woody (1992), consistently controlled for context effects. However, results obtained by Balthazard and Woody (1992) did not reveal any significant differences in correlations between subjects who completed the absorption scale in a hypnotic or nonhypnotic context. Caution is obviously warranted in interpreting and comparing results of both studies, and further replications that address some of the methodological weaknesses in both studies are needed to provide evidence for, or discomfirmation of, a specific two-factor model of hypnotic responding.

The hypnotic-susceptibility scales and the factor-analytical examinations discussed above presume that hypnotic ability is dimensional (i.e., that individual differences in hypnotic susceptibility are differences in the degree of expression on one or more dimensions). However, hypnotic ability may also be typological and reflect differences in kind rather than differences in degree. As Balthazard and Woody (1989) argue, the observed bidimensional distribution can be produced by a scale that measures a purely dimensional ability, but also by a scale whose scores reflect two underlying types that yield a reasonably unimodal distribution of scores. This means that the shape of the distribution is not as informative as once was hoped. Oakman and Woody (1996) did conduct a set of four studies that examined the HGSHS:A and the Waterloo-Stanford Group C Scale of Hypnotic Susceptibility (WSGC; Bowers 1993) for possible underlying types of hypnotic ability. Using large sample sizes and sophisticated analytical methods for detecting underlying typologies (see Meehl, 1992; Meehl & Golden, 1982) they found a pattern of results that is entirely consistent with the existence of a latent hypnotic type. Results suggested that individuals who are highly responsive to hypnotic suggestions differ in a fundamental way, rather than in degree (i.e., along a continuum of levels) from those who are relatively unresponsive. These findings suggest a causal influence for a latent type of hypnotic ability, but further replication is needed. Several factors have been suggested that might account for the development of such a trait. Some researchers have emphasised the developmental role of dissociation as a learned coping strategy to deal with trauma or stressful events (Nash, 1992; Spiegel & Cardeña, 1991, but see Tillman, Nash, & Lerner, 1994 who failed to replicate these results).

Others have emphasised the role of fantasy proneness and imaginative involvement in the development of hypnotic ability (e.g., Hilgard & LeBaron, 1984; LeBaron, Zeltzer, & Fanurik, 1988; Lynn & Rhue, 1988; Rhue & Lynn, 1987; Wilson & Barber, 1983). Furthermore, as has already been pointed out, there is some evidence for a genetic component of hypnotic ability (Morgan, 1973). A heritable component could explain the observed typology and stability of the hypnotic ability trait.

5.3. *Absorption*

Absorption has been defined by Tellegen and Atkinson (1974, p. 274) as "total attention, involving full commitment of available perceptual, motoric, imaginative and ideational resources to a unified representation of the attentional object."

5.3.1. Correlates of absorption

Absorption, as measured by the Tellegen Absorption Scale (TAS, Tellegen & Atkinson, 1974), has consistently been found to correlate moderately with hypnotisability. The strength of the relationship between absorption and hypnotic susceptibility is dependent on the difficulty of hypnotic performance (Balthazard & Woody, 1992, see also Table 2 p. 148). For the HGSHS:A the correlation ranges between .20 and .30 (e.g., Finke & McDonald, 1978; Kihlstrom, Register, Hoyt, Albright, Gregorian, Heindel, & Morrison, 1989; Tellegen & Atkinson, 1974; Yanchar & Johnson, 1981; for a review see Roche & McConkey, 1990). Correlations between the TAS and more difficult hypnotic-susceptibility scales tend to be somewhat higher, e.g. roughly between .35 and .40. for the SHSS:C (Balthazard & Woody, 1992). Absorption, as assessed by the TAS, has also been associated with differential responsivity to meditation (Greenfield, 1977, cited in Pekala, Wenger, & Levine, 1985), EMG biofeedback (Qualls & Sheehan, 1981), and self-reported changes associated with marijuana intoxication (Fabian & Fishkin, 1981).

Like hypnotic susceptibility, absorption is unrelated to the major personality dimensions of extraversion-introversion, stability-neuroticism, and psychoticism (Glisky & Kihlstrom, 1993).

However, absorption is related to a broader construct of openness which has been suggested as the fifth factor in the "Big Five" structure of personality (see Goldberg, 1990). Openness is a very broad construct that includes many attributes, only some of which are related to hypnotic susceptibility (Glisky, Tartaryn, Tobias, & McConkey; 1991). Absorption is closely related only to openness to subjective and self-altering experiences (e.g., imagery, fantasy, and feelings) and it are these facets that are also related to hypnotic susceptibility. Other qualities of openness that refer more to openness of ideas, action, and values are related to intellectance and liberalism, but not hypnotic susceptibility. It appears that, both the specific qualities of openness that are capture by measures of absorption (e.g., TAS), and the characteristics tapped by measures of hypnotic susceptibility, are associated with altered states of consciousness that are neglected by traditional measures of individual differences in personality characteristics (Hilgard, 1975; O'Grady, 1980).

A review of the literature on absoption caused Crawford (1994b) to conclude that there are two distinct focused attentional abilities that are frequently intermingeled. Moderately focused attention refers to the ability to attend moderately to a certain stimulus so that environmental distractors are no longer disruptive, although some may still be attended to. This ability is more closely related to ambient attention (see also p. 105). Extremely focused attention and disattention on the other hand reflect the ability to attend to a task so fully that irrelevant stimuli are apparently not even noticed and provide no distraction. It is this ability for extreme attention and disattention that is more closely related to hypnotisability and loads on the TAS in factor analyses.

5.3.2. **Absorption and altered states of consciousness**

Tart (1977) has argued that altered states of consciousness can be distinguished from nonaltered states by changes in the pattern among dimensions of consciousness. Pekala et al. (1985) found that, in comparison to lows, individuals with high and medium absorption scores exhibited a significantly different pattern of alterations in several dimensions of consciousness.

In a nonhypnotic condition with eyes closed, they experienced, in particular, greater alterations in self-awareness, perception of time, and body image; more vivid imagery, more inwardly directed and absorbed attention; and greater positive affect. Alterations in time were greater and alterations in meaning more profound and unusual in comparison to the eyes open condition. With eyes closed, they not only exhibited a different pattern organisation of subdimensions of consciousness, but also perceived being in a radically different state of consciousness. These already significant phenomenological differences in normal waking consciousness between individuals with low and medium-high absorption levels were significantly greater again in a hypnotic-like (relaxation-meditation) condition.

Thus, it appears that hypnotic-like procedures may accentuate significant differences in the reported intensities and patterns of phenomenological experience across individuals that already exist in the normal nonhypnotic state. In individuals with high absorption scores, eye closure allows these differences to be perceived as associated with an altered state of consciousness. The trait of absorption may help to determine who will be more susceptible to hypnosis as well as who will experience greater alterations in subjective experience during ordinary waking consciousness (Pekala et al., 1985).

5.3.3. **Possible moderators of the correrelation between absorption and hypnotic susceptibility**

Kirsch (1985) has suggested that the correrelation between absorption and hypnotic responsiveness is mediated by expectancy. Council, Kirsch, Vickery, and Carlson (1983) found that, although scores on the TAS predicted individual responses on the hypnotic suggestions, the latter were more highly correlated with response expectancies, which in turn were even more highly correlated with the wider construct of responsiveness. When the variance associated with expectancy was controlled for, the correrelation between absorption and hypnotisability was nonsignificant. Furthermore, Council, Kirsch, and Hafner (1986) and de Groot, Gwynn, and Spanos (1988) argued that the relationship between absorption and hypnotic susceptibility is context-dependent.

They found that, when absorption was measured outside the hypnotic context (i.e., without informing subjects that the researcher is interested in hypnosis or that there will be a subsequent hypnotic-susceptibility assessment) the correlation failed to be significant. However, two independent studies by Nadon, Hoyt, Register and Kihlstrom (1991) found only small and unreliable evidence of a context effect, despite using large sample sizes and powerful statistical techniques. Their results, which are supported by a considerable amount of other literature, strongly suggest that the relation between absorption and hypnotic responding is much more than an artefact of the context in which they are assessed, and reaffirm the construct validity of absorption as a predictor of hypnotic responsiveness. Moreover, they also found no evidence for the finding by de Groot et al. (1988) that the context effect was moderated by gender. A set of four studies by Glisky et al. (1991) also failed to find support for a moderating role of gender.

5.3.4. The spectral analysis of hypnotic performance with respect to absorption

Balthazard and Woody (1992) described what they refer to as a continuum or spectrum of hypnotic performance. By plotting hypnotic performance on each item along a graph with the two factors as axes (e.g., hypnotic susceptibility and absorption), they derive at a factor space representing a two-dimensional fan-shaped continuum. The graphical representation of this spectrum, which they see as the essential factor-analytic description, is shown in Figure 6.

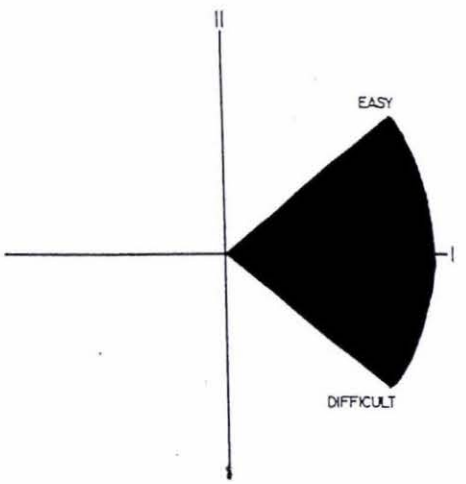

Figure 6. The spectrum of hypnotic performance

Balthazard and Woody (1992) then plotted the level of latent (i.e., biserial) correlation between absorption and individual hypnotic performance on each item, with the items being arranged according to their position along the hypnotic spectrum which is indexed by item-difficulty (see Figure 7). They called this data-analytic technique "spectral analysis." Table 2 shows the item difficulty, estimated item reliability, and biserial correlation with absorption for all items of the HGSHS:A and the WGSC in order of increasing difficulty.

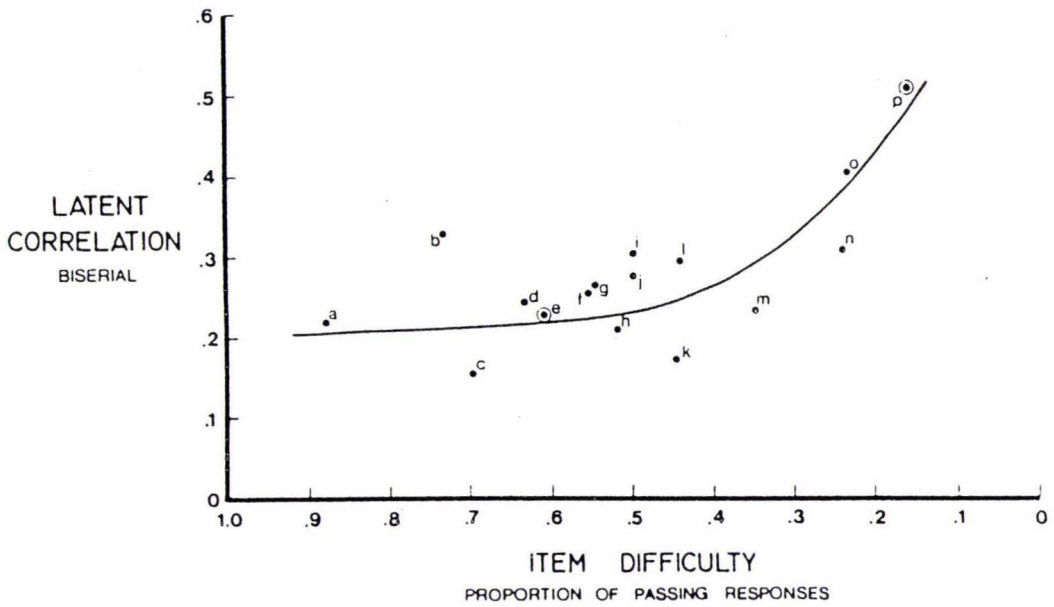

Figure 7. The spectral analysis of hypnotic performance with respect to absorption.

The pattern of results indicates quite clearly that absorption is more strongly related to difficult hypnotic items than to easy ones. Balthazard and Woody (1992) took this one step further and calculated an item response function for each item. The item response function or item-characteristic curve expresses the probability of passing a given item as a function of the level of absorption. Figures 8 and 9 show such an item-characteristic curve for respectively a moderately easy and a very difficult hypnotic suggestion. Taken together, the results of such item characteristic curves suggest that easy hypnotic suggestions do not require the processes tapped by individual differences in absorption, whereas a certain level of absorption appears to be necessary to pass difficult hypnotic suggestions (Balthazard & Woody, 1992). These authors go as far as to suggest that a high level of absorption may by itself be sufficient to pass more difficult hypnotic suggestions.

Table 2. *Item difficulty, estimated item reliability, and biserial correlation with absorption for all items of the HGSHS:A and the WSGC.*

Suggestion	HGSHS:A	WGSC	Item Difficulty	Biserial Correlation	Estimated Item Reliability
a Hand Lowering,	x	x	.89	.23	.47
b. Head Falling	x		.73	.34	.44
c. Hands Moving Apart	x	x	.69	.16	.58
d. Eye Closure	x		.63	.24	.67
e. Communication Inhibition	x		.61	.23	.82
f. Arm Rigidity	x	x	.55	.26	.72
g. Age Regression		x	.53	.28	.73
h. Arm Immobilisation	x	x	.52	.17	.71
i. Eye Catalepsy	x		.50	.31	.82
j. Taste Hallucination		x	.49	.28	.55
k. Posthypnotic Suggestion	x	x	.44	.20	.60
l. Dream		x	.43	.30	.51
m. Mosquito / Fly Hallucination	x	x	.34	.24	.63
n. Negative Visual Hallucination		x	.23	.31	.74
o. Amnesia	x	x	.23	.43	.79
p. Music Hallucination		x	.15	.53	.70

Note: suggestions are listed in order of increasing difficulty.

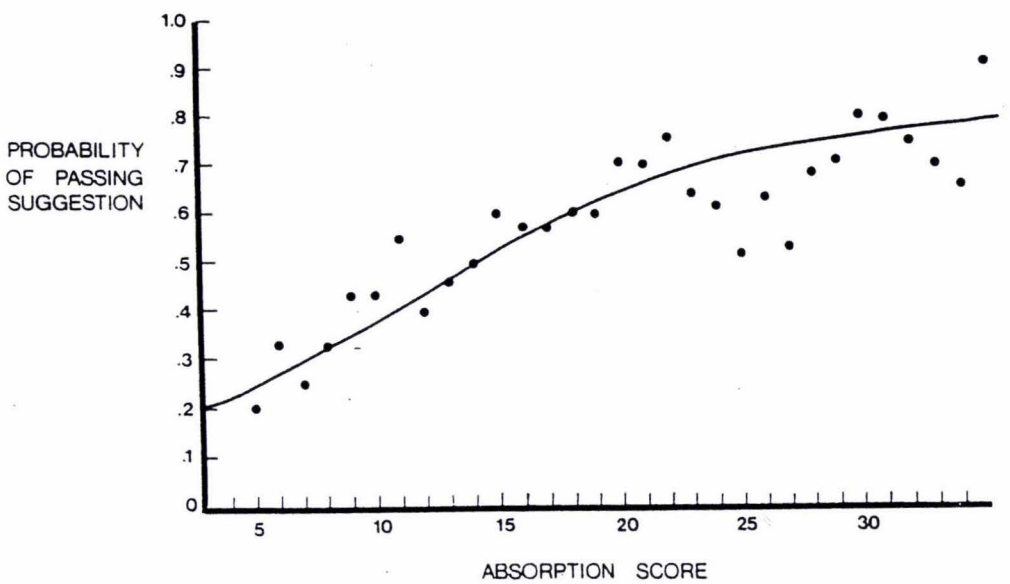

Figure 8. Item-characteristic curve for Communication Inhibition suggestion, HGSHS:A.

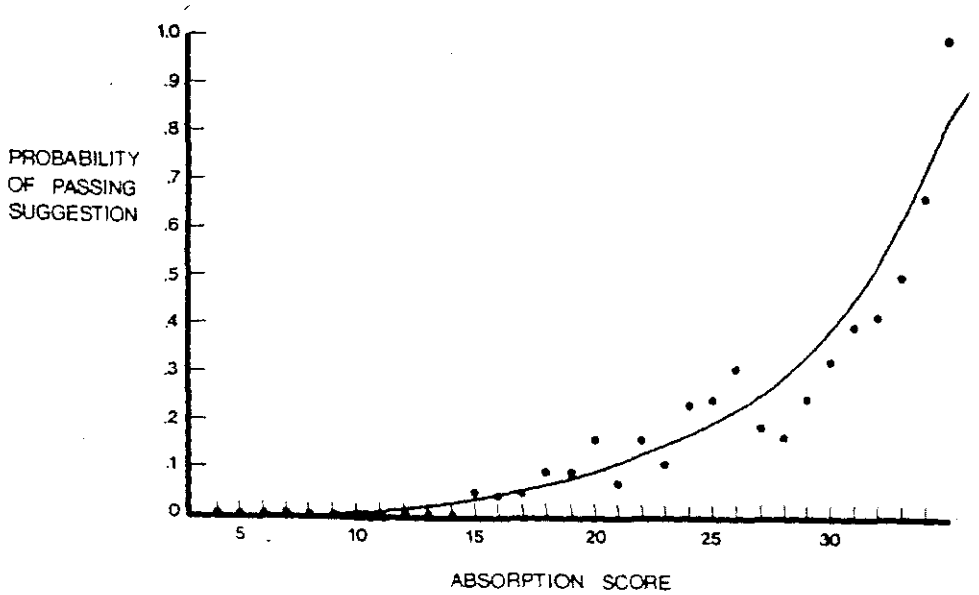

Figure 9. Item-characteristic curve for Music Hallucination suggestion, WSGC.

These results are very interesting for a number of reasons. Firstly, they support the suggestion by Shor et al. (1962) that both ability and nonability components contribute to hypnotic performance. It is suggested that ability components are the primary determinants of more difficult hypnotic performance, whereas the performance of easier hypnotic items is mainly driven by non-ability components. In a similar light, Tellegen (1978/1979, p 228) described a two-factor model of hypnotic performance consisting of a "genuine, responsiveness factor" and a "compliance factor." Results of the spectral analysis provide some evidence that it is the "ability factor" or "genuine responsiveness factor" that is tapped by the absorption scale. Secondly, they provide the best empirical evidence so far that the spectrum of hypnotic performance is not an artefact of some sort. Thirdly, they also provide a possible solution to the controversy over the replicability of the earlier discussed context effect.

It is possible that the context effect depends on the difficulty of the hypnotic item and the hypnotic ability of the sample used. The relationship between absorption and hypnotic responsiveness might be stable across different context when subjects rely on ability components for their performance - subjects with high hypnotic ability performing relatively difficult suggestions. In contrast, when subjects with relatively low hypnotic ability perform relatively easy suggestions and the correlation depends more on the non-ability component, this relationship may be quite responsive to context manipulations (Balthazard & Woody, 1992).

Kirsch et al. (1995) failed to find a correlation between hypnotic susceptibility and absorption, which most likely results from the fact that they measured both variables in different testing contexts. The item difficulty coefficients of both studies corresponded closely ($r = .94$, $p < .01$), but there were significant differences in the biserial correlations with absorption between both data sets. In general, most of the biserial correlations in Balthazard and Woody's data were higher. Table 3 shows a summary of the most relevant results of the study by Kirsch et al. (1995) for experiment 4 which used the same hypnotic-susceptibility screening measure (WSGC).

Kirsch et al. (1995) used two sets of screening criteria: (1) relatively low (6 or less items passed) and relatively high (7 or more), and (2) low (4 items passed or less) and high (9 items or more). The relative low and relative high criteria divide the largest group of moderate hypnotic responsiveness between them. The selection criteria for the second group were most similar to those used by Balthazard and Woody (1992) and the current study - the only difference being that the latter two studies used passing equal or less than 3 items, rather than equal or less than 4 items, as their criteria for low hypnotic susceptibility. It has repeatedly been demonstrated that those with high to very high hypnotic susceptibility differ fundamentally in their responding in various situations from those less responsive individuals. Accurate hypnotic-susceptibility screening is, therefore, essential if we want to be able to draw meaningful conclusions and detect possible hypnotic-susceptibility effects.

Kirsch et al. (1995) argue that the correlations they observed were directly opposite to those predicted by two-factor models of hypnotic responding (e.g., Balthazard & Woody, 1992; Shor et al., 1962; Telegen, 1978/1979; Woody et al., 1992). This indeed appears to be the case when the less stringent criteria (i.e., relatively low and relatively high) are used, but is less clearly supported by correlations for the low and high susceptibility groups.

Table 3. *Correlations of trait and situational variables with hypnotic responsiveness as a function of hypnotisability level. Summary based on Kirsch, Silva, Comey, and Reed (1995) experiment 4 .*

Hypnotisability	Absorption	Fantasy proneness	Attitude	Expectancy
Low (n=45)	.11	.23	.35*	.35*
High (n=20)	-.36	-.42*	.26	.50**

* $p < .05$ ** $p < .01$

The clearest finding was that expectancy was the strongest correlate of hypnotic responsiveness, and more so for high susceptibles (highs) than for those who are relatively unsusceptible to hypnosis (lows). Twenty-five percent of the variance in hypnotic responsiveness of the highs could be explained by expectancy. Kirsch et al. (1995) suggest that differences in correlations within each data set are due to random variation.

Thus; absorption, or the ability for focused attention on the suggestion behaviour coupled with a disattention to other information, is generally regarded as an important cognitive process in the successful responding to, in particular, more demanding hypnotic suggestions (e.g., Hilgard, 1975; Shor, 1979; Spanos & Barber, 1974; Tellegen & Atkinson, 1974). However, there are strong indications that absorption alone does not adequately account for hypnotic behaviour in persons with high to medium hypnotic susceptibility (Bartis & Zamansky, 1990; Zamansky, 1977; Zamansky & Clark, 1986).

5.3.5. Dealing with the inherent conflict between suggested behaviour and actual experience

Hypnotic suggestions present the hypnotic subject with an inherent conflict between the information about the suggested behaviour and reality-based information about his or her actual experience and behavioural response. It is this ability to simultaneously maintain such conflicting, but functionally isolated, perspectives on the same experience that has been regarded to involve dissociation (Zamansky & Bartis, 1985).

To explore the relative contribution of absorption and dissociation in mediating the hypnotic performance of high- and low-hypnotisable subjects, Zamansky and colleagues conducted a series of experiments that manipulated (heightened) this inherent conflict by deliberately introducing thoughts and images that contradicted and were incompatible with the suggested target behaviour. In this condition, it should be more difficult to maintain a unified focus of attention on the target suggestion, and, consequently, absorption should become less effective as a cognitive strategy. In the unmanipulated situation, both high and low hypnotisables tended to pass more suggestions, and were more inclined to rate their experience as involuntary, when they focused exclusively or predominantly on the suggested behaviour and largely ignored reality-based information about their behavioural response (e.g., Bartis & Zamansky, 1990). However, significant differences emerged between both hypnotic-susceptibility groups when subjects also attended to reality-based information. Following these spontaneous dissociations, low hypnotisables were less likely to report their experience as involuntary. High hypnotisables, on the other hand, were able to be aware of this apparent conflict in information without it causing a reduction in their experience of involuntariness (Bartis & Zamansky, 1990). These differences in the hypnotic experience of high and low hypnotisables became even more apparent with the introduction of contradictory suggestions that enhanced the incongruence by directing the subject's attention to the true state of events.

Despite the increase in difficulty produced by the introduction of incongruent information, high hypnotisables were able to perform the target suggestion successfully. The same applied to a slightly lesser extend for medium hypnotisables.

Low hypnotisables, on the other hand, experienced a clear deterioration in their response to target suggestions (Bartis and Zamansky, 1990; Zamansky and Clark, 1986). These results are supported by earlier research findings (Kihlstrom, Evans, Orne, & Orne, 1980; Spanos, Weekes, & de Groh, 1984; Zamansky, 1977). They indicate that, while absorption and imaginative involvement may facilitate hypnotic responding, the exclusive focus of attention on the suggestions or a corresponding inattention to contradictory thoughts and images is not essential for the successful hypnotic performance of high-hypnotisable subjects (Zamansky & Clark, 1986).

These results may be explained by suggesting that, like low hypnotisables, those with medium to high hypnotic susceptibility, despite such diversions, simply continued to enact the behaviour they saw as expected in the role of hypnotic subject. They are also consistent with the notion that people with moderate to high hypnotic susceptibility are better able to suppress incompatible cognitions and modify the hierarchical control arrangement by directly activating the targeted cognitive control system, thereby dissociating it from executive control and the influence of conflicting thoughts.

The study by Bartis and Zamansky (1990) incorporated an experiment that examined responding to a target suggestion (your outstretched arm is heavy and moving down) in both a congruent and an incongruent imagery condition. Subjects were asked to imagine either a heavy weight (congruent condition) or a large helium filled balloon (incongruent condition) tied to their arm. While only 2 out of 10 low hypnotisables were able to pass the target suggestion in the incongruent imagery condition, 6 out of 8 low hypnotisables were able to do so in a congruent imagery condition. All 10 highly hypnotisable subjects passed the suggestion in the congruent imagery condition, and 11 out of 13 high hypnotisables did so with given suggestions containing incongruent imagery. This suggests that demand characteristics and role expectations may be important determinants of the hypnotic performance of low hypnotisables. Low hypnotisables may also use absorption, but they have difficulty when they are faced with simultaneous contradictory information or imagery. In such situations of heightened conflict, absorption ceases to be a viable strategy for passing the suggestion.

The arm lowering suggestion itself requires only a rather simple ideomotor response; however, the presence of incongruent imagery requires subjects to be simultaneously aware of the content of the contradictory suggestion or imagery and of the importance of not responding to them. Such behaviour is a typical example of dissociation (i.e., the ability to maintain simultaneously conflicting, but functionally isolated, perspectives on the same experience). High hypnotisables appear to be quite capable of such behaviour. They reported a high degree of imaginative involvement in imagery opposite to their behavioural response, while maintaining that their behaviour was nonvolitional.

Taken together these results suggest that high hypnotisables are able to employ both absorption and dissociation. Which strategy they predominantly use may depend, at least in part, on the degree of inherent conflict between the hypnotic suggestion and their behavioural response. Low hypnotisables, who are relatively lacking in the ability to dissociate, may need to become fully absorbed in the target suggestions in order to pass them and/or rely on compliance with role demands and expectations.

5.4. *Dissociation*

Dissociative experiences are not limited to hypnotic situations. In its broadest sense dissociation simply means that two or more mental processes or contents are not associated or integrated (Cardeña, 1994). In their latest diagnostic manual (DSM IV), the American Psychiatric Association define dissociations as experiences that involve "a disruption of the usually integrated functions of consciousness, memory, identity, or perception of the environment" (American Psychiatric Association, 1994, p. 766).

Classical dissociation theory (Janet, 1889, cited in Hilgard, 1973; Prince, 1921) included the notion that two tasks performed simultaneously could theoretically be functionally independent of one another. Some researchers extended this to mean that dissociated mental processes would be so isolated from other ongoing cognitions that they would not interfere with each other (White & Shevac, 1942). However, experiments failed to find evidence in support of this notion of noninterference.

Green and Lynn (1995) comment that this appears to have been one of the major factors why dissociation, after initial interest in the early parts of this century, fell out of favour again. Hilgard (1973) was able to renew interest in dissociation by incorporating the notion of partial dissociations into his neodissociation theory of hypnosis. This adaptation of dissociation theory tried to bridge the existing gap between theory and empirical research by recognising that dissociations, like many other psychological processes, may be a matter of degree and involve only partial separations of other mental processes.

Partial dissociations are not uncommon in everyday live, for example, when we become so absorbed in reading a book or watching a movie that we are unaware of our immediate surroundings. This may be manifest by gaps in our autobiographical memory, loss of time, and a changed sense of self. Highly hypnotisable performers, such as actors or musicians, frequently dissociate their ordinary awareness of themselves when they are performing and feel strangely disconnected from the result. The mental state reached during deep meditation is another form of dissociation. In such states of deep absorption, people may not be able to report on their experiences without disrupting the absorbed state, but they remain still quite conscious all along.

The larger domain of dissociation (Cardeña, 1994) includes a variety of dissociative phenomena. Some of these may be present in certain hypnotic situations (e.g., posthypnotic amnesia, or during age regression when some highly hypnotisables experience themselves as a child seen through the eyes of an adult onlooker). Posthypnotic amnesia can be seen as a dissociation between explicit memory, which requires conscious recollection of an event, and implicit memory, which is influenced by the prior event but does not require its conscious recollection (see Schachter, 1987). Studies have demonstrated that suggested posthypnotic amnesia does impair performance on free- and cued-recall tasks (explicit memory), but leaves performance on tasks requiring implicit memory, such as free association and proactive and retroactive interference largely unaffected (for a review see Kihlstrom, 1985a). Similar sorts of dissociations have been observed between explicit and implicit perception.

Examples include not only hypnotic analgesia, but also phenomena such as blindsight (see Weiskrantz, 1986, 1997) and the observation that hypnotic suggestions for deafness or blindness can produce subjectively compelling impairments of auditory or visual acuity, while having little negative impact on intrusion or priming effects (Bryant & McConkey, 1989a,b; Spanos, Jones, & Malfara, 1982; Sutcliffe, 1961).

Dissociative processes are also involved in such ordinary phenomena as automatic behaviours, perception without awareness, and in dreams and hallucinations (Hilgard, 1986). Furthermore, dissociations may be manifest in particular neurological syndromes (Farthing, 1992) and a variety of self-altering psychopathologies, for example, traumatic amnesia, or in a very extreme form in multiple personality disorders (Baars, 1988; Hilgard, 1992; Spiegel, 1990). Dissociations can also be used as a way of defence, whereby one or more incompatible mental contents are excluded from consciousness. Such dissociations are different from repression, in that the different mental contents, which co-occur largely independent of each other, maintain active participation in the self-system through parallel access to awareness.

Hilgard's neodissociation theory (see section 5.6.1.) recognises the complexity of consciousness and the self-system. It proposes a hierarchical organisation between the various mental activities (e.g., perception, memory, and planning) that are involved with different tasks or actions. At any one time, several of these mental structures or subsystems try to become activated. They can do so either through executive initiative and control, in which case they are perceived as conscious, or directly by automatic activation, in which case awareness is only on a subconscious level. Neodissociation theory views dissociations as a division between such concurrent streams of mental activity whereby one streams retains normal access to phenomenal awareness while others are inaccessible to conscious awareness and operate on a subconscious level outside of voluntary control (Hilgard, 1986). Because the dominant-subordinate relationship among the various subsystems is not fixed, hypnosis can produce the kinds of changes it does - by facilitating conscious processing of some available memories or imaginative situations (as in suggestions for age regression or hallucinations) and suppressing the conscious awareness of others (as in suggested amnesia, analgesia, or loss of motor control).

Dissociations can be partial (involving only a single or relatively few subsystems) or more widespread (involving many subsystems). When dissociations are widespread, the modifications in consciousness and personality may be profound and become recognised and identified by the hypnotised person as an altered state.

5.5. *Unconscious Influences in Hypnosis* ⊛

5.5.1. **Conscious and unconscious influences**

A stimulus must be perceived to be able to affect behaviour, but this does not necessarily require its representation in conscious awareness, as is evident for instance in subliminal perception. Lundh (1979, cited in Bowers, 1990) did emphasise the importance of the distinction between perception and noticing, a concept further expanded by Bowers (1987) into his notion of first- and second-order consciousness. According to Bowers, *first-order consciousness* involves noticing something that is perceived. It is the process whereby perceived information is selectively attended to and becomes noticed information that is consciously perceived (Bowers, 1990). Much information is either never selectively attended to or immediately forgotten and thus unavailable to first-order consciousness. Such information cannot be invoked to explain one's action. *Second-order consciousness* involves introspection of information represented in first-order consciousness. This includes understanding how our thoughts, feeling, and behaviours are influenced by many factors, and the integration of noticed information with our theories, beliefs, and assumptions about our selves (self-concept) and our wider environment.

In addition to these conscious processes, human behaviour is also subject to unconscious influences. There are ample indications that our thoughts and behaviours can be influenced by information that is not presented in first-order consciousness (see e.g., Marcel, 1983; Cheesman & Merikle, 1986). As has been well-documented, the introspection about the causes of our own and others thoughts and actions is frequently flawed (see e.g., Nisbett & Ross, 1980; Lyons, 1986).

Bowers (1987) has argued that neither observation nor introspection can deliver an unmistaken account of our own actions, and that human action is necessarily subject to unconscious influences. Information about our own actions is often incomplete, and unconscious influences are incorporated to derive at an account that is consistent with our wider beliefs, goals, and value systems.

Bowers (1990) makes a further distinction between Type I and Type II unconscious influences. *Type I unconscious influences* determine thought and behaviour in an indirect, subtle, way that is typically unnoticed and/or disavowed by the ordinary person trying to understand his or her behaviour. Such influences are present, for example, in interventions designed to influence a person's thoughts or behaviours through procedures that are so subtle that the person is not aware of their coercive nature. They may influence what information is attended to and how it is understood. *Type II unconscious influences,* on the other hand, are the result of alterations in how information is received and processed. They operate, for example, when a person is asleep, drugged, extremely fatigued or stressed, or in a state of high arousal. These situations all involve the down-regulation of some nonessential functions so that the body can either rest and recuperate or be maximally prepared for decisive action against real or potential threats.

Hypnosis may be another way to activate such a state. Information processing during such states is characterised by a loss of *generalised reality orienting* (GRO; Shor, 1979) and a shift towards increased primary process thinking. The relationship among various levels of cognitive control is altered and subsystems of control become less embedded in, or guided by, overarching conscious plans and intentions than would otherwise be the case (Miller et al., 1960; Hilgard, 1986; Kihlstrom, 1984). There are well-documented reports of subsequent responding to suggestions made under general anaesthetic or during Stage I sleep (see e.g., Bennett, 1988; Evans, Gustafson, O'Connell, Orne, & Shor, 1966). These indicate that in certain conditions, a person can display directed and discriminate behaviour without having to be consciously aware of the conditions that initiate the behaviour.

Advocates of the social-psychological model of hypnosis argue that hypnotic behaviour may be subject to Type I unconscious influences, but deny that Type II unconscious influences are involved. They argue that responding to hypnotic suggestions is strategically enacted and requires conscious attentional engagement. Bowers (1990) readily acknowledges that Type I unconscious influences, such as role demands, situational cues, and demand characteristics can and often do effect hypnotic behaviour; but argues that such influences are not sufficient to account for successful performance of more challenging hypnotic phenomena. While Type I unconscious influences are important for understanding attitude and behaviour change in nonhypnotic situations (see e.g., Frank, 1973; Cialdini, 1985), Bowers (1990) argues that they are not important for understanding the mechanisms that are specific to hypnotic behaviour. The differences between these conflicting explanations of hypnotic behaviour will be explored more fully in section 5.6.

Demand characteristics are an example of Type I unconscious influences. They can change a person's behaviour often without them being clearly aware of their effect. Bowers (1973), however, has emphasised the difference between recognised and unrecognised demand characteristics. The importance of this distinction becomes clearer when considered in the context of first- and second-order consciousness. If simply noticed in first-order consciousness, demand characteristics can be implicit but powerful shapers of experimental behaviour. However, when they are interpreted in second-order consciousness as an obvious attempt to coerce compliance, subjects may demonstrate considerable reactance (Brehm & Brehm, 1981).

5.5.2. **Efficacy of direct versus indirect suggestions**

According to the social-psychological view, individual differences in hypnotic ability are largely due to differences in how people interpret ambiguously worded suggestions. High hypnotic ability is seen to result largely from a talent to interpret test items in a way that leads to high test scores (Spanos, 1986). Gorassini and Spanos (1986) argue that individual differences can be limited by making hypnotic suggestions less ambiguous. This appears to be contrary to the accepted and well-documented view in social psychology that, in the normal state, a suggestion is more effective the more subtle it is (Cialdini, 1985: Kelly, 1973).

Crucial to the utility of hypnosis is not just the overt compliance with the suggestions, but the subjective experience that is consistent with the outward behaviour. According to conventional social-psychological wisdom, explicit and unambiguous suggestions should mitigate against the internal attribution and experience of the suggested behaviour that is typical of hypnotic behaviour. In a hypnotic context, the use of explicit and direct suggestions would thus be ill advised.

This conventional social-psychological view does not seem to apply to suggestions delivered in the hypnotic state, at least not for all hypnotic subjects. Some hypnotists particularly utilise indirect and permissively worded suggestions to maximise the likelihood of producing hypnotically suggested effects (Barber, 1977, 1980; Erickson & Rossi, 1980). The implication is that such subtle and indirect communications are successful, at least in part, because of the Type I unconscious influences they exert on thought and behaviour. While indirect suggestion may be beneficial with resistant and chronic clients who might otherwise baulk at responding hypnotically (see e.g., Dolan, 1985), there is no clear evidence to suggest that they are more effective in individuals who are moderately or highly responsive to hypnosis.

Initial reports of the effectiveness of Rapid Induction Analgesia (RIA - Barber, 1977), a hypnotic technique using indirect suggestions, cited a near 100% success rate with clinical subjects who underwent a number of painful dental procedures, regardless of their hypnotic susceptibility (Barber, 1977, Mayer et al., 1976). These results appeared to suggest that the type of suggestions used played an important role in the ability to become successfully hypnotised, and that a much higher percentage of the population could develop clinically useful hypnosis than had originally been assumed. However, subsequent studies have consistently failed to replicate Barber's extremely high success rate. Several studies using RIA in a variety of experimental and clinical settings found this technique to be effective only in a much smaller percentage of subjects (e.g., Crowley, 1980; Gillet & Coe, 1984, Snow, 1979). Van Gorp, Meyer, and Dunbar (1985) found that, while traditional hypnosis significantly reduced cold-pressor pain, RIA was no more effective than a no-treatment control condition.

Gillett and Coe (1984), using a similar sample of dental patients as Barber (1977) and a verbatim copy of the RIA procedure (Barber, 1977, pp. 142-147), found indirect suggestions to be effective in 52% of subjects, a percentage roughly equal to that found by Gottfredson (1973, cited in Gillett and Coe, 1984) with standard hypnotic techniques. However, there were some differences between these studies and the original studies by Barber and colleagues. Both Van Gorp et al. (1985) and Gillett and Coe (1984) used a tape-recorded version compared to Barber's personalised communication. Furthermore, Barber (1977) provided continuous suggestions for analgesia and hypnotic deepening throughout the painful procedures, rather than the traditional posthypnotic suggestion used in other studies.

Two studies that used a personally administered version of the RIA script found that indirect suggestions could indeed significantly reduce pain ratings, and could do so regardless of the subject's level of hypnotic susceptibility. Fricton and Roth (1985) found that direct and indirect induction methods were equally effective in increasing pain threshold following tooth pulp stimulation. However, direct suggestions were only effective for highly hypnotisables. Maurer, Santangelo, and Claiborn (1993), who used supra-threshold cold-pressor pain, also found that both direct and indirect techniques significantly reduced pain ratings, but direct suggestions were more effective than indirect suggestions. Highs tended to respond more positively to the direct than to the indirect technique. Interestingly, Maurer et al. found that the reduction in reported pain was independent of hypnotic susceptibility for both direct and indirect delivery methods. This latter finding is contrary to virtually all other research which clearly indicates that highs respond much better than lows when using direct suggestions. A possible explanation for this discrepancy might be that most of the above cited studies relied solely on the HGSHG:A for determining hypnotic susceptibility and used 'liberal' classification criteria, that is 0-4 for lows and 8-12 for highs (Fricton & Roth, 1985; Gillett & Coe, 1984; Maurer et al., 1993; Van Gorp et al., 1985). This can result in an inexact and unstable classification that lacks predictive validity (Orne, 1971). Despite using a personally administered version of the RAI script, the observed effectiveness of this measure fell far short of the very high levels reported by Barber (1977). This might be because a largely standardised version of the RIA script does not adequately reproduce the individualised approach of the indirect technique used by Barber.

The effectiveness of the indirect method appears to rely more heavily on personal contact with the hypnotist. Furthermore, it is likely that the continuously delivered suggestion in the study by Barber (1977) would be more effective than the traditional posthypnotic suggestion used in subsequent studies.

In summary, indirect suggestions can effectively reduce reported pain, but the majority of research indicates that they are no more effective than direct suggestions. However, unlike direct hypnotic suggestions, indirect hypnotic suggestions are not differentially effective for subjects with high or low hypnotic susceptibility. Thus, a substantial number of lows, who otherwise would be relatively unresponsive, can achieve significant pain reductions when using indirect suggestions. Those who are highly susceptible tend to prefer and respond best to, direct suggestions.

5.5.3. **Conclusions from experimental studies using the real-simulator control design**

Further indications as to what type of influences is operating during hypnotic suggestions can come from studies using a real-simulator design (see Orne, 1971). The real-simulator design is a type of control experiment in which highly responsive persons who are truly hypnotised ("reals") act as usual to the suggestions of the hypnotist. A second group of persons who repeatedly have demonstrated to be unresponsive to hypnosis are asked to respond voluntary as they believe a truly hypnotised person would. These "simulators" are used as a control group, enabling the researcher to find out how much of a demand the suggestions of the hypnotist have placed on the truly hypnotised subjects. Their unresponsiveness to hypnosis under normal conditions rules out the influence of prior positive expectations about hypnosis. Simulators are particularly responsive to any cues as to what behaviour is expected and will respond to compliance cues or other demand characteristics if these are present. Although their behavioural response can indicate the presence of demand characteristics, this does not mean that the hypnotic performance of the truly hypnotised group is also due to demand characteristics. However, it can indicate that the hypnotic behaviour under investigation is within the possible repertoire of the unhypnotised individual.

If this is found to be so, the conclusion must be drawn that the experimental procedure was unable to identify whether the behaviour of the truly hypnotised individuals was due to "genuine" hypnotic responding or was a function of the demand characteristics of the situation. Orne (1971) has provided strict guidelines for using the real-simulator model of experimental control.

A controlled laboratory study by McConkey (1984) who used a real-simulator design found that truly hypnotised highly susceptibles, who had all demonstrated a positive visual hallucination following a direct suggestion, varied greatly in their response when the suggestion was delivered in an indirect way. Most simulators in the control group reported the visual hallucination, which they in fact had not experienced, indicating that, at least for them, demand characteristics were influential in responding to the indirect suggestion. A postexperimental interview revealed that some of the really hypnotised subjects perceived the indirect suggestion as an illegitimate request for an experiential alteration because the indirect suggestion was not embedded in the appropriate verbal framework necessary for them to identify the situations as hypnotic (McConkey, 1984). For these otherwise hypnotically responsive subjects, indirect suggestions had a paradoxical effect and engendered reactance rather than compliance or "genuine" hypnotic responding. Taken together, these results clearly establish that hypnotic behaviour following indirect suggestions is not correlated with hypnotic ability. The outcome of indirect suggestions can, therefore, not reasonably be attributed to the effect of the hypnotic suggestion per se (Miller and Bowers, 1986).

It is generally excepted in social psychology that clear and explicit directives for expected behaviour lead to particularly high levels of overt compliance (see e.g., Orne, 1962: Milgram, 1963). The absence of a significant correlation between compliance and hypnotic ability suggests that factors other than compliance are involved. Furthermore, proponents of the social-psychological model argue that attitudes to hypnosis and expectancies of appropriate hypnotic behaviour are susceptible to manipulation by hypnotic interventions and can become powerful shapers of hypnotic responding.

However, data reported by other researchers indicates that expectancies have either no effect at all (e.g., Ashford & Hammer, 1978) or only a small effect (e.g., Shor, Pistole, Easton, & Kihlstrom, 1984) on hypnotic responsiveness. The latter study found that subject's expectations of their performance on each item of the HGSHS:A were less accurate in predicting actual performance than their hypnotic ability score based on performance on all the other test items. These authors concluded that, "Expectations do have some effect on response to hypnosis, ... but they are far from self-fulfilling prophecies" (Shor et al., 1984, p. 383).

When in a specifically hypnotic context, Type I unconscious influences may subtly engender cooperation and a belief that one's behaviour is involuntary and results from hypnotic influences. To the extent that Type I unconscious influences are effective, the hypnotist may indeed exercise real if subtle control over the person being hypnotised. However, Bowers (1990) argues that these influences (e.g., expectancies or social compliance with role demands and other demand characteristics) do not appear to be sufficient to account for successful performance on suggestions involving considerable alterations and distortions in perception or memory. This conclusion is supported by Shor et al.'s (1962) suggestion that hypnotic ability consists of an ability and a nonability component, Tellegen's distinction between a genuine responsiveness factor and a compliance factor (Tellegen, 1978/1979), and with the results of Balthazard and Woody's (1992) spectral analysis of hypnotic ability. The exclusive application of a social-psychological interpretation, which denies the involvement of Type II unconscious influences and a genuine hypnotic-ability factor, is argued to be insufficient to explain the hypnotic behaviour of persons with high hypnotic susceptibility (Bowers, 1990).

5.6. *Models of Hypnotic Responding*

What is striking about hypnosis is not so much the experiences and behaviours that can be elicited using hypnotic suggestions, but rather the alterations in conscious experience (e.g., involuntariness, amnesia, and analgesia) that accompany them (Kihlstrom, 1998). It is mainly the mechanisms for these phenomena that theorists differ on, and several explanations have been proposed to account for such alterations in conscious experience.

The main theoretical models of hypnotic responding are based on either neodissociation theory or on a social-psychological variant of sociocognitive theory (see Lynn and Rhue, 1991; and Spanos & Chaves, 1989). Further development of the original neodissociation model have lead to a further distinction between a dissociated-experience model and a dissociated-control model (Bowers, 1990, 1992).

5.6.1. **Neodissociation theory**

Although its development originated from the study of hypnotic phenomena and in particular hypnotic analgesia, neodissociation theory is intended to be more general than a comprehensive theory of hypnosis (Hilgard, 1991). It tries to understand the particular alterations in consciousness that characterise many phenomena of mental life, including, for example, responses to hypnotic suggestions by highly hypnotisable individuals. Rather than seeing hypnosis merely as a response to suggestions, neodissociation theory regards the essence of hypnosis to be a division (dissociation) of awareness such that hypnotised individuals are unaware of perceptions and memories of which they should otherwise be aware (Hilgard, 1977). Neodissociation theory incorporates the important recognition that dissociations can be partial and that behaviour is organised as a hierarchical series of cognitive subsystems of control that carry out habitual action sequences (Hilgard, 1973, 1992). In this context, the term dissociation is not used as a causal construct, indicating that dissociations cause hypnotic responding, but rather as a descriptive construct that specifies a quality of experience involving the interference with, or loss of, familiar associative processes that can be observed during such responses (Kihlstrom, 1998).

5.6.1.1. Hilgard's neodissociation model of hypnosis

Hilgard (1973) incorporated the increased understanding of dissociations with new findings in cognitive psychology and the recently proposed gate-control theory of pain (Melzack & Wall, 1965) to arrive at the first real theory of hypnotic pain reduction.

According to the neodissociation model, hypnotic analgesia involves two psychological components (Hilgard & Hilgard, 1994). The first component is available to all individuals regardless of their hypnotic susceptibility. It involves the use of conscious coping strategies, such as relaxation and attention diversion, and is subject to demand characteristics, compliance with situational cues, and the enactment of perceived role expectations. The second component involves a distortion of awareness of bodily processes such as the dissociation of pain from executive control and conscious awareness (Hilgard, 1977).

People are understood to vary widely in their capacity to experience dissociations, and only those who possess a high hypnotic ability appear to be able to dissociate successfully the perception of pain from conscious awareness. Effective dissociations can markedly reduce, or even eliminate, the experience of pain and distress. In contrast, the first component is thought to be relatively ineffective and to produce, at best, modest reductions in the magnitude of pain that is significantly intense. Thus, the neodissociation view does recognise the influence of social-psychological factors, but proposes that the successful performance of more difficult hypnotic suggestions (i.e., those requiring a considerable alteration in perception and/or memory) depends on an ability to dissociate streams of consciousness.

Underlying the neodissociation model are three main assumptions: (1) the existence of interacting, subordinate, cognitive systems that operate with relative unity and functional autonomy; (2) the existence of some sort of hierarchical control that manages the interaction or competition between these cognitive subsystems; and (3) the existence of a central overarching control structure also called the "executive ego." (Hilgard, 1991, 1994). The term subsystems refers to identifiable activities or information programs that can be activated and executed independently, and is used to distinguish between these structures and the larger control and monitoring functions that regulate them. There are subsystems, or sets of subsystems, for many functions or competencies including, for example, specific movement sequences, pain responding, or memory traces for certain object recognitions. Each of these subsystems has the capacity to process its own inputs and outputs as well as interact with other subsystems and the central supervisory control structure (Hilgard, 1991).

Any one subsystem, or coalition of subsystems, can be dominant at a given time, until it is succeeded by the activation of another as this becomes more dominant and the former recedes or habituates. The hierarchy is determined by the competitive strengths of the subsystems and is continually shifting under the management of the central control mechanism, which is responsible for the facilitations and inhibitions that are required to selectively activate competing subsystems (Hilgard, 1992). Once activated, a subsystem continuous with a measure of autonomy. As the person becomes absorbed in what he or she is doing, the activity becomes habituated and more or less automatic. Once habituated, a skilled task is no longer reliant on conscious representations and central control and its own self-monitoring takes over. Hence, we normally have little awareness of the actions involved in well-rehearsed skilled performances.

The "executive ego" is the managing director of the attentional system and governs the planning, activation, and monitoring of subsystems required to execute the appropriate actions. Its content is normally available to consciousness. This executive control system provides the stage where novel and complex action sequences are initiated, their consequences are monitored, and competing demands are integrated so they can form consistent and holistic behaviours. The executive system monitors input from external sources as well as feedback from activated subsystems and can tune the system to meet environmental demands. The functions of the executive ego correspond thus largely with those of Norman and Shallice's supervisory attentional system and Baars' global workspace. Global Workspace theory, however, provides a more detailed description of central executive functions.

One of the ways by which a subsystem or coalition of subsystems can become activated is through hypnotic suggestions. These can be particularly useful because they permit the manipulation of the hierarchies according to which subsystems are controlled. They do so by dissociating the activated subsystem from executive control and monitoring. The executive monitoring function normally helps to integrate actions and behaviours with the broader goals, plans, and belief systems that determine our self-identity. If the outcome of actions does not comply with the desired goal, or is challenged by other demands (e.g., general reality orientation) the monitoring function provides feedback to reprogram the control function.

If this relationship is harmonious, we experience normal trial and error behaviour. However, the monitoring and control functions are not always well-balanced. This is evident during hypnosis, when normal monitoring is weakened so that there is little or no feedback to modify the executive control (Kihlstrom, 1985b).

According to the neodissociation model, effective hypnosis is argued to result in inhibition or loss of normal executive control. The resulting absence of conscious awareness of executive initiative and ongoing effort is seen to be closely linked with the reported experience of nonvolition. Two distinct mechanisms have been proposed to explain the process of dissociation. These have been referred to as *dissociated experience* and *dissociated control* (Bowers, 1990). The distinction between these two processes, and the predictions that can be made about the cognitive effort involved in implementing them, is of fundamental importance in the context of the current study and will, therefore, be discussed in more detail in the following sections.

5.6.1.2. *The dissociated-experience model*

According to Hilgard's original interpretation of neodissociation theory, hypnotic procedures can create a division in the normal integrity of the executive control structure by erecting an amnesic-like barrier that separates (i.e., dissociates) part of the executive control from conscious awareness (Hilgard, 1965). Information to the dissociated part becomes unavailable to consciousness and is no longer subject to the normal feedback and monitoring functions associated with high-level (executive) processing. Furthermore, the dissociated part does no longer independently undertake any new lines of thought or action. (Hilgard, 1992). The dissociated part, however, can initiate and inhibit movements and monitor stimuli of which the remainder of consciousness is unaware. This situation has been referred to as dissociated experience (Bowers, 1992). Rather than being merely a response to suggestions, the core of hypnosis is thus suggested to be a division of awareness such that the hypnotised subject is unaware of perceptions and memories of which they should normally be aware (Kihlstrom, 1998).

The dissociation of experience thus involves the inhibition or absence of the normal self-monitoring function of the executive control system (or supervisory attentional system, SAS) over the hypnotically suggested behaviour. The highly hypnotisable person experiences and reports the hypnotically suggested actions as being involuntary because they are controlled by the part of the executive control mechanism that has become inaccessible to phenomenal awareness and is no longer subject to executive feedback and reality monitoring (Bowers, 1990, 1992). On the other hand the normal monitoring function performed by the still conscious part of the executive structure remains largely untouched, and the hypnotised person retains normal awareness of nonhypnotic activity and sensory modalities that are not affected by the particular hypnotic suggestions.

The hypnotically suggested behaviour is thus voluntarily (i.e., intentionally) executed and controlled, but its volitional origin is blocked from conscious awareness. The hypnotised person is in control over the cognitive and physical effort needed to execute the suggested behaviours, but has no conscious experience of this control (Bowers, 1990). Such reports of nonvolition are seen as prima facia evidence that executive initiative and effort are only minimally involved in the production of the suggested behaviours (Hilgard, 1973). The dissociated-experience model is thus in agreement with sociocognitive theories that the nonvolition experienced during hypnosis is an illusion rather than a reality (Kihlstrom, 1992). They differ, however, on how this illusion is achieved, as will be explained in section 5.6.2.

Complex behaviours typically involve much more information (stimuli) than the few selected bits we consciously attend to and are aware of. Thus, even outside of hypnosis, there are constantly many activities that are dissociated from conscious awareness. As Baars (1991, p. 440) has argued, the chief function of consciousness may be to "help integrate otherwise dissociated functions." If, as is claimed, executive control and monitoring functions are weakened during hypnosis, the already dissociated nature of cognitive processes should become even more evident. Along a similar line, Frith (1987, 1995) has proposed that schizophrenics suffer from an impairment in the normal internal monitoring function of the executive ego. This leads to lack of awareness of the intended and self-initiated nature of their own actions, which the schizophrenic patient then attributes to external events and forces.

The monitoring processes of the executive or supervisory system normally prevent such misattributions from happening (Bentall, 1990).

Highly hypnotisable individuals appear to be able to process information on two levels simultaneously. For example, during effective hypnotic analgesia they may report little or no pain at the overt level; while simultaneously, on a covert (subconscious) level, being aware of the pain to a degree quite similar to that during fully conscious awareness (Hilgard, Hilgard, Morgan, Macdonald, & Johnson, 1978; Hilgard, et al., 1975; Knox, Morgan, & Hilgard, 1974).

Hilgard has tried to explain this by proposing that effective hypnosis can create a division (i.e., dissociation) of the cognitive control function of the executive ego into two concurrent streams that are separated by an amnesic barrier (Hilgard, 1974, 1994). For example, information from subsystems involved in the perception and memory of the pain are now only available to the dissociated part of the executive control structure. The unaffected (i.e., conscious) part of the executive control structure is now no longer aware of the pain experienced. The dissociated part, on the other hand, fully registers the experience, but this information is temporarily shielded from conscious awareness.

Specific instructions that make the individual aware of the existence of this hidden part can bring its stored contents back to full awareness again. Hilgard and associates have labelled this phenomenon, which is not exclusive to pain, the "*hidden observer.*" However, in low cue situations it has only been observed in a number of highly susceptible individuals who typically also report the unsuggested presence of an adult observer part during successful age regression (Laurence & Perry, 1981; Nogrady, McConkey, Laurence & Perry, 1983). When the hidden observer experience is revealed through specific instructions, it does not produce a re-enactment of the (e.g., painful) experience, but merely a cognitive recall of what took place. Hilgard and associates interpret the hidden observer phenomenon as evidence of a split in consciousness between the overt (conscious) level and the covert (subconscious) level and thus the involvement of dissociative processes (e.g., Hilgard & Hilgard, 1994).

A similar phenomenon is occasionally observed under general anaesthesia in short operations where the patient does not require a paralysing agent and continuous ventilation. Under these circumstances, patients can sometimes be engaged in conversation and have been found to report that part of them is aware of the pain (Marcel, 1993). For a sensation to be reported it needs to be accessible to reflexive consciousness. The phenomena described here, as well as some others involving certain neurological disorders (see Marcel, 1993), suggest that the unity of reflexive consciousness can be separated from phenomenal sensations, resulting in divided access to any single sensation or experience.

Strenghts: The dissociated-experience model can be used to explain a variety of suggested phenomena including analgesia, amnesia, and hallucinations. It is also consistent with self-administered hypnosis. During self-hypnosis, a single individual takes on the roles of both hypnotist and person being hypnotised. Hilgard (1986) has described hetero-hypnosis as essentially aided self-hypnosis wherein the hypnotic subject accepts the hypnotist as an aid to influence the direction of the hypnotic procedure through suggestions.

The type of division of consciousness (amnesic barrier) proposed by the dissociated-experience model does not require the presence of an external hypnotist. At the same time as the person participates in the suggestion, a small observer part of executive function remains separate as a monitor. This self-monitoring part is a normal aspect of the hypnotic experience and can expand its usual observer role to initiate the kind of executive action required in self-hypnosis. Hilgard and LeBaron (1984) have compared this with the actions of a pilot who decides to place the controls of the aircraft on automatic pilot. The operations required to fly the plane no longer require the voluntary action of the pilot. The pilot, however, remains in charge and can take over the controls again in an emergency or whenever desired. It is the same in the case of hypnosis, whether it be hetero- or self-hypnosis: when the time comes to terminate hypnosis, the monitoring or observing self can take control again and do so.

Weaknesses: Although Hilgard's neodissociation theory has greatly contributed to the understanding of dissociative phenomena and has fuelled a renewed interest in unconscious aspects of mental life (Kihlstrom, 1998), its reliance on a amnesic barrier to explain key aspects of hypnosis such as nonvolition remains problematic. Suggested amnesia is a rather rare phenomenon even among highly hypnotisable persons and incidents of spontaneous amnesia are even rarer (Kirsch & Lynn, 1995). So far, there has been no evidence for the existence of an amnesia-like barrier as proposed by Hilgard. As Kirsch and Lynn (1998a) point out, the dissociated-experience account fails to explain adequately how hypnotic suggestions bring about the formation of an amnesic-like barrier or why individual differences in dissociation are so pronounced. Hilgard was aware of this and has frequently acknowledged that, in its current state, neodissociation theory did not provide fully satisfactory explanations for all proposed mechanisms (e.g., Hilgard, 1973, 1991, p. 98).

This by itself is no reason to dismiss neodissociation theory, as most well-established theories were incomplete when first presented. In fact, the social-psychological account suffers from the same problem as it does not explicitly state any mechanism(s) whereby suggestions and expectations can automatically trigger behavioural responses and misattributions (Kihlstrom, 1998). It needs to be recognised though that, almost thirty years after the inception of neodissociation theory, its supporters have presented no further clarification for the mechanism whereby the proposed amnesic barrier is erected.

5.6.1.3. *The dissociated-control model*

Kenneth Bowers and associates have conducted a number of experiments that led them to conclude that another mechanism was responsible for the dissociation of conscious awareness observed during effective hypnosis. According to their dissociated-control model (Bowers, 1990, 1992), effective hypnotic responding does not result from the dissociation of experience, whether through the creation of an amnesic-like barrier or any other means, but rather from the dissociation of cognitive and behavioural subsystems from executive control.

The hypnotic process is argued to inhibit or weaken executive control, thereby allowing the subsystems addressed by the particular hypnotic suggestions to be directly and automatically activated and bypass the normal initiative or intervention of executive attentional control. As a consequence, high-level cognitive resources ought to be minimally involved in reducing pain.

Hypnotic suggestions are hypothesised to "release lower-level functions from the integration that is normally imposed on them by consciousness" (Woody & Bowers, 1994, p. 267). The weakening of executive control results in an altered state of consciousness that is functionally similar to that of patients with certain frontal lobe disorders. For example, Lhermitte (1986) has described a frontal lobe condition called *environmental dependency syndrome,* which is characterised by a disinhibition of working memory, a lack of autonomous behaviour, and a complete dependence upon environmental stimuli. In this state, patients are highly suggestible (or stimulus bound), and their behaviour appears dissociated from context. For example, when patients with this condition had the word museum mentioned to them before they entered an apartment; they proceeded to tour it, inspecting objects as if being in a museum. Thus according to Bowers (1992), the hypnotic process may alter the actual underlying control of behaviour, not just the self-perception of such control, as suggested by the dissociated-experience model and the social-psychological model.

Strengths: The dissociated-control model is highly consistent with Norman and Shallice's model of willed versus automatic control of behaviour. The nature of the involvement of the supervisory attentional system has an important influence on how a particular action is experienced. When the supervisory system is involved in actively modulating the selection of schemata by the contention-scheduling system, we have the phenomenal experience of will or deliberate conscious control. In contrast, when the supervisory system is neither modulating nor monitoring the contention-scheduling system, the action is perceived as automatic and nonvolitional. Between these two extremes, a range of other states of awareness is possible. For example, if the supervisory attentional system is only monitoring, but not actively modulating, the contention-scheduling process, the situation is experience as a so called ideomotor act (i.e., an act whereby the action immediately follows the idea of it in the mind, rather than after considerable planning as in a genuinely willed act).

The emphasis on automatic triggering of behavioural responses, rather than on the conscious employment of attentional strategies and enactments, is in line with cutting edge research in cognitive science which indicates that high level cognitive effort is not necessary to produce subjective and behavioural responses (see Bargh, 1994).

Thus, hypnosis can be thought of as weakening of the control and monitoring function of the supervisory attentional system. This would lead to an inhibition of the normal modulation of the contention-scheduling system. The active modulation of the lower level system by the supervisory system is experienced as will or deliberate conscious control. Hypnosis, which allegedly inhibits the modulating function of the supervisory system, is; therefore, experienced as nonvolitional. The weakening of the supervisory system explains what is meant by "dissociating" lower levels of control from higher level, executive control (Woody & Bowers, 1994). Control at the level of the contention-scheduling system relates to what is meant by the direct activation of subsystems of control. The hypnotised person is especially dependent on the lower (i.e., contention scheduling) level of control, and this control can not be modulated readily in a wilful (i.e., volitional) manner.

The dissociated-control model provides no real explanation how this weakening of executive control is brought about. There is, however, substantial neurophysiological evidence that willed action and the self-monitoring of volition is generated by a different system from that responsible for more automatic stimulus-driven action. Willed action and internal self-monitoring appear to be critically dependent on frontal areas including the dorsolateral prefrontal cortex, the anterior cingulate cortex, the supplementary motor areas, and parts of the basal ganglia (Frith, 1992; McGuire, Silbersweig, Wright, Murray, David, Frackowiak, & Frith, 1995). There is increasing evidence that during hypnosis highly hypnotisable individuals exhibit a distinct inhibition of functions that are subserved by the frontal and prefrontal cortex (for a review, see e.g., Crawford & Gruzelier, 1992, see also section 5.7.2 and 5.7.3.). The frontal cortex is believed to be the site of executive control in the hierarchical organisation and regulation of activity (Kolb & Whishaw, 1990; Pribram, 1973). In highly susceptible individuals, hypnosis is argued to weaken this supervisory control and increase dependence on a lower (contention-scheduling) level of control (Norman & Shallice, 1986).

The sole reliance on contention scheduling results in the weakening of volitional control and the general impoverishment (including description and verification) of spontaneous, self-generated behaviour that is also one of the classic hallmarks of patients with frontal lobe lesions (Kolb & Whishaw, 1990, see also Shallice, 1994). Furthermore, the impairment of memory for recency and the temporal ordering of events is a well-established phenomena in both frontal lobe patients and highly hypnotised subjects (e.g., Evans & Kihlstrom, 1973; Geiselman, Fishman, Jaenicke, Larner, MacKinnon, Shoenberg, & Swartz, 1983; Kihlstrom & Wilson, 1984; Kolb & Whishaw, 1990; Spanos, Radtke-Boderik, & Stam, 1982; Wilson & Kihlstrom, 1986).

Hypnotic amnesia has also been linked to what Shallice (1991) refers to as frontal amnesia; that is, the impairment of part of the supervisory system that is concerned with formulating the description of any memory that is required, and the verification that any candidate memories that have been retrieved are relevant. According to the dissociated-control model, hypnosis alters executive controls over memory functions in a way that makes it more difficult to retrieve material under conditions that require the control system to generate preliminary descriptions, thereby causing faults in the verification of retrieved material. In contrast, the dissociated-experience model proposes that hypnosis blocks access to memories and awareness in a barrier-like, comparatively all-or-nothing, fashion (Woody & Bowers, 1994).

Critique: Kirsch and Lynn (1997) have argued that there are two major problems with the dissociated-control model. Firstly, it cannot explain self-hypnosis because the weakening of executive control would require that the suggestions be externally administered. In this situation there is no hypnotist or other external stimulus to instigate a behavioural schema, and any weakening of frontal control ought to make it more difficult for the central executive to do so (Kirsch & Lynn, 1998a). In reply to this, Woody and Sadler (1998) have pointed out that, because executive control is indeed only weakened rather than totally eliminated, the possibility of self-hypnosis is not excluded. Be this as it may, although the dissociated-control view may not preclude self-hypnosis, neither does it explain it (Kirsch & Lynn, 1998b).

Although not part of the explanation for the dissociated-control view, there is mounting evidence that highly hypnotisable person's exhibit greater cognitive flexibility and in particular a greater capacity for focused attention and disattention of extraneous (distracting) stimuli (see section 5.7.2., p. 202). Highs appear to possess a greater capacity to shift between modes of cognitive processing, that is from a strategic processing style involving the ongoing monitoring and evaluation of environmental stimuli and concurrent demands, to a largely autonomous and automatic processing style devoted to the performance of a single task and inhibition of extraneous information. The hypnotic procedure may facilitate this shift by guiding the person's cognitive activity towards selectively focused attention on the suggested state and away from part or all of the actual sensory or cognitive experience. High hypnotisables could be seen as having both the means (an inherent capacity for greater cognitive flexibility) and the method (a greater responsiveness to hypnotic suggestions) to enable successful hypnotic responding.

High hypnotisables tend to be more involved in the hypnotic procedure and have a more positive view of the hypnotist. However, unlike low hypnotisables, they are relatively immune to manipulations of the interpersonal relationship between hypnotist and hypnotic subject. High hypnotisables have been found to be just as responsive to hypnotic procedures when these are administered by a hypnotist who acts in an unfriendly, critical, and aloof manner than when the hypnotist interacts in a friendly, engaging manner designed to establish rapport and increase feelings of comfort and security (Lynn, Weekes, Neufeld, Zivney, Brentar, & Weiss, 1991). Low hypnotisables, on the other hand, were more responsive when the hypnotist behaved in the optimum interpersonal condition than in the less optimum condition. These results are supported by findings of earlier research into the interpersonal climate between hypnotist and hypnotic subject (see McDermot & Sheehan, 1976; Perry & Sheehan, 1978; Sheehan, 1980). They indicate that hypnotic rapport is not sufficient to account for differences in hypnotisability (Gfeller, Lynn, & Prible, 1987). High hypnotisables tend to exhibit a vigilance for, and sensitivity to, matters that might enhance their responsiveness (e.g., slight variations in the wording of suggestions). In contrast, low hypnotisables appear to exhibit a lack of preparedness to respond to the hypnotist in the absence of special efforts to improve the hypnotist-subject relationship.

In fact, certain unhypnotisable subjects appear to be motivated to actively and purposefully assert their independence from the hypnotists influence (Lynn, Rhue, & Weekes, 1990). This was also evident from remarks made by some low-hypnotisable subjects who failed to pass any or virtually any suggestions during the hypnotic screening part of the current study.

People are in general responsive to demand characteristics and role expectancies, particularly when these are presented in a favourable manner and social context. If, as the social-psychological model proposes, compliance with expectancies and role demands is the main determinant of hypnotic responding, why then are such a large proportion of the population unresponsive to hypnosis even when this is presented as being favourable. A possible reason might be that these people, based on prior experience, either know or strongly expect that they are less apt to engage in the cognitive mode that characterise hypnosis and hypnotic-like experiences. As we will see, there are neuro-psychological and neurophysiological indicators that high and low hypnotisables differ in certain cognitive processes in both the hypnotic as well as nonhypnotic state.

It appears that, for people with high hypnotic susceptibility, hypnotic responsiveness is influenced mainly by the hypnotic procedure and context, rather than by the particular hypnotic suggestion or who delivers it. Self-hypnosis does not really alter the context of hypnosis nor its general content (i.e., relaxation, the gradual adoption of a receptive state, exclusive focus on suggested imagery, and a reduced awareness of external information). This change in cognitive mode is primed by the hypnotic instructions, rather than by the interpersonal interaction with the hypnotist. During self-hypnosis the person may gradually move from being the hypnotist who initiates and directs the procedure to becoming the hypnotised person. These two functions are neither mutually exclusive nor incompatible. As the person concentrates on the hypnotic process he or she gradually moves from the executive controlled initiation of the hypnotic process into an increasing reliance on the particular automatically controlled subsystems (schemata) that become activated by the hypnotic suggestions.

The second problem according to Kirsch and Lynn (1997) is that the dissociated-control explanation relies on the induction of a special state or condition to produce relatively simple and common ideomotor responses. However, performance of these simpler suggested behaviours does not require the process of dissociation (Bowers, 1990; Hilgard, 1977). They can also be achieved by using nondissociative means (e.g., absorption, imaginative involvement, or responding to demand characteristic and role expectancies). It is only the more difficult suggestions (i.e., those involving perceptual or cognitive distortions such as hallucinations, analgesia, or posthypnotic amnesia) that require the ability to dissociate levels of cognitive control for their successful performance. It is true that hypnotic and nonhypnotic suggestibility are highly correlated (about .85, Barber & Glass; Hilgard & Tart, 1966), and that a formal hypnotic induction per se has only a relatively small effect on suggestibility (Barber, 1969; Hilgard, 1965; Spanos et al., 1989; Tenenbaum et al., 1990; Wadden & Anderton, 1982). This may suggest that responses to hypnotic and nonhypnotic suggestions are brought about by the same causal mechanisms and that the induction of a hypnotic state is not one of those. However, as section 5.7. (p. 198) will show in more detail, there is substantial neurophysiological evidence that people who are highly hypnotisable posses a greater cognitive flexibility including a greater capacity for focused attention and for disattention to extraneous stimuli.

The fact that both the dissociated-experience account and the dissociated-control account argue that only persons who are highly responsive to hypnotic suggestions are able to effectively achieve the proposed dissociations does pose some problems. This means that any study designed to investigate the mechanisms of hypnosis must first accurately and reliably separate those subjects who are either highly responsive or relatively unresponsive to hypnotic suggestions from the majority who fall somewhere in between. The question remains how well standard hypnotic-susceptibility tests are able to do this, and in particular whether, as some studies (e.g., Balthazard & Woody, 1992; Laurence and Perry, 1983; Szechtman, Woody, Bowers, & Nahmias, 1998; Woody, & Sadler, 1998) indicate that there are distinct subsamples of responsiveness among the group that is generally regarded as highly responsive (i.e., those passing 9 or more items on standard hypnotic-susceptibility tests such as the HGSHS, SHSS, or WGSC).

5.6.2. **The social-psychological model of hypnosis**

5.6.2.1. *Effortful goal-directed actions and misattribution of experience*

The social-psychological account of hypnosis, which is a variant of the wider group of sociocognitive theories, rejects the assumption that hypnotic behaviour results from an unusual mental state or process (Barber, 1969; Sarbin & Coe, 1972; Spanos & Chaves; 1989; Wagstaff, 1991). While several researchers have proposed variations that each emphasise different aspects of the sociocognitive perspective, they all maintain that, despite its nonordinary appearance, hypnotic behaviour is fundamentally similar to other forms of social contact and can be accounted for without recourse to special psychological states or processes such as dissociation and the construction of amnesic barriers (Spanos, 1991; Spanos & Coe, 1992).

Most promenent among the sociocognitive theories of hypnosis is the social-psychological model of Nicolas Spanos. This view is based on the notion that people are sentient agents that are continually involved in organising sensory inputs into meaningful schemata that are used to guide their actions (Spanos, 1991). People are strongly influenced in determining and attributing their actions by their understanding of the situational context, their own self-representations, and the role they perceive to be most appropriate for the particular situation. Hypnotic behaviour is argued to be no different from behaviour in other social contexts, and is seen to result from effortful, goal-directed actions by motivated individuals who are attuned to the contextual demands of the hypnotic situation and generate experiences and enact behaviours to meet what they tacitly understand to be the role of the hypnotic subject (Coe & Sarbin, 1991; Spanos, 1991).

People are prone to misattributions about the cause of their behaviour and this is not exclusive to hypnotic contexts as is evident in many everyday situations (see e.g., Nisbett & Wilson, 1977). Hypnotic performances are seen to be shaped by the same needs that affect people outside the hypnotic context including the need to maintain a sense of personal control, self-esteem, and the regard of others, along with the need to optimise affect and minimise conflict (Lynn, Rhue, & Weekes, 1990). All of these factors can be important response determinants.

We typically attribute our own and others experiences to being either "actions," which are voluntary and determined by the actor's will, or "occurrences" or "happenings," which are perceived as involuntary and caused by factors other than the self (Kruglanski, 1975). We tend not to accept direct responsibility for "occurrences or happenings (Coe, 1978; Sarbin & Coe, 1979). It is, therefore, not surprising that misrepresentations of private experiences are not uncommon, particularly in social situations where they may be perceived as appropriate ways to facilitate interpersonal relations (Kiesler & Kiesler, 1970). Sociocognitive theorists argue that this tendency is further enhanced by the nature of hypnotic procedures.

The experience of hypnosis as being involuntary is seen to be invoked by multiple factors including: a person's preconceptions about hypnosis (e.g., Lynn, Nash, Rhue, Frauman, & Sweeney, 1984; Spanos, Brett, Menary, & Cross, 1987), the structure and wording of the suggestions (e.g., Spanos & Gorassini, 1984), the patterns of imaginative activity that accompany a response to many suggestions (e.g., Spanos & Barber, 1972), context-generated expectancies (e.g., Kirsch, 1985), and self-observations of hypnotic responses (Coe & Sarbin, 1977, 1991).

The structure and wording of a typical hypnotic induction and suggestion provides many cues, both subtle and explicit, that create a relaxed and passive (receptive) state; direct attention inwards, thereby diminishing the effect of external influences; and reduce normal vigilance and critical thought. These factors are all conductive to defining self-generated responses as involuntary. It is, therefore, seen as not surprising that people with high hypnotic susceptibility typically report their hypnotic behaviour as involuntary. Apart from being more susceptible to suggestions anyway, they are likely to attribute the cause of their responses to the hypnotic process as they are motivated to act consistent with what they perceive to be the role of a good hypnotic subject. The imaginative activity involved in many hypnotic suggestions and procedures may further assist to legitimise and reinforce this process (Lynn, Rhue, & Weekes, 1986). The hypnotic context can thus enhance people's readiness to attribute the suggested actions to automatic "occurrences," rather than their own wilful actions. This may be reinforced by situation-specific beliefs people hold.

McConkey (1984, 1986) and Wilson, Greene, and Loftus (1986) found that most people have a prehypnotic belief that the experience of nonvolition is a key attribute of hypnosis. Compliance with expectancies and perceived clues as to what is the role of a good hypnotic subject are seen as an important component of hypnotic responding (Wagstaff, 1991).

Advocates of the social-psychological view maintain that hypnotised people actually retain control over their behaviour, but, as a result of such misattributions based on context-generated interpretations of their goal-directed actions, frequently perceive and report them as being involuntary (e.g., Lynn et al., 1990; Lynn, Rhue, & Weekes, 1989; Spanos, Rivers, & Ross, 1977; Spanos, 1986). They see this as being in direct contrast with "special-process" theories. However, the dissociated-control view does not state that hypnotic subjects hand over control of their actions to the hypnotist, rather control of their behaviour takes place on a subconscious and automatic level. Automatic meaning, controlled within itself and not reliant on external monitoring and control. Theorists favouring the social-psychological account argue that the structure of the instructions and particularly the passive wording of suggestions is an important factor in determining whether the behavioural response is reported as involuntary.

Several studies have compared subjects reactions and reports to information delivered as either direct instructions (e.g., Raise your arm) or passively worded suggestion (e.g., Your arm is rising). Combined results showed that: (1) subjects almost always made the requested response following direct instructions (describing voluntary action), but frequently failed to do so when given the suggestions (describing an involuntary happening); (2) subjects rated their responses as more involuntary when given the suggestions as opposed to the instructions; and (3) these relationships were roughly equivalent for hypnotic and nonhypnotic conditions (e.g., Spanos & Barber, 1972; Spanos & de Groh, 1983; Spanos & Gorassini, 1984; Spanos & Katsanis, 1989). Based on these results, Spanos and Katsanis (1989) suggested that subjects in hypnotic and nonhypnotic conditions are equally likely to use cognitive coping strategies, and that the extend to which subjects define their pain reductions and their use of coping strategies as effortful or involuntary is more closely related to the wording on the instructions than to the definition of the situation as hypnotic or nonhypnotic.

This is in direct contrast to the conclusion reached by Miller and Bowers (1986) that hypnotic analgesia occurs as a result of a dissociative process (i.e., without strategic involvement in cognitive strategies), whereas nonhypnotic analgesia is mediated by the use of cognitive strategies.

5.6.2.2. *Further results from real-simulator control experiments and conclusions reached* ⊙

Spanos and Hewitt (1980) have criticised Hilgard's interpretation of the hidden observer phenomenon and have argued that it is an artefact of experimenter induced demands (i.e., a particular form of instructions whose wording strongly suggests compliance). They were able to demonstrate the phenomenon when using instructions similar to those used by Hilgard et al. (1975), but failed to do so when a different form of instructions was used. Hidden observer instructions are often (but not always) worded in such a manner as to convey to the participant that the experimenter expects that such a hidden part will emerge (e.g., Hilgard et al., 1978). The number of highly responsive participants who display a hidden observer response has been found to vary substantially depending on the explicitness of instructions provided, ranging from as low as 14% in some low cue situations to as high as 94% in some high cue conditions (see e.g., Crawford et al., 1979; Hilgard et al., 1975; Laurence & Perry, 1983; Maré., Lynn, Kvaal, Segal, & Sivec, 1994; Spanos, Gwynn, & Stam, 1983; Spanos & Hewitt, 1980). Furthermore, Spanos, de Groot, Tiller, Weekes, and Bertrand (1985) found roughly similar frequencies of hidden observer responding among hypnotised participants, simulators, and unhypnotised imagination control participants following high-demand hidden observer instructions. The vast majority of participants in all three conditions reported higher hidden than overt pain. The failure to find differences in the frequency of hidden observer reports between hypnotic and nonhypnotic conditions indicates that hidden observer responding is not exclusive to hypnotic situations, which is acknowledged by Hilgard and colleagues.

Other researchers have conducted a series of studies using the real-simulator design to further examine hidden observer responding and the effect of situational cues (see e.g., Hilgard et al., 1978; Laurence & Perry, 1981; Maré et al., 1994; Nogrady et al., 1983). Remember that real-simulator studies can identify the presence of demand characteristics that are powerful enough to engender hidden observer responding (see p. 162). If simulators are found to display a hidden observer response, it can not be excluded, nor confirmed, that hidden observer responding by truly hypnotised participants (reals) might also result from situational cues.

Hilgard et al. (1978) found that 75% of low-suggestible simulators, but less than 50% of the highly suggestible reals displayed an hidden observer. However, this difference did not reach statistical significance, at least not for the small sample sizes used (n=12/condition). The direction of this difference is in line with the common finding in simulation experiments that simulators tend to overreact. During an honesty inquiry at the end of the session, none of the reals modified their reported pain, but all of the simulators did. For them, play-acting the experience of hypnotic analgesia did not resulted in any pain reduction beyond what they previously had experienced when honestly responding to nonhypnotic analgesia suggestions (e.g., attention diversion). Simulators had been quite successful in simulating the effects of hypnotic analgesia and the hidden observer report, but the actual experiences of reals and simulators proved to be very different (Hilgard et al., 1978). This was consistently supported by comments made during a separate postexperimental interview. Half of the reals who reported the hidden observer effect were sceptical of the phenomenon before the experiment and the other half thought it to be plausible. On the other hand, some reals who did not experience a hidden observer reported before the test that they believed such a phenomenon might indeed exist. This lack of correspondence between expectations and subsequent reports of a hidden observer part, despite the presence of explicit and strong response cues, does not fit well with the social-psychological explanation that the hidden observer phenomenon is an experimental creation resulting from compliance with situational demands (Spanos, 1983).

Laurence, Perry, and Kihlstrom (1983) concluded that there are to many loopholes in Spanos and Hewitt's design (e.g., failure to replicate Hilgard's procedure, differential treatment of experimental and control group) to warrant the absolute and categorical conclusion reached by these authors that the hidden observer phenomenon is an experimental creations (see Spanos, 1983 for a reply to this critique). They criticise Spanos and Hewitt for holding the dogmatic view that the hidden observer phenomenon is either a genuine hypnotic experience (which they refute) or an experimental creation.

This completely overlooks the plausible option that some highly susceptible individuals may genuinely experience a duality in awareness, but that its manifestation can be influenced by experimenter cues, contextual demands, and subject's beliefs and expectations (Laurence et al., 1983). Because hypnosis has a large component of suggestion in it, experimenter expectations are always implied in the instructions given. After all hypnosis is an interpersonal phenomenon and without suggestion nothing happens in hypnosis. (Kihlstrom, 1998).

The studies by Laurence and Perry (1981) and Nogrady et al. (1983) also included a postexperimental interview in their design. Theirs was a structured interview following the Experimental Analysis Technique (EAT) based on interpersonal process-recall techniques originally used during counselling and further developed by McConkey (see Sheehan, McConkey, & Cross, 1978). The interview has subjects watch a video recording of the session to assist their recall. The tape is stopped at predetermined points and subjects are asked to describe their experiences. In addition, subjects can ask the investigator to stop the tape at any time when they want to make some comments. During the EAT inquiry, participants are also asked some specific questions about hidden observer experiences. Sheehan et al. (1978) comment that the subjective information offered during these interviews (e.g., individuation of subject's behaviour, nature of rapport, subject's cognitive style) reveals that the objective measures of hypnotic performance (test scores, response ratings) are frequently misleading indices of the complexity of the experience involved. All investigators were blind as to which participants were highly hypnotisable and genuinely responding and which were simulating to be highly hypnotised.

Hidden observer instructions in the Laurence and Perry (1981) and Nogrady et al. (1983) studies included that there *may* be another part of them that, if present, could be aware rather than Hilgard's instructions that there *is* another part ... etc. Both studies used subject's reports of multiple levels of awareness as criterion for a hidden observer response, rather than subject's pain reports.

Nogrady et al. (1983) carefully designed their hidden observer instructions to minimise any compliance cues. Furthermore, a third member of their investigative team independently rated aspects of the experiment that specifically related to dissociation and the hidden observer experience. Because this study used unconventional criteria for classifying hypnotic susceptibility, some caution is needed when interpreting their results. Participants with hypnotisability scores of six or below were classified as low suggestible and those scoring seven or above were classified as high medium or as high when the items passed included the amnesia suggestion. Nevertheless, the results reveal a clear pattern. Five out of twelve (42%) highly susceptible participants experienced a hidden observer compared to none of the participants with high-medium or low hypnotic susceptibility. These carefully controlled results support the earlier findings by Hilgard (1978) and Laurence and Perry (1981). The fact that none of the simulators experienced the hidden observer suggest that the procedure used by Nogrady et al (1983) did not carry cue demands for hidden-observer responding and was successful in eliciting, but not creating, the hidden observer response in some highly susceptible participants.

A further examination of responses to individual items of the prior hypnotic-susceptibility test revealed an important clue that might explain why some highly susceptible participants report hidden observers and others do not. One of the hypnotic suggestions involves an age regression to when participants were five years old. This experience can take two forms. In the first form participants become completely absorbed in the experience of being a five-year-old child again. In the second form they also return to their childhood, but in addition preserve an adult observer part that is aware of both the inward experience of the child and the environmental context of the experiment (Hilgard, 1994). This duality of experience (adult-child) has some similar characteristics to the hidden observer experience.

Both Laurence and Perry (1981) and Nogrady et al. (1983) found an almost perfect correlation between the presence or absence of this duality experience and the subsequent experience of a hidden observer during pain. However, and this is the interesting part, the observed correlation was opposite to what would be expected if participants simply complied with the hypnotist's demands. The hypnotist's suggestion to become a child again does not imply preserving an adult observer part. Yet, both studies found that all participants who reported a hidden observer (high-susceptibles only) also displayed this uncued duality in age regression, while none of the simulators experienced duality during age regression.

These findings suggest that the same cognitive process might be involved in both types of suggestions (Nogrady et al., 1983). Comments made during the postexperimental (EAT) inquiry confirmed that the experiences of reals and simulators were very different. For example, Laurence & Perry (1981) observed that 9 out of 23 participants (39%) reported a hidden observer. Seven of these attempted to write down what year it was and copied the sentence "I am participating in a psychological experiment" during the age regression item, and 4 did so without making spelling mistakes. Verbal reports further indicated that all those who experienced a hidden observer also expressed a strong feeling of duality during age regression, either by simultaneously being child and adult or by switching between them. They reported the hidden observer during hypnotic analgesia as occurring involuntary and equated it in an objective and matter of fact way with reality testing. Those who wrote down the sentence correctly saw no contradiction between doing so and the fact that most of the words they spelled were way beyond the capacity of most 5-year-olds.

By contrast, of the 14 participants who did not experience a hidden observer, 10 made no attempt to write a reply to the age regression questions, and only 1 of the 4 who responded did so without making a spelling mistake. They commented that either they did not understand the sentence or it was too difficult for them. Verbal responses also indicated that none experienced the child-adult duality and that they frequently were confused by the hidden observer instructions. Some were annoyed upon being told that there was another part that was aware of the pain.

Others felt regret that they had to disappoint the experimenter in being unable to experience the suggested part. They were quite definite in stating that they did not experience the effect although they waited for it to happen.

The consistently observed heterogeneity of hidden observer reports that is exclusive to high hypnotisables parallels other findings across a range of hypnotic phenomena which show that roughly half of all high-susceptible subjects display trance logic (Orne, 1959; Sheehan, Obstoj, & McConkey, 1976), counter preconceptions about hypnosis (Sheehan, 1980), show posthypnotic persistence of an uncancelled suggestion (Perry, 1977), and breach posthypnotic amnesia (McConkey & Sheehan, 1981). In none of these cases was the response pattern directly related to the overall level of hypnotic susceptibility.

Nogrady et al. (1983) suggest that this variability among highly hypnotisable subjects might reflect the styles or modes of cognition that are used by each subgroup. Comments made during the postsession interview appear to support this notion. All of the subjects who reported a hidden observer indicated that this experience was not unique or even unusual for them as they often experience a feeling of detachment in everyday situations. The hypnotic procedure simply provided them with a context for this phenomenon.

Nogrady et al. (1983) proposed the hypothesis that highly hypnotisables who report multiple levels of awareness might also be highly skilled in dividing their attention. This might make them better able to simultaneously process real and suggested information in a way that facilitates hypnotic responding. Studies in nonhypnotic situations have clearly shown that tasks can be easily executed when input is processed simultaneously into awareness (Hirst et al., 1980; Spelke Hirst, & Neisser, 1976). The other group of highly hypnotisables might be more deeply involved in their hypnotic experience (i.e., exhibit more focussed attention) and, therefore, be less likely to experience multiple levels of awareness. Further research could examine if the presence or absence of hidden observer experiences is correlated with differences in the level of hypnotic depth or the degree of absorption.

An alternative hypothesis could be that those who experience a hidden observer are high in self-monitoring and highly self-conscious, while those who do not experience the hidden observer effect might be relatively low on these variables. However, it would seem to the current author that individuals who are high in self-monitoring and highly self-conscious would be less likely to be good hypnotic subjects. Although this could be influenced by perceived role demands, it is inconsistent with the finding that the level of hidden observer responding among genuinely hypnotised individuals falls only very slightly in low cue situations (see Nogrady et al., 1983).

Taken together studies indicate that, for both simulators and nonsimulators, the rate of hidden observer responding varies as a function of the nature and explicitness of the instructions used to communicate with it. However, they do not seem to vary to the same degree. Very explicit and highly demanding response cues lead to a high rate of hidden observer reports, about 86% for simulators and around 79% for hypnotised participants (Spanos et al., 1985). With moderately demanding cues, response rates fall to about 50% for those who are truly hypnotised, but remain high at about 75% for simulators (Hilgard et al., 1978). Martin and Lynn (1996) suggest that this frequent finding might result from the fact that simulators are not constrained by the demand for honesty and, therefore, more likely to overplay their role. When demand cues are weak, the rate of hidden observer reports for hypnotised participants falls only slightly further to 42%, but drops to 0% for simulators (Nogrady et al., 1983). This suggests that at least some highly hypnotisables are not faking.

Proponents of the social-psychological view argue that these differences in the rate of hidden observer reports results from the fact that hypnotised participants and simulators have different roles and respond to situational cues in accordance with their roles. Really hypnotised individuals are seen to respond in terms of their perceived experiences. Simulators, however, role-play and are argued to face response costs (e.g., experimental termination and exclusion from the study) if their pretence is detected (Kirsch & Lynn, 1998b). When situational demands are subtle and ambiguous, simulators respond conservatively and report no hidden observer. However, when there are strong response cues and it is clear how a good hypnotic subject should behave, simulators produce more hidden observer reports.

Spanos and colleagues have also demonstrated that hidden observer reports are not limited to the recall of the original stimulus, but can be manipulated and are highly sensitive to the nature of the instructions given to elicit them. Depending on the instructions, the hidden observer might experience, for example: either more or less pain; things in normal view or in reverse; or even two hidden observers, one storing memories of abstract words and the other storing memories of concrete words (Spanos & Hewitt, 1980; Spanos, Flynn, & Gwynn, 1988; Spanos et al., 1983; Spanos, Radtke, & Bertrand, 1984). A subsequent set of studies did demonstrate that the apparent division in consciousness could be produced by instructions similar to those used to elicit the hidden observer (Spanos, Flynn, & Gabora, 1989; Spanos & McLean, 1986; Spanos, Perlini, Patrick, Bell, & Gwynn, 1990). Based on these results, Spanos and Coe (1992) conclude that hidden observer reports are best explained as resulting from reporting bias due to the situational demands of the instructional cues. Furthermore, several studies have demonstrated that hypnotic subjects can resist suggestions when resistance is defined as consistent with the role of a good hypnotic subject (e.g., Lynn et al., 1984; Spanos, Cobb, & Gorassini, 1985). The subjective experience of involuntariness is seen to result from the fact that hypnotised subjects simply do not appreciate in second-order consciousness the power of the hypnotic suggestions and demands, despite the fact that they are very direct and explicit demands to behave in a particular way (Bowers, 1990).

Kirsch and Lynn (1998b) argue that such flexible observer responses do not fit the hidden observer explanation provided by neodissociation theory. According to Hilgard (1986), the role of the hidden instruction is to reveal the division in consciousness, not to create a division in consciousness. The nature of the hidden observer should thus depend on the type of suggestion given and not on differences in the wording of hidden observer instructions (Kihlstrom, 1998b).

It is generally agreed that hidden observer responses in at least a portion of highly susceptibles are not faked and reflect genuine shifts in subjective experience. What is debated, though, is the origin of this effect. It appears that a specific instruction is needed to engender the hidden observer report of covertly experienced pain.

Hilgard and colleagues view the hidden observer phenomenon as more than compliance with situational cues, and see it as direct evidence of dissociation of consciousness (e.g., Hilgard, 1986). The hidden observer reports are seen to originate from the undivided part of the executive ego that fully experiences the stimulus and has normal access to this remembered information that is temporarily unavailable to the part of the executive control structure that is separated from consciousness. They argue that the hidden observer is a spontaneously occurring phenomenon in response to the hypnotic induction, and that the function of the hidden observer instructions is merely to provide access to the separated part of consciousness.

Spanos and Coe (1992), on the other hand, conclude that hidden observer reports are best explained as resulting from reporting bias due to the situational demands of the instructional cues. Hidden observer instructions constitute just another type of hypnotic suggestion, in this case one that creates the apparent division of consciousness. The hidden observer is simply seen as one of the many experiences that can be produced by suggestion and thus as an experimental creation rather than an outward manifestation of the basis of hypnotic responding (e.g., Spanos, 1986).

A satisfactory resolution to this debate is obviously hindered by: the difficulty to attribute causal factors to subjective reports of private experiences that are highly sensitive to demand characteristics; the difficulty to design hypnosis experiments that adequately control for such factors; and the difficulty for other researchers to evaluate post hoc how well demand characteristics were indeed controlled for.

5.6.2.3. *Critique of the social-psychological view of hypnosis*

The social-psychological explanation of hypnotic responding is also not without its problems. It is not consistent with Norman and Shallice's model of attentional processes. In the context of this model, hypnosis and cognitive-behavioural strategy have opposite effects. Cognitive-behavioural pain coping strategies require strong ongoing activation of the supervisory system.

An important feature of such a state of high concentration and focussed attention is that a lapse in its effortful maintenance brings failure of the perceptual control. Hypnosis is suggested to involve a weakening of the supervisory control system. The ultimate effect of this should be to diminish the capacity for initiating and maintaining a well-organised set of deliberate attentional strategies, not to increase it. People who are highly hypnotisable would not be expected to be very good at self-generating attentional control strategies nor at effortfully maintaining them (Woody & Bowers, 1994). In support of this, Hargadon et al. (1995) did show that effective hypnotic analgesia could be obtained in the absence of any deliberate cognitive strategies, such as engaging in goal-directed counterpain imagery. A completely unelaborated hypnotic suggestion for the reduction of pain seems sufficient to produce analgesia in highly hypnotisables. This suggests that deliberate attentional control is not the main mechanism underlying effective hypnotic analgesia, or at least is not the sole mechanism whereby this can be achieved.

5.6.3. **Predictions regarding attentional involvement**

The different theories of hypnosis offer diametrically opposed predictions about the attentional involvement of executive control and the expected level of interference during dual-task performance. This enables researchers to develop a direct test of both proposed dissociative mechanisms.

Both the dissociated-experience model and the social-psychological model view hypnotic responses as intentionally performed effortful (i.e., attention demanding) acts. In the case of the social-psychological explanation this is represented by the strategic effort required to act in accordance with expectancies and perceived role demands. In the case of the original neodissociation (i.e., dissociated experience) explanation, cognitive effort is needed to create and maintain an amnesic barrier that keeps the dissociated stream of mental activity out of conscious awareness (Hilgard, 1986). These cognitive resources must be diverted from other ongoing activity. Both these theories, therefore, predict more rather than less interference when one of two competing tasks is performed in response to hypnotic suggestions.

The dissociated-control model, on the other hand, predicts that the automatic activation of the targeted subsystem(s) bypasses the need for executive and attention-demanding cognitive control and should result in a measurable lower cognitive cost. The simultaneous performance of two tasks should, therefore, result in less interference when one is performed hypnotically.

Findings from studies that have examined task interference have been inconsistent and equivocal. Stevenson (1976) and Knox, Crutchfield, & Hilgard (1975) observed the largest task interference in situations where conscious (deliberate) performance on one task was combined with subconscious performance on another task. This is consistent with predictions based on the dissociated-experience model, but inconsistent with those of the dissociated-control model. Observations by Bowers and Brenneman (1981) initially appeared to support the notion of dissociated control, but were found in a follow-up study to be attributable to passive attention rather than hypnosis. Finally, Green and Lynn (1995) obtained results that were inconsistent with predictions of both models of dissociation.

Miller and Bowers (1986) found that highly hypnotisable subjects were able to achieve hypnotic analgesia without reporting any deliberate strategy use. In contrast, subjects using stress inoculation, a combination of cognitive coping strategies, achieved pain relief only when, and to the extent that, they became involved in the effortful use of coping strategies. Neither strategy use nor pain reductions were correlated with hypnotic ability. This suggests that, pain reductions achieved by hypnotic and nonhypnotic interventions are brought about by different means. Results are inconsistent with sociocognitive theories and are most easily explained by the dissociated-control explanation of neodissociation theory. To provide a more distinctive test of dissociation theories, Miller and Bowers (1993) conducted a follow-up study that also measured task interference on a simultaneously performed attention-demanding secondary task as a direct measure of cognitive effort involved in both hypnotic and nonhypnotic interventions for the relief of pain and distress. These two studies by Miller and Bowers form the basis for the experiment in the current study and will be discussed in more detail in Chapter 6.

5.6.4. Signs of a rapprochement: sociocognitive and dissociation explanations may apply to different ends of the contiuum of hypnotic responding

As Kirmayer (1992) has stated, hypnosis can be seen as special -- if only for the magical expectations it conjures and the conceptual confusion it provokes. Common responses to this confusion have ranged from credulous awe to sceptical debunking. Whereas some practitioners have uncritically and self-servingly regarded hypnosis as being mysterious and beyond ordinary understanding, others have resorted to at times rather personal critiques to attack such positions. Both of these extreme responses have done little to promote legitimate scientific investigation (Bowers, 1992; Coe, 1992).

Based on the differences in their theoretical explanations of the hypnotic process, theorists have often been grouped into two opposing camps (i.e., special process versus sociocognitive theorists). Unfortunately, such a division obscures at least as much as it reveals, and does not account for the substantial heterogeneity within each camp (Kihlstrom, 1992). This approach seems increasingly less warranted as evidence is mounting that, for most contributing factors, differences between the hypnotic and nonhypnotic state are best understood as existing along a continuum rather than as resulting from a state versus nonstate or trait versus situation (context) interpretation. Kirsch and Lynn (1995) have, therefore, strongly argued that the different theoretical explanations are best viewed as different positions taken along these continua. Although social discourse and narrative may shape the hypnotic experience to a considerable extend, they themselves are influenced by mechanisms of attention and automaticity (Kirmayer, 1992). Thus, a broader understanding of hypnotic experience must consider both cognitive processes and social context. Neodissociation theory draws attention to dissociations, the very interesting but previously ill-considered aspects of many facets of mental life, while sociocognitive theories highlight the importance of attitudes, beliefs, motivations, expectations, and role playing. When put together, they provide the beginning of a comprehensive theory of hypnosis (Kihlstrom, 1998).

It is not only possible, but also appears increasingly more likely, that hypnosis involves not just one, but two or even more processes, and thus evidence in favour of one is not necessarily evidence against another (Woody & Sadler, 1998).

There are a number of possible ways in which the attributes underlying successful hypnotic responding might interact. Sociocognitive and special-process effects can be separate but coexisting, both aiding in the production of hypnotic performance, but in a way, that is not more than the sum of them both. This additive model appears to be the most common view (e.g., Tellegen & Atkinson, 1978/1979). The combined effect may also be synergistic; that is, each mechanism potentates the other and their joint influence is greater than the two individual parts. Finally, the interaction might be disjunctive. In this situation, being high on both does not yield any better performance than being high on any one. According to the disjunctive model, individuals who possess at least moderate levels of both attributes can enact the given suggestions in either way. Rather than expecting that any one of the currently proposed theoretical accounts of hypnosis provide a comprehensive explanation for all hypnotic phenomena and their underlying mechanisms, it appears to be more profitable to consider that they each shed light on the subject matter from different angels and provide some insights that other views conceal (Woody & Sadler, 1998).

Several independent studies have recently provided strong indications that individual differences in hypnotic responding may reflect differences in kind (i.e., underlying mechanisms) rather than differences in dimension (i.e., position along a continuum of a single trait). For example, a set of studies by Oakman and Woody (1996) provided clear indications that individual differences in hypnotic susceptibility may be typological rather than dimensional and that the processes used by people who are highly responsive to hypnotic suggestions differ in a fundamental and qualitative way from those used by people who are relatively unresponsive. In addition, Woody, Drogovic, and Oakman (1997) found that individual differences in response to nonhypnotic suggestibility (alcohol expectancy placebo) were quite strongly correlated with responsiveness to easy suggestions (direct motor items) in an unrelated hypnotic context using the HGSHS:A. However, correlations with more difficult (challenge) items were weak and trailed toward zero as items became harder.

While expectancies appear to be a major determinant for passing easy items, the passing of more difficult items had virtually nothing to do with expectancy effects. This suggests that different processes underlie the ability to pass each type of items.

The nature of such a latent typology of hypnotic ability would best be measured by an approach that considers multiple indicators, much like that used in diagnostic research. Possible factors that have been suggested and would be consistent with a typology of hypnotic ability include: absorption and imaginative involvement, dissociation, differences in cognitive flexibility, and the existence of a genetic component to hypnotic ability.

Another very interesting finding has been that these individual differences appear to apply not only to the distinction between low and high hypnotic ability, but are also evident within the population of highly hypnotisable people who normally are considered to be, and treated as, a single homogeneous group. For example, Nogrady et al. (1983) found that only those high hypnotisables who reported the uncued experience of an adult observer during age regression did experience a hidden observer during hypnotic analgesia. Furthermore, a recent PET of auditory hallucinations by Szechtman et al. (1998) found that highly hypnotisable subjects who could readily hallucinate during hypnosis displayed strikingly different patterns of brain activation from highly hypnotisable subjects who were relatively incapable of hallucinations not only during the hypnotic hallucination condition, but also while simply listening to a brief recorded message.

Schnyer and Allen (1995) also observed changes in 40 Hz EEG activity among high hypnotisables. Although close to half of all college students have been found to pass recall amnesia, only a small proportion (approx. 5%) exhibit recognition amnesia (Kihlstrom & Register, 1984; Kihlstrom & Shor, 1978). The standard criteria for recall amnesia involve recalling three or fewer test items following suggested amnesia. Recognition amnesia has been measured as identifying 25% or fewer presentations of words learned under hypnosis, but covered by an amnesia suggestion, when these are intermingled with another list of words also learned under hypnosis that has not been covered by an amnesia suggestion.

Schnyer and Allen found that high hypnotisables (highs) who reported recognition amnesia differed electrophysiologically prior to hypnosis (i.e., exhibited higher 40 Hz activity) from highs who did not show recognition amnesia, from low hypnotisables (lows) who successfully simulated recognition amnesia to a similar extend, and from nonsimulating lows. High frequency EEG activity round the 40 Hz has been identified to correlate with focused attention (De Pascalis, 1993; De Pascalis & Penna, 1990; Loring & Sheer, 1984). Highs who reported recognition amnesia could also be distinguished from both groups of lows *during* hypnosis by a larger N1-P1 component of event related potentials. Lows did not significantly differ from each other, regardless of whether they successfully simulated recognition amnesia or not. Highs who did not experience recognition amnesia did not differ significantly from highs who did or from both groups of lows. Hypnotic susceptibility and recognition amnesia were assessed during the same session to control for variability over time.

These findings suggests that there may be important and psychophysiologically relevant individual differences among those traditionally classified by standard measures of hypnotic susceptibility as the single category of "highly susceptible" (Schnyer & Allen, 1995). Only those who exhibit exceptional hypnotic susceptibility (i.e., pass suggestions involving marked perceptual alterations, such as amnesia or hallucinations) appear to display the characteristic increase in 40 Hz activity identified with focused attention. This apparent heterogeneity among high hypnotisables is consistent with findings by Balthazard and Woody (1992) and supports their conclusion that absorption is primarily related to more difficult hypnotic performances.

As indicated, a proportion of hypnotic subjects are simply unresponsive to hypnosis. They frequently have a negative view of hypnosis and/or their ability to perform the suggested behaviour and intentionally decide to resist the suggestion. Others vary in their level of responsiveness, and the different theoretical explanations of hypnosis may primarily apply to different aspects of this spectrum.

Norman and Shallice's model of attentional processing provides an intriguing approach to understanding how direct motor and challenge items differ and indicates how the different explenations of hypnotic responding can be integrated into a broader model of volitional versus nonvolitional action.

Remember that this model proposes two complimentary systems that are responsible for the initiation and control of action. A lower level system (contention scheduling) that handles the selection of relatively routine acts, and a higher level system (supervisory attentional control) that assists with nonroutine actions by modulating the lower level system and also monitors competing demands and the nature of actions. It is the active modulation of contention scheduling by the supervisory control system that is experienced as will or deliberate conscious control.

Responses to easy hypnotic suggestions such as direct motor items do not require higher level control; that is, they are selected and controlled through contention scheduling and do not require active, ongoing, modulation by the supervisory system. Although they are monitored by the supervisory system, they can be carried out more or less automatically and require so little attentional effort that the role of volition is ambiguous or indeterminate. In such situations, people look for situational factors to provide them with a clue as to how to attribute their actions. The hypnotic context offers a plausible explanation for the nature of the experience and hypnotic subjects typically report their experience as involuntary; it happened because of hypnosis and not through my own will. The social-psychological model appears to apply primarily to such situations in which there is contention scheduling without active modulation by the supervisory system. Most people with little genuine hypnotic ability can still pass direct motor suggestions. No dissociative mechanism is needed, although people with high hypnotic ability may well use this approach. The dissociated-experience model primarily applies to the internal self-monitoring function of the supervisory system. It postulates an amnesic barrier that separates this internal control. The resulting impairment in internal monitoring leads to a lack of awareness of the intended and self-initiated nature of one's own actions, which are then misattributed to external events. This is not unsimilar to some aspects of schizophrenia. Finally, the dissociated-control model applies to the executive control function of the supervisory system. Hypnosis is argued to involve a weakening of the executive control function of the supervisory system. This releases lower levels of control from the integration that is normally imposed on them by the higher level executive control. The weakening of supervisory control and monitoring results in the inhibition of the normal modulation of contention scheduling. The hypnotically suggested behaviour is, therefore, genuinely experienced as less volitional.

The weakening of executive control resembles an altered state of consciousness that is functionally similar to that of patients with certain frontal lobe disorders. Thus, both the dissociated-experience model and the dissociated-control model propose an alteration in the internal self-monitoring of volition that has been found to be critically dependent of frontal lobe functions (McGuire et al., 1995).

5.7. *The Neuropsychophysiology of Hypnosis*

5.7.1. **Evidence of neuropsychological changes during hypnosis**

There is considerable evidence that people who are either highly responsive or relatively unresponsive to hypnosis exhibit substantial cognitive differences in performance on various attention-specific tasks. Highly hypnotisable subjects were better able than low hypnotisables to ignore distracting stimuli and more accurately complete a tracking task (Mitchell, 1970), reported fewer intrusions while staring at a candle or concentrating on their own breath (Van Nuy's, 1973), and were more resistant to the masking effect in a backward masking task (Saccuzzo, Safran, Anderson, & McNeill, 1982). They also showed superior performance on understanding and remembering a target story presented over a nontarget story (Karlin, 1979) and at detecting shifts in illusionary stimuli during a complex task involving reversible visual illusions (Wallace, Knight, & Garret, 1976). This latter finding was further supported by results of a study by Crawford, Brown et al., (1993) who used discriminant analysis to determine which aspects of attentional processing could distinguish between high- and low-hypnotisable subjects. Results showed that approx. 70% of low and high hypnotisables could be correctly discriminated between by measures of sustained and extremely focused attention. On the other hand, both groups could not be correctly distinguished by measures of divided or selective attention, unless the latter required great cognitive effort to disregard irrelevant stimuli. Highs were significantly more responsive to reversible figures (Necker Cube illusion) and visual illusions (autokinetic movement illusion task) than lows (see also Wallace & Garrett, 1973; Wallace, Garrett, & Anstadt, 1974).

Both these tasks require sustained attention in an impoverished environment. Highs also scored significantly higher than lows on measures of moderately focused attention (TAS) and extremely focused attention (Differential Attentional Processes Inventory; Crawford, 1993, cited in Crawford et al., 1993). However, they did not differ in performance on random number generation and dichotic listening, two tasks that require the ability to select and discriminate between stimuli and divide attention between them.

High and low hypnotisables have also been found to differ in the automaticity with which they perform the Stroop task. Stroop effects provide an index of the affect of distraction on focused attentional processing (MacLeod, 1991; Schneider & Schiffren, 1977). Cheesman and Merikle (1986) designed a paradigm that was able to separate automatic and strategic influences in a variation of the Stroop Color-Naming Task. They were able to do this by manipulating congruent trial probability and cue visibility, and by providing instructions to either ignore or use the word to predict the colour. The manipulation of cue visibility involved backward masking to present colour words in such an impoverished fashion (below what they called the subjective threshold of awareness) that no strategy could be adopted. Using this paradigm, Dixon, Brunet, and Laurence (1990) found that high hypnotisables showed significantly greater discrepancies between the reaction times of word congruent and incongruent trials than their moderate- or low-hypnotisable counterparts, indicating that they processed words more automatically. A replication of this study by Dixon and Laurence (1992) varied the temporal delay (interstimulus interval) between word and colour presentation to provide a better way of separating strategic and automatic processing. As interstimulus intervals increased above 200 msec (i.e., the minimum time needed to implement a strategy), the pattern of colour-naming reaction times switched from a standard Stroop effect (faster congruent than incongruent trial naming) to a reversal of the Stroop effect (faster incongruent than congruent trial naming) for both high- and low-hypnotisable subjects. However, low hypnotisables needed a longer delay than high hypnotisables before this reversal effect became evident, indicating that high hypnotisables were better able than low hypnotisables to implement a strategy designed to reduce incongruent-trial reaction times. This finding concurs with earlier results obtained by Sheehan, Donovan, and MacLeod (1988).

When interstimulus intervals were very small (e.g., 16.7 msec) and strategic effects were absent, highs, but not lows, showed significant Stroop effects despite instructions designed to elicit the exact opposite pattern of reaction times. Highs made more errors in this condition, indicating that the increased reaction time for incongruent trials did not result from a trade-off between speed and accuracy. Thus, high hypnotisables tend to process words more automatically than low hypnotisables. Furthermore, Dixon and Laurence (1992) and Dixon et al. (1990) showed that such findings are not limited to hypnosis and can also occur in experimental situations that are conducted outside the hypnotic context. These findings are hard to reconcile with a pure social-psychological interpretation of hypnosis, but are consistent with a synergistic view that recognises the impact of both subject's beliefs, attitudes, and expectations and such individual cognitive differences as absorption, automaticity, and imagery capabilities.

A number of other neuropsychological differences have been observed between high and low hypnotisables. For example, Wallace and Patterson (1984) found that highs performed faster on a timed visual search task that had subjects locate a target letter among a large field of nontargets. The more striking observation was that highs and lows used substantially different search strategies. Lows adopted a serial letter-by-letter search strategy, devoting as much time in perceiving and processing of nontarget letters as on the target letter. Highs, however, focused their attention on the target stimulus and searched for it in a parallel row by row manner. In a second experiment Wallace and Patterson (1984) found that highs were faster at solving double, but not single, digit arithmetic problems while being just as accurate. Again, there were substantial differences in approach. Lows tended to pay more attention on distracting factors such as neatness, column alignment, and writing down of carry over numbers. Contrary to instructions they tended to recheck answers and correct any errors made. Highs, on the other hand, appeared to concentrate on speed at the cost of neatness. Their writing was messy, less well aligned, and none of the highs wrote down carry-over numbers. Despite concentrating on speed, highs were just as accurate as lows. These results suggest that highs are better able to ignore (task irrelevant) distraction, attend to relevant cues, and maintain focused attention on selected stimuli.

At least part of the difference appears to come from the fact that lows and highs use different strategies for the performance of attention-demanding cognitive tasks. Crawford and Allen (1983) found that high hypnotisables consistently showed enhanced visual memory performance (i.e., more correctly remembered items on a visual discrimination task) during hypnosis, while their low-hypnotisable counterparts showed either no significant change or a significant decrease in performance during the hypnotic as compared to nonhypnotic condition. There were no significant differences between both hypnotic-susceptibility groups in the nonhypnotic condition. Experimenter ratings and subjects self-reports indicated that, in the nonhypnotic condition, both high and low hypnotisables used predominantly detail-oriented strategies (i.e., the memorisation and rehearsal of individual details). During hypnosis, only the highs shifted towards a significantly more holistic strategy (i.e., looking at and remembering the whole picture with accompanying imagery). Analysis revealed that differences could not be accounted for by demand characteristics and/or expectancies.

In addition, Gruzelier and Warren (1993) found that following a hypnotic induction highs displayed a significant reduction in word fluency to letter categories while lows showed a significant increase. Verbal fluency to letter designated categories has been found to involve (primarily left hemisphere) frontal lobe function (Benton, 1968). Both highs and lows generated more novel visual forms under time constraint, which is a task involving predominantly the right hemisphere frontal lobe task. Thus, unlike lows, highs exhibited a typical dissociation between these two tasks. Furthermore, finger tapping dexterity improved during hypnosis for lows, but decreased for highs and more so for the right than the left hand. Performance on this finger tapping test reflects contralateral sensory motor functions associated with involvement of anterior motor and pre-motor areas (Luria, 1973). The left hemisphere is involved in executive function of motor planning and inhibition of this function may lead to in particular contralateral slowing. These results support the suggestion that highly susceptible individuals experience a reduction (inhibition) of left frontal functions. Overall, findings suggest that highly hypnotisables not only have a superior capacity for focused attention and inhibition of task-irrelevant stimuli, but also possess a greater capacity for cognitive flexibility including the ability to shift into a passive, holistic, associational mode of processing when appropriate.

This hypothesis is further supported by evidence of differences at the neurophysiological level that are discussed next.

5.7.2. **Evidence of neurophysiological changes during hypnosis**

Despite the fact that hypnotic susceptibility is a rather stable personal characteristic (Perry, Nadon, & Button, 1992; Piccione et al., 1989), few individual difference variables have been found that can reliably predict hypnotisability (Kirsch & Council, 1992; Silva & Kirsch, 1992). However, advances in various neurophysiological techniques for recording brain activity have made it possible to search for specific psychophysiological markers that might provide more stable personality correlates with individual differences in hypnotic responsiveness.

If hypnotic phenomena involve more than mere subjective reports, they should be reflected in altered processing of the perceived stimulus, which should be possible to detect by cortical event-related potentials. There are three broad questions that are of particular interest: (1) is there a psychophysiological index that can distinguish between individuals with low and high hypnotic susceptibility in the nonhypnotic state?, (2) are there measures of brain activity that distinguish hypnosis from the nonhypnotic state?, and (3) do high- and low-hypnotisable individuals show psychophysiological differences in the hypnotic state (a possibility not predicted by the social-psychological view of hypnosis)?

Some researchers have questioned how relevant some of the evoked potential measures used are to attention, particularly alpha band (8-13 Hz) activity (e.g., Perlini & Spanos, 1991). While there are some indications of regional specificity and shifts in hemispheric involvement (for a review see Crawford, 1994b, Crawford & Gruzelier, 1992), which may be a reflection of shifts in attentional focus, differences in lateralisation ratios have largely been confined to alpha- or beta-band activity and not been observed consistently (e.g., De Pascalis, Silveri, & Palambo, 1988; Graffin, Ray, & Lundy, 1995). Any conclusion that can be drawn from these findings remains tentative at best and requires, among others, a more indepth understading of the function of specific brain areas.

This review will, therefore, restrict itself to the more acknowledged utility of differences in theta activity, cerebral blood flow measures, and somatosensory event-related potentials. It will consider only studies that include stringent and stable hypnotic-susceptibility assessments, sufficient electrode placement, and sound signal processing technologies.

5.7.2.1. *Do people with high and low hypnotic susceptibility differ in brain activity during the nonhypnotic state?*

There is evidence from electroencephalogram (EEG) recordings that mean theta power (range 4-8 Hz) is strongly and positively related to the trait of hypnotic susceptibility (for a review see Crawford & Gruzelier, 1992). Increased theta power activity has been associated with attentional readiness and sustained attention during selective, narrowly focused, processing and intense mental effort (e.g., problem solving, perceptual processing, and cognitive tasks) and with the production of imagery (for a review see Schachter, 1977). Both animal and human studies have indicated that theta recordings at the surface of the scalp originate in the hippocampal area of the brain and are related to focussed attention and selective disattention (for review see Crawford, 1994b).

Some caution, however, is needed when interpreting findings of increased theta activity (Crawford, 1994b; Sabourin, Cutcomb, Crawford, & Pribram, 1990) as this may not only relate to increases in attentional processing, but may also reflect instances of decreased attention-relevant processing as have been observed in studies of persons with cognitive impairment and dementia (John, Prichep, Fridman, & Easton, 1988) or attention-deficit disorders with hypothesised disruptions of cortical-subcortical attentional mechanisms (Lubar, 1991). This may become clearer when we consider the difference between low (4-5.9 Hz) and high (6-8 Hz) amplitude theta power activity. Regular, high amplitude, theta power is associated with what Vogel, Broverman, and Klaiber (1968, p. 172, cited in Crawford, 1994b) have called "Class II inhibition", that is "a selective inactivation of particular responses so that a continuing excitatory state becomes directed or patterned." Crawford (1994b) refers to this as the ability for focused attention and disattention.

This is in contrast to more irregular and low voltage theta activity ("Class I inhibition") which is characterised by gross inactivation of an entire exitatory process and is associated with relaxation, general inactivity or drowsiness, and sleep. Hypnosis does not share any important EEG properties with sleep (Evans, 1979). Barabasz, Crawford and Barabasz (1993; cited in Crawford, 1994b) found that attention-deficit children produced substantially more low theta, but not high theta, power compared to normal children.

Although increments of theta power can be observed in a variety of locations, they are most prominent in frontal and central areas. Stringently screened highly hypnotisable individuals have been found to generated substantially more theta power in central, occipital, and particularly frontal locations than individuals with low hypnotic susceptibility during a nonhypnotic rest (baseline) condition with either eyes open or eyes closed (Sabourin et al., 1990). These results are largely supported by Graffin et al. (1995) who also found that high hypnotisables generated more theta activity than lows during a nonhypnotic condition with eyes closed. These differences were significant at frontal and temporal locations, but nonsignificant at parietal ($p < .07$) and occipital ($p < .09$) locations. Crawford (1990, cited in Sabourin et al., 1990) found that highs generated substantially more high theta (5.5 –7.5 Hz) than lows at frontal, temporal, parietal, and occipital locations, but that there were no differences between hypnotic-susceptibility groups in low theta (3.5 – 5.5 Hz).

Further support for differences in brain activity in the nonhypnotic state comes from a study by Crawford, Corby, and Koppel (1994, cited in Crawford, 1994b) who examined auditory event-related potentials in high- and low-hypnotisable subjects instructed to ignore auditory tones while reading a book or counting their pulse. Results showed that, as stimulus intensities increased lows showed a decrease in N1 latencies, while highs exhibited longer N1 latencies. Such latency decreases are interpreted as an index of increased attentional processing allocated to the distracting or novel stimuli (see Hilyard & Picton, 1979). This differential latency change was positively associated with hypnotic susceptibility ($r = .44$, $p < .05$) and absorption as measured on the TAS ($r = .58$, $p < .01$).

Some studies of somatosensory event-related potentials (SERPs) have demonstrated differential SERP involvement of the far frontal region between low and very highly hypnotisable subjects during a (nonhypnotic) attention to pain condition (Crawford, Pribram, Kugler, Xie, Zhang, & Knebel, 1993; Crawford, Pribram, Xie, & Zhang, 1993). While low hypnotisables consistently showed relatively little far frontal activation in comparison to the posterior areas, over 50% of the very highly hypnotisables displayed great SERP reactivity in all regions. This may be a reflection of neurophysiologiocal differences in focused attention (Crawford, 1994a).

Finally, we have already seen (pp. 195-196) that those highly susceptible individuals able to experience recognition amnesia exhibited significantly higher 40 Hz activity prior to hypnosis than high hypnotisables who did not show recognition amnesia, low hypnotisables who successfully simulated recognition amnesia to a similar extend, or nonsimulating lows (Schnyer & Allen, 1995). This study clearly showed that, while simulation may be sufficient to obtain behaviour similarities between high- and low-hypnotisable individuals, it does not create electrophysiological similarities.

The above results appear to suggest that highly hypnotisable individuals possess or can manifest a heightened state of attentional readiness and concentration. This corresponds well with findings that absorption is primarily related to more difficult hypnotic performances (Balthazard & Woody, 1992) and remains one of the most consistent correlates of hypnotisability (De Pascalis, 1989; Glisky, Tataryn, Tobias, Kihlstrom, & McConkey, 1991; Nadon, et al., 1991; Tellegen & Atkinson, 1974). The differences in, particularly frontal, theta power between high- and low-susceptible individuals in the nonhypnotic condition also correspond with the observed trait-like nature of hypnotic susceptibility.

5.7.2.2. *Are there changes in brain activity that distinguish hypnosis from the nonhypnotic state?*

Sabourin et al. (1990) who used an ABA design (waking-hypnosis-waking conditions) found that, while maintaining their baseline differences, both high and low hypnotisables showed significant increases in mean theta power when moving from the initial waking condition to hypnosis.

While the percentage increase was somewhat larger for lows than for highs, overall highs clearly exhibited larger mean theta-power amplitudes. These increases were evident at frontal, central, and occipital locations (largest at occipital locations) and reversed again when subjects came out of hypnosis.

Graffin et al (1995) also measured EEG differences in baseline theta activity immediately before and immediately after a hypnotic induction. In accordance with Sabourin et al. (1990), they observed an increase in theta activity for low susceptibles. However, unlike Sabourin et al., they found that highs displayed a *decrease* in theta activity from the baseline period immediately preceding the hypnotic induction to that immediately following the hypnotic induction. The interaction effects of group (high vs. low susceptibility) by condition (preinduction and postinduction) were highly significant at parietal and occipital locations, but just failed to reach statistical significance at temporal ($p < .035$) and frontal ($p < .09$) locations. This suggests that the hypnotic induction itself differentially affects high and low hypnotisables and that these groups may process the hypnotic state differently.

5.7.2.3. *Do people with high and low hypnotic susceptibility show fundamental differences in the patterns of brain activity during hypnosis?*

Sabourin et al. (1990) also found that highs displayed significantly more mean theta power than lows across frontal, central, and occipital during: (1) a standard hypnotic induction; (2) subsequent trance deepening suggestions; and (3) follow-up hypnosis testing involving a motor item (arm immobilisation), a hallucinatory item (mosquito hallucination), and a fantasy item (hypnotic dreaming).

Graffin et al. (1995) recorded differences in theta power at two-minute intervals during a ten-minute long standard hypnotic induction similar to that used by Sabourin et al (1990). Results showed that, over the course of the hypnotic induction, subjects displayed a gradual and significant increase ($p < .0001$) in theta activity at parietal and occipital locations and a gradual but nonsignificant increase ($p < .19$) at temporal locations. At frontal locations, theta power remained quite stable ($p < .87$) during the hypnotic induction.

Unfortunately, the article by Graffin et al. does not provide a breakdown of theta activity by hypnotic-susceptibility group during the hypnotic induction. Graffin et al. interpreted the overall results of their study as indicating that frontal differences in theta power activity reflect state-independent (i.e., trait-like) individual differences in hypnotic susceptibility, whereas posterior EEG differences relate to state differences (i.e., between hypnotic and nonhypnotic conditions).

Further support for processing differences in the hypnotic state comes from studies using regional cerebral blood flow (rCBF) measures of brain activity. For example, Crawford, Gur, Skolnick, Gur, and Benson (1993) used the xenon (^{133}Xe) inhalation method to record rCBF measures of cortical activity in high- and low-hypnotisable subjects during ischemic pain with and without suggested hypnotic analgesia. Recordings were made of the arrival and disappearance of the gamma radiation of the ^{133}Xe isotope over 16 locations of each hemisphere and the initial slope of the clearance curves of this diffusible tracer was used as the measure of regional blood flow and glucose metabolism. This measure has been demonstrated to reflect cognitive activation (Gur, Gur, Obrist, Hungerbuhler, Younkin, Rosen, Skolnick, & Reivich, 1982; Gur, Gur, Obrist, Skolnick, & Reivich, 1987).

The study by Crawford, Gur et al. (1993) used six very low and five very highly hypnotisable men who had been carefully selected during preliminary hypnotic training sessions using three standardised hypnotic-susceptibility measures. All high hypnotisables had demonstrated that they could totally eliminate the perception of experimentally induced cold-pressor and ischemic pain. Both hypnotic-susceptibility groups did not differ significantly on measures of depression, anxiety (both low) or self-reported imageability of mental images, but as expected highs reported more absorptive experiences on the TAS. Highs and lows were compared during two states (waking and following a hypnotic induction) across three task conditions (rest with eyes closed and exposure to ischemic pain with and without suggested analgesia). Both high and low hypnotisables showed similar values and topographical distributions of resting CBF during the nonhypnotic condition. As expected, and consistent with other neuroimaging studies, there was an increase in CBF in the somatosensory cortex during attention to ischemic pain in the nonhypnotic condition.

Following a hypnotic induction, these values remained quite similar (i.e., were slightly reduced) for lows regardless of task condition. Highs, however, exhibited significantly enhanced CBF (i.e., beyond that noted in the somatosensory cortex during attention to pain) in the orbitofrontal cortex and sensorimotor cortex during hypnotic rest and even more dramatically so when experiencing hypnotic analgesia.

Furthermore, both high and low hypnotisables showed major changes in the topographical distribution of rCBF changes between hypnotic analgesia and the other two hypnotic conditions (rest and attending to pain). When exposed to the pain in the hypnotic condition but instructed not to reduce their pain perception, both highs and lows exhibited increased CBF activity over the somatosensory cortex compared to surrounding areas. However, during hypnotic analgesia highly significant changes in CBF activity emerged over the orbitofrontal cortex. While highs showed further significant CBF increases over the somatosensory area, lows exhibited significant decreases in CBF over this area (Crawford, Gur, et al., 1993).

Studies of SERPs have provided further evidence of hypnotic-susceptibility moderated changes in brain dynamics during hypnosis. Pain-related SERP's have been shown to occur at least by 160ms after stimulation and SERP amplitudes have been found to correlate with perceived pain level (see e.g., Chen, Chapman, & Harkins, 1979; Stowell, 1984). Studies of scalp recordings of SERPs following brief painful electrical stimulation have found that, during hypnotic analgesia, very highly hypnotisable subjects (i.e., those able to completely eliminate the perception of sensory pain and distress during prior cold-pressor training) exhibited substantial decreases in early (N_{100} to P_{200}) components of SERPs (Crawford, Pribram, Kugler et al. 1993; Crawford, Pribram, Xie et al., 1993; DePascalis, Crawford, & Marruci, 1992a,b, cited in Crawford 1994a; Mészáres, Bányai, & Greguss, 1980, cited in Crawford, 1994a; Spiegel, Bierre, Rootenberg, 1989). By contrast, lows showed at best only minor reductions in these early (preconscious) SERP components. In some of their highly hypnotisable subjects, Crawford, Pribram, Xie et al., (1993) observed either a pre-stimulus contingent negative variation (CNV) or a late 400-500 msec negativity in the far frontal region. This later CNV component is likely to be associated with a preparation to respond or inhibit a response (see Birbaumer et al, 1990).

The occurrence of a far frontal CNV during hypnotic analgesia suggests that the far frontal cortex is involved in a topographically specific inhibitory feedback circuit that cooperates in the regulation of thalamo-cortical activities (Crawford; 1994a). That is, for some highly hypnotisable individuals the hypnotic analgesia condition may be like an inhibitory no-go condition, much like that observed in monkeys by Crowne, Konow, Drake and Pribram (1972, cited in Crawford, 1994a).

Crawford, Pribram, Xie et al. (1993) and Crawford, Pribram, Kugler et al. (1993) used a specially developed procedure (Brain Scope) which enabled them to view SERPs as they evolved during each epoch. Their results revealed a very dynamic movement of SERPs across the number of trials that is lost when only averaged SERPs are used as is standard practice in other studies. Results showed large individual differences in habituation rate, amplitude, latency, and morphologies of SERPs. These two studies also demonstrated the differential SERP involvement between far frontal and posterior regions of the brain previously demonstrated by Desmedt and Bourguet (1985, cited in Crawford, 1994a). Over half of the highly hypnotisables experienced strong arousal activity in the far frontal region during attention to pain which flattened out during hypnotic analgesia to the point were it was hard to measure. By contrast, the frontal and more posterior SERPs, while reduced in amplitude, were still evident. The other group of highs showed little SERP activity in the far frontal region in either attend or disattend to pain conditions, but substantial reductions of SERPs at all locations during hypnotic analgesia. This suggests that there are at least two types of highly hypnotisable individuals, both of which can eliminate the perception of pain, that have differential SERP topographic patterns particularly in the far frontal region (Crawford, 1994a).

Krotopov, Crawford, and Polyakov (1997) conducted an initial study using intracranial SERP recordings in one very hypnotisable and one unresponsive subject following painful electrical stimulation. During hypnosis, the highly hypnotisable individual reported a dramatic decrease in pain perception that was accompanied by: (a) a significant reduction of the positive SERP component within the 140-160 ms post-stimulus range in the left anterior cingulate cortex, and (b) a significant enhancement of the negative SERP component within the range of 200-260 ms in the left anterior temporal cortex (Bodmann area 21).

A return to an attending to pain condition following the hypnotic procedure resulted in a significant enhancement (rebound) of the same positivity at this site. By contrast, no changes were observed in the SERP's of the hypnotically unresponsive patient. The reduced activity in the anterior cingulate cortex is consistent with its suggested involvement in the encoding of the unpleasantness of pain (Rainville et a., 1997).

5.7.3. **A neuropsychophysiological model of hypnosis**

5.7.3.1. *Summary of main findings leading to its development*

As we have seen, the amount of pain reduction during hypnotic analgesia is correlated with hypnotic susceptibility (e.g., Hilgard, 1975). Those who are highly susceptible to hypnotic suggestions can, following the proper hypnotic suggestions, significantly or even completely eliminate the sensory experience of pain from conscious awareness without inhibiting normal autonomic responses such as blood pressure, heart rate, and skin conductance (Hilgard & Hilgard, 1994).

We are normally continually exposed to sensory stimulation and excitation of our nervous system. To ensure that we do not simply get flooded by all this stimulation, and to allow for purposeful goal-directed actions, inhibitory neurons continually modulate or down-regulate this excitatory activity in the brain and spinal cord. Two major inhibitory mechanisms involved in modulating pain perception are descending inhibitory control resulting from stimulation of certain brain structures and spinal inhibition or gating resulting from nonpainful stimulation of nerves (Aα and Aβ fibres) at the level of the spinal cord. The unique contribution of hypnosis may also have to do with a neural mechanism involving inhibition. The fact that hypnotic analgesia can be rapidly reversed by suggestions indicates that any neural inhibition due to hypnosis is unlikely to be mediated by endogenous opiate-like systems or mechanisms of stress-induced analgesia (e.g., Barber & Mayer, 1977; De Benedittis, Panerai, & Villamira, 1989; Domangue, Margolis, Lieberman, & Kaji, 1985; Goldstein & Hilgard, 1975; Spiegel & Albert, 1983).

However, there are indications of hypnosis-mediated involvement of non-nociceptive inhibition at the spinal level as well as involvement of higher centres. For example, Danziger et al. (1998) and Kiernan et al. (1995) observed that highly hypnotisable subjects were able to suppress spinally mediated nociceptive flexion reflexes during hypnotic analgesia. However, this accounted for only part of the observed reduction in pain sensation and other, including cortical or subcortical, inhibitory mechanisms are also expected to play an important role.

Hypnosis has been found to be able to both amplify and attenuate cortical responses depending on the type of suggestions. For example, studies of ERPs following painful electrical stimulation found that hypnotic analgesia suggestions reduced the amplitude of later components of ERPs, indicating less awareness of pain, while hypnotic suggestions of greater sensitivity increased late ERP components (Arendt-Nielsen et al., 1990; Spiegel et al., 1989).

Hypnosis is seen as a state of enhanced attention that activates an interplay between cortical and subcortical brain dynamics during hypnotic phenomena, such as hypnotic analgesia. This interplay of cortical and subcortical brain dynamics, involving both the descending inhibitory pathways from the far frontal cortex and the paralleling ascending sensory systems, is of utmost importance if we are to understand the perception and inhibition of painful stimuli (Crawford 1994b). During the hypnotic process, a shift occurs in anterior to posterior brain activity. Firstly, it is proposed that anterior, frontal lobe functions become engaged through instructions of focused attention, and once engaged become inhibited. This inhibition underpins the suspension of reality testing and results in the abdication of planning functions and the reduction of attentional monitoring of external cues that characterise hypnosis. Secondly, posterior functions become augmented as the person enters a passive, receptive mode and imagery is made vivid.

There are also indications of a shift from left to right hemisphere involvement, but this finding has not always been consistently reported and there is still debate regarding methodological issues and the exact interpretation of the meaning of such changes in hemispheric specificity (see e.g., Crawford & Gruzelier, 1992).

The accumulated evidence of various types of neurophysiological studies of brain activity during hypnosis clearly indicates that highs have a greater ability to sustain focused attention on relevant activities and to disattend nonimportant stimuli in the environment. Highs have also demonstrated to posses greater cognitive flexibility, that is the ability to shift cognitive strategies and states of awareness, than lows. Sustained attentional abilities are recognised as a function of the fronto-limbic system, while the ability to disattend to extraneous stimuli is seen as a function of the posterior cerebral cortex (see section 3.6.1., pp. 105-106). It is the far frontal cortex that is seen as the site of what Hilgard (1973,1991) refers to as the executive control system or what Norman and Shallice (1986) call the supervisory attentional control system (see Baddeley, 1996; Goldman-Rakic, 1995).

5.7.3.2. *Crawford et al's neuropsychophysiological model of hypnosis*

Based on this accumulated evidence of neurophysiological and neuropsychological changes in attentional processing and brain dynamics during hypnosis, Helen Crawford and associates have proposed a neuropsychophysiological working model of hypnosis (Crawford, 1989, Crawford & Gruzelier, 1992).

This model proposes proposes that the "executive controller" of the far frontal cortex, via the far fronto-limbic attentional system, becomes involved in acting as a gate against the ascent of painful stimuli to conscious awareness. Highly hypnotisable individuals are argued to possess stronger attentional filtering abilities that are associated with the fronto-limbic attentional system. Their greater cognitive flexibility enables them to more easily give up their generalised reality orientation and shift from reality to fantasy, be more dissociated from certain awareness' or cognitions, become more deeply involved in imaginative activities and produce imagery (even of a hallucinatory nature) vividly and effortlessly, and shift to greater holistic information processing styles. In short, it is proposed that the executive controller of the far frontal cortex, via the far fronto-limbic attentional system, acts as a gate against the ascent of painful stimuli into conscious awareness by inhibition of incoming somatosensory information from the thalamic region.

This neuropsychophysiological model of hypnosis involving CNS inhibition or "gating" of, for example pain, signals is consistent with the neodissociation model of hypnosis in which suggestions may directly activate pain control schema (Hilgard, 1973; Miller & Bowers, 1993). Hilgards' executive control system is the far frontal cortex "directing" the inhibition of incoming stimuli. It is also consistent with a trait view of hypnotisability that may possibly be assisted by a heritability component (Morgan 1973). Furthermore, it is also consistent with Melzack's (1993) proposition that the hypothosised neuromatrix in the brain – not peripheral stimulation per se – is in large part responsible for the awareness of the body's sensation of pain. Finally, this model can comfortably coexist with social-psychological theories that emphasises the strategic use of pain coping strategies (Spanos, 1986; Spanos & Chaves, 1989). However, it provides a better rationale for the unique benefits observed following hypnotically delivered analgesia suggestions.

CHAPTER SIX

The Current Study

The present study aims to explore further the findings of two studies by Miller and Bowers (1986, 1993). Based on the combined results of these studies, they proposed that the process of hypnotic analgesia involves dissociated control rather than dissociated experience, and that this process is fundamentally different from that typically used by various cognitive-behavioural pain-coping strategies in that it does not require conscious attention-demanding effort.

6.1. *Miller and Bowers (1986, 1993)*

Miller and Bowers (1986) examined reductions in cold-pressor pain for subjects with high and low hypnotic susceptibility following: hypnotic suggestions for analgesia, stress inoculation, and stress inoculation defined as hypnosis. In the hypnotic analgesia condition, high hypnotisables were able to reduce pain to a very considerable degree despite the virtual absence of any reported strategy use. Low hypnotisables, on the other hand, were unable to achieve any significant pain reductions in the hypnotic analgesia condition. Like their highly hypnotisable counterparts, they did not use any cognitive strategy. The observed correlation between hypnotic ability and pain reduction disappeared in the stress inoculation condition, even when this was defined as hypnosis. Almost all subjects in the stress inoculation conditions used cognitive strategies, and were able to achieve pain reductions to the extent that they did so. This suggests that pain reductions in hypnotic and nonhypnotic treatments are brought about by different means (Miller & Bowers, 1986). Nonhypnotic treatments depended on cognitive strategy use, while effective hypnotic analgesia depended on factors related to hypnotic ability. The important finding from this study was that effective hypnotic analgesia did not depend on deliberate use of cognitive strategies as predicted by the social-psychological model of hypnosis.

However, the study by Miller and Bowers (1986) did not clarify by what mechanism (i.e., dissociated experience or dissociated control) hypnotic analgesia was achieved. Results can be understood to mean that strategic efforts to reduce pain were absent (dissociated control) or that their presence was cognitively hidden by an amnesia like process (dissociated experience). Furthermore, indications of strategy use depended solely on subjective self-reports.

To address these issues, Miller and Bowers (1993) conducted a follow-up study designed to provide a more distinctive test of the dissociative process, which they argue underlies effective hypnotic responding. This second study set out to evaluate both dissociation explanations by examining their differential predictions about cognitive involvement within the rationale of limited-capacity theories of attention. To facilitate this, they added a secondary cognitively demanding task to their design that competed with pain reduction for attentional resources. Interference in performance on this secondary task would provide a direct index of the cognitive effort used to execute the coping strategy and obtain pain relief that was not dependent on subjects' memory recall and self-report of strategy use.

According to both the social-psychological view and the dissociated-experience explanation, effective analgesia depends on effortful involvement in cognitively demanding coping strategies, and would thus be expected to result in marked interference with the performance on the competing cognitive task. This should be even more pronounced if the dissociated-experience explanation is correct, because the act of constructing and maintaining an amnesic barrier is itself attention demanding (Miller & Bowers, 1993). On the other hand, if hypnotic analgesia involves the dissociation of control (i.e., the direct activation of subsystems of control without executive initiative and monitoring) no such interference would be expected.

Results revealed that stress inoculation, but not hypnotic analgesia further impaired performance on a cognitively demanding task that competed with pain reduction for attentional resources. This outcome suggests that hypnotic analgesia occurs with little or no cognitive effort to reduce pain. These findings challenge the social-psychological account of hypnosis and are also inconsistent with the notion of dissociated experience (i.e., the involvement of an amnesic barrier).

However, they do support the notion of dissociated control, which argues that the hypnotic process directly activates subschemata for pain reduction, thereby averting the need for executive cognitive effort.

This finding has a potentially significant impact on pain management. Cognitive strategies may be quite effective in controlling pain of short-duration, but the continued attention needed is hard to maintain over prolonged periods of time particularly when in the face of other competing demands. However, if, as suggested, effective hypnotic analgesia is achieved through the direct activation of subsystems of pain control, such factors should not be so problematic as more high-level cognitive resources would remain available to attend to the ongoing demands of everyday life. Thus, those individuals who are highly responsive to hypnosis would be able to achieve not only comparable or superior pain relief, but would also be able to maintain this over time and in a manner that would leave their normal ability to attend to other environmental stimuli relatively unaffected.

6.2. *The Current Study*

The main aim of the current study was to investigate whether the absence of interference with secondary task performance that was observed by Miller and Bowers (1993) among highly hypnotisables when using hypnotic analgesia to cope with painful stimulation would be replicated in a study using a modified methodology that included a different secondary task and different method of pain stimulation.

6.2.1. **Methodological issues**

The current study attempted to introduce some controls that would increase the sensitivity of the design and allow for greater specificity when analysing the effects of the experimental manipulation.

6.2.1.1. *Secondary attention-demanding task*

Miller and Bowers (1986, 1993) used a vocabulary task as their secondary attention-demanding task. This task had subjects read a list of target words each provided with five one-word alternatives, one of which was a synonym of the target word, and call out the alternative that best corresponded with the meaning of the target word. Performance on this task consisted of several components skills (reading, accessing memory representations of the target word and alternatives, evaluating the similarity between combinations, oral responding) that individually may or may not have competed with pain for access to attentional resources. Responding was of an interval nature and allowed for the possibility that subjects switched attention between coping strategy and task requirements during the reading and deliberation period in between responding.

To control for this possibility, the current study used a pursuit-tracking task that required a more unitary skill and was expected to be more demanding of continuous attentional involvement. This task had subjects control the position of a cursor on a computer screen so that it stayed on the line of a wave pattern that tracked along the screen. They did this by sliding a knob up and down along a potentiometer that was contained within a control box. A purpose-made computer programme controlled the presentation of the wave pattern and synchronised it with the administration of the pain stimuli. The computer programme recorded each second: the position along the wave pattern, the average tracking deviation over the preceding ten 100 msec intervals, and the administered intensity of the pain stimulus. This enabled both tasks to be plotted along side each other on a virtually continuous basis, which allowed for far greater specificity when interpreting interference effects at different and possibly distinct stages of the experimental manipulation (e.g., stimulus onset).

6.2.1.2. *Method of experimental pain stimulation*

Most methods of experimental pain stimulation, including the cold-pressor pain used in the Miller and Bowers' studies, are polymodal in nature (i.e., they stimulate a variety of receptors, including both nociceptors and non-nociceptors). Thus, they can not be considered "pure" pain stimuli (Arendt-Nielsen et al., 1990).

Other disadvantages of cold-pressor pain are that the intensity of the pain is not constant during the immersion, that frequently some subjects withdraw their arm from the ice water before the trial is finished, and the prolonged carry-over effects that generally make it unpractical to use repeated-measures designs.

The current study, therefore, used potassium iontophoresis as the method of pain stimulation. Potassium iontophoresis has been found to selectively excite Aδ and C fibres (Kumazawa & Mizumura, 1977; Uchida & Murao, 1974). Its stimulation is of a nonelectrical nature and does not produce an electric shock sensation. Neither does it excite non-nociceptive afferents due to pressure or temperature changes. Potassium iontophoresis can be used at high stimulus intensities and in repeated stimulations without the risk of substantial tissue trauma and the corresponding release of pain-producing chemicals that can be associated with thermal or mechanical pain-stimulation methods (Humphries, Long, & Johnson, 1994).

Potassium iontophoresis is particularly suitable as an experimental pain stimulus because: the reported intensity of the induced pain is linearly related to the amount of current applied, there are no significant carry-over effects, and within-subject variability is small (Voudouris, Peck, & Coleman, 1985). This enables researchers to present iontophoretic pain stimuli repeatedly and rapidly, and makes it feasible to use repeated-measures designs. These compare subjects with themselves under the various conditions rather than with an, assumably, comparable group of other subjects. This is particularly relevant in pain research because of the large between-subject variability in pain responding. Finally, unlike the studies by Miller and Bowers, the current study used individually determined pain levels so that the administered pain stimuli where of comparable intensity between subjects. In line with the multidimensional nature of pain experience, ratings were recorded for both sensory (pain-intensity) and affective (pain-unpleasantness) qualities of experienced pain

6.2.1.3. *Experimental design*

Within-subjects designs that use subjects as there own controls are in general statistically more powerful in detecting relatively weak effects than between-subjects designs using similar sample sizes.

Twithin-subjects designs minimise the risk of committing a Type II error (failing to show a true effect when one exists) and permit a more sensitive evaluation of differential effects resulting from the experimental manipulation (Barabasz & Barabasz, 1992). The current study used a mixed repeated measures design. Within each hypnotic-ability group, subjects were compared with themselves under different treatment (hypnotic vs. nonhypnotic) and tracking (on vs. off) conditions at two levels (30% and 60%) of induced pain. Hypnotic ability was the between-subjects factor with two levels, low and high.

Experimental studies using independent-group (i.e., between-subjects) designs have consistently failed to find significant differences in pain reduction between subjects that used hypnotic analgesia and subjects who used nonhypnotic (waking) analgesia, that is suggestions for pain reduction without a prior hypnotic induction (e.g., Evans, & Paul, 1970; Spanos, Kennedy, & Gwynn, 1984: Spanos, Radtke-Boderik, Ferguson, & Jones, 1979; Stam, & Spanos, 1980). Conversely, within-subjects repeated-measures designs have consistently found that pain reductions were significantly facilitated by the prior administration of a hypnotic induction (e.g., Hilgard et al., 1978; Malone et al., 1989; Stacher, Schuster, Bauer, Lahoda, & Schulze, 1975; Tenenbaum et al., 1990).

Stam and Spanos (1980) did demonstrate how easily experimenter induced expectancies and counter-expectancies can produce significant order effects. They argued that the greater pain reduction following hypnotic analgesia is due to the implicit belief of highly susceptible subjects that hypnotic analgesia will be more effective in reducing pain, which when combined with the structure of within-subjects designs, can create a significant hold-back effect. It was argued that subjects exposed to both conditions would refrain from maximally responding during the nonhypnotic analgesia trial so that they could experience and report less pain during the hypnotic analgesia trial. However, a study by Jacobs, Kurtz, and Strube (1995) that minimised experimenter-induced expectations to better examine the impact of design-induced expectations, failed to find any support for a design-generated holdback or reverse-order holdback effect.

Researchers that randomised or counterbalanced the order of conditions found no significant order effect, and concluded that the administration of a hypnotic induction was responsible for the greater pain reduction (e.g., Malone et al., 1989; Stacher et al., 1975).

6.2.2. **Comments on the rationale for the hypothesised interference effects.**

The rationale behind Miller and Bowers' (1993) exploration of dissociation mechanisms during hypnotic analgesia was based on a concept of information processing that envisages available attentional resources as being a single, central, limited-capacity pool (i.e., a finite reservoir). Their proposed test of hypnotically mediated changes in task-interference was based on the assumption that: (1) pain processing has high priority on attentional resources and displaces other demands for attention, and (2) the demands of the secondary task compete with pain processing for these same limited-capacity attentional resources. Using this concept of a united pool of executive attention resources, such a situation can be depicted in a simplified way by the diagram in Figure 10.

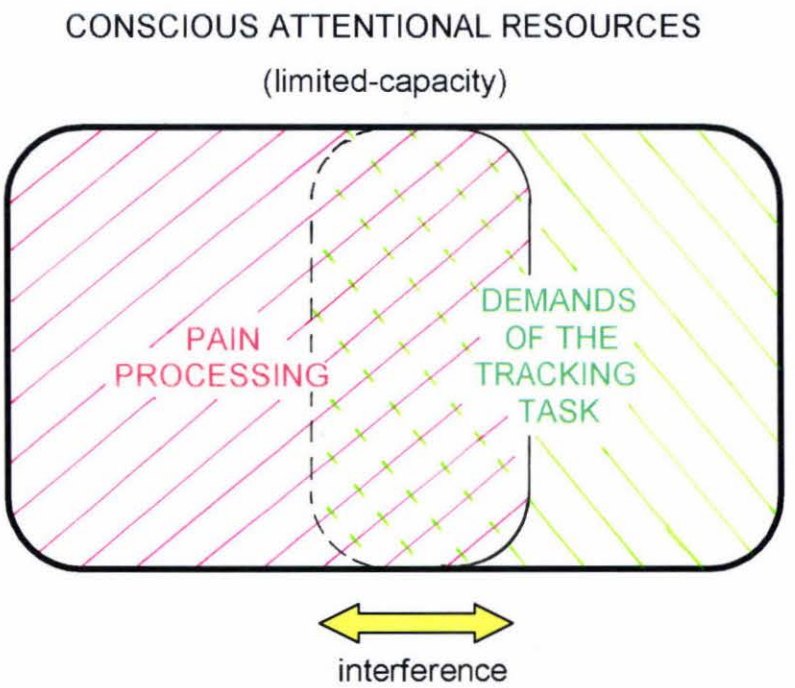

Figure 10. Diagram depicting competition for limited resources between the attentional demands of pain processing and tracking-task performance

The attentional requirements of the pain-coping strategy itself form a possible third component competing for limited attentional resources. If, as suggested, the process of hypnotic analgesia circumvents the need for attention-demanding executive control, subjects should be able to reduce the high-priority demands that pain processing makes on attentional resources without the additional requirement for attentional resources needed to implement the hypnotic suggestions. This would leave more attentional resources available for the successful performance of the tracking task. It is expected that this will be particularly evident in highly hypnotisable subjects who possess the ability to dissociate and make effective use of hypnotic suggestions for analgesia. This situation can be depicted by the diagram in Figure 11.

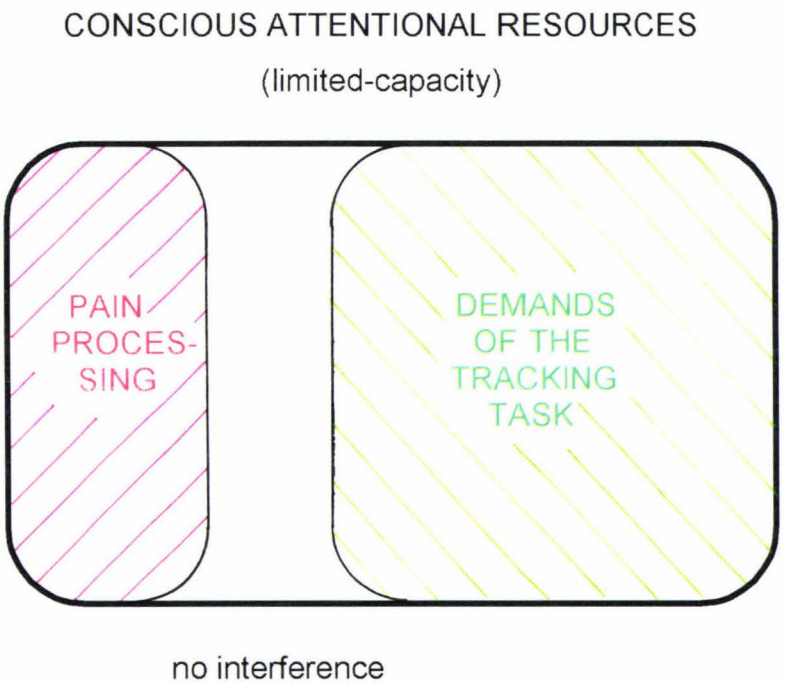

Figure 11. Diagram depicting effective use of hypnotic suggestions by subjects with high hypnotic ability as hypothesised.

Relief of pain and distress can also be achieved by using various cognitive strategies. These typically achieve pain relief by diverting attention away from that normally capture by pain thereby limiting its ability for conscious processing and responding. However, they can only do so to the extent of (and at the expense of) the effortful (i.e., attention-demanding) strategic employment of such conscious pain-coping strategies.

In this case, it is anticipated that, particularly when the pain stimulus is severe enough, the combined need for attentional resources required for pain processing, coping strategy use, and tracking-task performance will again exceed the limited resources available. As pain has high processing priority, it is expected that the resulting interference will manifest itself in larger tracking-deviation scores. Figure 12 shows this situation in a simplified form.

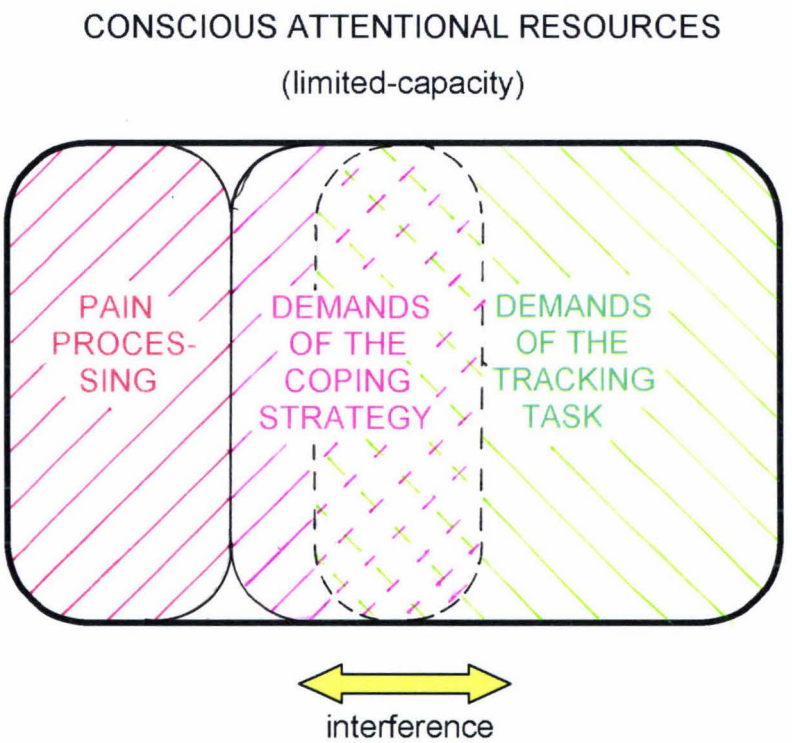

Figure 12. Diagram depicting the use of nonhypnotic strategies to cope with painful stimulation, while simultaneously performing an attention-demanding tracking task.

The tracking-performance scores provide an index of cognitive effort independent from subject's verbal reports of strategy use or absorption in the tracking task. Comparing the difference in tracking performance between treatment conditions can give an indication of the extent of this interference and the need for attention-demanding cognitive effort required to execute the coping strategy.

Alternatively, a conceptualisation based on multiple resource theory would provide a different picture. Multiple resource theory also acknowledges that the capacity for executive (conscious) attentional processing is limited. However, rather than treating this as a single united pool of finite resources, multiple resource theory proposes that different types and stages of attentional processing may have distinct attentional capacities. Accordingly, two or more tasks could each require attentional resources without necessarily producing interference effects as long as their performance did not rely on the same type of attentional processing, or their combined performance did not result in a general interference effect. In this case, the absence of interfere could mean that: (1) performance of the coping strategy does not require executive attentional resources, or (2) performance of the coping strategy does require attentional resources, but does not rely on the same attentional resources as pain processing. Thus, when taking a multiple resource perspective, no definitive conclusion can be made. The current experiment will not be able to provide an effective test of the main hypothesis if pain processing and the execution of the coping strategy do not rely on the same attentional resources.

6.3. *Hypotheses*

The main research question is: "Does cognitive pain-coping strategy use, but not hypnotic analgesia, rely on conscious attentional resources for its successful execution." It is expected that this treatment effect will be moderated by hypnotic ability and will only be present for subjects who are highly responsive to hypnosis. In addition, it is most likely to be evident at pain levels that are noxious enough to normally initiate pain processing and coping strategy use that would require substantial attentional involvement.

In line with previous research, it is further expected that highly hypnotisable individuals receive the greatest reductions in pain ratings during hypnoses, while low-hypnotisable subjects will receive the greatest reduction in pain ratings when using nonhypnotic pain coping strategies.

The following specific hypotheses were derived from this notion:

1. Both high- and low-hypnotisable subjects will experience impaired performance on the secondary attention-demanding task during painful stimulation in the nonhypnotic condition.

2. There will be no impairment in performance on the secondary attention-demanding task during painful stimulation in the hypnotic condition, but this will only be evident for highly hypnotisable subjects.

3. There are no significant differences in the self-reported ratings of both pain intensity and pain unpleasantness between high- and low-hypnotisable subjects in the nonhypnotic condition.

4. In the hypnotic condition, highly hypnotisable subjects will rate the pain stimulations as significantly less intense and less unpleasant than low-hypnotisable subjects, or than high- and low-hypnotisable subjects in the nonhypnotic condition.

The current study consisted of two major parts. The first part involved the screening for hypnotic ability of prospective subjects. Those who were selected from this screening process were then invited to take part in the second phase, the experimental part, of the study.

METHOD

CHAPTER SEVEN

SCREENING FOR HYPNOTIC ABILITY

7.1. *Introduction*

When conducting research into hypnosis, it is important to assess beforehand how susceptible subjects are to hypnosis, either for screening purposes or to establish that subjects can indeed experience the hypnotic phenomena that the study tries to induce. The Stanford Hypnotic Susceptibility Scale: Form C (SHSS:C; Weitzenhoffer & Hilgard, 1962) is generally seen as the most accurate predictor of individual hypnotic performance (Register & Kihlstrom, 1986). However, the SHSS:C has to be administered individually, which requires 1.5 hours per subject, and it is not intended as an introduction to hypnosis and requires prior exposure to hypnotic induction (e.g., through pre-screening with an introductory measure such as the SHSS: Forms A or B). This places the administration of the SHSS:C well beyond the time and resources available to most researchers for the screening of prospective subjects prior to experimentation. To address some of these issues, Shor and Orne (1962) developed a standardised scale that can be administered in large groups, called the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A). Despite the psychometric superiority of the SHSS:C, the HGSHS:A quickly became the sole measure for classifying subjects into high and low hypnotic-susceptibility groups in the majority of hypnosis research. A survey by Bowers (1993) of three major journals found that, of the 254 hypnosis studies published between 1976 and 1986, the HGSHS:A had been used 179 times, but less than 25% of studies had used a follow-up assessment with the SHSS:C. However, the HGSHS:A was never designed for this purpose. Orne (1971), in fact, insisted that multiple assessment was essential for reliable classification.

Exclusive reliance on a single introductory measure of hypnotic susceptibility, such as the HGSHS:A, is likely to yield misleading results, at least on some occasions, as many individuals do not reach their optimal degree of hypnotic susceptibility in one session (Perry et al., 1992).

To achieve an accurate enough predictor of individual hypnotic performance, the current study used two subsequent tests of hypnotic susceptibility. The procedure followed was the same as that used by Miller and Bowers (1986, 1993). Subjects who met the screening criteria of the introductory measure (HGSHS:A) where then invited to take part in a second and more demanding screening of hypnotic susceptibility using the Waterloo Stanford Group C Scale (WSGC; Bowers, Laurence, & Hart, 1982)

7.2. *Initial Assessment*

7.2.1. **Subjects**

One hundred and ninety unpaid volunteers, solicited from undergraduate and graduate classes in various departments within the social science faculty, took part in the first phase of the screening process. This group of volunteers consisted of 131 females and 59 males. The difference in gender proportion largely reflects gender differences in the make up of student numbers in most social science classes. Both groups ranged in age from 18 to 47 years, and the mean age was 22.9 years for females and 22.5 years for males. Eight subjects did not complete the response booklet for the HGSHS:A. The main reason given was that, at some point during the assessment they no longer felt hypnotised, became fully alert, and stopped responding to the suggestions. Prior to participating, all subjects had read an information sheet outlining the nature of the assessment (Appendix 1), and signed a consent form (Appendix 2). The consent form included consent to be contacted by telephone should they be selected for participation in any of the further stages of the study.

7.2.2. **Measures**

The initial screening process used the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A; Shor & Orne, 1962). As part of the initial assessment, subjects also completed the Tellegen Absorption Scale (TAS; Tellegen & Atkinson, 1974; Tellegen, 1976) and the Toronto Alexithymia Scale. (Taylor, Ryan, & Bagby, 1985). These two self-report inventories were included mainly to gather information for a separate study intended to investigate the relationship between alexithymia, absorption, and hypnotic ability. Because the data for the Toronto Alexithymia Scale did not form part of the present study, this measure will only be discussed briefly.

7.2.2.1. *Harvard Group Scale of Hypnotic Susceptibility: Form A.*

The HGSHS:A, which is an adaptation for group administration of the SHSS:A, was developed specifically with economy in mind (Bertrand, 1989). Like the Stanford scales, the HGSHS:A consists of a hypnotic induction followed by 12 hypnotic suggestions and a standard procedure to bring subjects back to a normal, fully awake, state of consciousness. The HGSHS:A is self-scored by subjects who judge, in retrospect, whether or not they performed the suggested behaviours according to the criterion provided for each item in a special response booklet. The investigator simply adds the number of items passed together to arrive at a total hypnotic-susceptibility score ranging from 0 to 12. The entire procedure is standardised so that all subjects are treated alike, and can be recorded on tape. This enables it to be administered to large groups simultaneously, thereby saving substantial time. Several studies have found correlations between subjects' self-report ratings and those made by objective observers to be around .85 (Bentler & Hilgard, 1963; O'Connell, 1964; Shor & Orne, 1963).

Conventionally, 0-4, 5-7, and 8-12 have been used as cut-off points for the purpose of collapsing hypnotic-susceptibility scores into categories of low, medium, high hypnotic susceptibility respectively (e.g., Hilgard, 1965; Register, & Kihlstrom, 1986).

The latter category is sometimes further divided in to high (8-10) and very high or virtuoso (11-12) performance. The current study used the more conservative cut-off scores of 0-3, 4-8, and 9-12 for both hypnotic-susceptibility assessments, in accordance with the classification criteria used by Miller and Bowers (1986, 1993).

Of the remaining 182 participants who completed the HGSHS:A, 29 (15,9%) passed no more than three items, 97 (53.3%) passed between four and eight items, and 56 participants (30.8%) passed nine or more items. Subjects who passed three or less items were classified as relatively unsusceptible to hypnosis, and those who passed nine or more items as highly susceptible.

The HGSHS:A is a relatively uncomplicated scale that provides a reliable and effective assessment of initial ratings of hypnotic susceptibility. However, several studies have found that the HGSHS:A correlates only about .60 with the SHSS:C, which is generally regarded as the best available criterion of hypnotisability (Bentler & Roberts, 1963; Coe, 1964; Evans & Schmeidler, 1966, Register & Kihlstrom, 1986). This is well below the maximum possible correlation of .82 that can be obtained between these two measures based on their individual reliabilities (Evans & Schmeidler, 1966). Register and Kihlstrom (1986) found that only one third of their HGSHS:A high-susceptible subjects were able to be so classified on a subsequent administration of the SHSS:C. Thus, the HGSHA:A is a poor predictor of performance on the SHSS:C. It is best suited for identifying those candidates which are the most (or least) promising for further hypnotic assessment or intervention. When used in this context it also provides subjects with an informed basis for deciding whether to participate in any further hypnotic procedures. The HGSHS:A is less suitable, and was never designed, for distinguishing diagnostic subgroups such as subjects with low and high hypnotic ability (Register & Kihlstrom, 1986).

7.2.2.2. *Tellegen Absorption Scale*

The Tellegen Absorption Scale (TAS; Tellegen & Atkinson, 1974) is a self-report inventory that asks subjects to provide a true/false response to a list of 34 statements describing various situations of being involved in imaginative or absorbing situations.

The TAS emerged out of attempts to capture the types of experiences (i.e., interests and involvements) outside the hypnotic context that were predictive of hypnotic susceptibility. In developing the absorption scale, Tellegen and Atkinson started with a pool of 71 items consisting mainly of items previously found to correlate with susceptibility (e.g. As, 1963; Roberts & Tellegen, 1973) or that were part of subscales found to relate to susceptibility (Lee-Teng, 1965). Factor analyses of responses to these items resulted in eleven factor scores, of which six showed moderate to high loadings on only one factor, which was the only factor that was consistently correlated with indicators of hypnotic susceptibility. This factor was labelled "Openness to Absorbing and Self-Altering Experiences" or "Absorption" (Tellegen & Atkinson, 1974, p. 271). Absorption was interpreted as "total attention, involving full commitment of available perceptual, motoric, imaginative and ideational resources to a unified representation of the attentional object" (Tellegen & Atkinson, 1974, p. 274). Tellegen (1982) cites an internal reliability of r = .88 and a 30-day test-retest reliability of r = .91 (.85 by Kihlstrom et al. 1989).

Tellegen later incorporated the absorption scale as a subscale into a larger personality inventory, the Differential Personality Questionnaire (DPQ; Tellegen, 1976) and its successor the Multidimensional Personality Questionnaire (MPQ; Tellegen, 1982). In these later publications Tellegen (1982, 1992, cited in Glisky & Kihlstrom, 1993) expanded the original construct of absorption by proposing that the overall phenomenon of *openness to experience* incorporates two distinct mental sets (i.e., experiential and instrumental). According to Tellegen, the experiential mental set tied in with absorption. This *experiential* mental set involved a receptivity or openness to undergo sensory or imaginal events, combined with a tendency to dwell on them, so that the experiences have a quality of effortlessness or involuntariness. The *instrumental* mental set, by contrast, involved goal-directed readiness to make discriminations, plans, and decisions. In a more recent manuscript (Tellegen, 1992, p. 1, cited in Glisky & Kihlstrom, 1993) characterised absorption as a "disposition to enter ... psychological states characterized by a marked restructuring of the phenomenal self and world." Radtke and Stam (1991) have further suggested that absorption assesses involvement in subjective experiences, not just opennes to them.

7.2.2.3. *Toronto Alexithymia Scale*

The Toronto Alexithymia Scale (Taylor et al., 1985) is a 26 item self-report inventory that assesses the level of ease with which subjects understand and express their emotions. Subjects indicate on a five point Likert scale the extend to which they agree or disagree with each statement. Factor analysis has indicated that the construct of alexithymia, as assessed by the Toronto Alexithymia Scale, is made up of four main factors: (1) difficulty in identifying and distinguishing between feelings and bodily sensations, (2) difficulty in communicating feelings, (3) reduced daydreaming, and (4) externally-oriented thinking.

7.2.3. **Procedure**

Thirty sessions were held for the initial assessment stage, using either a large classroom or a lecture theatre as venue. Group sizes ranged from twenty-six to as small as one. Participants were welcomed and initial rapport was established. Following this, a brief overview of the assessment was given, and participants were told they should feel free to ask any questions they might have concerning the assessment or its procedure before we started. They were then asked to read the information sheet (see Appendix 1) and, when satisfied with the information provided, to completed the consent form (see Appendix 2).

The standard self-report inventories for the TAS and the Toronto Alexithymia Scale had been combined with the response booklet for the HGSHS:A into one response booklet for this initial assessment. Subjects first completed the two questionnaires for the TAS and the Toronto Alexithymia Scale. It was emphasised that, we were interested in their choice of option that **most closely** described their preferred answer to each statement. When everybody had finished, participants were informed that in a few minutes we were going to administer a standard procedure for measuring susceptibility to hypnosis. The doors were then closed and a notice placed on the outside informing people that the session was in progress and no person could be allowed in any more during this session.

The investigator then gave a brief introduction to hypnosis and the assessment of hypnotic susceptibility, which in an uncontrived fashion covered the points mentioned in the manual for the HGSGS:A (pp 3-4; see Appendix 3). These preliminary remarks are intended to establish rapport and make subjects feel at ease by explaining what is going to happen and give them the opportunity to ask questions before the induction is started. Subjects were asked not to leave the room until all had completed the response booklet. The tape recorder was then turned on, and the main procedure for the HGSHS:A started. This procedure had been recorded on tape by Dr. Bill Zika and followed the standard transcript and instruction set out in the manual for the HGSHS:A (Shor & Orne, 1962).

The researcher remained present throughout the session, and for most sessions was accompanied by an assistant. Without being unnecessarily probing, they remained alert should any participant show or report any signs of being disturbed by the procedure. Upon completion of the response booklet, subjects were informed that if they experienced any distress during or following the assessment they could follow this up with the researcher personally, or if they preferred with Dr. Bill Zika, who at that stage was head of Student Counselling Services at Massey University, and had agreed to act as a support person when needed. The researcher then thanked subjects for their participation and ended the session.

7.3. *Follow-up Assessment.*

It has been strongly argued that, to arrive at a hypnotic ability score that has sufficient predictive validity to warrant its use as a criterion for allocating subjects to high and low hypnotic-ability treatment groups, it is necessary to employ a follow-up assessment with a cognitively more challenging measure of hypnotic susceptibility (e.g. Bowers, 1993; Orne, 1971). The current study used a follow-up assessment with the Waterloo-Stanford Group C Scale of Hypnotic Susceptibility (WSGC; Bowers et al., 1982) in accordance with the selection procedure used in the studies by Miller and Bowers (1986; 1993).

7.3.1. **Subjects**

Ninety-three participants, selected on the basis of their score on the HGSHS:A, were contacted by telephone and invited to take part in a second more challenging assessment of their hypnotic ability. This group included the eight subjects who had only partially completed the HGSHS:A because they felt no longer hypnotised. Seventy-eight of these that took part in the follow-up assessment using the WGSC. This group consisted of fifty females and twenty-eight were males. The mean age for both gender groups was 22.7 years (range 18-46 for females and 18-47 for males).

7.3.2. **Measure - Waterloo-Stanford Group C Scale**

The Waterloo-Stanford Group C Scale of Hypnotic Susceptibility was developed to address the obvious need for a group scale of hypnotic susceptibility that could substitute for the SHSS:C. The WSGC is not a strict item for item translation of the SHSS:C as some modifications had to be made to make the procedure suitable for group administration. The anosmia to ammonia item, which was too awkward to be administered in a group setting, was replaced by a posthypnotic suggestion involving automatic writing. The negative visual hallucination was changed slightly and used three coloured balls placed in a triangular formation in the middle of the floor, instead of the three coloured boxes placed on a small table in front of the subject for the individually administered SHSS:C. The auditory hallucination was also changed because group administration precluded the interactive quality of the original item. And finally it was found that hands coming together was easier for subjects to self-score than the hands going apart item of the SHSS:C (Bowers, 1993).

The wording of the induction procedure was altered considerably to reflect current conceptions of hypnosis, for example, all references to the word "sleep" were omitted and the tone of suggestions was generally more permissive than that used on the SHSS:C. One significant departure was made in the scoring of the WGSC. The SHSS:C has the amnesia item scored as a pass when no more than three scale items are remembered.

The amnesia item on the WSGC includes reversibility of amnesia to reflect memory loss due specifically to suggested amnesia and unconfounded by spontaneous forgetting. This has been recommended by several researchers because it adds important information to the scoring of this item otherwise not available with group scales (e.g., Kilhstrom & Evans, 1976; Kihlstrom & Register, 1984; Radtke & Spanos, 1981). The amnesia item on the WSGC uses a conservative scoring criterion that rates responses as a pass when subjects remember three or less items before they are told "now you can remember everything" *and* at least three *additional* items after this instruction has been given.

Notwithstanding these changes, the WSGC appears to have retained much of the superior psychometric properties of the SHSS:C. Bowers (1993) found that the mean WSGC score for their normative sample was only about half a scale unit higher than that of the SHSS:C. The two scales correlated .85 with each other. This is as high as the upper limit of the theoretical correlation between these two scales, based on the internal consistency of both scales. The internal consistency, assessed by the KR20 formula, was .84 for the SHSS:C and .81 for the WSGC. The cross-test item correlations are generally quite high ranging from .55 to .89. The only exceptions were the dream (.44) and the posthypnotic suggestion (.42) that replaced the anosmia for ammonia item on the SHSS:C. This is not that surprising seen that the group administration does not have the interactive quality that is clearly present with the individual administration of these two items. A comparison of scores for two independent samples indicated that the WGSC had considerable (r = .92) cross-sample consistency. Bowers (1993) concluded that, when a large number of subjects are required for subsequent experiments and time and resources are scares, when subjects are university students rather than clinical patients, and when they have been screened on the HGSHS:A, small group testing with the WSGC may be a valid and attractive alternative to the SHSS:C for obtaining an index of hypnotic ability that has high predictive validity.

7.3.3. **Materials**

Each subject received a clipboard and a pen. For the negative visual hallucination (item 10) a 90cm square, ¾ inch thick, plywood board was used with three divots at the vertices of an equilateral triangle having 40cm sides. Three coloured plastic balls, 8cm in diameter, were placed on this board. The colours of the balls were red, blue, and green. This deviates slightly from the set-up described by Miller and Bowers (1993) who used pink-, yellow-, and black-coloured tennis balls on a circular board, 77 cm in diameter. The board used by Bowers (1993) was painted creamy white to counteract the bright red carpet in the room they used. The room used for the current study had a rather dark and dull coloured carpet and it was not seen as necessary to paint the board.

7.3.4. **Procedure**

Twenty-six sessions were held for the administration of the WGSC. A smaller and more comfortable tutorial room was used as venue and no group sizes were larger than six with some as small as one or two. Subjects first read the information sheet for this part of the study (Appendix 4), and when satisfied with the information provided signed the consent form (Appendix 5). The information sheet explained that, based on their score on this measure, they might be invited to take part in the final part of the study, an experiment on imaginative involvement and coping with pain. The informed consent form included consent to be contacted by telephone should they qualify for the experimental part of the study.

The clipboards, pens, and response booklets were then handed out and subjects filled in the personal details on the cover page of the response booklet. When finished, they were asked to turn the response booklet over so that the blank rear page was on top, clip it to the board, and place clipboard and pen on the floor in front of them. It was explained that at some stage during the procedure they would need the clipboard and pen and that these would be handed to them. The researcher then followed the standard introduction and made the following announcement.

"In a few minutes, I am going to administer a standard procedure for measuring hypnotic ability. At the end of the standard procedure, you will be asked to report on your experience in the response booklet that has been given to you. This procedure is similar to the one that was administered to you earlier in the large group test. If any of you are wearing contact lenses, you may wish to take them out now. Now I think we can begin. "

The researcher then switched on the tape recorder. The procedure for the WGSC had been recorded on tape by Dr. Bill Zika according to the transcript and instructions of the manual for the WGSC (Bowers et al., 1982). The only alteration made was to exchange the American terms "fifth grade" and "second grade" with their New Zealand equivalents "standard 4" and "standard 1."

At some places during the procedure (items 8 and 10), the tape has to be paused, pens and clipboards handed out or collected, response booklets turned over, or the board and balls placed in the middle of the floor and later remove again. It is essential that the researcher is prepared for this so that these actions can be performed smoothly and without unnecessary disturbance to the subjects. Furthermore, the researcher needs to be alert for any signs of possible distress or indications that subjects have not returned completely to the present at the end of the age regression item or have regained full normal wakefulness at the end of the procedure.

Following the hypnotic procedure and return to full normal wakefulness, subjects were asked to completed the response booklet. When all were finished the researcher ensured he had everybody's attention before starting the debriefing. This included the following message. "You may recall that during the session today, you were asked to hold up your hand when you heard a recording of Jingle Bells. In fact, no recording was played -- there was no music in the room. Also, near the end of the session, you were told that when you opened your eyes, you would see *two* balls in the middle of the floor. Actually, there were three balls there. The purpose of these two items was not to deceive you. We know from past research that the perception of persons who are highly susceptible to hypnosis will sometimes be altered to coincide with suggestions that do not accurately reflects the actual stimuli presented.

The intention in presenting these two suggestions just mentioned was to assess your responsiveness to suggestions that involve such perceptual alterations."

Finally, subjects were asked if they had any further questions, and reminded that if they had experienced anything that they wanted to follow up, they could do so by seeing the researcher or Dr. Bill Zika at Student Counselling Services. The researcher thanked subjects for their participation and for their time so graciously made available, and then closed the session.

CHAPTER EIGHT

EXPERIMENTAL STAGE

8.1. *Experimental Design*

The experimental part of the study used a mixed 2 (treatment conditions) by 2 (tracking conditions) by 2 (pain levels) repeated-measures design with hypnotic ability serving as the between-subjects factor. Subjects were administered eight series (blocks) of three stimulus trials each (see Figure 13). During four of these they received painful stimulation at the 30% pain level and during the other four at the 60% pain level. For each pain level, two stimulus blocks were administered while subjects simultaneously performed a pursuit-tracking task and two without the tracking task. Each time, they used hypnotic suggestions to cope with the pain during one of these trials and their preferred nonhypnotic coping strategy during the other.

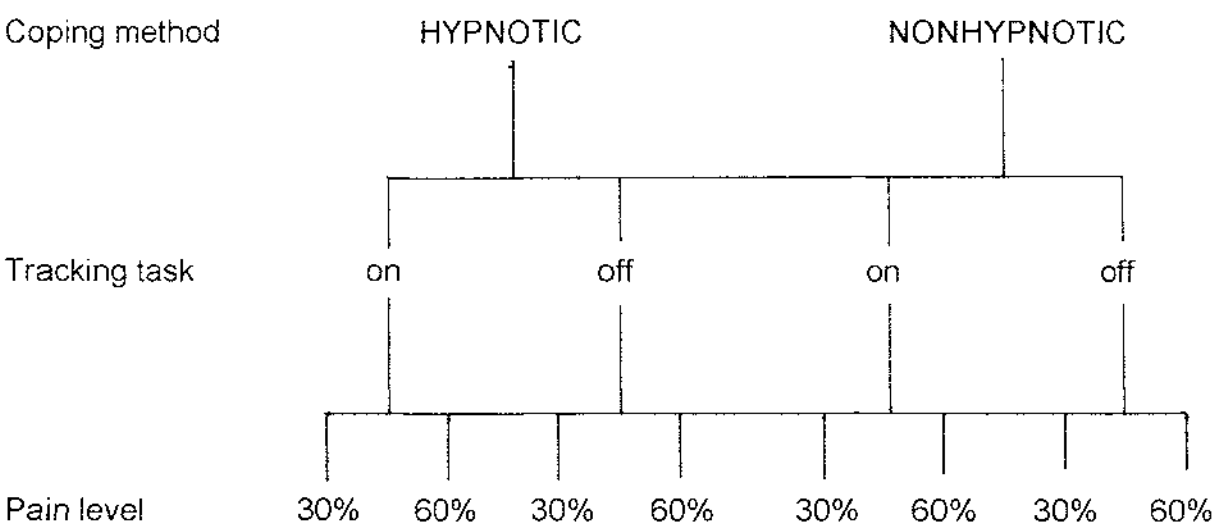

Figure 13. Experimental design showing all treatment combinations.

The order of administration of treatment conditions (hypnotic first vs. nonhypnotic first) and tracking task (tracking-task off vs. tracking-task on) was counterbalanced to control for sequence effects (Dunham, 1988). Subjects in each hypnotic-ability group were randomly assigned to one of these four treatment orders with the restriction that they matched as closely as possible for gender.

A computer programme automatically recorder tracking errors (i.e., the deviation between cursor position and tracking wave) during the stimulus blocks when subjects attended to the tracking task. Following each treatment block, ratings were also collected on a number of other dependent variables (DV's). These included in order of presentation: (1) hypnotic depth, (2) pain intensity, (3) pain unpleasantness, (4) absorption in tracking task, and (5) coping strategies used. For obvious reasons hypnotic depth ratings were only taken following the hypnotic conditions (4x) and rating of absorption in tracking tasks only for conditions with the tracking task on (4x). All other ratings were taken directly following each treatment combination (8x).

8.2. *Subjects*

Fifty subjects qualified to take part in the experimental stage of the study because they had been classified as being either highly susceptible to hypnosis suggestions (i.e., scoring 9 or more) or relatively unsusceptible (i.e., scoring three or lower) on both hypnotic-susceptibility screening tests. They were contacted by telephone and invited to take part in the final stage of the study for which they were offered a payment of $15. Due to unforseen circumstances experimentation was delayed, which unfortunately meant that a substantial number of potential subjects were no longer available. However, twenty-seven volunteers could still be secured for the experimental stage of the study. One subject terminated the stimulation trials part way through the experiment and was excluded from subsequent experimentation and data analysis. Of the twenty-six subjects that completed the experimental session, fourteen had been allocated to the high hypnotic-ability group (mean score on WGSC 9.86) and twelve to the low hypnotic-ability group (mean WSGC score 0.83). Both hypnotic-ability groups were made up of equal numbers of males and females and there were no significant differences in age distribution.

Prior to participating, all subjects read an information sheet (Appendix 6), which outlined the nature of the experiment, and completed a consent form (Appendix 7). To determine if any contra indicating medical conditions were present, subjects also completed a health checklist (Appendix 8). No subjects were excluded for medical reasons.

8.3. *Apparatus*

An IBM compatible PC was used to control the administration of pain stimuli, display the tracking task, and to record and store all tracking performance data. A portable tape recorder was used to administer the hypnotic induction and suggestions.

8.3.1. **Pain stimulus delivery**

Potassium iontophoresis was used as the experimental pain stimulus. Iontophoresis (or ion transfer) is a nonpenetrating way of facilitating transdermal delivery of, for example, drugs, many of which are in ionised form and, as such, cannot adequately cross the skin barrier. By passing a small electric current through the ionised solution (in this case potassium chloride), the ions are able to pass through the superficial skin layers. Our skin, which contains approximately 40% water, has a negative charge and iontophoresis, through the process of electro-osmosis, effects the movement of water into the body from the positive pole toward the outer skin at the negative pole. This leads to shrinkage of the skin pores at the positive pole. This process is helpful in the transfer of positively charged ions (e.g., potassium ions K^+) from the positive electrode, as it acts in the same direction, facilitating the absorption of a positively charged solution. The solution to be delivered is placed at the side of the electrode with same charge as the solution, that is positively charged ions are introduced into the tissue from the positive pole, while ions with a negative charge are applied from the negative pole. For a more detailed description of iontophoresis and its therapeutic uses, see Tyle and Kari (1988).

Potassium ions have been found to excite both A-delta and C nerve fibres (e.g., Guilbaud, 1988; Kumazawa & Mizumura, 1977; Uchida & Murao, 1974). Subjects typically report the iontophoretic stimulation as a pricking pain at low stimulus intensities changing into a burning sensation at higher stimulus levels (Humphries et al. 1994). This corresponds well with observations that first pain is mediated by A-delta fibres and produces a pricking sensation, whereas second pain appears to be mediated by C fibres and result in pain sensations with a burning or throbbing quality (Price, 1972; Willis, 1985, p. 37).

The pain stimuli were delivered through an iontophoretic pain generator developed by the Psychology Department at Massey University. This device consisted of a computer controlled constant-current power source designed to deliver a selected amount of current ranging from 0 to 25 mA. Intensity levels could be selected in 0.1 mA steps. The delivery of specified current levels was ramped up and down in order to avoid the sensation of electric shock associated with sudden current changes (Balogun, 1986). As a safety precaution, the stimulus was automatically ramped down to zero (at a rate of 5mA/sec) when it reached 25 mA, or when a subject pressed the cut-off switch. Pressing the cut-off switch stopped the delivery of any further stimuli.

The placement of the electrodes on the subject's forearm was similar to that described by Benjamin and Helvey (1963), and the same as used by other studies at Massey University (e.g., Humphries, Johnson, & Long, 1996; Humphries et al., 1994; Johnson et al., 1998). In the current study, the electrodes were always placed on the subject's nondominant arm. The cathode (- electrode) consisted of a silver plate (4cm x 13cm), which was insulated from the palmar surface of the subject's arm by several layers of saline-saturated medical gauze (9% w/v sodium chloride). The anode (+ electrode) consisted of a perforated copper plate, which was suspended in an approx. 4 cm high PVC ring. The PVC ring was secured by two rubber straps so that it sat flat on the volar surface of the subject's forearm and formed a bowl with the surface of the arm acting as its base (see Figure 14).

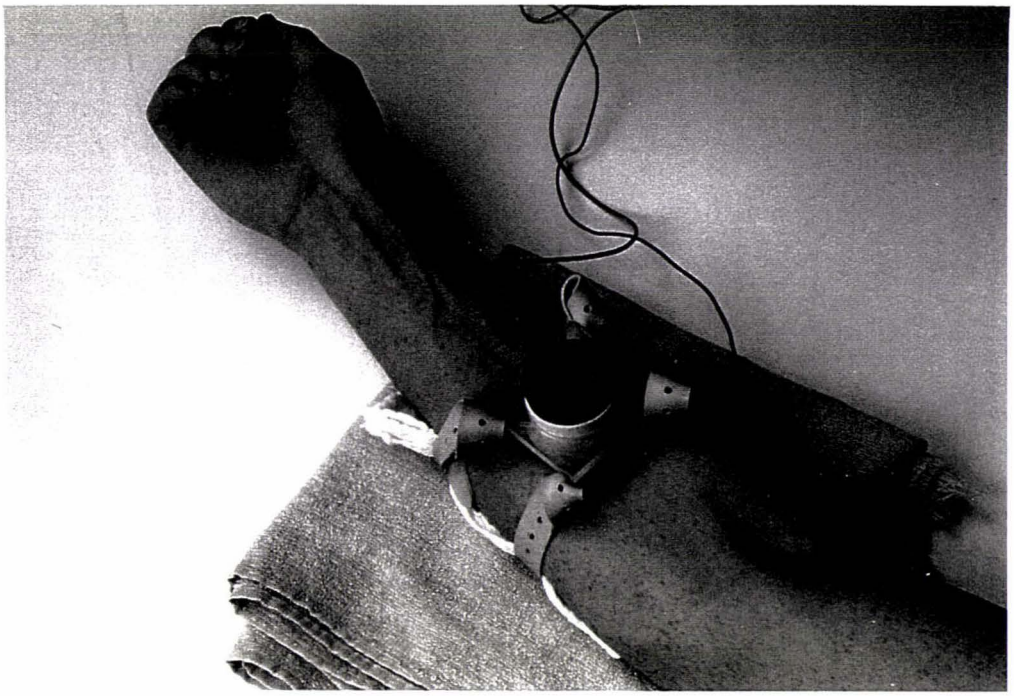

Figure 14. Electrode placement for iontophoretic pain stimulation, showing anode bowl on volar surface of subject's arm.

The anode bowl was filled with a potassium chloride solution (3% w/v) to above the level of the anode. Being 4cm in diameter ensured that a 12.5 cm^2 surface area of skin was in direct contact with the solution. Each mA/sec of applied current resulted in the delivery of 0.405 μg of potassium ions. One-percent (w/v) biological grade agar was added to the potassium chloride solution to give it the consistency of a gel and prevent it from leaking between the base of the bowl and the subject's skin. This permitted the anode bowl to be attached to the subject's arm without the need for excessive pressure.

8.3.2. **Tracking task and control of pain stimulus delivery**

A custom made software program, developed by the Psychology Department at Massey University, was used to control the pursuit-tracking task, deliver the pain stimuli, and record all tracking data.

This program allowed the researcher to manipulate a tracking wave form by altering one or more of its parameters (e.g. speed, number of cycles, amplitude, line width, total running time etc.). The current study used a sine wave that moved across the screen at a speed of two pixels per iteration. The time between iterations was set at 100 msec. The sine wave always started at the bottom left corner of the computer screen and at the same point along the wave oscillation, being the lower midpoint (trough) of one of its oscillations.

Cursor movements on the computer screen were controlled by a control box that housed a potentiometer slide. By moving the knob of the potentiometer slide up or down (range 10 cm), subjects directed the vertical movement of a square cursor on the VDU. The tracking task consisted of trying to keep the cursor on the sine wave as it moved along the screen. Subjects were instructed to start each treatment block with the potentiometer slide in the bottom position. This ensured that, at the start of each trial, the cursor was always at the bottom of the screen at the same place where the tracking wave started. This minimised the initial catching up needed to keep the cursor on the sine wave as the latter started to move along the screen.

The software program included two control files for the administration of pain stimuli. One was used for the threshold and tolerance trials and enabled the researcher to specify the time delay before onset of the stimulus and the ramp rate. A second control file was used for the main part of the experiment to controlled the administration of the eight blocks of stimulus trials. Its presentation was synchronised with that of the tracking task so that both started at the same time. For each stimulus block, the experimenter specified as appropriate either the 30% or 60% pain level for that particular subject. The ramp rate (1mA/sec), time delay between stimuli (20 sec), and time that stimuli stayed on at the 30 % or 60% pain level (10 sec) were constant for all trial blocks and all subjects (see Figure 15).

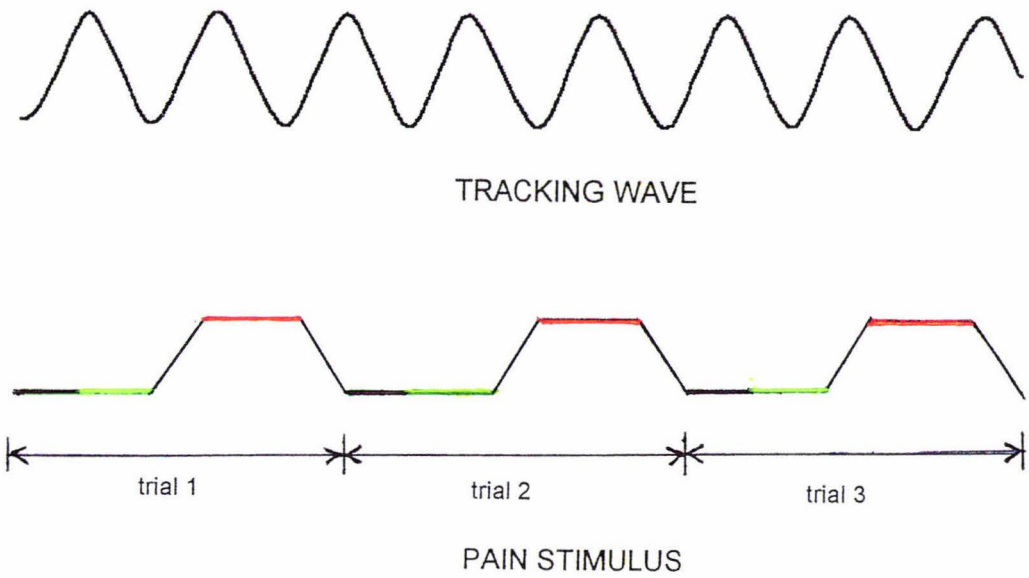

Figure 15. Full tracking wave and block of three stimulus trials for each condition.

The software program recorded per second: (1) the total time elapsed in seconds; (2) the pain stimulus level, that is the amount of current applied to the iontophoretic device in 0.1 mA units; and (3) the average tracking deviation over the preceding ten 100 msec intervals. The individual tracking data files were coded per subject and condition and later combined into a tracking-data master file. Tracking data collected over the 10 seconds immediately preceding the presentation of the pain stimulus (green lines in Figure 15) represented the pain-off situations. Tracking data collected over the 10 seconds when the pain stimulus was full on at either the 30% or 60% pain level (red lines in Figure 15) represented the pain-on situations. The average tracking values for both pain-on and pain-off situations then became the individual tracking variables used for subsequent data analyses.

8.4. *Measures*

Subjects provided ratings of pain intensity and unpleasantness, level of absorption in the tracking task, strategy use, and hypnotic depth. Pain ratings and ratings of absorption in the tracking task were all made using visual analogue scales (VAS). The VAS has been found to be a reliable and valid measure for assessing pain ratings (Duncan, Bushnell, & Lavigne, 1989; Price, McGrath, Rafii & Buckingham, 1983). The VAS's used were all 150 mm in length and anchored at both ends with no intervals between the anchors. All VAS ratings were completed in paper and pencil form.

8.4.1. **Pain ratings**

It is now well-accepted that pain responding involves both sensory and affective components, although the independence of these two components is still under discussion (see Fernandez & Turk, 1992). Pain is increasingly studied as a multidimensional experience and several studies have established that different interventions frequently are differentially effective in reducing sensory and affective dimensions of pain experience (Gracely, McGrath, & Dubner, 1978). The sensory component of pain is best reflected by ratings of the intensity of the pain stimulus, while the affective component relates to the discomfort or unpleasantness of the pain. Results indicate that the psychological context of the particular intervention used can differentially influence the affective dimension of pain (Price, Hawkins, & Baker, 1987). Dahlgren, Kurtz, Strube, and Malone (1995) and Malone et al. (1989) found that hypnotic analgesia reduced pain intensity significantly more than pain unpleasantness, whereas hypnotic relaxation reduced pain unpleasantness more than pain intensity. Separate ratings were, therefore, collected for pain intensity and pain unpleasantness.

8.4.1.1. *Pain intensity*

Following each block of stimulus trials, subjects were asked to indicate on a VAS how intensely painful they felt the preceding three stimuli to be, by placing a slash at the place along the line that best described their experience (see Figure 16). Ratings related to average intensity over the three stimulus trials.

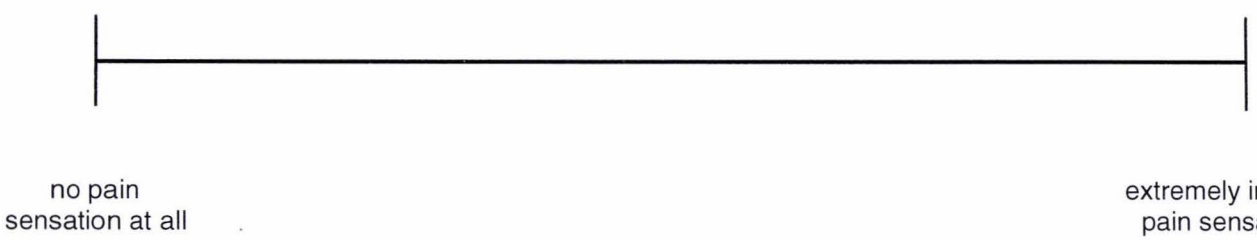

Figure 16. Visual analogue scale for subjects' rating of pain intensity.

8.4.1.2. *Pain unpleasantness*

Following each stimulus block, subjects used a similar VAS to indicate how unpleasant they felt the preceding three stimuli to be. The VAS for pain unpleasantness was anchored with "not uncomfortable" and "excruciating." These labels had been selected from sensory and affective pain descriptors validated by Gracely et al. (1978).

8.4.2. **Absorption in tracking task**

To establish a measure of subjects' involvement in the tracking task, subjects were asked to indicate on a similar VAS how absorbed they were in attending to the tracking task. The descriptors used to anchor each side of the scale were "not absorbed at all" and "completely absorbed."

8.4.3. **Strategy use**

After each block of three pain trials subjects indicated which if any coping strategies they had used to achieve pain relief. They did this by selecting (✓) ***one or more*** of the following options as appropriate. It was explained that a coping strategy was seen as "any ***deliberate*** attempt to engage in an activity that might be helpful in reducing the pain."

_____ I deliberately used the hypnotic suggestions for relaxation and analgesia

_____ I deliberately attended to the tracking task

_____ I used other deliberate coping strategies, please describe briefly

_____

_____

_____ I made **no** deliberate attempt to use any coping strategies

8.4.4. **Hypnotic depth**

Tellegen (1978/1979) has highlighted the importance of recognising not only between subject differences in hypnotic performance, but also the intra-individual fluctuations in hypnotic involvement. Tellegen argued that a person's hypnotic performance comprises the influence of a *"trait or average state"* component and a *"momentary state"* component. The trait component reflects a person's average level of hypnotic ability and is largely tapped by the standard hypnotic-susceptibility scales. Although this trait component varies substantially between people, it has been shown to be a stable personality trait that is, without special interventions, remarkably resistant to modification by normal experiences encountered in daily life (Piccione et al., 1989). Environmental factors, however, can markedly effect the momentary state of hypnotic involvement and cause short-term variations in an individual's level of hypnotic performance. Hypnotic depth is the term used for the momentary degree of involvement in hypnosis that can readily be judged by the hypnotised person (Hilgard, 1977).

The fact that some subjects who passed nine or more items on the HGSHS:A only passed three or less items on a subsequent assessment with the WGSC, or vice versa, suggest the likely influence of such "environmental" factors during the assessment of subjects in the current study (see also Schnyder & Allen, 1995). This was supported by comments made by two subjects that their ability to become involved in the hypnotic induction was seriously impaired by the fact that they had a headache at the time, or a bad cold and dripping nose. It is, therefore, important to obtain a measure of a subject's level of hypnotic depth at the time of assessment. This was particularly relevant in the current study because hypnotic-susceptibility scores had been obtained several weeks prior to the experimental session. Furthermore, it is possible that having to complete a set of ratings following each block of stimulus trials could interfere with a subject's ability to maintain their hypnotic state and lead to a gradual decline in hypnotic depth. Conversely, hypnotic depth levels may remain largely stable or might even be enhanced by the repeated administration of deepening suggestions at the start of each new condition.

To track any possible changes in hypnotic involvement across conditions, subjects were, therefore, also asked to provide a rating of their hypnotic depth following each block of stimulus trials in the hypnotic condition.

A number of self-report scales have been developed to assess momentary states of hypnotic depth. A review of these scales by Tart (1978/1979) concluded that they can provide a quick and convenient assessment of the intensity of a person's momentary hypnotic state. The current study used the Long Stanford Scale (Larsen, 1965; Tart, 1966, both cited in Tart, 1970), which is one of the two hypnotic depth scales recommended by Tart (1978/1979) for both experimental and clinical work. Tart (1970) found that, when using the Long Stanford Scale, the average of hypnotic depth ratings following each suggestion on the SHSS:C was found to correlate .77 and .76 ($p < .0005$, 1-tailed) with respectively the behavioural and the experiential score on the individually administered SHHS:C. Hypnotic depth ratings taken immediately before the administration of each suggestion on the SHSS:C were always greater for subsequently passed than for subsequently failed items. This difference was statistically significant ($p < .005$, 1-tailed) and increased with increasing item difficulty. The curve of mean depth reports following each item on the SHSS:C showed a significant rise ($p < .05$, 1-tailed) for highly hypnotisable subjects, but was essentially flat for subjects with low hypnotic ability (Tart, 1970). This suggests that the hypnotic suggestions themselves acted as deepening procedures.

Comparisons between *instant* and *deliberate* reporting of hypnotic depth revealed that the correlation between hypnotic depth scores on the Long Stanford Scale and the behavioural scores on the SHSS:C was higher when hypnotic depth was reported instantly ($r = .85$, $p < .005$, 1-tailed) than when it followed a short deliberation ($r = .67$, $p < .001$, 1-tailed), but this difference was not significant ($p = .11$, 1-tailed; Tart, 1970).

To summarise, the Long Stanford Scale can provide a valid and reliable measure of the momentary intensity of a person's hypnotic state that correlates highly with behavioural measures of hypnotic susceptibility. Immediately reported ratings of hypnotic depth are just as reliable as ratings given after some deliberation, and the reporting of hypnotic depth does not itself interfere with hypnotic performance.

8.5. *Procedure*

Subjects were seen individually in a room specifically used for experimental pain research. Upon arrival, subjects were reminded that they could be paid $15 for participating and that this did not depend on them having fully completed the experimental session. Following completion of the informed consent form and health checklist (Appendices 7 and 8) they were given a brief overview of the experimental procedure.

8.5.1. **Familiarisation**

The purpose of the familiarisation part was to acquaint subjects with the tasks to be performed and to reduce anxiety relating to the experimental procedure and the anticipation of pain. The pursuit-tracking task was demonstrated and subjects had a three-minute practice to become familiar with the requirements of this task and the use of the cursor control slide. Following this, the iontophoretic procedure was explained and subjects were assured that, if they did not want to tolerate any more, they could at all times terminate the stimulus trial by pressing a cut-off switch. Furthermore, all pain stimuli administered during the main part of the experiment would be well below the maximum intensity that they beforehand had indicated to be tolerable.

Before applying the electrodes for the iontophoresis, a standard preparation procedure was used to lower and stabilise skin resistance. This protocol involved lightly scrubbing the volar and palmar surfaces of the subject's forearm with warm soapy water. This was followed by cleaning both surfaces with distilled water, followed by a 10% acetone 90% alcohol solution, and finally once more with distilled water. Subjects were comfortably seated at a table and the electrodes were attached to their nondominant forearm. The cut-off switch was positioned so that it could easily be accessed by their free hand.

It was explained that pain sensations have both a sensory component, usually expressed as the intensity of the painful stimulus, and an affective component, expressed by how unpleasant or distressing we experience it to be. Pain is not a uniform experience and some types of pain might be experienced as more distressing then others. Some typical descriptors used to define sensory and affective aspects of pain were given. It was explained that after each block of three stimulus trials, they would be asked to rate first how intensely painful they felt the preceding three stimuli to be and then how unpleasant they were. The procedure for using the VAS scales was then briefly explained.

Following this, subjects received one block of three stimulus trials at 5mA intensity during which they also practised the tracking task. This gave them an idea what the iontophoretic stimulation would feel like and helped to further reduce anxiety, which can substantially influence pain ratings (Weisenberg, 1987). At the end of this set of trials, subjects practiced rating the average intensity and unpleasantness of the three stimuli by using VAS scales similar to those used in the main experiment. It was then explained that pain responding varies substantially between people and we would, therefore, establish each subject's individual threshold and tolerance level. These values would then be used to determine the individual levels of iontophoretic stimulation that they would receive during the main part of the experiment.

8.5.2. **Assessment of individual pain levels - pain threshold & tolerance trials**

Subjects were administered a block of three threshold-tolerance trials to assess their individual pain threshold and pain tolerance levels. Each subject's average threshold and tolerance value over the three trials was then used to calculate their individual 30% and 60% pain level that would be used during the main experiment. The following formulae were used for this:

30% pain level = threshold + .3 x (tolerance – threshold), and
60% pain level = threshold + .6 x (tolerance – threshold).

In order to avoid anticipation of pain sensation the trials had varying ramp rates and different delays between the signalled start of each trial and onset of the stimulus, which are provided in Table 4.

Table 4. *Stimulus delays and ramp rates for pain threshold-tolerance trials*

Trial	Stimulus delay (s)	Ramp rate (mA/s)
1	10	.4
2	5	.8
3	15	1.2

The presentation of these three threshold-tolerance trials was identical for all subjects. During each trial the stimulus gradually increased at the specified rate. Subjects were instructed to press a button on a control pad as soon as they first felt the stimulus to be painful. This represented their pain threshold, and the program automatically recorded the stimulus intensity at the time the threshold button was pressed. The stimulus kept increasing at a gradual rate and at the point where the subject felt they no longer wanted to tolerate any more, they pressed a second button. This terminated the stimulus trial and recorded the tolerance value.

Using individually determined pain levels ensured that the stimuli administered were more or less similar in perceived painfulness across subjects and that in rating their intensity and unpleasantness most of the range of the VAS scales would be used. By administering the familiarisation and threshold-tolerance trials in the same session as the experimental trials, possible changes in pain responding between sessions were minimised. Furthermore, the repeated administration of electric stimulation to the skin has been found to lower skin resistance and facilitate optimal pain responding (Tursky, 1974).

8.5.3. **Main experiment**

All subjects were administered both treatments conditions in a randomly assigned and counterbalanced order. In each treatment condition, subjects performed four blocks of three stimulus trials each, two at the 30% and two at the 60% pain level. One of each with the tracking task on and the other without the tracking task. The order of tracking-task presentation (on/off or off/on) was also counterbalanced. At the end of the session subjects were debriefed, thanked for their participation, and paid $15. The entire procedure for the experimental stage took approximately 90 minutes.

8.5.3.1. *Nonhypnotic analgesia condition*

In the nonhypnotic coping condition, subjects were informed about a variety of strategies that can be used to reduce the pain and discomfort when we are exposed to a painful situation. It was explained that most of these involve some form of diverting attention away from the pain, and psychologists generally refer to such strategies as cognitive coping strategies. Some examples of such strategies were given including: (1) diverting attention away from the pain (e.g., thinking about something else, getting involved in some other activity), (2) using imagination to transform the context of the painful sensation (e.g., thinking of the tingling feeling as the sensation you have when you just had a cool shower after a hot day or a full on game of sports), or (3) creating fantasy situations that are inconsistent with the experience of pain (e.g., lying on a warm sunny beach, or having a nice massage).

It was explained that such strategies help us to relax and focus our attention away from the pain. It was also pointed out that some people, at times when they experience that they can not adequately distract from the pain, prefer to imagine themselves as a passive onlooker observing the rhythm and quality of the sensation as it changes in intensity. This might help because it is seen to reduce the unpredictability of the pain, which is one of its more distressing qualities. By becoming aware of a sensation and monitoring it, it is possible to focus some of our attention on the less distressing qualities of the sensation.

In was further pointed out that catastrophising, that is focusing on the negative aspects of the situation or on our inability to cope with the experience, only increase our awareness of the unpleasantness and distressing character of the situation. In general, by breathing calmly and deeply and using a coping strategy that you feel to be helpful, you will experience less of the negative aspects of the situation. Finally, it was pointed out that performing the tracking task is an activity that requires attention. It could, therefore, be argued that by becoming involved in this task you are diverting attention away from the pain. The tracking task itself could thus be seen as a possible coping strategy and its usefulness would, al least partly, depend on the extend to which you become absorbed in it.

Subjects were then given a few minutes to select their preferred strategies and practice using it. Where needed the experimenter provided some negative sensations and thoughts that might arise during the pain trials and encouraged subjects to use their preferred cognitive coping strategies. Subjects were then instructed that in a moment they would receive four blocks of stimulus trials and that they would perform the tracking task during some of these. They were encouraged to use any coping strategy that they found helpful in staying relaxed and reducing the pain and discomfort they might feel. Following each block of trials, they were going to report on their experience. This treatment procedure took approximately 30 minutes.

8.5.3.2. *Hypnotic analgesia condition*

In the hypnotic-analgesia condition, subjects were informed that hypnosis is one of the ways that can be used to reduce pain and distress. All subjects were assured that anyone chosen for this study had sufficient ability to benefit from using this strategy. This was done to reduce any negative expectations that subjects with low hypnotic susceptibility might have regarding their ability to use hypnotic suggestions. Some examples of situations wherein hypnotic analgesia is use successfully were mentioned. Subjects were informed that in a moment they would be given a hypnotic induction followed by some hypnotic suggestion.

The procedure had again been recorded on tape to keep its administration constant, but this time had been recording by the experimenter himself. Subjects were informed that following the induction you will receive four blocks of pain stimulation and during some of these you will simultaneously perform the tracking task. While doing this, you will remain hypnotised. At certain times during this experience, I will be interested in knowing just how hypnotised you are. You will be able to tell this by calling out a number between zero and ten depending on how hypnotised you feel yourself to be. The researcher then explained the standard procedure for the *instant* reporting of hypnotic depth as described for the Long Stanford Scale (Tart, 1970, p. 111).

The tape was then started and the subject received a 15 minute hypnotic induction followed by suggestions for relaxation and analgesia. These followed the instructions described by Barber (1969, pp. 251-255). The hypnotic procedure included the following suggestions. "You will remain comfortable and relaxed with no sensation in your arm at all. Your hand and forearm will feel like a block of wood or as if they are covered by a long, heavy, leather glove, with no sensation in them at all. You will continue to feel very relaxed and remain hypnotised." At the end of the tape the following instruction was given. "Although hypnotised you will be able to keep your eyes open, to move about, to write things, and report on your experience at the end of each trial. Your arm will feel completely numb and relaxed, with no sensation in it at all. It will be so numb, that when you receive some stimulations in a few moments you will have no sensations at all." This deepening suggestion was repeated before the start of each subsequent set of stimulus trials. Subjects then received the first of four blocks of stimulations in the hypnotic condition.

Immediately following each stimulus block the researcher said "State" and the subject called out the number between zero and ten that represented how hypnotised they felt to be. Following this, subjects completed the other ratings of their experience. Ratings for the last set of stimulus trials were followed by a standard procedure to bring subjects back to full normal alertness. The total procedure for the hypnotic condition took approximately 35 minutes.

RESULTS

CHAPTER NINE

TRACKING-PERFORMANCE DATA

9.1. *Introduction*

The results section will firstly report the results of the test of the main research question: "Does cognitive pain-coping strategy use, but not hypnotic analgesia, rely on conscious attentional resources for its successful execution." Because the current study evaluates the difference in tracking performance between pain stimulus-off and pain stimulus-on situations for the various treatment conditions, the expected Coping Method main effect would here translate into a Coping Method x Stimulus interaction effect. It is further anticipated that: (1) this treatment effect is moderated by hypnotic ability, and (2) it is most likely to be evident at pain stimulus levels which are unpleasant enough to initiate pain processing and coping mechanisms which require substantial attentional resources, in this case rather at the 60% pain level than at the 30% pain level. If these hypotheses are supported, we would expect to find a significant Pain-Level main effect and significant effects for the interactions between Hypnotic Ability x Coping Method x Stimulus, and/or Hypnotic Ability x Coping Method x Pain Level x Stimulus.

Chapter 10 will report results of analyses of subjects' pain-intensity and pain-unpleasantness ratings, as well as analyses of additional data collected for further clarification of possible interactions. Finally, chapter 11 will provide some descriptive statistics of the results of the preliminary screening for hypnotic ability.

All data was analyses using SPSS for Windows, release 6.1.3, software.

9.2. *Tracking-Performance Data*

All tracking data measurements were on an interval scale.

Prior to analysis, the tracking data was screened for accuracy of input and missing values, and examined for possible violations of assumptions underlying the statistical tests used (Everitt & Hay, 1992; Tabachnick & Fidell, 1989).

9.2.1. **Accuracy of Input and Missing Data**

All tracking data was automatically recorded and stored by the custom-made computer program that controlled the experiment. This ensured the accuracy of initial data collection and prevented the possibility of missing data. Tracking files for each subject were then coded per condition and saved, to be transferred later into a final data file together with the other data collected. Careful screening of the data file did not reveal any errors in data input or transfer.

9.2.2. **Violation of Assumptions**

Univariate assumptions for repeated-measures analysis of variance are that: (1) the dependent variable (DV) is normally distributed in the population for each level of the within-subjects factor, (2) the population variances of the difference variables are equal, and that (3) cases represent a random sample from the population and there is no dependency in the scores between subjects (Green, Salkind, & Akey, 1997). Paired-samples *t* tests also assume that the difference variable is normally distributed and that the difference scores are independent of each other.

9.2.2.1. *Normality*

Graphical methods for examining normality of sample distributions indicated deviation from normality and the presence of, at times extreme, outlying values in the low hypnotic-ability (LHA) group. Distribution for the LHA group frequently showed a significant positive skew, skewness / s. e. skewness > 3.

Normal, and detrended normal, probability plots for the LHA group clearly revealed a nonrandom deviation from expected normal values. They also indicated the presence of outlying values that were markedly removed from, and did not appear to be connected to, the other values. Such deviations from normality in the LHA group were evident irrespective of the condition of the pain stimulus (off or on), the intensity level (30% or 60%), or the particular part of the tracking wave for which the DV was examined.

Statistical testing further confirmed deviation from normality for the LHA group, with the Shapiro-Wilks tests almost consistently being significant ($p < .001$). It needs to be remembered that; although, analysis of variance procedures with moderate to large sample sizes are reasonably robust to departures of normality (Green et al., 1997; Norusis, 1993), the sample size for the LHA group is only small (n=12) and scores for this group include outliers. The significant deviation from normality, together with the below-discussed difference in variability, is, therefore, more likely to affect results.

9.2.2.2. *Homogeneity of variances*

Pairwise box plots for both hypnotic-ability groups showed that, the LHA group had a greater variance in mean tracking-performance scores than the high hypnotic-ability (HHA) group. The Levine statistic was significant ($p < .05$) for most treatment combinations. This test of homogeneity of variances is less dependent on the assumption of normality and, therefore, particularly useful with analysis of variance procedures. Spread versus level plots further indicated a relationship between the level of hypnotic ability and the variability associated with it.

The rejection of the hypothesis that the group variances are equal suggests that a transformation of variables should be considered to stabilise the variances. This is particularly relevant here; because the factors used in subsequent repeated-measures ANOVA's have only two levels, and SPSS, therefore, conducts only standard univariate *F* tests. These require homogeneity of variances and do not provide epsilon statistics that can be used to correct *p* values for possible violations of this assumption. Even with equal group sizes, heterogeneity of variances will attenuate the power of analysis of variance procedures, which is already poor for small to moderate group and effect sizes. Stevens (1980), therefore, advised researchers to check the homogeneity of variances and find variance stabilising transformations where needed.

9.2.2.3. *Transformation of variables*

Several power transformations were tried, and overall a natural log transformation proved to be the most useful. Because many tracking-performance values were zero (i.e., no cursor deviation from the tracking wave), one was added to all values before calculating their natural logarithm. This transformation reduced differences in variance between groups to an acceptable level (Levine statistic, $p > .05$) and the, at times marked, positive skew for the LHA group. A natural logarithm transformation greatly improved normality (Shapiro-Wilks, $p > .05$) for almost all treatment combinations in the LHA group, and the occasional treatment combination in the HHA group, which were significant before transformation. Furthermore, it reduced the influence of outliers while leaving the rank order of mean tracking-performance values relatively unaltered

Comparison of repeated-measures analyses performed on both transformed and untransformed data revealed a marked difference in results, suggesting that in this case it could not be safely assumed that the procedures were robust against violation of the normality and homogeneity of variance assumptions.

The transformed data still exhibited extreme outlying values in the LHA group. Careful examination of the data file revealed that two cases in this group had a distinct response pattern. Case no. 109 had almost consistently the highest mean tracking score by far, frequently being extreme values. Case no. 74 had generally the second highest mean tracking value, still being well above other cases in that group, but on several occasions had extreme scores even higher than those of case no. 109. When these two cases were removed from the LHA group, the untransformed data for the remaining cases satisfactorily met tests of normality and homogeneity of variance.

Scores had been accurately recorded and entered, and these cases were part of the intended target population, that is, they had met the criteria for both hypnotic ability screening tests. It was, therefore, decided that they should remain in the analysis, but that it was appropriate to adjust their values to reduce their influence and bring them more in line with other cases in their group. To achieve this, the value of three standard deviations above the mean was calculated for the LHA group with cases no. 74 and no. 109 removed (n=10), for all tracking-performance variables used. All scores for the full LHA group (n=12) that were larger than this value were then replaced by it. No scores were more than three standard deviations below the mean. No unusual or extreme response pattern was evident for scores in the HHA group. Again, any scores larger or smaller than three standard deviations from the mean were brought back to that value. The adjustment only had to be used once for the HHA group. This procedure ensured that the adjusted values, while still the largest mean tracking scores, no longer unduly influenced skewness, departure from normality, and differences in variability.

When applied to the untransformed data, this adjustment of extreme scores resulted in normal, to near normal, distributions of tracking-performance scores for the LHA group. Differences in variability between the groups were no longer significant. Results on these measures were very similar to those achieved by transforming the data.

To assess the impact of this adjustment on further analyses, comparisons were made between the results of repeated-measures ANOVA's performed on adjusted and unadjusted versions of both transformed and untransformed data. When untransformed data was adjusted for extreme outliers, there was a marked difference in the results of subsequent repeated-measures ANOVA's. This, again, suggests that it cannot be safely assumed that the original (i.e., untransformed and/or unadjusted) data is robust against violations of the normality and homogeneity of variance assumptions. Adding adjustment of extreme outliers to already transformed data made a moderate difference, but did not provide any marked improvements above those achieved by adjusting the untransformed data. Therefore, adjustment of the two extreme outliers in the LHA group was chosen as the preferred method to achieve adequate normality and homogeneity of variance. This achieved similar results as applying a natural logarithm transformation to all data, with or without additional adjustment, but involved much less alteration of original scores and, therefore, had less impact on the interpretation of results.

9.2.2.4. *Random sample and independence of scores*

Because all subjects were university students, it can not be said that they represented a truly random sample. This is, however, not seen as a real impediment here because: (1) there is no evidence to suggest that university students, as a group, differ in a systematic way from the wider population in either pain responding or hypnotic susceptibility; (2) the screening process eliminates the influence of any possible differences in hypnotic responding, should they exist, and (3) pain ratings are either treated as within-subjects factors, or are adjusted for individual differences in pain level when comparisons are made between subjects.

The most crucial assumption is that of independence of scores, and there is little room for violation (Weinfurt, 1995). All subjects were tested individually during separate sessions. Other participants were, therefore, not able to affect a subject's score at the time of measurement. Following the debriefing at the end of each session, subjects were asked not to talk to other participants in the study until all had completed the experimental stage.

9.2.3. Analyses

The shortcomings of conventional null-hypothesis testing have been widely documented (see e.g., Cohen, 1990; Greenwald, Gonzalez, Harris, & Guthrie, 1996; Hunter, 1997). This study will use, where appropriate, the recommendations suggested by Greenwald et al. (1996) to address some of these flaws. They include: (1) reporting *p* values as numerical values rather than in their minimal form as simply "significant" or "not significant", or as < or > the alpha criterion; (2) treating $p \cong .05$ as interesting, but unconvincing, support for an isolated null-hypothesis result; (3) treating $p \cong .005$ as an indication of demonstrability for an isolated result; (4) report results of all important hypothesis tests; and (5) reporting enough data to permit secondary analysis. For an in-depth discussion of the utility of null-hypothesis significance testing and the use of effect-size measures and confidence intervals see Chow (1988) and peer commentary.

In this results section the terms "significant" or "significance", when used in relation to *p* values, refer to statistical significance and should not be taken to mean that the effects are significant, that is, important or large. They merely indicate that the effect is not nil (Cohen, 1990). As recommended, eta square (η^2) values and post hoc power estimates are provided as measures of, respectively, the size of the effect and the probability of detecting a significant effect if one existed [see e.g., Cohen (1988, 1994); Stevens (1980); and Weinfurt (1995)]. All estimates of effect size and observed power in this study are at the .05 level, and all reported η^2 values are partial eta squares. Cohen's (1988, p. 283) guidelines for effect-size indexes were used, that is small effect size $\eta^2 = .01$, medium effect size $\eta^2 = .06$, and large effect size $\eta^2 = .14$.

9.2.3.1. *Data from full tracking wave for all three trials combined*

The initial analysis assessed the main hypotheses by examining tracking-performance data for each condition, obtained over the full tracking wave for each block of three pain-stimulus trials combined (see Figure 20, p. 268).

A mixed-design repeated-measures analysis of variance was conducted to evaluate the effect of hypnotic ability and coping methods on tracking performance under various pain stimulus conditions. Mean tracking performance (i.e., cursor deviation from the tracking wave) was the dependent variable. Hypnotic Ability with two levels (low versus high) was the between-subjects factor. The within-subjects factors were Coping Method with two levels (hypnotic and nonhypnotic), Pain Level with two levels (30% and 60%), and Stimulus with two levels (pain stimulus off and pain stimulus on).

All univariate homogeneity of variance tests (Bartlett-Box), and the multivariate test for homogeneity of dispersion matrices, were nonsignificant, Box's M = 79.56, F (36,1832) = 1.39, $p > .05$, indicating that the homogeneity of variances assumption was not violated. Because all factors had only two levels, SPSS conducts only standard univariate F tests.

The main effect for Stimulus was significant, F (1,24) = 5.48, p = .028, η^2 = .19, but the interaction of Coping Method x Stimulus which approached significance, F (1,24) = 3.43, p = .076, η^2 = .12, indicated that this Stimulus effect was moderated by Coping Method. The Pain-Level main effect also approached significance, F (1,24) = 3.87, p = .061, η^2 = .14. The interaction of Hypnotic Ability x Coping Method x Stimulus was nonsignificant, F (1,24) = .33, p = .570, but the four-way interaction of Hypnotic Ability x Coping Method x Pain Level x Stimulus came much closer to being significant, F (1,24) = 2.88, p = .102, η^2 = .11. The estimated power for the analyses of these last two interactions was .06 and .37 respectively.

Table 5 shows the means and standard deviations of mean tracking-deviation scores for all treatment conditions, in both pain-off and pain-on situations by hypnotic-ability group.

Table 5. *Means and standard deviations of tracking-deviation scores in pain-off and pain-on situations for both hypnotic-ability groups in all treatment conditions. Data representing the full tracking wave for all three stimulus trials combined.*

		HYPNOTIC ABILITY							
		LOW				HIGH			
Pain Stimulus		off		on		off		on	
Coping Method	Pain Level	M	SD	M	SD	M	SD	M	SD
Hypnotic	30%	1.764	.881	2.278	1.738	1.526	.690	1.929	1.005
	60%	1.542	.898	2.022	1.470	1.539	.615	1.705	1.259
Nonhypnotic	30%	1.780	1.127	1.892	.843	1.686	.919	1.423	.484
	60%	1.524	.769	1.477	.796	1.436	.705	1.778	1.142

To further explore the relationships between the independent variables, paired-samples *t* test comparisons were made for each factor between the remaining four treatment conditions.

Pain stimulus comparisons: When using hypnotic analgesia, subjects in both hypnotic-ability groups made, on average, more tracking errors when they simultaneously received painful stimulus. However, this pain-stimulus effect only came close to being significant for the HHA group at the 30% pain level, t (1,13) = -1,94, p = .075, 95% CI (-.851, .046). When using nonhypnotic coping strategies none of the pain stimulus differences were significant.

Figure 17 shows the difference in mean tracking performance between situations when the pain stimulus is off and when it is on, for both hypnotic-ability groups in all treatment conditions (i.e., hypnotic and nonhypnotic analgesia at both 30% and 60% pain level).

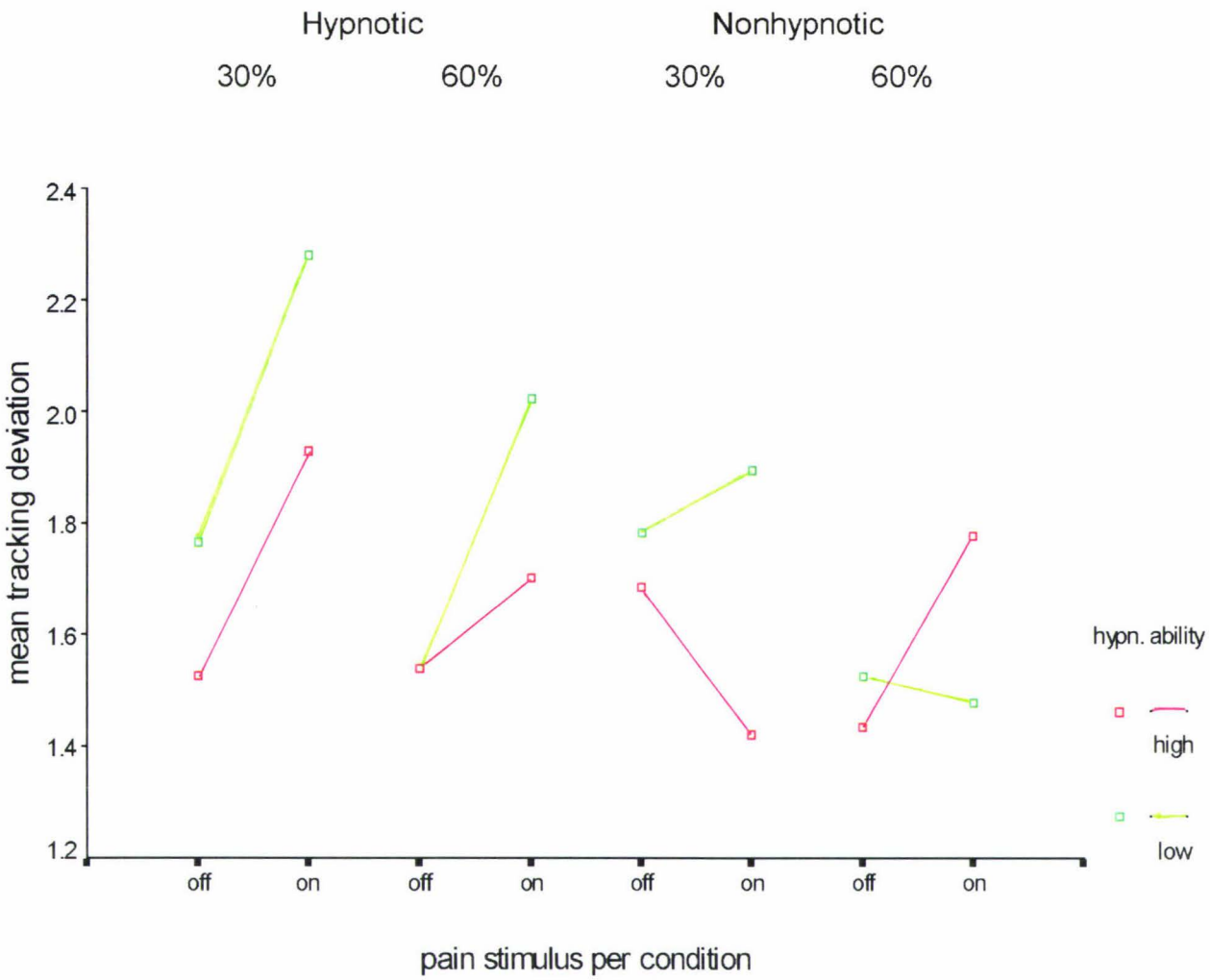

Figure 17. Difference in mean tracking-deviation scores between pain-off and pain-on situations for all treatment conditions by hypnotic ability. Data representing the full tracking wave for all three stimulus trials combined

Coping-method comparisons between treatment conditions with the pain stimulus on revealed that, at the 30% pain level, subjects in both hypnotic-ability groups made less tracking errors when using nonhypnotic as compared to hypnotic coping strategies (see Figure 18), but this coping-method difference was only significant for the HHA group, t (1,13) = 2.19, p = .048, 95% CI (.006, 1.004). At the 60% pain level, subjects in the LHA group made, on average, significantly less tracking errors when using nonhypnotic as compared to hypnotic coping strategies, t (1,11) = 2.35, p = .039, 95% CI (.034, .056). High-hypnotisable subjects tended to made less tracking errors at the 60% pain level when using hypnotic analgesia, but this coping-method difference was nonsignificant.

Pain-level comparisons: The only significant pain-level difference was for subjects in the LHA group who made, on average, significantly less tracking errors when using nonhypnotic coping strategies at the 60% rather than the 30% pain level, t (1,11) 3.60, p = .004, 95% CI (.161, .668).

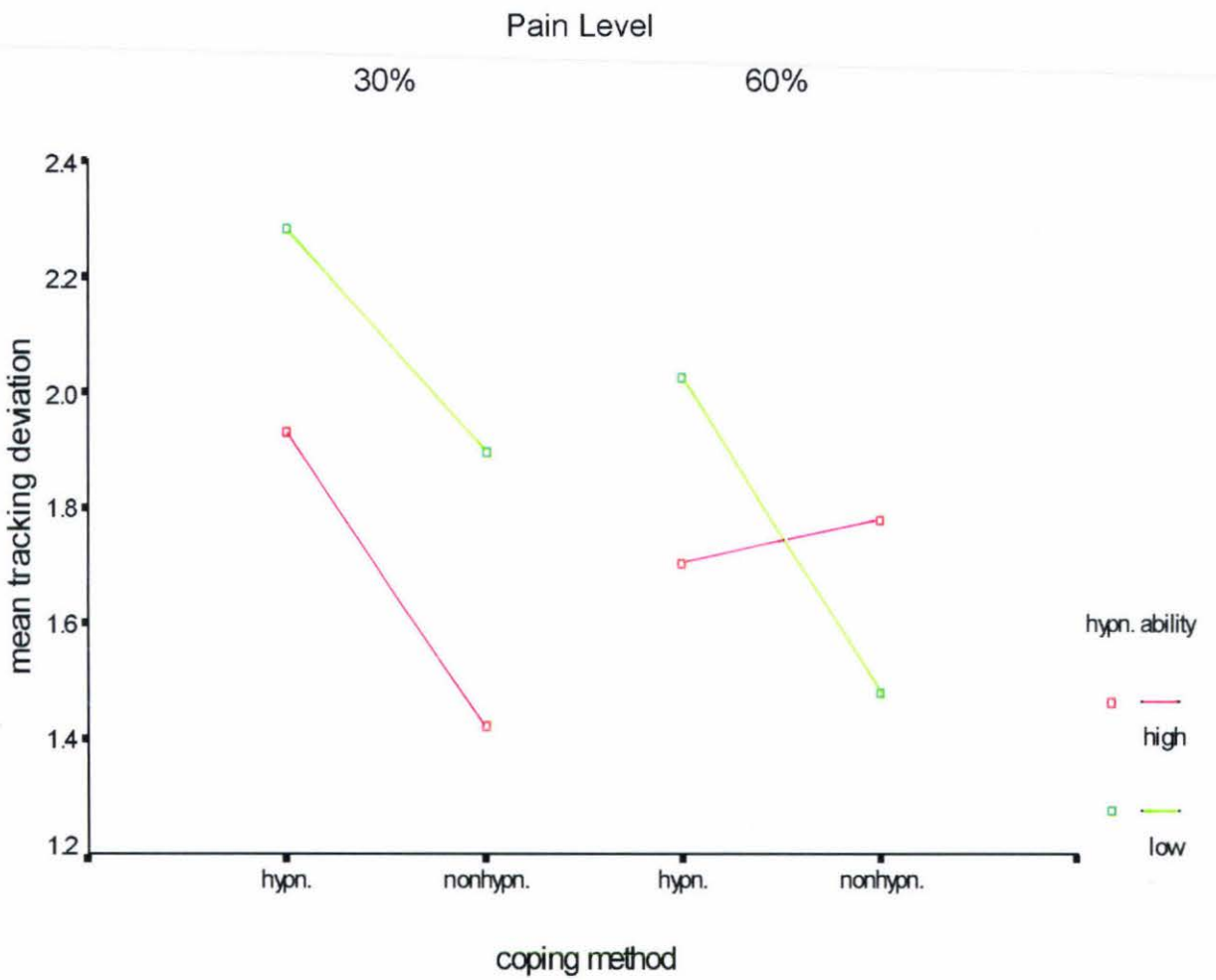

Figure 18. Difference in mean tracking-deviation scores between treatments, for pain-on situations at both pain levels by hypnotic-ability. Data representing the full tracking wave for all three stimulus trials combined.

As both Table 5 and Figure 19 show, there is a substantial variance in tracking performance scores even when measured during periods when no painful stimuli were administered. This suggests that tracking performance was influenced by factors other than hypnotic ability, coping method, or pain level.

It was, therefore, decided to use the scores for the *difference* in tracking deviation between pain-off and pain-on situations as the criteria for comparisons between the treatment conditions.

Such tracking-difference values are provided in Table 6, together with the percentage increase or decrease in tracking errors they represent. Positive values relate to increases in tracking errors and negative values to improvements in tracking performance (i.e., less tracking errors). Of importance is the finding that none of the differences in tracking performance between pain-off and pain-on situations were statistically significant.

Table 6. *Mean tracking-deviation scores for the difference between pain-off and pain-on situations. Data representing the full tracking wave for all three stimulus trials combined.*

Coping Method	Pain Level	Hypnotic Ability	Pain Stimulus off	on	difference	diff. in %	*p*
Hypnotic	30%	low	1.764	2.278	.514	29.13	.134
		high	1.526	1.929	.403	26.41	.075
	60%	low	1.542	2.022	.480	31.17	.125
		high	1.539	1.705	.166	10.79	.576
Nonhypnotic	30%	low	1.780	1.892	.112	6.29	.489
		high	1.686	1.423	- .263	- 15.60	.266
	60%	low	1.524	1.477	- .047	- 3.08	.685
		high	1.436	1.778	.342	23.82	.188

Figure 19 plots the mean tracking-difference scores between pain-off and pain-on situations with their 95% confidence intervals. Values below the dotted line through zero represent improvements in tracking performance (i.e., less tracking deviation) when the pain was on, whereas values above the line depict increases in tracking errors.

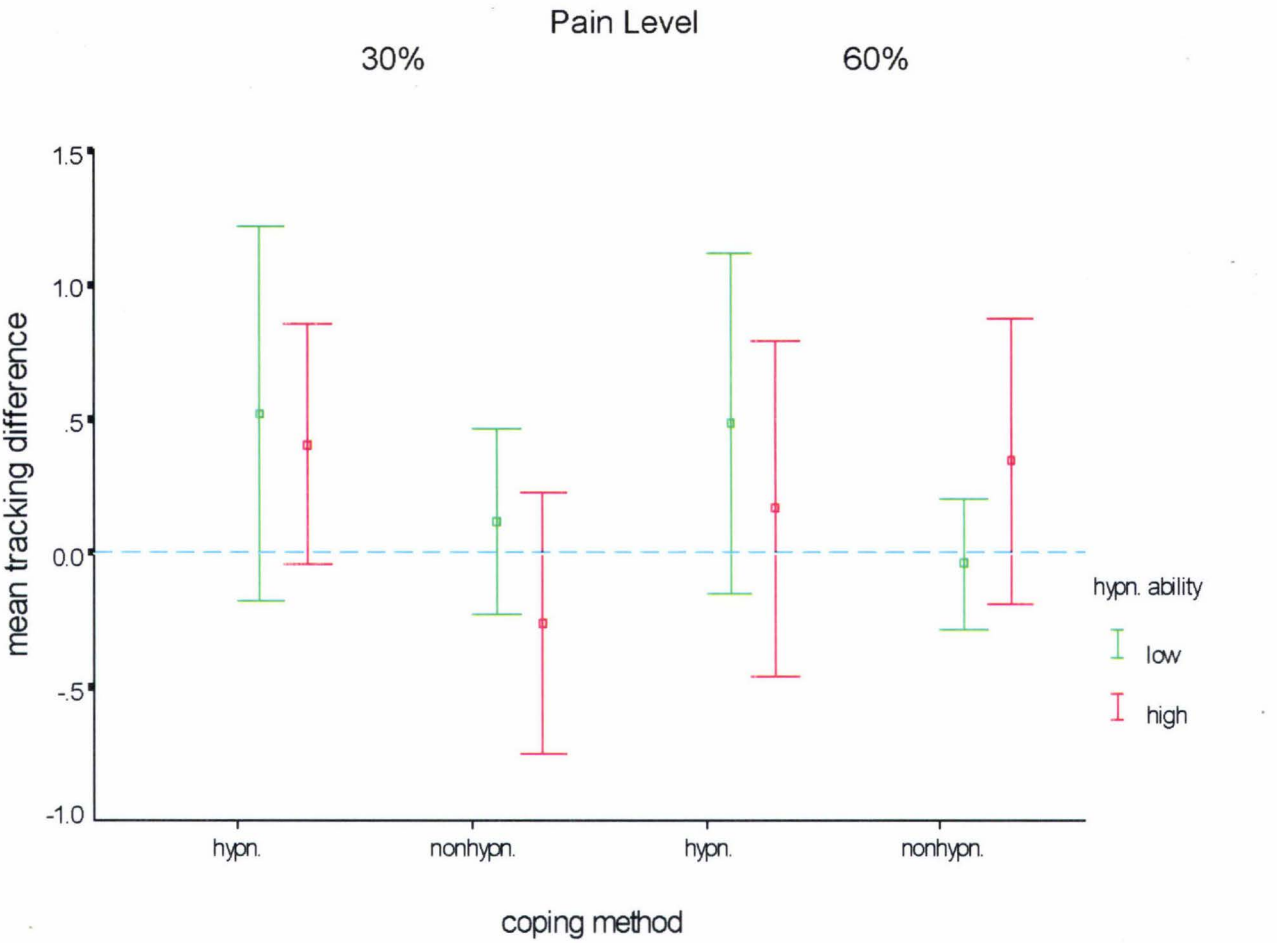

Figure 19. Between-treatment comparison of mean tracking-difference values, with 95% confidence intervals, at both pain levels by hypnotic ability. Data representing the full tracking wave for all three stimulus trials combined.

9.2.3.2. *Exploration of tracking-wave differences*

Observations of cursor tracking on the computer screen, during both the initial familiarisation trial and the subsequent experimental trials, indicated quite clearly that the task of keeping the cursor on the tracking wave was not constant throughout the waveform. Rather, there appeared to be two parts to the waveform, each requiring its own distinct response pattern (see Figure 20). During the "peaks" and "troughs" of the wave oscillations, cursor movements require a change in direction, from upwards to downwards or vice versa, but the required speed of movement (i.e., movement per time unit) is smallest, being zero right at the top or bottom of the waveform. In contrast, during the periods between the "peaks" and "troughs," the direction of cursor movement is constant, but the required speed of movement is greatest.

Hereafter, the "peaks" and "troughs" of the waveform will be referred to as the extreme parts of the waveform, and the areas between them as the middle parts of the waveform.

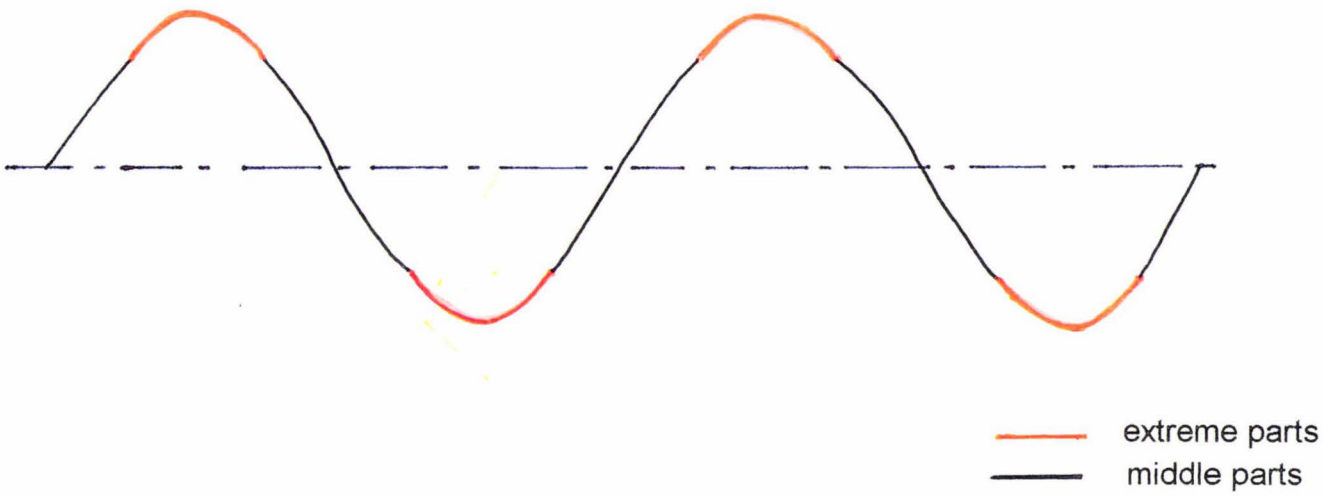

Figure 20. Section of the tracking wave showing the division between extreme and middle parts of the waveform.

To further investigate differences between these two parts of the tracking wave, separate variables were computed for each tracking variable, one based only on data for the extreme parts of the tracking wave and the other representing only the middle parts. Both had approximately equal numbers of data points. Paired-samples *t* tests revealed that there was a significant difference ($p < .001$) between the mean tracking-deviation scores for extreme and middle parts of the waveform at all treatment conditions.

Examination of descriptive statistics for both parts of the waveform further revealed that: (1) considerably more tracking errors were made over the middle parts: (2) the middle parts were more sensitive to differences between the hypnotic-ability groups, particularly at the 60% pain level: and (3) differences in mean tracking-deviation scores between pain-off and pain-on situations among treatment conditions exhibited a consistent pattern over the middle parts, whereas such differences for the extreme parts were much more random.

This is consistent with observations which suggested that a sizeable proportion of tracking deviations were due to either a delay in catching up with, or alternatively the overshooting of, the waveform as it started to move away from the cursor after the latter had been momentarily static at the top or bottom of each oscillation. Such deviations might be caused by a delay in the subject's initiation of movement following the brief pause, and/or could result from minor initial resistance (stickiness) in the potentiometer slide that controlled cursor movements on the computer screen. They are more likely to be incidental and, at least potentially, could add an additional, and unwanted, component to the total variance in tracking performance between treatment conditions that would contaminate results.

The middle parts of the waveform require continuous movement and were not affected by "accidental" variations relating to attributes of the task itself. They are more likely to be demanding of continuous attention, which was what the tracking task was designed to require. It was therefore decided that, from here on, only data for the middle part of the wave would be used for further analysis.

9.2.3.3. *Data from middle parts of tracking wave for all three trials combined*

The following results were obtained when the same repeated-measures ANOVA was performed on data of all three trials combined, but this time only from the middle parts of the tracking wave. Again, the assumption of homogeneity of variances was not violated, Box's M = 71.42, F (36,1832) = 1.24, $p > .05$. The Stimulus main effect was still significant, F (1,24) = 4.85, p = .037, η^2 = .17. The four-way interaction of Hypnotic Ability x Coping Method x Pain Level x Stimulus was now just significant, F (1,24) = 4.25, p = .050, η^2 = .15. The estimated power of the analysis of this four-way interaction was .51. None of the other main or interaction effects were significant. However, the main effect for Pain Level, F (1,24) = 4.01, p = .057, η^2 = .014, and the interaction of Coping Methods x Pain Level, F (1,24) = 3.99, p = .057, η^2 = .14, came close to being significant. The interaction of Hypnotic Ability x Pain Level, F (1,24) = 3.17, p = .088, η^2 = .12, approached significance. Table 7 shows mean tracking-performance scores by hypnotic-ability group for this data set.

Table 7. *Means and standard deviations of tracking-performance scores for both hypnotic-ability groups in all treatment conditions. Data from the middle parts of the tracking wave for all three stimulus trials combined.*

		HYPNOTIC ABILITY							
		LOW				HIGH			
Pain Stimulus		off		on		off		on	
Coping Method	Pain Level	M	SD	M	SD	M	SD	M	SD
Hypnotic	30%	2.451	1.130	3.053	2.350	1.900	.950	2.578	1.318
	60%	1.996	.997	2.940	2.205	2.178	1.005	2.472	1.714
Nonhypnotic	30%	2.682	1.798	2.654	1.244	2.385	1.284	1.993	.707
	60%	2.202	1.331	1.992	.980	1.817	.684	2.289	1.330

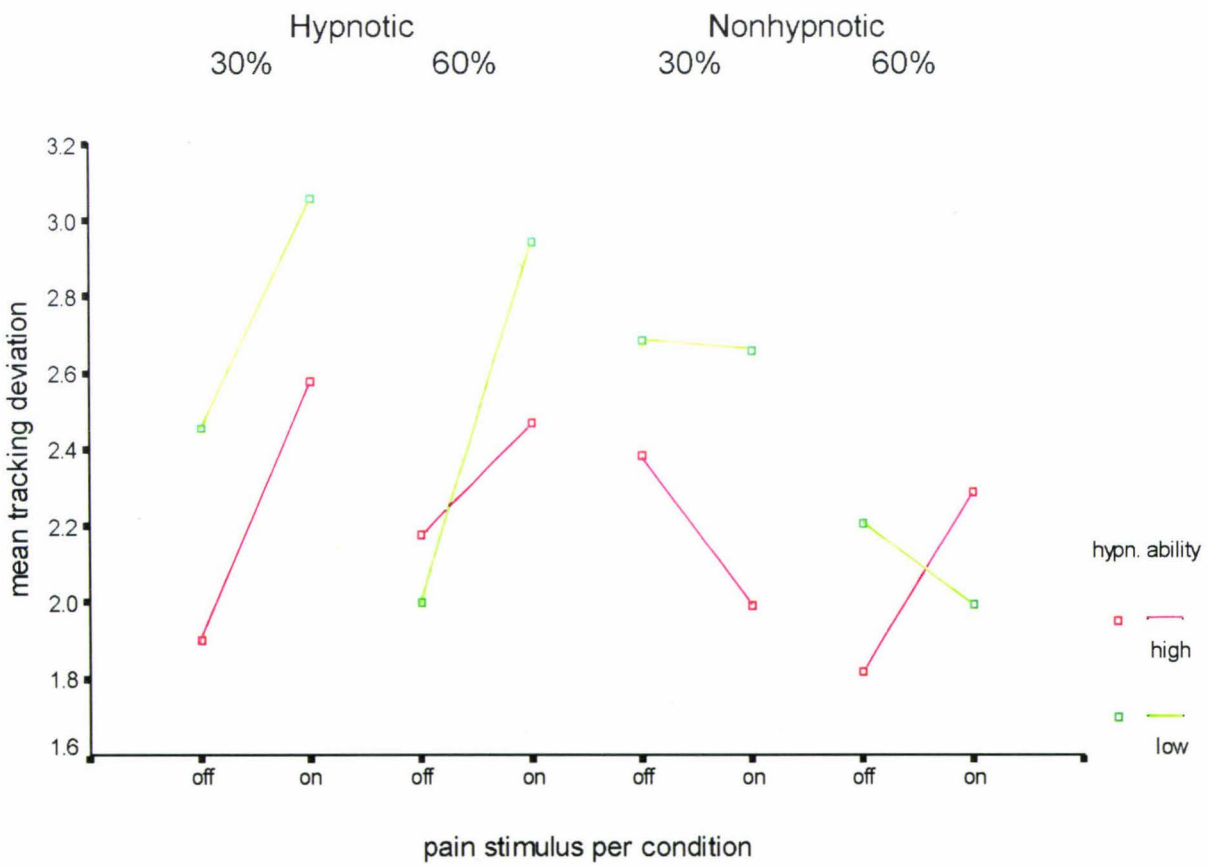

Figure 21. Difference in mean tracking-deviation scores between pain-off and pain-on situations in all treatment conditions by hypnotic ability. Data representing the middle parts of the tracking wave for all three stimulus trials combined.

Pain stimulus comparisons: Paired-samples *t* tests for the various treatment combinations revealed that, when using hypnotic coping methods, subjects in both hypnotic-ability groups made, on average, more tracking errors when they also received painful stimulation (see Figure 21). However, this stimulus effect only came close to being significant for the LHA group at the 60% pain level, t (1,11) = -2.08, p = .062, 95% CI (-1.944, .056). There were no significant stimulus differences for either hypnotic-ability group when nonhypnotic coping strategies were used.

Coping-method comparisons. Both hypnotic-ability groups made, on average, more tracking errors at either the 30% or 60% pain level when using hypnotic as compared to nonhypnotic coping methods (see Figure 22). However, this difference for coping method was only significant for the LHA group at the 60% pain level, t (1,11) = 2.29, p = .043, 95% CI (.038, 1.859).

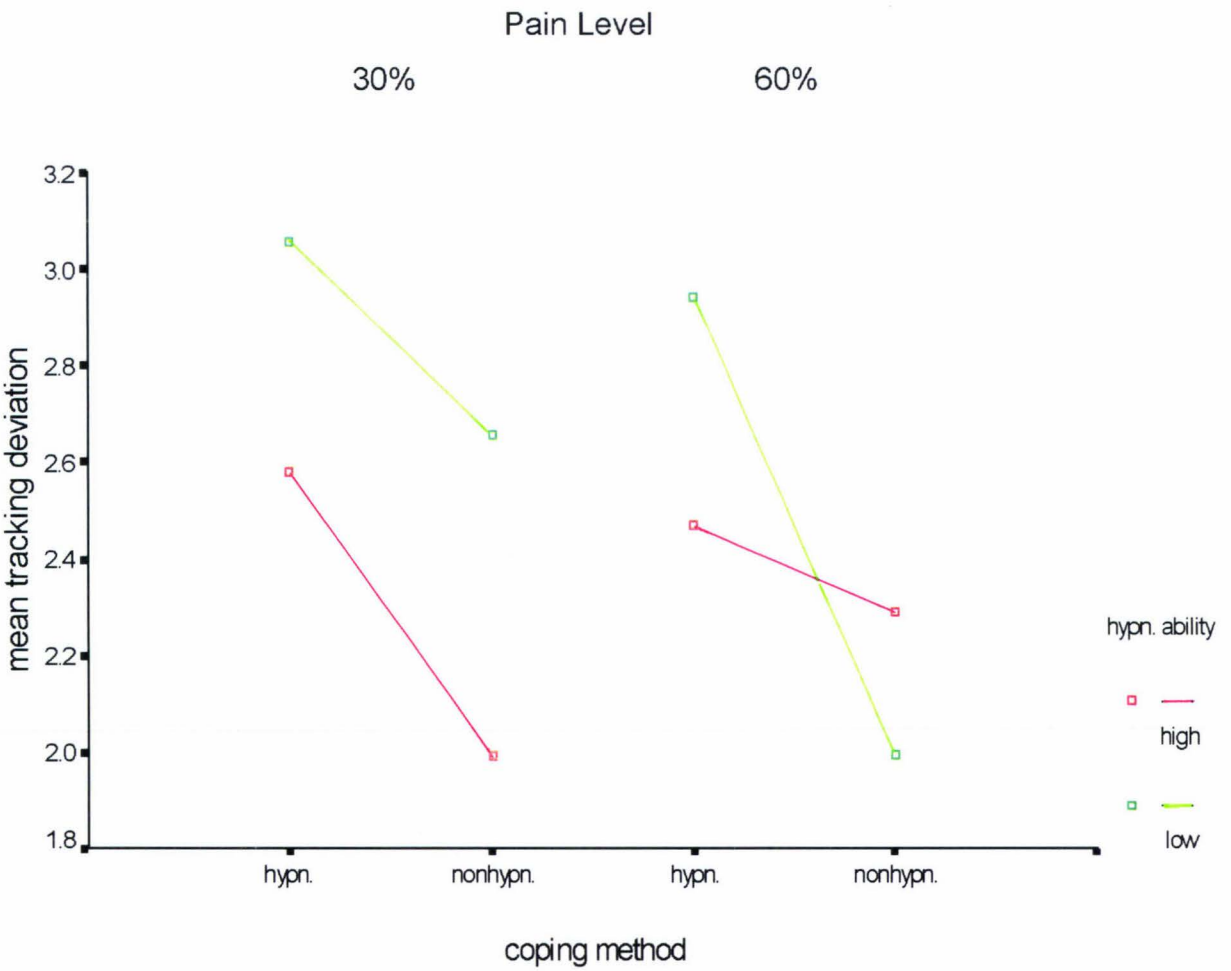

Figure 22. Difference in mean tracking-deviation scores between treatments for pain-on situations at both pain levels by hypnotic ability. Data representing the middle parts of the tracking wave only for all three stimulus trials combined.

Subjects in the LHA group made, on average, significantly less tracking errors at the 60% pain level than at the 30% pain level, t (1,11) = 3.62, p = .004, 95% CI (.260, 1.064). There were no significant pain-level differences for the HHA group (see Figure 22).

When the repeated-measures ANOVA was conducted for treatment conditions at the 60% pain level only, the Stimulus main effect remained significant, F (1,24) = 4.69, p = .040, η^2 = 16. The main effect for Coping Method, F (1,24) = 3.54, p = .072, η^2 = .13, and the interaction of Hypnotic Ability x Coping Method x Stimulus, F (1,24) = 3.41, p = .077, η^2 = .12, both approached significance. The estimated power of the analysis of this 3-way interaction effect was .42. Table 8 provides the mean tracking-deviation scores for pain-off and pain-on situations and the percentage increase or decrease in tracking deviation this represents. Figure 23 shows the mean tracking-difference scores with 95% confidence intervals for all treatment conditions. The hypothesised interaction effect of Hypnotic Ability x Coping Method was not significant, either overall (p = .816) or at the 30% pain level (p = .925) or 60% pain level (p = .775) individually.

Table 8. *Mean tracking-deviation scores for the difference between pain-off and pain-on situations. Data representing the middle parts of the tracking wave for all three stimulus trials combined.*

Coping Method	Pain Level	Hypnotic Ability	Pain Stimulus off	on	difference	diff. in %	p
Hypnotic	30%	low	2.451	3.053.	.602	24.56	.232
		high	1.900	2.578	.678	35.68	.102
	60%	low	1.996	2.940	.944	47.29	.062
		high	2.178	2.472	.294	13.50	.462
Nonhypnotic	30%	low	2.682	2.654	- .028	- 1.04	.918
		high	2.385	1.993	- .392	- 16.44	.320
	60%	low	2.202	1.992	- .210	- 9.54	.326
		high	1.817	2.289	.472	25.98	.151

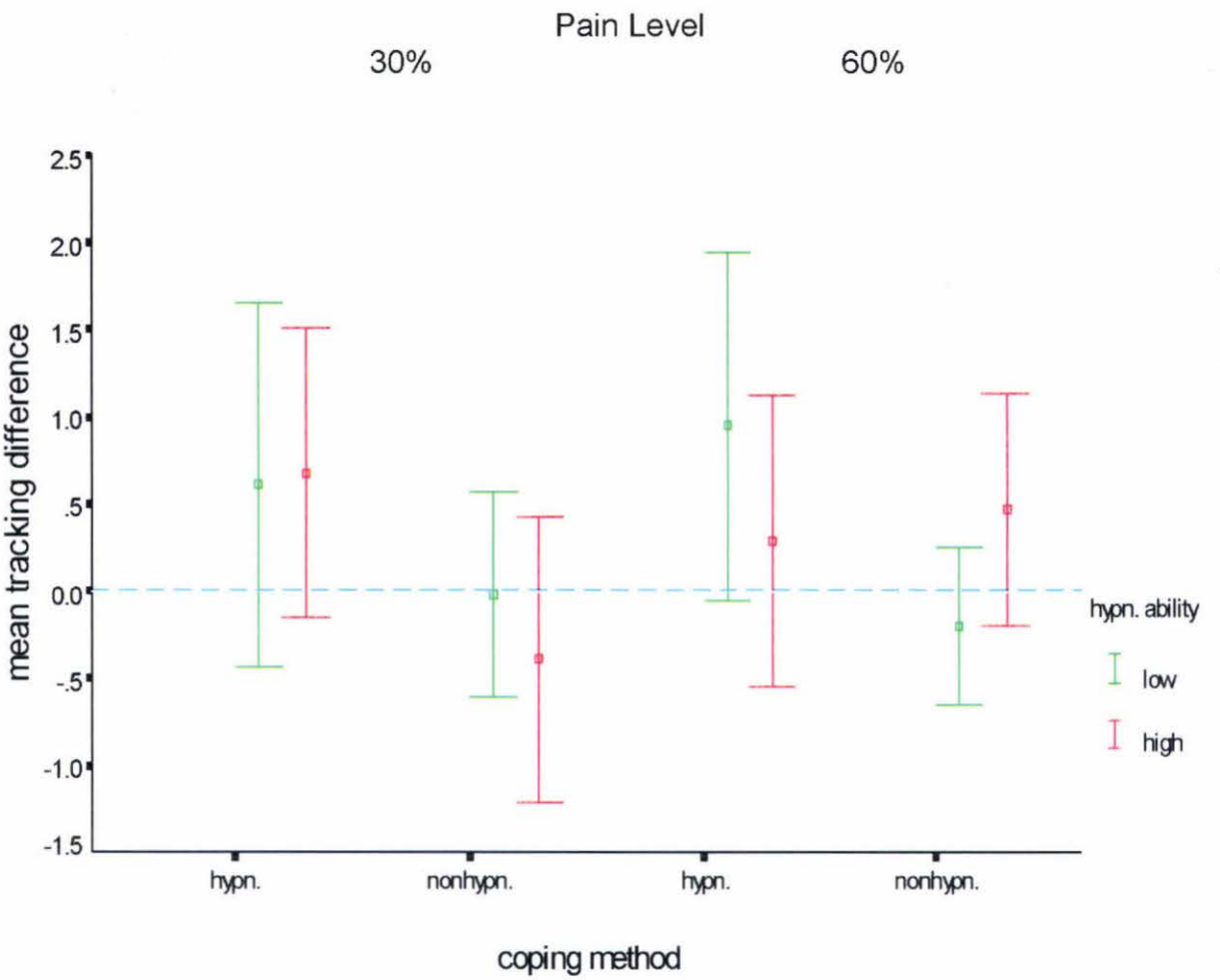

Figure 23. Between-treatment comparison of mean tracking-difference values, with 95% confidence intervals, at both pain levels by hypnotic ability. Data representing the middle parts of tracking wave for all three stimulus trials combined.

9.2.3.4. *Data from middle parts of the tracking wave for trial one only*

Several studies have demonstrated that it is particularly the onset of pain and its novelty which cause the greatest disruption of ongoing activity (e.g., Crombez et al., 1994, 1996). Therefore, a similar repeated-measures ANOVA was conducted, but this time for data collected over the middle parts of the tracking wave during the first trial of each block of three stimulus trials.

The assumption of homogeneity of variances was not violated, Box's M = 76.41, F (36,1832) = 1.33, $p > .05$. The Coping Method x Pain Level interaction effect was significant, F (1,24) = 8.56, p = .007, η^2 = .26. Of all the other effects, only the interactions of Coping Method x Stimulus, F (1,24) = 3.22, p = .085, η^2 = .12, and Pain Level x Stimulus, F (1,24) = 3.03, p = .094, η^2 = .11, approached significance. Table 9 lists the mean tracking-performance scores for both high- and low-hypnotisable subjects in all treatment conditions, using tracking data collected over for middle parts of the wave form for trial one only

Table 9. *Means and standard deviations of tracking-performance scores for both hypnotic-ability groups in all treatment conditions. Data from the middle parts of the tracking wave for trial one only .*

		HYPNOTIC ABILITY							
		LOW				HIGH			
Pain Stimulus		off		on		off		on	
Coping Method	Pain Level	M	SD	M	SD	M	SD	M	SD
Hypnotic	30%	2.444	.852	2.409	2.014	1.643	.602	2.296	1.346
	60%	2.280	1.221	3.688	3.180	2.060	1.300	2.471	2.213
Nonhypnotic	30%	3.597	2.549	2.673	1.692	2.036	1.396	2.155	1.141
	60%	2.000	1.131	1.957	1.262	1.452	.856	2.265	2.299

Paired-samples t tests for the various treatment conditions (four comparisons per factor) were conducted to follow-up significant main or interaction effects. *Pain stimulus comparisons* revealed that, the HHA group made consistently more tracking errors when they simultaneously received painful stimulation (see Figure 24), but this stimulus effect only came close to being significant at the 30% pain level in the hypnotic analgesia condition, t (1, 13) = -2.10, p = .056, 95% CI (-1.326, .019).

Subjects in the LHA group made, on average, significantly *more* tracking errors in the hypnotic analgesia condition when they received painful stimulation at the 60% pain level, t (1,11) = -.2.26, p = .045, 95% CI (-2.776, -.039). In contrast, the LHA group made, on average, significantly *less* tracking errors in the nonhypnotic coping condition with the pain stimulus on at the 30% pain level, t (1,11) = 3.03, p = .011, 95% CI (.253, 1.595).

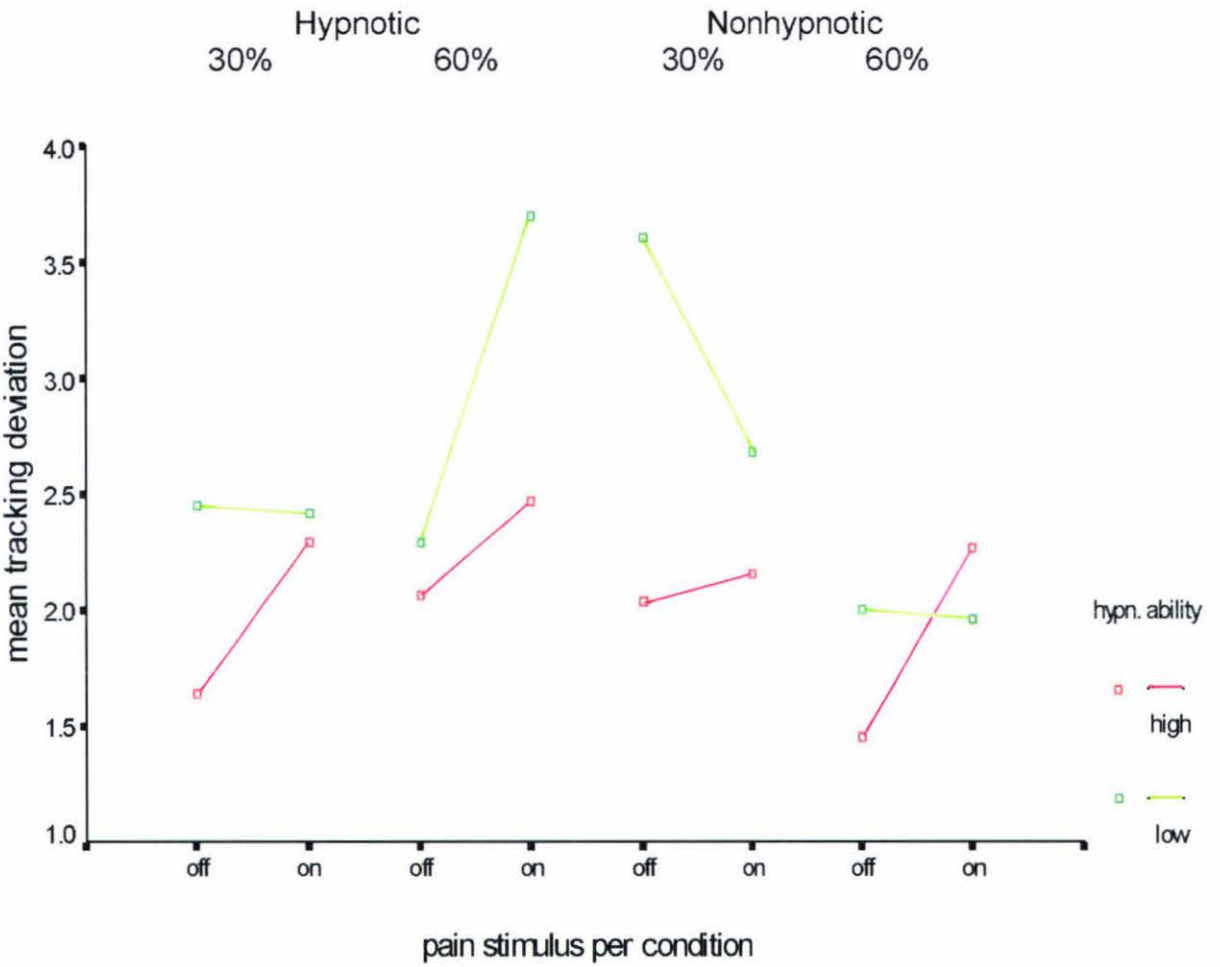

Figure 24. Difference in mean tracking-deviation scores between pain-off and pain-on situations for all treatment conditions by hypnotic ability. Data representing the middle parts of the tracking wave for trial one only.

Coping-method comparisons for treatment conditions with the pain stimulus on indicated that, subjects with low hypnotic ability made on average significantly less tracking errors when using nonhypnotic coping methods at the 60% pain level, t (1,11) = 2.53, p = .028, 95% CI (.222, 3.239). For the HHA group, none of the coping-method differences were significant (see Figure 25).

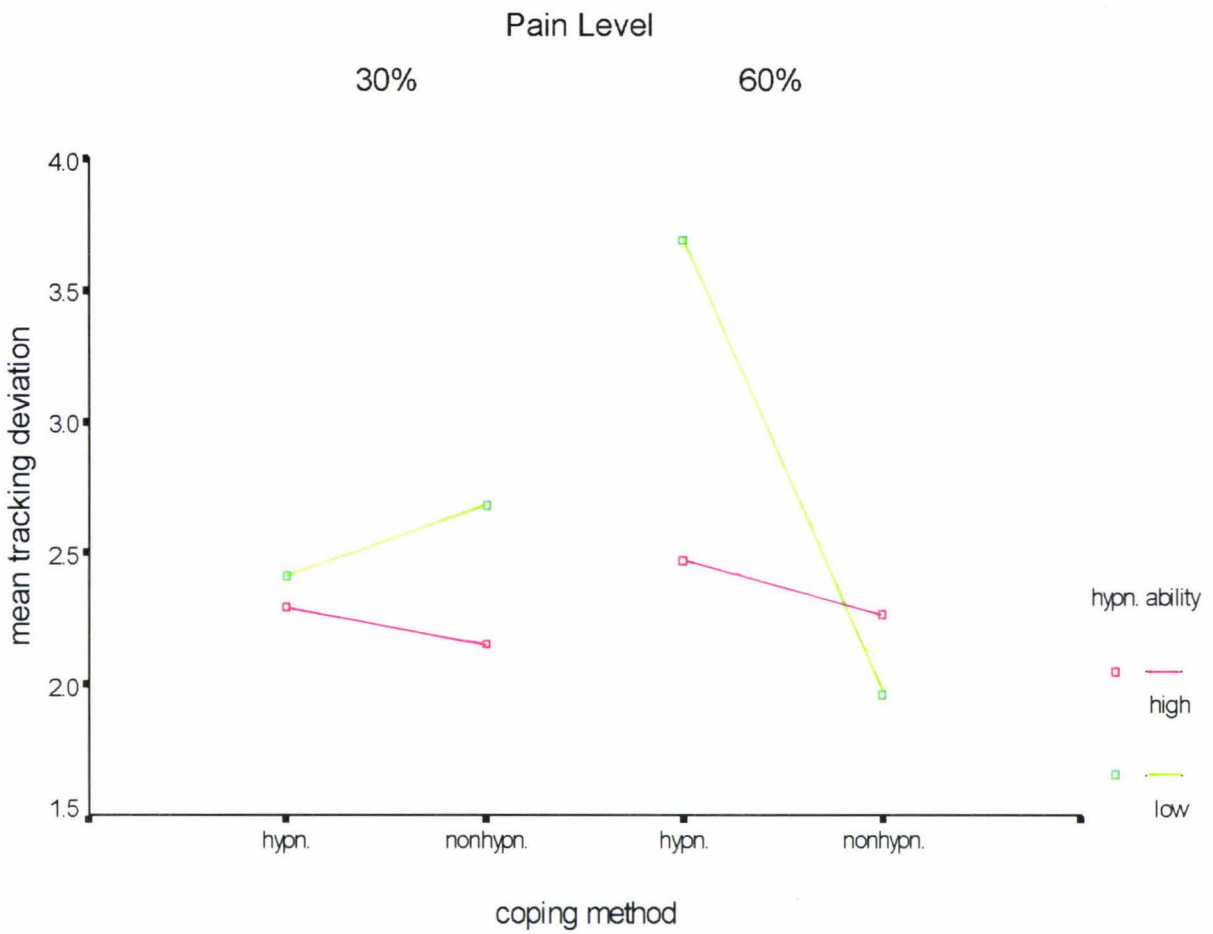

Figure 25. Difference in mean tracking-deviation scores between treatments, for pain-on situations at both pain levels by hypnotic ability. Data representing the middle parts of the tracking wave of trial one only.

Pain-level comparisons revealed that, when subjects with low hypnotic ability used nonhypnotic coping strategies, they made on average significantly more tracking errors when receiving painful stimulation at the 30% rather than the 60% pain level, t (1, 11) = 2.40, p = .035, 95% CI (.060, 1,372). It needs to be noted though that, in this treatment condition (i.e., nonhypnotic coping at the 30% pain level), the LHA group also made significantly more tracking errors when the pain stimulus was *off*, t (1,11) = 2.59, p = .025, 95% CI (.242, 2.954). At the 60% pain level, there was very little difference in tracking performance between the pain-off (mean 1,9997 SD 1.131) and pain-on situation (mean 1.9573 SD 1.262), t (1, 11) = .15, p = .880. However, at the 30% pain level, this difference was much larger (mean pain-off = 3.5975 SD 2.549, and mean pain-on = 2.6731 SD 1.692) and statistically significant, t (1, 11) = 3.03, p = .011, 95% CI (.253, 1.595).

In the hypnotic analgesia condition, the LHA group made more tracking errors at the 60% pain level, but this pain-level difference did not reach significance, t (1, 11) = -1.72, p = .114, 95% CI (-2.918, .360). Tracking performance scores for the HHA group showed almost no difference between pain levels in both hypnotic and nonhypnotic analgesia conditions.

Table 10 lists the difference in mean tracking-deviation scores between pain-off and pain-on situations together with the percentage increase or decrease in tracking deviation this represents. Positive values indicate increases in tracking errors, and negative values represent improvements in tracking performance (i.e., less tracking errors).

Table 10. *Mean tracking-performance scores for the difference between pain-off and pain-on situations. Data representing the middle parts of the tracking wave for trial one only.*

Coping Method	Pain Level	Hypnotic Ability	Pain Stimulus				
			off	on	difference	diff. in %	*p*
Hypnotic	30%	low	2.444	2.409	- .035	- 1.43	.952
		high	1.643	2.296	.653	39.74	.056
	60%	low	2.280	3.688	1.408	61.75	.045
		high	2.059	2.471	.412	20.01	.555
Nonhypnotic	30%	low	3.599	2.673	- .924	- 25.69	.011
		high	2.036	2.155	.119	5.84	.803
	60%	low	2.000	1.957	- .043	- 2.15	.880
		high	1.452	2.265	.813	55.99	.132

When the repeated-measures ANOVA was conducted for treatment combinations at the 60% pain level only, the main effect for Coping Method was significant, F (1,24) = 6.78, p = .016, η^2 = .22. The main effect for Stimulus was close to being significant, F (1,42) = .3.88, p = .061, η^2 = .14. The interaction of Hypnotic Ability x Coping Method x Stimulus was significant at the 60% pain level, F (1,24) = 4.63, p = .042, η^2 = .16. The observed power for the analysis of this interaction effect was .54. Figure 26 plots these mean tracking-difference scores with 95% confidence intervals for all treatment combinations. Values below the dotted line represent improvements in tracking performance, whereas values above the line show increases in tracking performance.

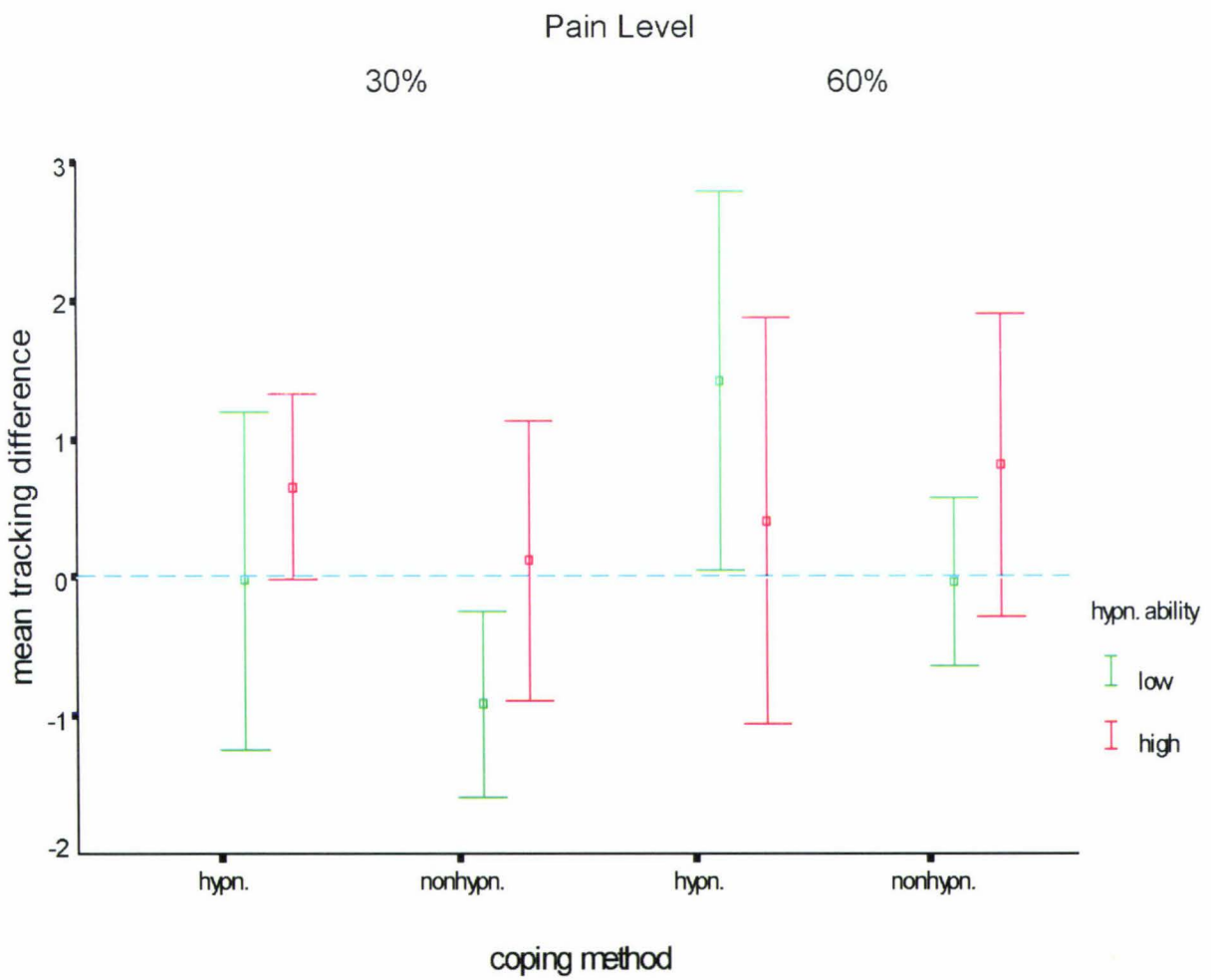

Figure 26. Between-treatment comparison of tracking-difference values, with 95% confidence intervals, at both pain levels by hypnotic ability. Data representing the middle parts of the tracking wave for trial one only.

9.3. *Summary of Main Findings*

The middle parts of the waveform were more sensitive to differences in mean tracking performance between both hypnotic-ability groups than data collected over the full tracking wave including the extreme parts ("peaks" and "troughs") were the wave changed direction. Tracking performance over the middle parts of the waveform appeared to be less subject to random variation.

A. Data for the middle parts of all three trials combined.

Subjects in both hypnotic-ability groups made, on average, more tracking errors at either pain level when using hypnotic as compared to nonhypnotic coping strategies (see Figure 22). However, this coping-method difference was only significant for the LHA group at the 60% pain level (p = .043).

Overall, subjects made more tracking errors when they simultaneously received painful stimulation. However, this finding was not consistently observed and in some treatment combinations subjects made, on average, less tracking errors when they received painful stimulation.

Subjects with low hypnotic susceptibility made less tracking errors at the 60% rather than the 30% pain level, but this pain-level effect was only significant (p = .004) in the nonhypnotic condition. However, the fact that the LHA group also made less tracking errors (p = .057) at times when there was no pain stimulation during the hypnotic condition at 60% pain-level trial, suggests that the above pain-level effect was more likely a artefact of task variability than a true pain-level effect. There were no significant pain-level differences for subjects with high hypnotic susceptibility.

The hypothesised interaction effect of Hypnotic Ability x Coping Method was not significant, either overall (p = .816) or at the 30% pain level (p = .925) or 60% pain level (p = .775) individually.

To examine whether, as has been shown, pain-induced attentional disruption is greater at the onset of pain, similar repeated-measures ANOVA's were performed for data from the first trial only.

B. Data for the middle parts of the first trial only.

Results of analysis of data from trial 1 only were very similar to those obtained for data of all three trials combined. Thus, this experiment did not The hypothesised interaction of Hypnotic Ability x Coping method was again nonsignificant.

As the 95% confidence intervals in Figure 23 and 26 show, in virtually all conditions the within-group variablity in tracking performance was markedly larger than the variability in tracking performance between conditions and between hypnotic-susceptibility groups. Furthermore, in almost all treatment comparisons, some subjects made more tracking errors when the received painful stimulation while others experienced an improvement in tracking performance.

Conclusion: The current study did not find any evidence for the hypothesised absence of interference with secondary task performance among highly hypnotisables when using hypnotic analgesia. However, the presence of this large between-subject variability within conditions prevents the conclusion that these findings support a social-psychological interpretation of hypnosis and are incompatible with predictions made by the dissociated-control model.

CHAPTER TEN

PAIN RATINGS AND OTHER DATA COLLECTED

The distributions for pain intensity, pain unpleasantness, and absorption in tracking-task variables did not exhibit any marked deviations from normality and there were no undue differences in variability between the hypnotic-ability groups. Preliminary independent-samples *t* tests did not find any significant differences in either pain-intensity or pain-unpleasantness ratings across the counterbalanced treatment orders. To determine the relative independence of both pain dimensions, Pearson correlations were performed between pain-intensity and pain-unpleasantness ratings for each treatment combination. They revealed an average correlation of .924.

10.1. *Pain Ratings*

10.1.1. **Pain intensity**

It is hypothesised that: "When using hypnotic coping strategies, subjects with high hypnotic ability will be more successful in reducing pain-intensity ratings than subjects with low hypnotic ability." It is furthermore expected that this effect will be most obvious at the 60% pain level. We thus anticipate finding a significant Pain-Level effect and a significant interaction for Hypnotic Ability x Coping Method and possibly also a significant 3 way interaction for Hypnotic Ability x Coping Method x Pain Level.

A mixed-design repeated-measures ANOVA was conducted to evaluate the effect of hypnotic-susceptibility level and type of coping method used on pain intensity ratings. Pain intensity ratings in mm on a visual analog scale (0-150mm) were the DV. Hypnotic Ability with two levels (low versus high) was the between-subjects factor. The within-subjects factors were Coping Method with two levels (hypnotic and nonhypnotic); Tracking with two levels (tracking-task on and tracking-task off); and Pain Level with two levels (30% and 60%).

The multivariate test of the homogeneity of variances assumption was not violated, Box's M = 52.27, F (36,1832) = .91, p > .05. As expected, there was a significant main effect for Pain Level, F (1,24) = 97.75, p < .001, η^2 = .80. Analyses further revealed a significant main effect for Coping Method, F (1,24) = 4.14, p = .046, η^2 = .16, which appeared to be moderated by a significant Hypnotic Ability x Coping Method interaction effect, F (1,24) = 5.43, p = .029, η^2 = .18. The observed power for the analysis of this interaction effect was .61, indicated a 61% probability of detecting a statistically significant interaction if present.

Of all the other main effects or interactions, only the Coping Method x Pain Level interaction came close to being significant, F (1,24) = 4.14, p = .053, η^2 = .15. The Coping Method main effect was significant at the 60% pain level, F (1,24) = 7.56, p = .011, η^2 = .24, but nonsignificant at the 30% pain level, F (1,24) = 1.45, p = .240. The Hypnotic Ability x Coping Method interaction effect was significant at the 60% pain level, F (1,24) = 6.48, p = .018, η^2 = .21, but only approached significance at the 30% significance level, F (1,24) = 3.31, p = .081, η^2 = .12. The 3-way interaction for Hypnotic Ability x Coping Method x Pain Level was not significant, F (1, 14) = .78, p = .387, η^2 = .03, but the observed power for this analysis was only .16. Neither the main effect for Tracking, F (1,24) = 2.18, p = .153, nor the Hypnotic Ability x Tracking interaction effect, F (1.24) = 1.15, p = .295, were significant. Table 11 shows the means and standard deviations of subjects' pain-intensity ratings for both hypnotic-ability groups in all treatment conditions.

Paired-sample t tests performed for data of both hypnotic-ability groups combined indicated that, overall subjects rated the iontophoretic stimulation at the 60% pain level as significantly more intense (p < .001) than at the 30% pain level in all treatment conditions (i.e., when using hypnotic or nonhypnotic coping methods both with tracking-task on or off). Paired-samples t tests following up the significant Coping Method main effect revealed that, subjects rated stimulation at the 60% pain level on average as less intense when using hypnotic as compared to nonhypnotic coping methods.

This coping-method difference at the 60% pain level was significant with the tracking-task on, t (1,25) = -3.01, p = .006, 95% CI (-30.56, -5.75), but only approached significance when the pain stimuli were administered without the tracking task, t (1,25) = -1.89, p = .071, 95% CI (-25.18, 1.10). There were no significant differences in pain-intensity ratings between the hypnotic and nonhypnotic treatment conditions at the 30% pain level.

Table 11. *Means and standard deviations of subjects' pain-intensity ratings for all treatment conditions by hypnotic ability.*

		HYPNOTIC ABILITY							
		LOW				HIGH			
Tracking Task		off		on		off		on	
Coping Method	Pain Level	M	SD	M	SD	M	SD	M	SD
Hypnotic	30%	84.75	39.86	64.50	28.28	55.79	40.12	52.79	33.06
	60%	104.25	36.33	99.83	30.67	75.21	42.36	69.07	39.06
Nonhypnotic	30%	76.42	37.21	66.25	32.95	70.64	38.44	70.29	32.92
	60%	104.33	30.68	101.83	27.28	97.50	33.96	101.07	30.16

When performed for each hypnotic-ability group separately, post hoc paired-samples t test comparisons for the four treatment conditions (i.e., at 30% or 60% pain level and both with either tracking-task on or off) indicated that subjects clearly distinguished between the 30% and the 60% pain level (see Figure 27). Both hypnotic-ability groups rated painful stimulation at the 60% pain level as significantly more intense than at the 30% pain level (LHA group < .002; HHA group < .02). Separate t tests also confirmed that the main effect for Coping Method was moderated by Hypnotic Ability. The HHA group rated the pain stimulus as significantly less intense when using hypnotic, as compared to a nonhypnotic, coping strategies in all four treatment conditions.

This difference was most significant in treatment conditions at the 60% pain level, particularly with tracking-task on, t (1,13) = - 4.16, p = .001, 95% CI (-48.62, -15.38). The LHA group showed no significant differences in pain intensity between the treatment conditions.

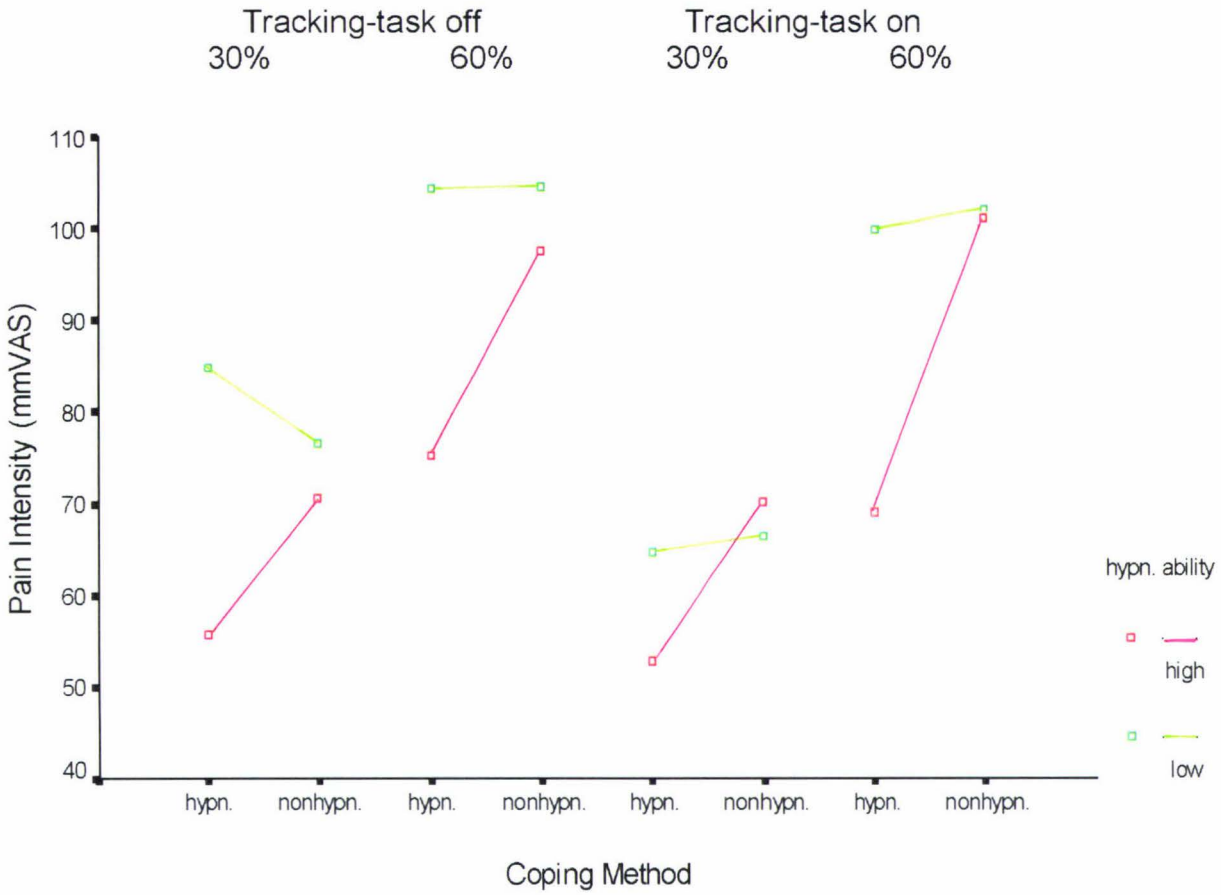

Figure 27. Mean pain-intensity ratings for both hypnotic-ability groups in all treatment conditions.

The LHA group tended to rate the pain stimuli as somewhat less intense when the tracking-task was on rather than off, but this tracking difference only approached significance in the hypnotic condition when the pain stimulus was on at the 30% pain level, t (1,11) = 1.89, p = .086, 95% CI (-3.362, 43.862). The HHA group showed very little difference (nonsignificant) in pain intensity ratings between tracking-task on and tracking-task off conditions. Figure 28 shows the mean pain-intensity ratings with 95% confidence intervals for treatment conditions with tracking-task on at both 30% and 60% pain levels.

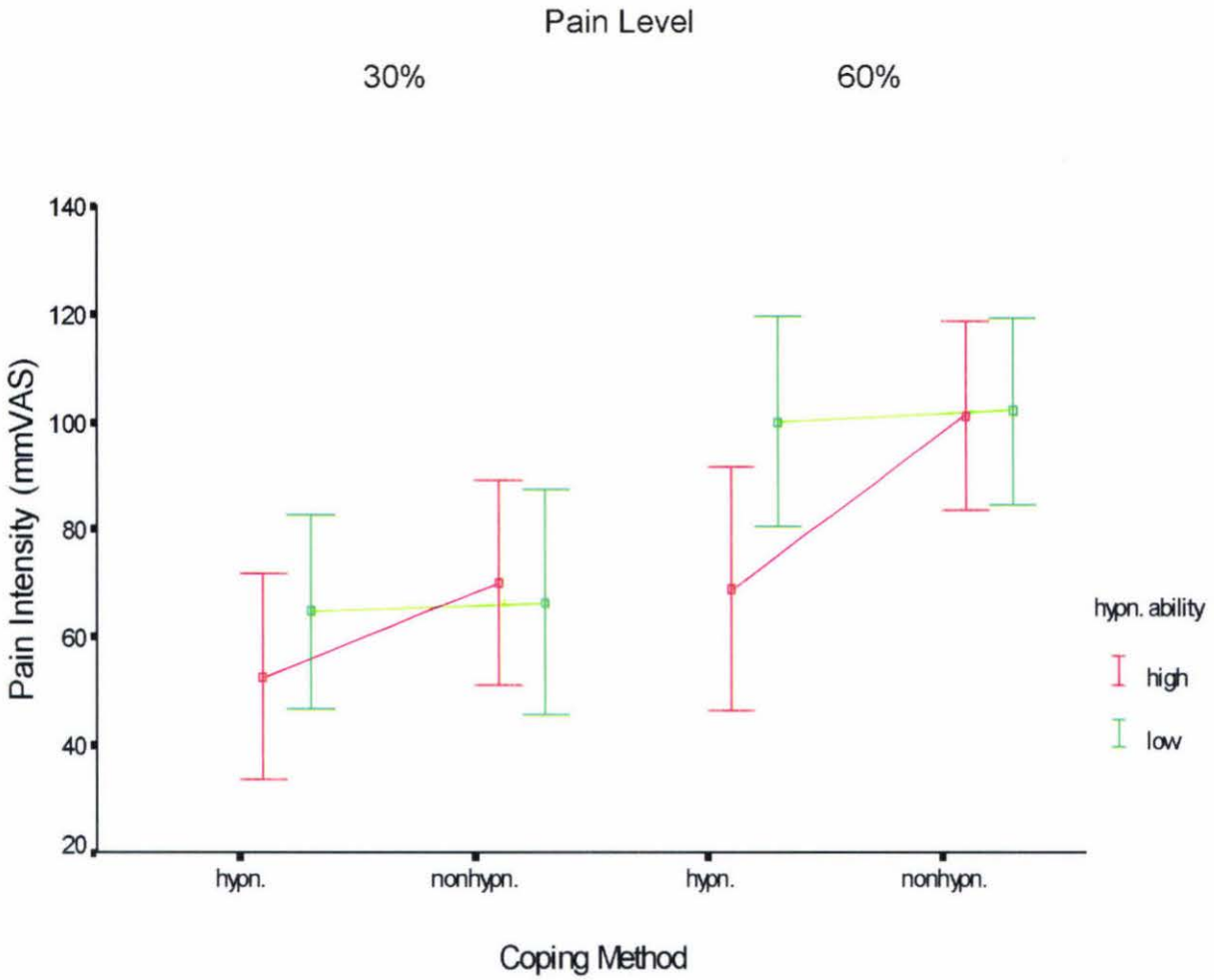

Figure 28. Mean pain-intensity ratings, with 95% confidence intervals, for both hypnotic-ability groups in treatment conditions with tracking-task on.

10.1.2. **Pain unpleasantness**

It is hypothesised that: "When using hypnotic coping strategies, subjects with high hypnotic ability will be more successful in reducing pain-unpleasantness ratings than subjects with low hypnotic ability." It is again expected that this effect will be most obvious at the 60% pain level. We thus anticipate finding a significant main effect for Pain-Level and a significant interaction for Hypnotic Ability x Coping Method and possibly also a significant 3 way interaction for Hypnotic Ability x Coping Method x Pain Level.

A similar mixed-design repeated-measures ANOVA was conducted to evaluate the effect of hypnotic-susceptibility level and type of coping method used on pain-unpleasantness ratings. The only difference being that, the DV was now subjects' pain-unpleasantness ratings in mm on a visual analog scale (0-150mm). The homogeneity of variances assumption was not violated, Box's M = 80.51, F (36,1832) = 1.40, $p > .05$.

Analyses again revealed a significant main effect for Pain Level, F (1,24) = 103.94, $p < .001$, $\eta^2 = .81$. The Coping Method main effect was also significant, F (1,24) = 5.99, $p = .022$, $\eta^2 = .20$, but the significant interaction for Hypnotic Ability x Coping Method, F (1, 24) = 4.69, $p = .041$, $\eta^2 = .16$, indicated that this effect for coping method was moderated by hypnotic ability. The observed power for the analysis of this interaction was .55. The interaction of Coping Method x Pain Level was also significant, F (1,24) = 4.57, $p = .043$, $\eta^2 = .16$ (observed power .54). The 3-way interaction of Hypnotic Ability x Tracking x Pain Level, F (1,24) = 3.94, $p = .059$, $\eta^2 = .14$, approached significance (observed power .48). Of all the other effects, only the main effect for Tracking did approach significance, F (1,24) = 4.08, $p = .055$, $\eta^2 = .14$, The Hypnotic Ability x Tracking interaction was nonsignificant, F (1,24) = 1.00, $p = .327$. Table 12 shows the means and standard deviations of subjects' pain-unpleasantness ratings for both hypnotic-ability groups in all treatment conditions.

When data for both hypnotic-ability groups were combined, overall pain-unpleasantness ratings were significantly higher ($p < .001$) at the 60% pain level than at the 30% pain level for all treatment conditions. Paired-samples t tests to follow-up the significant coping-method effect revealed that, on average subjects rated pain stimuli as less unpleasant in the hypnotic as compared to the nonhypnotic coping condition. This difference for coping method was significant at the 60% pain level, both with tracking-task off, t (1, 25) = -2.06, $p = .050$, 95% CI (-27.901, -.022), and tracking-task on, t (1,25) = -3.10, $p = .004$, 95% CI (-36.156, -7.536). At the 30% pain level the difference for coping method only approached significance when subjects simultaneously performed the tracking task, t (1,25) = -1.74, $p = .095$, 95% CI (-25.726, 2.187).

The only tracking-task difference that approached significance was in the hypnotic coping at the 60% pain-level condition where, on average, subjects rated the pain stimuli as less unpleasant when they simultaneously performed the tracking task, t (1,25) = 1.85, p = .077, 95% CI (-.871, 15.871). All other tracking-task comparisons were nonsignificant.

Table 12. *Means and standard deviations of subjects' pain-unpleasantness ratings for all treatment combinations by hypnotic ability.*

		HYPNOTIC ABILITY							
		LOW				HIGH			
Tracking Task		off		on		off		on	
Coping Method	Pain Level	M	SD	M	SD	M	SD	M	SD
Hypnotic	30%	76.92	43.39	59.08	29.45	46.79	41.36	42.14	33.81
	60%	93.67	36.82	90.75	31.59	72.14	40.59	60.71	40.54
Nonhypnotic	30%	72.58	33.05	57.50	33.20	61.00	34.31	65.36	34.18
	60%	97.58	24.13	98.50	30.17	94.71	34.78	94.64	35.90

To follow up the significant interaction for Hypnotic Ability x Coping Method, paired-samples t tests were calculated for each hypnotic-ability group separately. These indicated that, the HHA group rated the pain stimuli as significantly less unpleasant when using hypnotic as compared to nonhypnotic coping methods (see Figure 29) in all four treatment conditions. This difference was most pronounced for treatment conditions with tracking-task on, being t (1,13) = -2.94, p = .011, 95% CI (-40.27, -6.15) at the 30% pain level and t (1,13) = -3.38, p = .005, 95% CI (-55.63, -12.23) at the 60% pain level. With tracking-task off these differences were, t (1, 13) = -2.72, p = .017 at the 30% pain level, and t (1, 13) = -2.22, p = .045 at the 60% pain level. For the LHA group none of the coping-method differences were significant.

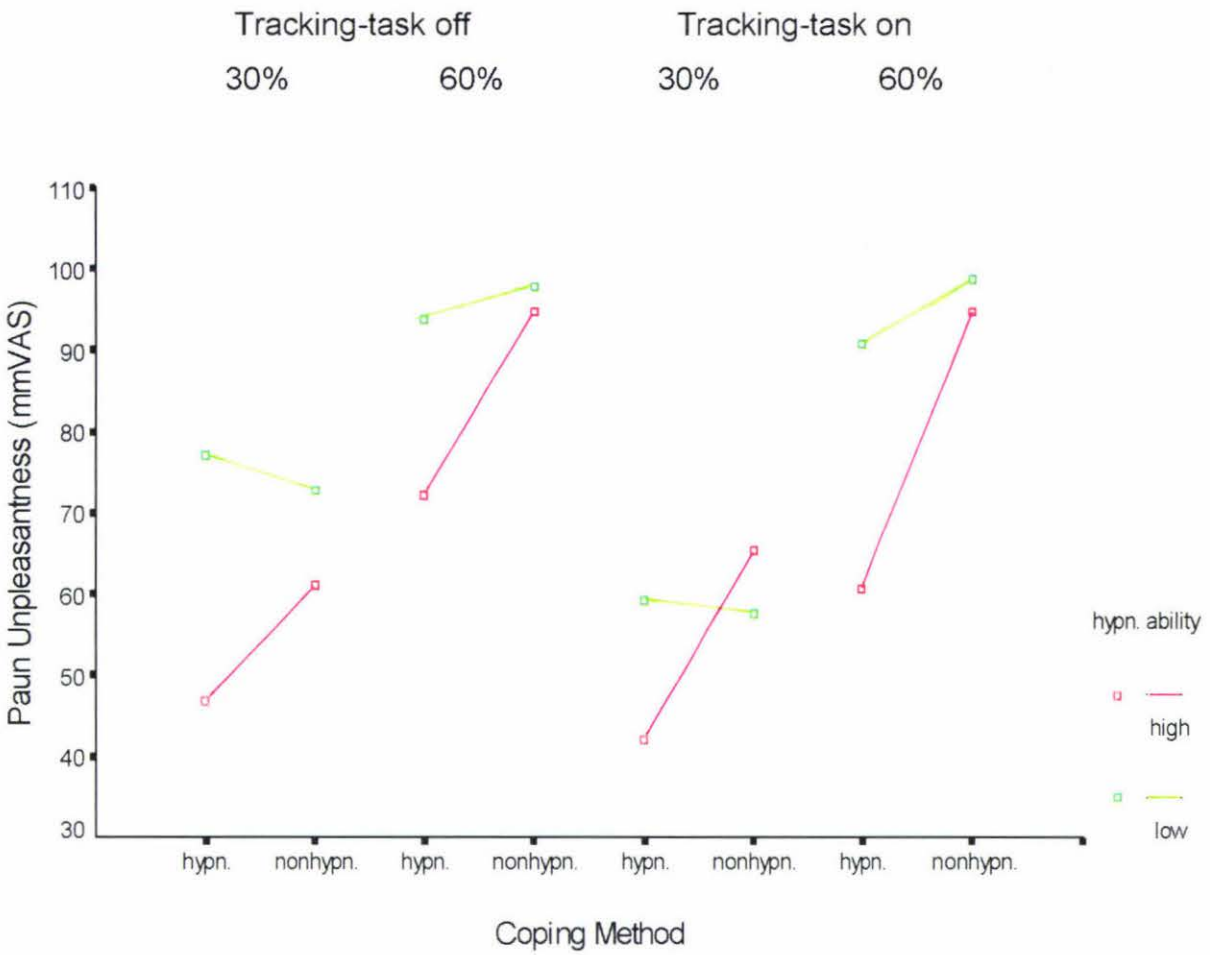

Figure 29. Mean pain-unpleasantness ratings for both hypnotic-ability groups in all treatment conditions.

Tracking-task comparisons revealed that, subjects in the LHA group rated the pain stimuli, on average, as significantly less unpleasant when the tracking task was on rather than off in the nonhypnotic coping at the 30% pain-level condition t (1, 11) = 2.24, p = .047, 95% CI (.260, 29.906). Their counterparts in the HHA group rated the painful stimulation as less unpleasant when the tracking task was on rather than off in the hypnotic coping at the 60% pain-level condition, but this tracking difference only approached significance, t (1, 11) = 2.02, p = .065, 95% CI (-.802, 23.659). None of the other tracking-task comparisons for either hypnotic-ability group were significant. Figure 30 shows the mean pain-unpleasantness ratings, with 95% confidence intervals, for all treatment conditions with tracking-task on.

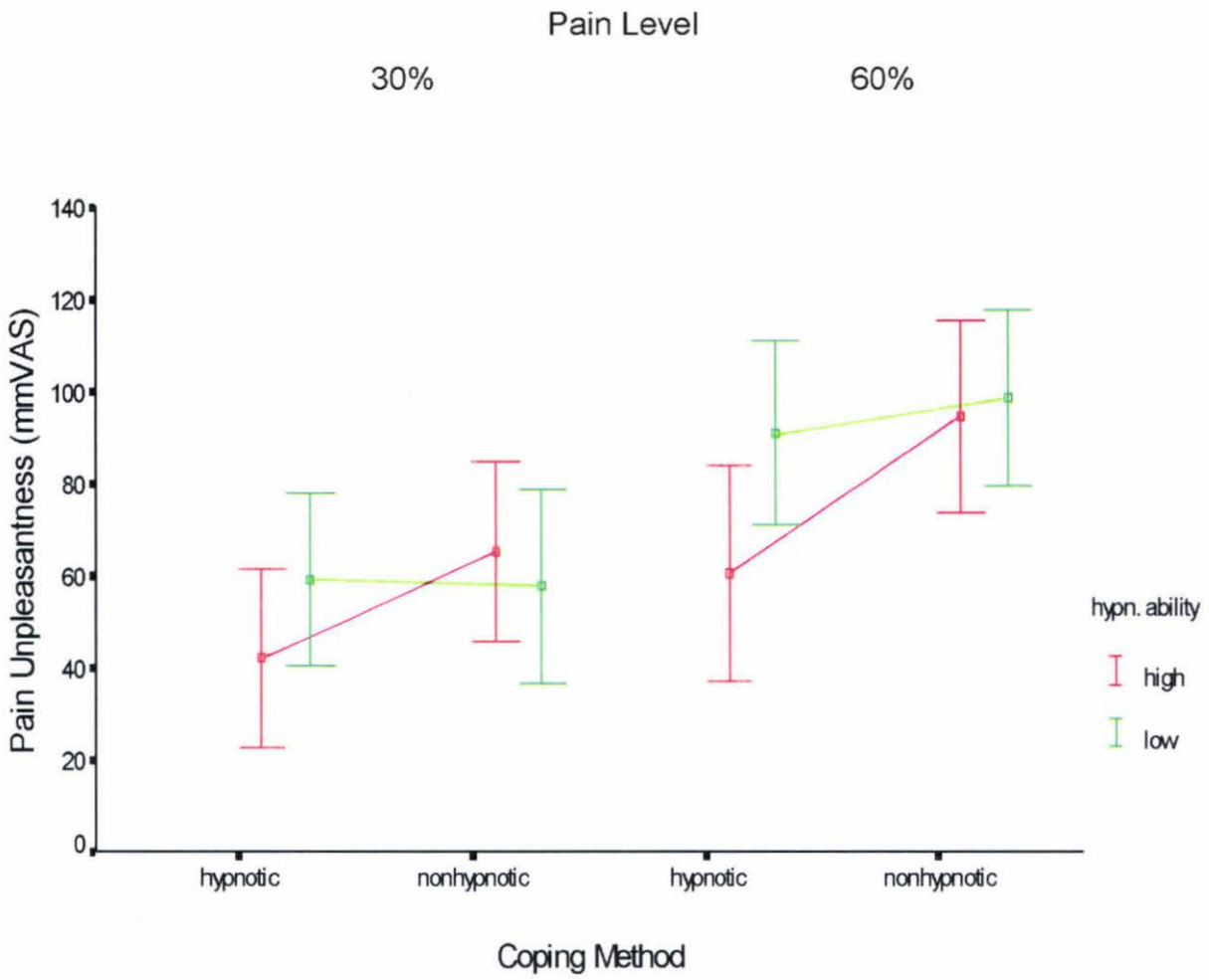

Figure 30. Mean pain-unpleasantness ratings, with 95% confidence intervals, for both hypnotic-ability groups in treatment conditions with tracking-task on.

10.2. *Absorption in Tracking Task*

A mixed-design repeated-measures ANOVA was conducted to evaluate the effect of hypnotic ability and coping method on subjects' ratings of their level of absorption in the tracking task at both pain levels. The DV was subjects' ratings of their level of absorption in the tracking task, measured in mm on a visual analog scale (0-150mm). Hypnotic Ability with two levels (low versus high) was again the between-subjects factor, and the within-subjects factors were Coping Method with two levels (hypnotic and nonhypnotic) and Pain Level with two levels (30% and 60%).

The assumption of homogeneity of variances was not violated, Box's M = 15.45, F (10,2589) = 1.26, p > .05. Analysis revealed a significant interaction effect for Coping Method x Pain Level, F (1,24) = 10.39, p = .004, η^2 = .30. The observed power for the analysis of this interaction was .87. None of the other main or interaction effects were significant or approached significance. The 3-way interaction of Hypnotic Ability x Coping Method x Pain Level was nonsignificant F (1, 24) = .10, p = .756 (observed power was only .05). Table 13 shows the means and standard deviations for the various absorption ratings.

Table 13. *Means and standard deviations for absorption in tracking-task ratings for all treatment conditions by hypnotic-ability group.*

		Hypnotic Ability			
		Low		High	
Coping Method	Pain Level	M	SD	M	SD
Hypnotic	30%	100.25	29.06	113.43	17.54
	60%	89.83	31.28	105.57	26.01
Nonhypnotic	30%	102.83	26.43	111.07	17.53
	60%	103.17	30.72	116.29	20.25

Paired-samples t tests to explore the pain-level effect revealed that, in the hypnotic coping condition subjects indicated that they were significantly more absorbed in the tracking task at the 30% pain level than at the 60% pain level, t (1.25) = 2.17, p = .040, 95% CI (.460, 17.617). There was no significant difference in absorption ratings between the two pain levels when nonhypnotic coping strategies were used.

Follow-up *t* tests for the significant Coping Method x Pain Level interaction showed that, the difference in the reported level of absorption in the tracking task between coping methods was only significant at the 60% pain level, where on average subjects reported to be significantly more absorbed in the tracking task when using nonhypnotic coping strategies, t (1, 25) = -2.35, p = .027, 95% CI (-22.365, -1.481).

When conducted for each hypnotic-ability group separately, it became evident that the greater absoption levels at the 60% pain level when using nonhypnotic coping strategies were only significant for the LHA group, t (1, 11) = -2.52, p = .028, 95% CI (-24.965, -1.702). In the hypnotic condition, subjects tended to be more absorbed in the tracking-task performance at the 30% pain level, but this came only close to being significant for subjects in the LHA group, t (1,11) = 2.16, p = .053, 95% CI (-.175, 21.009).

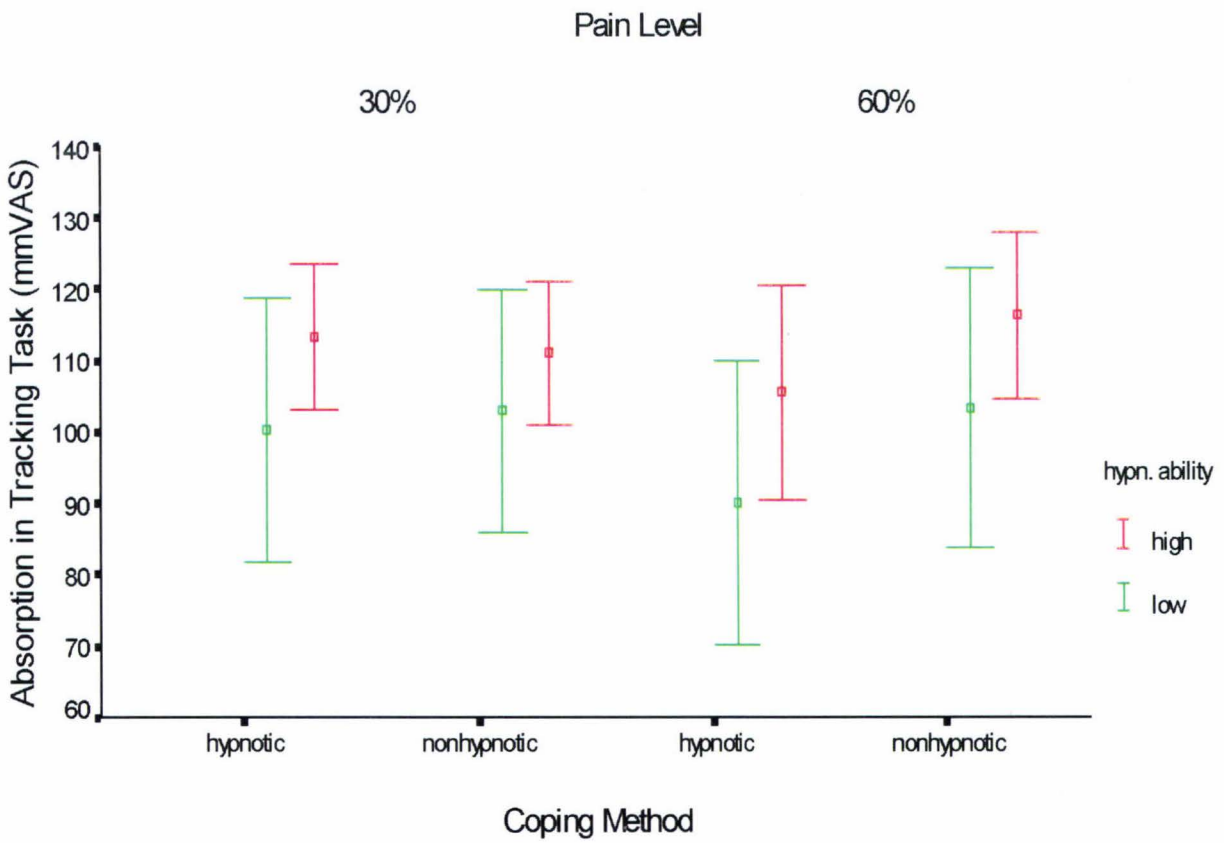

Figure 31. Mean ratings for absorption in the tracking task, with 95% confidence intervals, for both hypnotic-ability groups in all treatment conditions.

10.3. *Strategy Use*

After each set of stimulus trials, subjects indicated which strategies they had used in an attempt to reduce the pain. Options included: (1) deliberately used the hypnotic suggestions, (2) deliberately attended to the tracking task, (3) used other deliberate coping strategies, and (4) made no deliberate attempt to use any coping strategies. More than one option could be chosen. No specific hypotheses had been made about the type or frequency of deliberate coping strategies used. Table 14 shows, for both hypnotic-ability groups, the number of times each option was chosen per treatment combination.

When the difference in group numbers is taken into account, results indicate that, in the hypnotic analgesia condition, subjects in the HHA group more often made deliberate use of the hypnotic analgesia suggestions, and less often used other coping strategies compared to subjects in the LHA group. Apart from this, there were no marked differences in frequency of strategy use between both hypnotic-ability groups. When subjects were not simultaneously performing the tracking task, they made on average more frequent use of "other coping strategies."

Examination of subjects' descriptions of the "other deliberate coping strategies" they used revealed that seven of the fourteen subjects in the HHA group specifically mentioned using imagination, and another five described scenes which clearly involved imaginative thinking. Of the twelve subjects in the LHA group only two mentioned using imagination and one more described an imagined situation. The situations described by highly hypnotic subjects were more imaginative and involved scenes such as imagining: "a white swan which I could see in negative," "a green place," "beating the pain into submission with a baseball bat," "transferring the pain to someone else," "riding a motorbike along the highway," or imagining the pain as an itch and scratching it away. Subjects with low hypnotic ability who used imagination reported this as: "imagined the pain levelling of," "used imagination to divert attention," or mentally sang along with songs in my head. When subjects in the LHA group thought about other things these involved mainly objects in their immediate surrounding (e.g notice on noticeboard, objects on shelves, or hypnotic depth scale chart in front of them), or concentrating on the pain itself.

Furthermore, when using an "other coping strategy", subjects with low hypnotic ability tended to stick to the main strategy they used, whereas their highly hypnotic counterparts frequently switched between a variety of other strategies.

Table 14. *Number of times subjects in both hypnotic-ability groups used deliberate pain-coping strategies in each treatment condition.*

			HYPNOTIC ABILITY							
			Low (n=12)				High (n=14)			
Coping Method	Tracking Task	Pain Level	hypn. sugg.	tracking task	other strat.	no	hypn. sugg.	tracking task	other strat.	no
Hypnotic	on	30%	2	9	4	1	7	12	0	2
		60%	2	8	6	2	7	12	0	2
			(4)	(17)	(10)	(3)	(14)	(24)	(0)	(4)
	off	30%	3	---	8	2	9	---	4	2
		60%	3	---	7	2	10	---	2	3
			(6)		(15)	(4)	(19)		(6)	(5)
total hypnotic cond.			**10**	**17**	**25**	**7**	**33**	**24**	**6**	**9**
Nonhypn.	on	30%	---	9	4	1	---	13	6	0
		60%	---	9	5	1	---	12	4	1
				(18)	(9)	(2)		(25)	(10)	(1)
	off	30%	---	---	11	0	---	---	14	0
		60%	---	---	11	0	---	---	13	1
					(22)	(0)			(27)	(1)
total nonhypnotic cond.			---	**18**	**31**	**2**	---	**25**	**37**	**2**

10.4. *Hypnotic Depth*

Following each treatment combination that involved hypnotic coping, subjects indicated how deeply they felt they were hypnotised, on a scale from 0 to 10, during the set of three stimulus trials they had just completed. Overall, these hypnotic-depth ratings corresponded well with previously assessed levels of hypnotic ability, which determined their allocation to either the LHA or the HHA group. The Pearson correlation between the allocated level of hypnotic ability and the mean hypnotic-depth rating was .689.

The mean hypnotic-depth rating across the four hypnotic conditions was .854 for subjects in the LHA group, and 3.286 for their counterparts in the HHA group. One subject in the LHA group reported markedly higher (mean = 4.75, range 4 to 6) and two subjects in the HHA group reported markedly smaller (means .250 and 1.750, range 0-1 and 1-2 respectively) hypnotic-depth ratings than their respective group means. A separate variable called "hypnotic depth" with two levels (low and high) was calculated. All subjects with a mean hypnotic-depth score smaller than three were allocated to the low hypnotic-depth (LHD) group, and those with a mean score equal to, or higher than, three were allocated to the high hypnotic-depth (HHD) group. This caused the two subjects in the LHA, who deviated markedly from their group means for hypnotic depth, to switch from the LHA group to the HHD group, and the one subject in the HHA group to switch to the LHD group. Both hypnotic-depth groups now had 13 subjects. The mean hypnotic depth score across the four hypnotic treatment conditions was .577 for the LHD group and 4.180 for the HHD group.

Using hypnotic depth, rather than hypnotic ability, as the between-subjects factor made only minor differences in results of repeated-measures ANOVA's of tracking data. None of the *p* values for main effects or interactions changed from being significant to nonsignificant or vice versa. However, the use of hypnotic depth made a noticeable difference in the magnitude, but not pattern, of some of the results of analyses of pain-intensity or pain-unpleasantness data. Table 15 shows the means and standard deviations of pain-intensity ratings for both hypnotic-depth groups in all treatment conditions.

Table 15. *Means and standard deviations of subjects' pain-intensity ratings for all treatment conditions by hypnotic depth.*

		HYPNOTIC DEPTH							
		LOW				HIGH			
Tracking Task		off		on		off		on	
Coping Method	Pain Level	M	SD	M	SD	M	SD	M	SD
Hypnotic	30%	90.77	35.43	71.31	27.87	47.54	37.21	45.08	29.02
	60%	111.38	27.99	107.54	24.53	65.85	41.24	59.00	33.87
Nonhypnotic	30%	78.54	35.54	66.54	31.22	68.08	39.57	70.31	34.58
	60%	107.15	29.59	104.38	26.92	94.15	34.21	98.46	30.40

The Hypnotic Depth main effect was significant for both pain-intensity, F (1,24) = 4.94, p = .036, η^2 = .17, and pain-unpleasantness data, F (1,24) = 6.91, p = .015, η^2 = 22. The p values for most other main effects or interactions were smaller and some previously nonsignificant effects became significant when hypnotic depth was used as the between-subjects factor.

Results for pain-intensity data revealed a significant Coping Method main effect, F (1,24) = 7.41, p = .012, η^2 = .24 (previously p = .046). The Hypnotic Depth x Coping interaction, F (1,24) = 17.73, p < .001, η^2 = .42 (p = .041 for the Hypnotic Ability x Coping Method interaction) indicated that the main effect for coping method was moderated by the level of hypnotic depth. The observed power for the analysis of the Hypnotic Depth x Coping Method interaction was .98. The pain-level main effect was still significant at p < .001, and the Coping Method x Pain Level interaction was now just significant, F (1,24) = 4.43, p = .046, η^2 = .16 (previously p = .053).

The Hypnotic Depth x Pain Level interaction approached significance, F (1,24) = 3.19, p = .087, η^2 = .12, observed power .40 (the Hypnotic Ability x Pain Level interaction was nonsignificant, p = .255). The interaction effect of Coping Method x Track remained virtually unchanged, F (1,24) = 2.94, p = .099, η^2 = .11 (previously p = .102).

Using hypnotic depth ratings as the criterion for the between-subjects factor made only relatively minor changes to the results of most paired-samples t tests. Whereas, pain-intensity ratings for the LHA group had been as good as even for hypnotic and nonhypnotic coping conditions, the LHD group consistently rated treatment conditions involving nonhypnotic coping as less intensely painful, particularly those with tracking-task off, although these differences were not statistically significant. Like the HHA group, the HHD group rated the pain stimuli as significantly less intense in all treatment conditions involving hypnotic analgesia. However, the magnitude of the comparitive advantage hypnotic coping methods had in reducing pain intensity was markedly larger for the HHD group. Like the LHA group, the LHD group rated the pain stimuli consistently as less intense when they simultaneously performed the tracking task. For the LHA group this difference only approached significance in the hypnotic analgesia condition at the 30% pain level. For the LHD group this tracking difference at the 30% pain level approached significance in both the hypnotic coping, t (1, 12) = 1.96, p = .074, and the nonhypnotic coping condition, t (1,12) = 1.89, p = 083.

Figure 32 shows for each hypnotic depth group the difference in pain-intensity ratings between coping methods in all treatment conditions. When using hypnotic coping methods, subjects who reported high hypnotic-depth rated the pain stimuli as significantly less unpleasant than subjects who reported their hypnotic depth as low to zero. When nonhypnotic coping strategies were used, there were no significant differences between the pain-unpleasantness ratings of both hypnotic-depth groups.

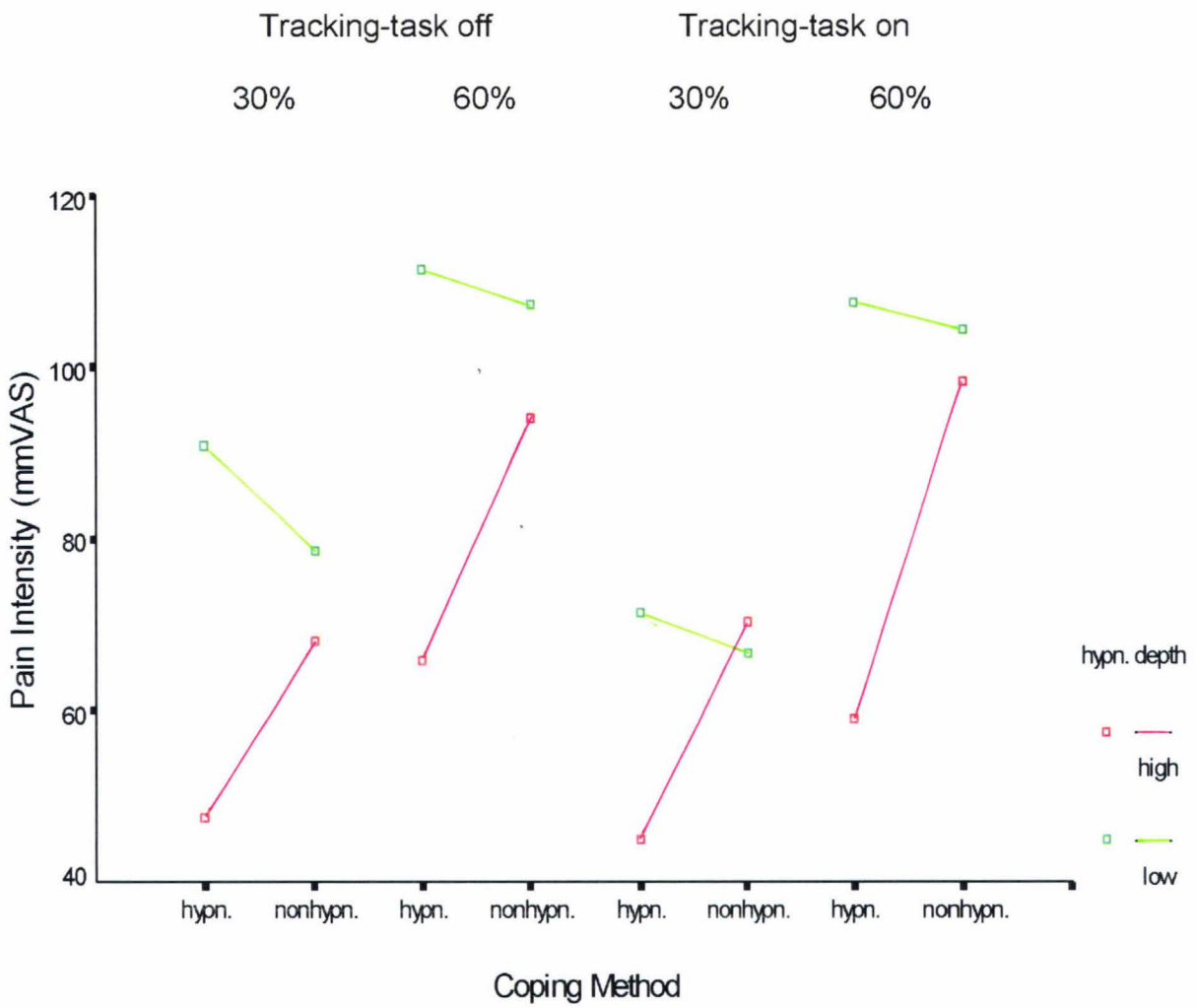

Figure 32. Mean pain-intensity rating for all treatment conditions by hypnotic depth.

Results for pain-unpleasantness data revealed a significant Coping Method main effect, F (1,24) = 9.32, p = .005, η^2 = .28 (previously p = .022). The Hypnotic Depth x Coping Method interaction effect was significant, F (1,24) = 14.90, p < .001, η^2 = .38. (p = .041 for the Hypnotic Ability x Coping Method interaction). The Pain Level main effect was still significant at p < .001, and the significant Coping Method x Pain Level interaction had changed only marginally.

The main effect for Tracking still approached significance, F (1,24) = 3.74, p = .065, η^2 = .13 (previously p = .055), and the Hypnotic Depth x Tracking x Pain Level interaction was just significant, F (1,24) = 4.33, p = .048, η^2 = .15 (p = .059 for the Hypnotic Ability x Tracking x Pain Level interaction).

Table 16 lists, for all treatment combinations, the means and standard deviations of pain-unpleasantness ratings for subjects in both hypnotic depth groups.

Table 16. *Means and standard deviations of subjects' pain-unpleasantness ratings for all treatment combinations by hypnotic depth.*

		HYPNOTIC DEPTH							
		LOW				HIGH			
Tracking Task		off		on		off		on	
Coping Method	Pain Level	M	SD	M	SD	M	SD	M	SD
Hypnotic	30%	84.61	38.94	66.54	32.28	36.77	36.22	33.38	23.46
	60%	103.08	28.29	101.15	23.92	61.08	39.01	48.00	32.85
Nonhypnotic	30%	75.61	32.36	62.92	33.11	57.08	33.40	60.54	34.77
	60%	100.77	24.52	102.00	28.68	91.31	34.63	90.85	36.73

Again, the use of hypnotic depth rather than hypnotic ability made in general only relatively minor differences to the results of paired samples *t* test comparisons. Both hypnotic-depth groups rated pain stimulation at the 60% pain level as significantly more unpleasant than stimulation at the 30% pain level. There were no significant coping-method differences for the LHD group. The HHD rated pain stimuli in all treatment conditions as more unpleasant when using nonhypnotic as compared to hypnotic coping methods. The magnitude of the superiority of hypnotic analgesia was greater for the HHD group than the HHA group.

Tracking differences changed slightly. When the LHD group used nonhypnotic coping strategies at the 30% pain level they rated the painful stimuli as less unpleasant when they simultaneously performed the tracking task.

However, this tracking difference for the LHD group only approached significance, t (1, 12) = 1.94, p = .076 (was .047 for LHA group). When the HHD group used hypnotic analgesia at the 60% pain level they rated the pain stimuli as significantly less unpleasant when they also performed the tracking task, t (1, 12) = 2.26, p = .043, 95% CI (.489, 25, 665). For the HHA group this difference only approached significance, p = .65. Figure 33 shows for each hypnotic depth group the difference in pain-unpleasantness ratings between coping methods in all treatment conditions.

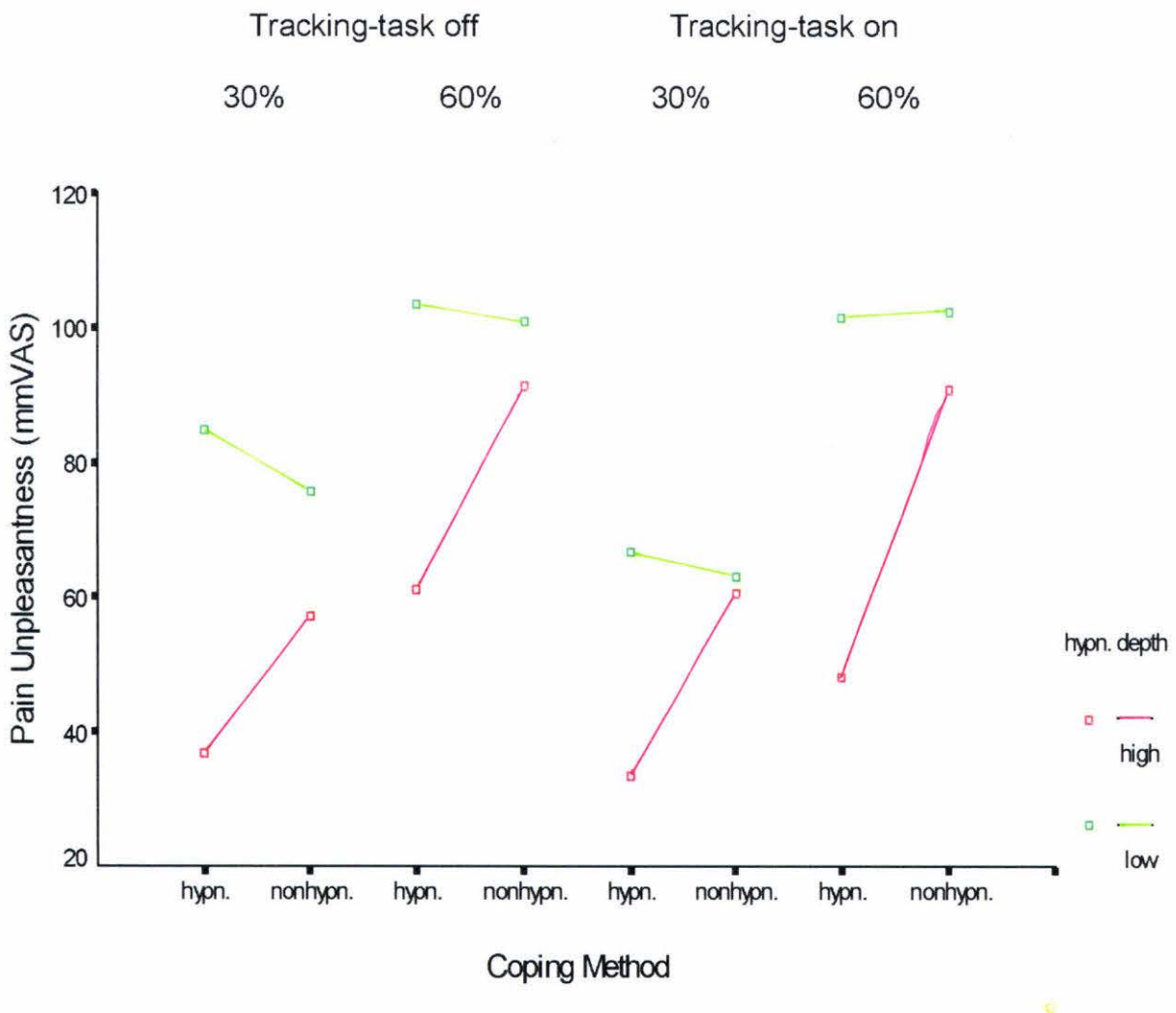

Figure 33. Mean pain-unpleasantness rating for all treatment conditions by hypnotic depth.

10.5. *Summary of Main Findings*

Pain ratings: Both hypnotic-ability groups rated iontophoretic stimulation at the 60% pain level as significantly more intense and more unpleasant ($p < .001$) than at the 30% pain level in all treatment conditions.

There was a significant Coping Method x Hypnotic Ability interaction effect. The HHA group rated the pain stimulus as significantly less intense and less unpleasant when using hypnotic, as compared to nonhypnotic, coping strategies. This was evident in all treatment conditions and most pronounced with tracking task on at the 60% pain level. The LHA group showed no significant differences in pain intensity or pain unpleasantness ratings between the hypnotic and nonhypnotic treatment conditions.

The LHA group rated the pain stimulus as markedly (but *ns*, $p = .086$) less intense in the hypnotic condition at the 30% pain level with tracking task on rather than off, and as significantly less unpleasant ($p = .047$) in the nonhypnotic condition at the 30% pain level with trackiing task on. There were no marked or significant tracking task differences for the LHA group in any of the conditions at the 60% pain level. The HHA group rated the pain stimulus as markedly (but *ns*, $p = .065$) less unpleasant in the hypnotic condition at the 60% pain level when the tracking task was on rather than off. All other tracking task comparisons for this group were nonsignificant.

Absorbtion scores: In all treatment conditions, high hypnotisables tended to be more absorbed in the tracking task than low hypnotisables. In the hypnotic condition, both high and low hypnotisables were, on average, markedly more absorbed in the tracking task at the 30% rather than the 60% pain level, but this difference only came close to being significant ($p = .053$) for the LHA group. In the nonhypnotic condition, there were no significant differences in absorption scores between pain levels within each hypnotic-ability group.

Strategy use: In the hypnotic analgesia condition, highs tended to use mainly hypnotic suggestions and tracking task performance as deliberate coping strategies, while the majority of lows used the tracking task and/or other coping strategies. In the nonhypnotic analgesia condition, there were no significant differences between the hypnotic-ability groups in the pattern of deliberate coping strategies used (tracking task and other strategies).

Hypnotic depth ratings: Subjects' hypnotic-depth ratings following each hypnotic condition correlated quite highly (r = .689) with their assigned hypnotic-ability level as determined by prior assessment. Using hypnotic-depth ratings made at the time of experimentation rather than prior-assessed hypnotic-susceptibility scores as the criterion for allocation to hypnotic-ability groups (i.e., the between-subjects factor) made only relatively minor changes to the results of analyses.

CHAPTER ELEVEN ⊛
HYPNOTIC ABILITY SCREENING DATA

11.1 *Harvard Group Scale of Hypnotic Susceptibility: Form A*

Roughly one sixth (15.9%) of subjects were relatively unresponsive to the hypnotic suggestions and passsed three or less items on the HGSHS:A. Just over half (53.3%) of subjects passed between four and eight items and fell in the medium hypnotic ability group. Close to one third (30.8%) of subjects passed nine or more items and were classified as highly susceptible (see Table 17).

Table 17. Number and percentage of subjects that passed each item on HGSHS:A.

	Items passed												
	0	1	2	3	4	5	6	7	8	9	10	11	12
number	6	2	10	11	8	17	22	31	19	26	14	11	5
percentage	3.3	1.1	5.5	6.0	4.4	9.4	12.1	17.0	10.4	14.3	7.7	6.0	2.8
	15.9 %				53.3 %					30.8 %			

Figure 34 shows the distribution of item-pass percentages for data on the HGSHS:A. Items 1, 2, 3, 7 (green bars) are ideomotor items (respectively head falling, eye closure, hand lowering, and hand moving). Items 4, 5, 6, 8, and 10 (red bars) represent the challenge items (respectively arm immobilisation, finger lock, arm rigidity, communication inhibition, and eye catalepsy). Finally, items 9, 11, and 12 (blue bars) are cognitive items (respectively hallucination, posthypnotic suggestion, and amnesia).

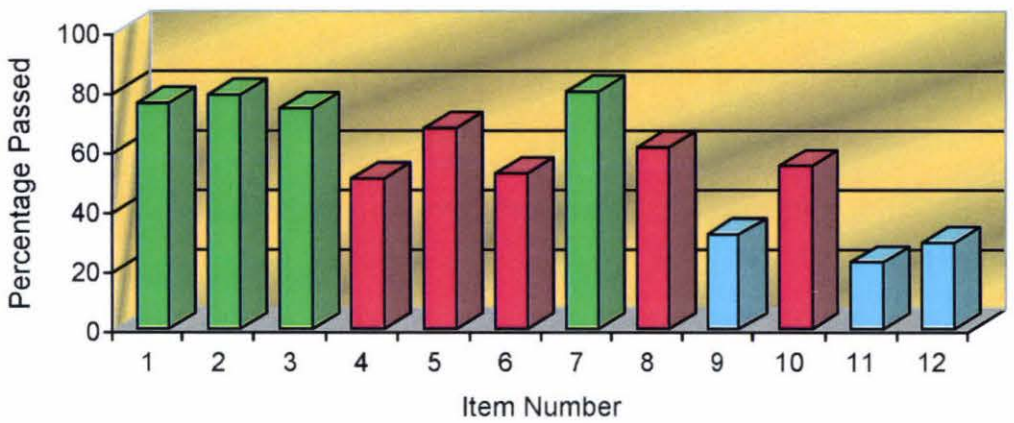

Figure 34. Distribution of item-pass percentages for HGSHS:A.

Table 18 shows the percentage and rank order of the number of subjects who passed each item for the current sample, and for normative data from an aggregate sample of Australian students (Sheehan & McConkey, 1979), a sample of Californian students (Coe, 1964), and the original sample of Harvard University students used by Shor and Orne (1963).

The rank order of item-pass percentages for the current sample corresponds quite well with those obtained for the various normative samples, suggesting that the current administration of the HGSHS:A was a valid assessment.

Table 18. *Item-pass percentages and rank order for current sample of the HGSHS:A, and normative data from Australian, Californian, and Harvard samples.*

Item	this study (N = 182)	aggr. sample Australian (N = 1944)	Californian (N = 168)	Harvard (N = 132)
1. Head Falling	76 (3)	61 (3)	68 (3)	86 (2.5)
2. Eye Closure	79 (2)	57 (4)	56 (4)	74 (4)
3. Hand Lowering	74 (4)	71 (1)	71 (2)	89 (1)
4. Arm Immobilisation	50 (9)	36 (9)	35 (9.5)	48 (9.5)
5. Finger Lock	68 (5)	53 (5)	52 (5)	67 (5)
6. Arm Rigidity	52 (8)	41 (7)	48 (6)	57 (6)
7. Hands Moving	80 (1)	71 (2)	77 (2)	86 (2.5)
8. Communication Inhibition	61 (6)	42 (6)	44 (7)	50 (8)
9. Hallucination	32 (10)	25 (11)	33 (12)	39 (11)
10. Eye Catalepsy	55 (7)	38 (8)	39 (8)	56 (7)
11. Posthypnotic Suggestion	22 (12)	17 (12)	34 (11)	36 (12)
12. Amnesia	29 (11)	33 (10)	35 (9.5)	48 (9.5)

11.2. *Tellegen Absorption Scale*

For studies with sample sizes larger than fifty and including both male and female subjects, the average correlation between the TAS and the HGSHS:A tends to be around .27, with some nonsignificant results (see de Groh, 1989). For the current sample this correlation was .239 (p = .001, two-tailed).

Some researchers have found that females scored significantly higher on absorption than males (e.g., Crawford, 1982; Farthing, Venturino, & Brown, 1983; Spanos & McPeake, 1975; Yanchar & Johnson, 1981). No such gender difference were observed for the sample in the current study. The mean absorption score was 20.22 (s.d. 5.50, range 5-31) for males and 21.18 (s.d. 5.66, range 6-34) for females, but this gender difference was not significant, t (2,188) = 1.08, p = .283, 95% CI (-.788, 2.683). This lack of support for a moderating role of gender is consistent with results of Nadon et al. (1991) and a set of four studies by Glisky et al. (1991).

The mean absorption score for subjects with low hypnotic susceptibility (score 3 or less on HGSHS:A) was 18.03 (s.d. 6.26, range 5-29), and 22.36 (s.d. 5.34, range 10-34) for subjects with highly susceptible subjects (score 9 or higher on HGSHS:A). This difference was statistically significant t (2,83) = -3.34, p = .001, 95% CI (-6.901. –1.745). The absorption scores for subjects in both hypnotic-ability groups clustered mainly around the mean, with roughly equal numbers of scores below and above the mean. In the low hypnotic-ability group (n = 29), 9 subjects scored more than 2 scale units below the mean and 9 others scored more than 2 scale units above the mean absorption score. For the high hypnotic-ability group (n = 56), these figures were 18 below and 23 above 2 scale units from the mean.

These findings differ from those obtained by Crawford (1982) who observed a significant gender difference in her sample t (2,54) = 3.35, p = .001, with females scoring significantly higher (mean 23.77) on absorption than males (mean 19.20). Crawford (1982) assessed subjects hypnotic susceptibility using the SHSS:A and a second assessment using the SHSS:C. The mean of these two measures was then used in comparisons with that of other measures (e.g., the TAS). Subjects were not classified by hypnotic ability, and mean TAS scores were, therefore, only provided by gender but not by hypnotic ability group (high – low). However, Crawford reports that the examination of scatterplots showed that highly hypnotisables consistently scored above the mean on the TAS, while low and moderate hypnotisables scored both below and above the mean absorption score.

When only those scoring high or low on both hypnotic-susceptibility measures (i.e., the high and low hypnotic ability groups for the experimental session) were considered, the highs scored on average significantly higher on absorption than the lows, t (2, 24) = -2.69, p = .013, 95% CI (-10.292, -1.351). The mean absorption score for the low hypnotic ability group was 16.72 (s.d. = 5.10, range 5-24), and for the high hypnotic ability group 22.57 (s.d. = 5.83, range 10-31). Absorption scores for the low hypnotic-ability group (n=12) clustered mainly around the mean, with only 2 lows scoring more than 2 scale units below the mean and only 3 lows scoring more than 2 scale units above the mean. In the high hypnotic-ability (n=14) group 7 subjects scored more than 2 scale units above the mean, but only two subjects scored more than 2 scale units below the mean.

Thus, when using the smaller sample based on the dual, more demanding, screening process only few subjects scored markely below the mean. These results correspond more closely with those found by Crawford (1982). A similar absence of low scores among high hypnotisables has also been reported for imagery vividness (Perry, 1973; Sutcliffe et al., 1970) and gestalt closure ability (Crawford, 1981).

11.3. *Waterloo-Stanford Group C Scale*

Table 19 presents percentage pass information for each item, in the order they are presented, for the current sample, the normative sample for the WGSC, and a comparative sample using the SHSS:C.

Table 19. *Item-pass percentages and rank order of item difficulty for current sample of WGSC, normative sample for WGSC, and a comparitive sample using the SHSS:C.*

Item	current study (n = 76)	WSGC (n = 65)	SHSS:C (n = 65)
1. Hand lowering	81 (1)	92 (1)	94 (1)
2. Hands move together	68 (2)	77 (2)	82 (2)
3. Mosquito hallucination	20 (12)	54 (7)	71 (3.5)
4. Taste hallucination	50 (8)	49 (8)	54 (8)
5. Arm rigidity	53 (5)	72 (3)	71 (3.5)
6. Dream	56 (4)	45 (9)	57 (7)
7. Arm immobilisation	66 (3)	65 (4.5)	66 (5)
8. Age regression	52 (6.5)	65 (4.5)	62 (6)
9. Hallucinated music	22 (11)	28 (12)	18[a] (11)
10. Negative visual hallucination	52 (6.5)	35 (10)	17 (12)
11. Posthypnotic drawing	44 (9)	55 (6)	34[b] (9.5)
12. Amnesia	36 (10)	32 (11)	34 (9.5)

a SHSS:C values refer to the hallucinated voice, which the hallucinated music replaces.

b SHSS:C values refer to the anosmia to ammonia item, which the posthypnotic drawing replaces.

Overall, the item-pass percentages correspond quite well between the samples. A considerably smaller number of subjects for the current sample passed the mosquito hallucination, 20% as to 54% for the normative sample of the WSGC, and the arm rigidity item, 53% for the current sample and 72% for the normative sample. By contrast, a markedly higher proportion of subjects passed the negative visual hallucination, 52% for the current sample as compared to 35% for the normative sample of the WGSC. Table 20 shows for the current sample on the WSGC the number of subjects that passed each item separated by hypnotic ability group.

Table 20. *Item-pass data for WGSC by hypnotic-susceptibility group.*

Hypnotic Susceptibility	n	Item[a] 1	2	3	4	5	6	7	8	9	10	11	12
Low	25	11	6	1	1	2	4	2	--	--	2	5	--
Medium	26	25	20	16	15	24	14	20	14	1	8	11	--
High	25	25	25	22	24	24	20	20	19	14	17	23	17

a See Table 17 for description of items.

Figure 35 shows the item-pass percentages separated by hypnotic-ability group, which clearly indicate the distinctive response patterns for the different hypnotic-ability groups.

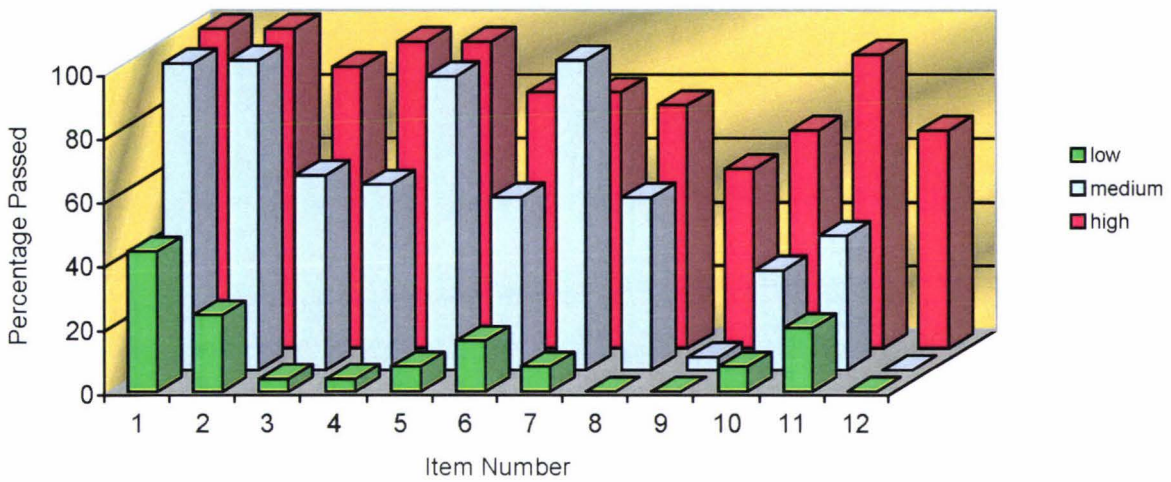

Figure 35. Distribution of item-pass percentages for WGSC by hypnotic-ability group.

Most subjects with low hypnotic ability did moderately well on the ideomotor suggestions (items 1 and 2), but very few if any passed any of the other items. The suggestion for post hypnotic drawing (item 11) being a slight exception in that it got passed by a relatively larger number of subjects in all hypnotic ability groups. Subjects with high hypnotic ability had consistently high pass rates, with the music hallucination (item 9) being the least passed (56%) item. Subjects with medium hypnotic ability did just as well as the highs on the ideomotor and challenge suggestions (respectively items 1 and 2, and 5 and 7). They did moderately well, although markedly less than the highs, on the easier hallucination suggestions (items 3 and 4) and on the dream and age regression suggestions (items 6 and 8). What sets the medium hypnotic ability group most clearly apart from the scoring pattern of the highs is that, for the medium ability group pass rates dropped sharply for the more difficult cognitive items, that is the difficult hallucinations (items 9 and 10) and the suggestions for posthypnotic drawing (item 11) and amnesia (item 12).

DISCUSSION

CHAPTER TWELVE
DISCUSSION

12.1. *Review of Hypotheses and Findings*

The main aim of the current study was to investigate whether the absence of interference with secondary task performance that was observed by Miller and Bowers (1993) among highly hypnotisables when using hypnotic analgesia to cope with painful stimulation would be replicated in a study using a modified methodology that included a different secondary task and different method of pain stimulation.

12.1.1. Hypotheses 1 and 2 – Differences in tracking performance (i.e., attentional interference)

The first hypothesis, that both high and low hypnotisables would experience impaired tracking performance during painful stimulation in the nonhypnotic condition was not supported.

Receiving simultaneous painful stimulation made no significant difference in subjects' tracking performance in all but one of the nonhypnotic conditions. Contrary to expectation, low hypnotisables actually experienced either no real difference or an improvement in tracking performance (i.e., made less tracking errors), but the improvement was only significant when low hypnotisables used nonhypnotic strategies to cope with painful stimulation at the lower (i.e., 30%) pain level during trial one, t (1.11) = 3.03, p = .011. While highly hypnotisable subjects consistently experienced a decline in tracking performance when using nonhypnotic coping strategies at the 60% pain level, none of these differences was statistically significant. In all other nonhypnotic conditions, both high and low hypnotisables experienced either slight improvements or slight impairments in tracking performance, but none of these came close to being significant

Hypothesis two represents the main research question and states that highs, but not lows, will experience no deterioration in tracking performance when using hypnotic suggestions to cope with the painful stimulation. This hypothesis was also not supported.

Contrary to what was hypothesised, high hypnotisables made, on average, consistently more tracking errors in the hypnotic analgesia condition than in the nonhypnotic condition, despite the fact that they achieving significantly larger reduction in both pain intensity and pain unpleasantness when using hypnotic analgesia. This finding was evident at both pain levels and for data obtained over either all three trials combined or trial one only. However, none of these treatment differences came close to being significant for high hypnotisables.

Low-hypnotisable subjects were expected to make more tracking errors when using hypnotic suggestions as compared to nonhypnotic strategies; and, on average, indeed did so in all but one of the conditions. These coping-method differences were significant at the 60% pain level, for data of all three trials combined, t (1,11) = 2.29, p = .043, and for data of trial one only, t (1,11) = 2.53, p = .028. At the 30% pain level and for data of trial one only, low hypnotisables experienced, on average, a very small (1.43%) and nonsignificant improvement in tracking performance.

Contrary to expectation, the tracking performance of high hypnotisables was not markedly better than that of the lows when using hypnotic suggestions, although at the 60% pain level they demonstrated only a small to moderate and nonsignificant (resp. 11%, 13.5% and 20%) increase in tracking errors while lows experienced a much larger and almost significant or significant (resp. 32%, 47% and 62%) increase in tracking errors.

As the 95% confidence intervals in Figure 23 and 26 show, in virtually all conditions the within-group variability in tracking performance was markedly larger than the variability in tracking performance between conditions and between hypnotic-susceptibility groups. Furthermore, in almost all treatment comparisons, some subjects made more tracking errors when they received painful stimulation while others experienced an improvement in tracking performance.

Conclusion: The current study did not find any evidence for the hypothesised absence of interference with secondary task performance among highly hypnotisables when using hypnotic analgesia. However, the presence of this large between-subject variability within conditions prevents the conclusion that these findings are incompatible with predictions made by the dissociated-control model and provide support for a social-psychological interpretation of hypnosis.

12.1.2. **Discussion**

Apart from the obvious possibility that the effective use of hypnosis, like the use of nonhypnotic coping strategies, does require attentional involvement, there could be a number of other reasons why the hypothesised absence of interference among high hypnotisables when using hypnotic analgesia was not observed in this experiment.

For the current experiment to be able to detect that high hypnotisables, but not low hypnotisables, experienced no interference when using hypnotic suggestions as their pain coping strategy, a number of conditions needed to be met. These include that:

1. High and low hypnotisables were accurately classified.
2. High hypnotisables were effectively hypnotised during the experimental session.
3. The stimulation used was painful enough to result in interference with the performance of the tracking task.
4. Performance of the tracking task required executive attentional effort.
5. The tracking task was sensitive enough to be able to demonstrate the influence of interference effects should these be present.

12.1.2.1. *Accuracy of hypnotic-susceptibility assessment*

Subjects had been assigned to either hypnotic-susceptibility group based on conservative selection criteria using hypnotic-susceptibility scores obtained during independent assessments with two well-established hypnotic-susceptibility scales.

This procedure improved the accuracy of hypnotic-ability assignment by provided an initial familiarisation with hypnosis and hypnotic-susceptibility testing, by enabling the inclusion of a more stringent assessment measure with superior psychometric and predictive properties, and by reducing the influence of possible situational factors that may affect test performance. Item pass rates for assessments on the HGSHS:A and WGSC were quite similar to those obtained by other studies using these instruments, which indicates that they were reliable assessments of hypnotic susceptibility (see Table 17 and 18). Thus, all indications are that subjects had been accurately assigned to either hypnotic-susceptibility group.

However, some more recent research has provided strong indications that those traditionally classified by standard hypnotic-susceptibility tests as highly susceptible constitute less of a homogeneous group as previously assumed (see pp. 191-192). Independent studies have observed distinct differences in responsiveness to certain hypnotic suggestions among subjects commonly classified as highly susceptible, and these differences were reflected in strikingly different patterns of brain activity as demonstrated by electrophysiological recordings.

Thus, although accurately assigned, the standard assessment procedures used may not have been sensitive enough to detect differences in responsiveness. This could have important implications for the outcome of hypotheses regarding the attentional involvement and task interference experienced in the current study. The same would apply to earlier studies, including Miller and Bowers (1986, 1993), that used standard hypnotic-ability classification criteria that do not differentiate between these proposed subgroups of highly susceptibles. Further research is needed to determine whether these initial indications of heterogeneity in responsiveness among highly hypnotisables are a robust phenomenon. If so, more sensitive scoring protocols and possibly also more sensitive assessment procedures would have to be developed, for example by inclusion of suggestions that tap the type of experiences that do differentiate between the subgroups) Without additional and/or improved assessment, it is impossible to know whether the particular make-up of a sample of highly hypnotisables includes distinct subgroups of hypnotic responding.

12.1.2.2. *Actual hypnotic status during experimental session*

Even an accurate assessment of hypnotic susceptibility does not guarantee that highly hypnotisable subjects were also effectively hypnotised during the experimental session. As reported earlier, a person's ability to become involved in a hypnotic procedure can be influenced by various situational factors acting either alone or in combination. During the experimental stage these may have included experiment-specific influences such as different and less relaxing surroundings, anxiety related to the painful stimulation, and the fact that the hypnotic induction was recorded by a different and less experienced person; or could be related to more general situational factors such as the person being uncomfortable, tired, unusually stressed, or ill at the time of examination. In addition, it is also possible that subjects who did become hypnotised were not able to maintain their hypnotic state across conditions. This is particularly relevant in the current experiment because subjects had to report several ratings following each block of stimulus trials which may have interfered with their ability to remain hypnotised. The deepening suggestions that were repeated at the start of each block of stimulus trials might not have been effective for all.

To have some means of assessing whether subjects did or did not become and remain hypnotised during the experimental session, hypnotic-depth ratings were recorded following each block of trials in the hypnotic condition. Analysis of these ratings shows that prior hypnotic-susceptibility scores correlated relatively highly (r = .689) with hypnotic depth ratings assessed during the experimental session. Using hypnotic depth ratings as criteria for hypnotic-ability group allocation resulted in only 3 out of 26 subjects being allocated to the opposite hypnotic-susceptibility group. There were no significant differences in the outcome of repeated-measures ANOVA's when the within-subject factor (i.e., hypnotic ability) was based on hypnotic depth ratings. This indicates that: (1) subjects' hypnotic-susceptibility group allocation presented a fair reflection of their actual hypnotic status during the experimental session, and (2) the absence of the hypothesised lack of secondary-task interference among highs when using hypnotic analgesia did not result from them not being effectively hypnotised.

12.1.2.3. *Pain stimulation*

Pain stimulus intensities for each subject had been individually set a level that was experienced as considerably painful by that subject, particularly at the 60% level. This was confirmed by subjects' pain-intensity and pain-unpleasantness ratings in all conditions. Considering the abundant literature on the interruptive quality of pain and its resistance to habituation, it is unlikely that the processing of the painful stimulation did not require considerable attentional involvement. Overall, subjects made more tracking errors during periods when they simultaneously received painful stimulation. However, this difference was not statistically significant, and neither was it consistent across all conditions or all subjects. In most conditions there were some individual subjects who experienced an improvement in tracking performance during periods when they received no pain stimulation, and in some conditions even the group average represented an improvement in tracking performance when the pain stimulation was off rather than on (see tables 7 & 9 and figures 23 & 26).

The fact that some subjects showed improved tracking performance when they received simultaneous pain stimulation may seem counterintuitive at first. However, the experience or anticipation of pain commonly leads to a heightened vigilance for painful or threatening stimuli. It is quite possible that this, at least for some subjects, did carry over into heightened vigilance in general, including for evidence of deviations between cursor and wave positions. Such increased vigilance could lead to improved tracking performance particularly when the combined demands of pain processing and tracking task performance did not exceed the available capacity of attentional resources. This situation would be most likely at the 30% pain level and when performance of the pursuit-tracking task did not require substantial attentional effort.

From the results of this study, it cannot be assumed that pain processing and tracking task performance did require the same attentional resources. However, unless the tracking task had become habituated, it seems unlikely that both activities did not rely on at least some of the same attentional resources. If pain is severe enough, it seems to interfere with virtually any activity.

12.1.2.4. *Reliance on attentional effort and sensitivity of the tracking task.*

The computer programme that controlled the presentation of the tracking task allowed for manipulation of the steepness (slope) of the curve, the speed with which the curve moved along the screen, the thickness of the line, and the size of the cursor. Different settings of these variables were trialed during preliminary testing to arrive at a combination that presented the most approprioate level of task difficulty (i.e., difficult enough to require concentrated attention, but not so difficult that relatively accurate performance was impossible and subjects were likely to become discouraged).

The design of the pursuit-tracking programme had been intended to also include the ability to change the shape and type of the curve at various intervals during its presentation so as to assure its unpredictability and continued requirement of cognitive effort. While being variable in its presentation, the task would have to be internally consistent in that tracking performance at the various phases should be of a comparable level of difficulty.

However, in its final form the program only allowed for the slope of the wave to be varied, but not its basic shape which followed a sine wave pattern. Furthermore, once selected, the slope of the wave was set for the duration of the trial. The oscillating movement of a sine wave has a "rhythmic" regularity to it, and observation during the experiment clearly revealed that subjects were able to adjust relatively quickly to this rhythm and the corresponding rhythmic fluctuation in speed and direction of control-slide movements required to keep the cursor on the wave. The regular pattern of movement required rapidly became a well-established skill (task schema) that could be performed with minimal higher cognitive effort. In fact, when well learned and accustomed to, it would be possible to perform the task quite well purely by relying on the temporal sequence of movements. Strictly seen, it would not even be necessary to continue looking at the display if it was not for the obvious drawback that, once out of sequence one would continue to accurately follow the pattern of the wave but always with the cursor being either just ahead of or lagging behind the line of the waveform.

Accurate performance relied largely on monitoring the distance between the position of the cursor and that of the line, and on deciding when the direction of movement had to be changed. Only when slide movements were either too fast (i.e., cursor "overshot" the wave) or too slow (i.e., cursor lagged behind the wave) was corrective action required. These situations might occur, for example, because: the task had not yet been learned well enough to be able to be performed it accurately in a rather automatic fashion, because a slip in attention (e.g., overconfidence in once ability) caused a tracking error; the subject became distracted by pain or other influences and attention was momentarily averted elsewhere; or the subject was either too slow in initiating movement or overcompensated when initiating movement after the brief period at the extremes of each oscillation when required slide movement were zero or close to zero. At other times, the task could be performed largely automatically and required only little high-level attentional involvement.

By the time the design of the tracking programme had been completed it was close to the end of the academic year and further modification of this programme was not feasible because the availability of, already extensively pretested, subjects could not be guaranteed beyond this point in time. Therefore, it was unfortunately necessary to conduct the experimental session with a less than optimal tracking task design. To assure adequate power for the repeated-measures analysis of the experimental session, the hypnotic-susceptibility testing stage had been designed to deliver at least 20 subjects for each hypnotic-susceptibility group. This goal was achieved, but due to the delay in availability of the tracking control programme, several prospective subjects were no longer available to participate in the experimental session. This meant that sample sizes were quite small even for repeated measures analyses, which resulted in a reduced power of analyses that was particularly evident when analysing the hypothesised interaction effects.

Not only was the tracking task not novel and challenging enough, but there were also strong indications that the performance of the tracking task was not internally consistent in its current configuration. Analyses of data clearly showed not only the presence of a large variability in both individual and average tracking performance between treatment conditions while receiving painful stimulation, but also during periods when subjects received no pain stimulation.

During these pain-off periods, there were no obvious external factors that should differentially influence tracking performance and, if the tracking task was relatively stable, there should have been little difference in average performance. However, results showed a large variation in tracking performance during pain-off periods (see tables 7 & 9). In fact, the variability in tracking performance between conditions during pain-off periods was very similar in magnitude to that during pain-on periods when subjects were exposed to experimental manipulation. Examination of individual tracking data strongly suggest the presence of a marked variability in tracking performance that was inherent in the particular configuration of the tracking task used. Differences in tracking performance appeared to be more closely related to internal differences in performance of the tracking task (within-subject differences) than in differences in tracking performance between pain levels and/or treatment conditions. The combination of a tracking task that was in general too easy and the presence of sporadic, nonsystematic, large tracking errors resulted in a task that lacked the necessary sensitivity to detect genuine treatment effects. It cannot be excluded that this inherent variability in task performance may have obscured any genuine treatment effect should this have been present.

In summary, the current study failed to demonstrate the absence of interference with secondary task performance that was observed by Miller and Bowers (1993) among highly hypnotisable subjects who used hypnotic suggestions as their pain coping strategy. There was no significant difference in pain-related interference between high hypnotisables using hypnotic analgesia and high or low hypnotisables using cognitive-behavioural coping strategies. Although present results do not support the proposed dissociated-control explanation of hypnotic responding, they cannot be seen as evidence that the dissociated control model of hypnosis is incorrect. Neither do they provide (direct) support for a social-psychological interpretation of hypnosis. Rather, observations made during the experiment and examination of tracking performance data indicate that the specific configuration of the tracking task as used in the current experiment lacked the sensitivity to reliably differentiate between the presence or absence of attention-related interference effects should they exist. In its current configuration, the task was relatively easy and required little practice for automaticity to develop.

Differences in tracking performance appeared to be more closely related to internal differences in performance of the tracking task than in tracking differences between pain levels and/or treatment conditions. The combination of a tracking task that was in general too easy and the presence of sporadic, nonsystematic, large tracking errors resulted in a task that lacked the necessary sensitivity to detect genuine treatment effects should these have been present. It cannot be excluded that such genuine the inherent variability in task performance may have obscured any genuine treatment effect should this have been present.

12.1.3. Hypotheses 3 and 4 – Pain ratings

As hypothesised, there were no significant differences in self-reported ratings of either the intensity or unpleasantness of the pain stimulation between both hypnotic susceptibility groups when using nonhypnotic coping strategies.

Also as hypothesised, high hypnotisables using hypnotic suggestions for analgesia and relaxation achieved significantly greater reductions in both the intensity and unpleasantness of pain than low hypnotisables using hypnotic analgesia or either low or high hypnotisables using their preferred nonhypnotic (i.e., cognitive-behavioural) coping strategy. This was evident at both mild (30%) and moderately severe (60%) levels of pain.

This finding clearly demonstrates the superior efficacy of hypnotic analgesia for those who are highly susceptible to hypnosis. The reduction in both the sensory and affective dimensions of pain is consistent with other studies that assessed both pain dimensions and used suggestions for both analgesia and relaxation (e.g., Kiernan et al., 1995; Malone et al., 1989; Price & Barber, 1987).

12.1.4. Discussion

At the 30% pain level, low hypnotisables rated the pain as less intense and less unpleasant when they simultaneously attended to the tracking task, but this tracking comparison (on vs off) was only significant (p = .046) for ratings of pain unpleasantness in the nonhypnotic condition. There were no marked differences in either pain intensity or pain unpleasantness for low hypnotisables at the 60% pain level. This suggests that, at least for some low hypnotisables, performance of the tracking task acted as a partially successful coping strategy, but only at the lower (i.e., 30%) level of pain intensity.

In both hypnotic and nonhypnotic coping conditions with tracking task on, low hypnotisables almost exclusively relied on the tracking task as their sole or dominant coping strategy. When not simultaneously performing the tracking task, they used mainly, deep breathing, concentrating on their breathing, or concentrating on items in their immediate surroundings (e.g., point in room or chart in front of them) as coping strategies. Only one low-hypnotisable subject used a strategy involving some imagination (imagining the pain to stop). Because low hypnotisables are not able (or willing) to use hypnosis effectively, they have to rely on cognitive-behavioural strategies to achieve pain relief. Many of these strategies, and in particular the more effective ones, involve imaginative distractions or reinterpretations on the pain experience. Low hypnotisables tend to have less well-developed abilities for using imaginative involvement. Results show that few if any used more elaborate strategies, even after having these explained to them and having had an opportunity to practice them. The time available to practice cognitive-behavioural strategies during the introduction of this treatment condition may have been too brief for low hypnotisables; who, in general, appear to have at best only very basic coping strategies spontaneously available to them. Indications are that they need more extensive training to become familiar with and skilled in these strategies to the extent that they feel confident enough that they can effectively use them. Some may have a basic belief that pain is out of their control. High hypnotisables, on the other hand, readily used imaginative strategies (ten out of fourteen) in the nonhypnotic condition. Not only did they use imagination more often, but their imagery was far more elaborate.

Even when using concentration on other things such as objects in the room, they were more creative at times (e.g., reading the chart backwards). Pain management programmes teaching cognitive-behavioural coping methods need to consider differences in participants ability to use imagery and differences in the amout of coaching and practice needed.

12.2. General Discussion

12.2.1. Attentional capture of visual motion.

Any test of the interference (or lack of interference) hypothesis using a dual-task paradigm needs to ensure that the secondary task demands executive cognitive effort and is novel enough to maintain doings so after the initial practice phase. A pursuit-tracking task may be one way of achieving this. However, contrary to popular belief, visual motion is not attention demanding by itself. Rather, as was demonstrated by Hillstrom and Yantis (1994), it is the appearance of new perceptual objects, and little else, that captures attention. Motion (or any other attribute such as colour, shape, luminance etc) has the ability to guide attention, but only when subjects adopt a deliberate state of attentional readiness for it and when motion predicts the position of a target (Folk, Remington, & Johnson, 1992; Folk, Remington, & Wright, 1994).

Hillstrom and Yantis (1994) showed that attention is drawn to a new perceptual object when: (1) it appears abruptly in a previously blank location, or (2) when it segregates from its background because of relative visual motion. An example of the latter occurs in the current experiment when the cursor separates from the line forming the wave pattern. Such segregation of a perceptual element from a perceptual group results in the creation of a new object file (i.e., a visual representation of a perceptual object containing specifications of the various attributes of the object).

It is this creation of a new object file that captures attention, but there is evidence that such attentional capture dissipates within a few hundred milliseconds (Yantis & Jones). Hillstrom and Yantis (1994) conclude that motion captures attention in a stimulus-driven fashion, but only transiently following the initial creation of a new object file and not throughout the motion as a results of increased salience.

Certain perceptual events such as abrupt visual onset (and pain) that enjoy an inherently high priority in the allocation of attention are thought to result in the purely stimulus-driven capture of attentional resources. Folk et al. (1992), however, have challenged this notion of a purely stimulus-driven bottom-up capture of attention and suggest that involuntary shifts of attention, even those elicited by abrupt onset, are ultimately contingent on control settings that reflect high-level task-induced behavioural goals. Folk et al. (1994) further extended on this and proposed that attentional control in the form of top-down modulation of attentional capture is limited to two broadly tuned control settings, namely static discontinuities and dynamic discontinuities. This distinction is consistent with evidence for the existence of two primary, parallel pathways in the processing of visual information (Livingstone and Hubel, 1988). Dynamic discontinuities, such as those associated with abrupt onset and apparent motion, are subserved by the magnocellular geniculate pathway which is composed of cells with high contrast sensitivity and fast temporal resolution, but low colour sensitivity and spatial resolution. In contrast, static discontinuities, such as sustained discontinuities across space, are subserved by the parvocellular geniculate pathway. Cells in this pathway exhibit the opposite pattern of characteristics (i.e., high colour sensitivity and spatial resolution, but low contrast sensitivity and temporal resolution). As Folk et al. (1994) suggest, motion captures attention, but only when the task requires monitoring for a dynamic discontinuity.

12.2.2. Methodological issues

The pursuit-tracking task used in the current study had subjects monitor the computer screen for any evidence of a discontinuity between the relative movements of the waveform and the cursor.

However, indications are that the task was too easy (i.e., not challenging and novel enough) in its present configuration. This meant that discontinuities occurred only sporadically and even then they only resulted in brief attentional capture. During most of the tracking task, performance required little or no high-level attentional effort.

An alternative option could have been using a Stroop-like task or a task based on the Wisconsin Card Sorting Test. Stroop performance is seen as a benchmark measure of attention because the two dimensions of the stimulus are competing for a limited capacity system (Sheehan et al., 1988). Furthermore, the interference effects observed in Stroop tasks have been found to be resistant to change in the face of extensive practice (for a review, see Jensen & Rohwer, 1966). Stroop Color-Naming tasks have repeatedly been used to study the nature of controlled and automatic processing in hypnosis (e.g., Cohen et al., 1990; Dixon et al., 1990; Dixon & Laurence, 1992).

The use of such a task was considered in the planning stage of the present study, but a pursuit-tracking task was chosen because this enabled task performance to be monitored on a continuous basis, and offered the opportunity to easily manipulate various task parameters. This can offer important advantages particularly when combined with iontophoretically administered pain stimulation that has the ability to accurately control and monitor the level of pain stimulation on an ongoing basis. Together these qualities enable researchers to be much more specific when exploring the impact of pain- and/or hypnosis-mediated interference effects at particular stages of information processing.

Improvements to the current study could involve the use of:

- A secondary task that is proven to require central cognitive attentional resources.
- A baseline assessment of tracking performance under concurrent painful stimulation while no coping method is used. Analyses can then compare differences in interruption of tracking performance before and after the introduction of each coping strategy.
- A researcher conducting the experimental session that was blind as to subjects' level of hypnotic susceptibility.

Practical considerations prevented the use of a separate investigator to score the hypnotic susceptibility tests and the allocation subjects to the hypnotic-ability groups. As a compromise, subjects were identified by number and the researcher tried as much as possible to remain unaware of subjects' hypnotic susceptibility level during the experimental session. Subjects were not in formed of their hypnotic susceptibility test scores. However, because they had been selected on the basis of being either unresponsive or highly responsive to hypnotic suggestions it was unavoidable that subjects were aware of their own ability to become hypnotised. A single level of pain stimulation would have been sufficient as long as it was sufficiently painful enough as was, for example, the 60% pain level in the current study. This would have simplified the data analyses.

The present study evaluated differences in tracking performance between high- and low-hypnotisable subjects receiving no pain or pain (30% or 60%) while using either hypnotic analgesia or cognitive-behavioural coping strategies. This provided an indication of how pain interfered with concurrend tracking performance while using either coping strategy. The dissociated-control model of hypnosis made the following predictions. If nonhypnotic strategies are used, subjects will achieve some measure of pain releave, which should lead to less interference and a comparitive reduction in tracking errors. However, the use of nonhypnotic strategies requires considerable cognitive effort resulting in more competition for attentional resources and greater interference. The net result would thus expected to be roughly similar or worse than baseline tracking performance. When using hypnotic analgesia, highly hypnotisables are expected to achieve full or significant relief of pain resulting in no or little interference with tracking performance. It is further predicted that the use of hypnosis does not require cantral attentional effort itself. The net result would thus be no or little increase in tracking errors compared to baseline tracking performance.

There was a obvious flaw in the design of the present study. Subjects simultaneously used the tracking task in half of all the treatment combination, but always used either hypnotic analgesia or cognitive-behavioural coping. This meant that there was no baseline for tracking performance and no pretreatment measure for tracking performance during exposure to pain that was unaffected by coping method.

Instead of using a coping strategy in all conditions and a tracking variable (on vs off) across conditions, subjects should have always performed the tracking task and the tracking variable should have been replaced by a coping task (on vs off) variable. This would provide a baseline for tracking performance, a pretreatment measure for tracking performance during pain interference, and treatment measures for tracking performance during interference of both pain and strategy use. Analyses can then compare differences between pre- and post-treatment interference for each treatment method. The study would then also require only six blocks of stimulus trials (or three when using only the 60% pain level) namely pain plus tracking, pain plus tracking plus hypnotic analgesia, and pain plus tracking plus cognitive-behavioural coping at each pain level.

12.2.3. Subsequent support for the dissociated-control model of hypnosis

A literature search did not find any subsequent studies, either by Miller and Bowers themselves or by any other researchers, that did attempt a direct test of the hypothesis that hypnotic analgesia does not require executive attentional effort. A study by Eastwood, Gaskovski, and Bowers (1998) was argued to provide indirect and tentative support for the dissociated-control model of hypnosis. This study used Wegner's ironic process theory (Wegner, 1994) to interpret the results of pain reduction scores achieved by high- and low-hypnotisable subjects using either hypnotic analgesia or stress inoculation to cope with pain under conditions of high and low mental load. The method of pain stimulation consisted of a strain-gauge simulator that provided painful pressure on the index finger of subjects' nondominant hand. In the high mental-load condition, subjects were required to report pain ratings every 5 seconds during the 90-second trial. In the low mental-load condition, pain reports were elicited every 45 seconds.

According to Wegner, mental control is accomplished via two complementary processes, an operating process and a monitoring process that work together to achieve the desired mental state. The operating process is conscious and intentional, and involves effortful attempts to bring into awareness content that will yield a desired state.

Simultaneously, the monitoring process automatically and largely effortlessly searches awareness for content that is inconsistent with the desired state. Because the operating process is effortful, it is more susceptible to interference by concurrent attention-demanding tasks. In contrast, the autonomous and usually unconscious monitoring process can operate in spite of additional attentional demands. Therefore, when the attentional demands of concurrent tasks reduce available resources, the effectiveness of the monitoring process increases relative to that of the operating process. This in turn results in the creation of mental states that are inconsistent with or even the opposite of what was intended, the so-called counterintuitive or ironic effects. Ironic effects are quite prominent in situations involving thought suppression. For example, the instruction to suppress all thoughts of a white bear can result in an increased frequency of white bear thoughts (Wegner, Schneider, Carter, & White, 1987). Ironic effects have also been observed following instructions for intentional relaxation (Wegner, Broome, and Blumberg (1997) and for the mental control of mood and mood-related thought (Wegner, Erber, & Zanakos (1993).

The experiment by Eastwood et al (1998) was based on the following rationale. Frequent pain reporting requires cognitive resources and the mental load imposed by such tasks will interfere with deliberate efforts to reduce pain. Furthermore, frequent pain reporting should also serve to draw one's attention back to the experience of pain. Attempting to reduce pain while consciously reporting it violates what Wegner (1994) calls the "reflexivity constraint," which stipulates that any attempt to produce a desired state must be compatible with the process involved in producing that state. Thus, frequent pain reporting should consume cognitive resources. Furthermore, frequent pain reporting may enhance ironic effects because pain reporting is inconsistent with the goal of pain reduction. However, it would appear to the current author that because subjects were actually reporting *less* pain than during their nonanalgesia pre-trial assessment such pain reports would not be incompatible with the goal of pain reduction.

Results of the study by Eastwood et al. (1998) revealed that for high hypnotisables using hypnotic analgesia there were no significant differences between pain reduction achieved under conditions of high or low mental load.

In other words, frequent pain reporting did not disrupt hypnotic analgesia among high hypnotisables, which supports the hypothesis that such performance is effortless. In contrast, low hypnotisables using hypnotic analgesia and low or high hypnotisables using stress inoculation experienced significant interference with pain reduction when having to provide frequent pain reports. This is consistent with Wegner's hypothesis that effortful attempts at mental control will be subject to ironic effects under mental load (Wegner, 1994; Wegner et al., 1987). However, the relative difference in pain reduction between high and low mental load conditions for high hypnotisables using hypnotic analgesia was not significantly smaller than the difference in pain reduction across mental loads for high hypnotisables using stress inoculation or low hypnotisables using hypnotic analgesia or stress inoculation. Subjects rated pain on a scale of 1 to 10. As Table 21 shows high hypnotisables using hypnotic analgesia did achieve less pain reduction under high mental load than under low mental load; but, unlike the other groups, this difference was nonsignificant. Note also that the standard deviations are large.

Table 21. Means and standard deviations of pain reduction scores.
From Eastwood, Gaskovski, and Bowers (1998).

	Hypnotic Analgesia		Stress Inoculation	
Ability	High Load	Low Load	High Load	Low Load
High	n = 12		n = 10	
M	2.08	2.75	-0.20*	1.90*
SD	2.86	2.25	1.60	1.26
Low	n = 11		n = 12	
M	-0.95**	0.86**	-0.29***	0.92***
SD	2.17	1.99	1.05	2.13

*p <.005, ** p < .01, *** p < .05

Unfortunately, no confidence intervals were provided for the mean pain-reduction scores in each condition. These would have assisted in interpreting the data and could possibly indicate if, for example, high hypnotisables formed a uniform group with regards to the presence or absence of interference effects under varying conditions of mental load. Furthermore, the above study does not provide pain scores for baseline and post treatment assessment, only pain reduction scores (i.e., the difference between these two). This means that, from the data provided, it is not possible to assess how intense the pain stimulation (mechanical finger pressure) was experienced by subjects. Again, this makes it more difficult to compare the pattern of results with results of other studies using different methods of pain stimulation.

Although the results of the study by Eastwood et al. (1998) are consistent with predictions of the dissociated-control model of hypnosis, they do not provide any evidence that hypnotic performance is effortless and does not require any higher-level attentional involvement at all. They do, however, clearly demonstrate the important point that the manner in which pain is measured and recorded in laboratory studies of analgesia has an effect on a participant's experience of pain. As Eastwood et al. argue, researchers ought to consider the method and frequency of pain reporting when engaging in experimental studies of analgesia.

Further support for this argument comes from, for example, Rainville, Feine, Bushnell, and Duncan (1992) who found that subjects experienced significant differences in the degree of unpleasantness evoked by four different methods of pain induction and were consistently able to differentiate between them. Some of the controversy regarding the relative efficacy of different strategies and the importance of different moderating factors may be, in part, a result of inconsistent methodological paradigms. Proponents of social-psychological and dissociation models of hypnosis have often employed different pain reporting strategies, and it is quite possible that the debate regarding attentional effort in hypnotic analgesia may be confounded by the use of different pain reporting frequencies.

12.2.4. Evidence arguing against the notion that the process of hypnosis does not require executive attentional effort.

The use of differences in reported pain under conditions of varying mental load as an index of interference and attentional effort is a rather indirect way of assessing attentional involvement. Using decrements in task performance provides a more direct measure, but even then interpretation still depends in part on assumptions regarding limited-capacity resources that are still debated and for which there is no definitive proof. The measurement of brain activity in cortical areas that are associated with high-level (executive or supervisory) cognitive processes does provide a direct measure of attention-demanding cognitive effort that does not rely on any prior assumptions of limited resource capacity. Positron emission tomography studies using cerebral blood flow imaging are the most promising. Such studies can provide reliable parameters of cortical activity that are sensitive to the effects of cognitive tasks (Gur et al., 1982, 1987; Obrist & Wilkinson, 1984; Risberg, 1986)

Crawford, Gur, et al. (1993) conducted a carefully controlled study that compared cortical activity (differences in rCBF patterns) between low- and extremely high-hypnotisable subjects in a nonhypnotic (waking) and hypnotic state while at rest and while experiencing ischemic pain under two conditions: attending to pain and hypnotic analgesia (see also pp. 207-208). The highly hypnotisable subjects (n = 5) had all demonstrated to be able to totally eliminate the perception of pain during prior training sessions with both cold-pressor and ischemic procedures. High- and low-hypnotisable subjects had similar values and topographic distributions of resting rCBF in the waking (nonhypnotic) condition. To reduce dimensionality of the data set, the value of the waking CBF was subtracted from the hypnosis CBF during each task condition. During the attend to pain condition (i.e., ischemic pain without suggestions), increased CBF was recorded over the somatosensory cortex relative to surrounding areas in both highs and lows. This is consistent with findings of other neuroimaging studies (e.g., Jones et al., 1991; Talbot et al., 1991), and may, partially, reflect accompanying muscular contraction during the ischemic pain (Pribram & McGuinness, 1975).

During hypnotic analgesia, there was a differential change in CBF with highs showing further significant CBF increases over the somatosensory cortex, while lows showed significant decreases in CBF over the somatosensory area. Furthermore, highs exhibited a highly significant bilateral CBF activation of the orbitofrontal cortex during hypnotic analgesia.

Thus during hypnotic analgesia, highs showed significant CBF increases in the orbitofrontal cortex and somatosensory cortex beyond those noted in the attend to pain condition. Lows who continued to experience pain showed some CBF decreases over the somatosensory cortex during suggested hypnotic analgesia. Subsequent studies have observed a similar pattern of brain activation for hypnotisables during hypnotic analgesia (Heinrichs, Klemm, Scholz, & Biersack, 1997; Maquet, Faymonville, Degueldre, Delfiore, Frank, Luxen, & Lamy, 1999; Rainville, Hofbauer et al., 1999).

The observed shifts in brain dynamics provide support for the neuropsychophysiological model of hypnosis as proposed by Crawford and Gruzelier (1992; see section 5.7.3.2., p. 212) and several hypotheses derived from it. For example, they support the hypothesis that hypnotic analgesia activates a topographically specific inhibitory feedback circuit that cooperates in the regulation of thalamocortical activities (see e.g., Birbaumer et al., 1990). They also support the hypothesis that highly hypnotisable individuals possess greater cognitive flexibility and a more efficient fronto-limbic attentional-disattentional system (Crawford & Gruzelier, 1993; Gruzelier & Warren, 1993). The finding that only highs show increased CBF during hypnosis has been consistently reported by several independent studies (see Crawford & Gruzelier, 1992). Increased CBF has also consistently been demonstrated during mental effort (for a review see Frith, 1991).

Taken together, these findings are very important because they indicate that hypnosis takes effort and is a cognitive task that demands attentional and disattentional allocations. Results indicate that even though highly hypnotisable individuals show phenomenal physical relaxation of the body, they are cognitively alert and are activating their supervisory, attentional control system during hypnosis and suggested analgesia (Crawford et al., 1993).

Increased activation in the orbitofrontal cortex (in particular Brodmann area 47) has also been found in functional imaging studies of rCBF during clinically relevant pain, altered mood (both depressed and elated) and performance on cognitive demanding tasks (for review see Petrovic, Petersson, Ghatan, Stone-Elander, & Ingvar, 2000).

Petrovic et al. (2000) conducted a PET study of attention-related modulation of pain-induced cerebral activation during performance of a distracting, cognitively demanding task. This study measured rCBF changes in brain activity during cold pressor pain (immersion in water with a temperature of 0 – 0.5 °C), nonpainful immersion in cold water (19 ± 0.5 °C), and either of these conditions combined with concurrent performance on a computerised, attention-demanding, perceptual maze task. Apart from widespread activation in areas relating to visuospatial processing, performance of the maze task also resulted in decreased activity in the prefrontal cortex. These task-related decreases in cortical activity are suggested to reflect a selective inhibitory modulation of nonrelevant cortical processing (Ghatan, Hsieh, Wirsen-Meurling, Wredling, Eriksson, Stone-Elander, Levander, & Ingvar, 1995; Ghatan, Hsieh, Petersson, Stone-Elander, Ingvar, 1998). The coexisting attention-based activation of task-relevant processing and top down inhibitory modulation of task-irrelevant processing is an important function of the prefrontal supervisory attentional control system. Induced pain resulted in significant activation of the contralateral primary somatosensory cortex S_I, contralateral (and to some extent also ipsilateral) somatosensory association areas including S_{II}, the anterior cingulate cortex, and the mid/anterior insula. During concurrent performance of the maze task, these pain-evoked activations were significantly lowered in the somatosensory association areas (including S_{II}) and the periaqueductal gray/midbrain, suggesting the modulation of pain related processing during cognitive distraction. At the same time, there was a relatively increase in activity in lateral orbitofrontal regions. This is suggested to represent the modulation of pain-related interference during additional cognitive load or the processing of pain with a relevant threat to the organism (Petrovic et al., 2000). This activation may be reversed (decreased orbitofrontal activity) when a pain stimulus is anticipated and no longer unpredictable such as following a prior practice session (Hsieh, 1995, cited in Petrovic, 2000).

A similar relative increase in orbitofrontal activity has been observed in studies of hypnotic modulation of pain perception (Rainville et al., 1997; Rainville, Hofbauer, et al., 1999).

Based on a review of neurophysiological research, Crawford, Knebel, and Vendemia (1998) propose that hypnotic analgesia is an active inhibitory process involving several brain systems mediating attentional and nociceptive processes. Even though the processes of hypnotic analgesia may be dissociated from conscious awareness and appear to be outside of volitional control, it is proposed that hypnotic analgesia depends on the activation of a supervisory attention control system. This is argued to involve the prefrontal cortex which then participates with other cortical and subcortical systems in the allocation of thalamocortical activities. Hypnotic analgesia affects the active allocation of attention and disattention associated with the prefrontal region and spatiotemporal aspects of pain perception associated with the posterior cortical systems. Highly hypnotisable individuals are argued to possess stronger attentional filtering abilities that are associated with the fronto-limbic attentional system. Not only do they have a superior capacity for sustained focused attention, but their greater cognitive flexibility enables them to more easily dissattend to task-irrelevant stimuli, shift between cognitive modes of processing, and suspend their generalised reality orientation. It is proposed that the executive controller of the prefrontal cortex, via the fronto-limbic attentional system, acts as a gate against the ascent of painful stimuli into conscious awareness by inhibition of incoming somatosensory information from the thalamic region

12.2.5. Final conclusion and recommendations

The combined evidence of neurophysiological studies indicates that: (1) as proposed by dissociation models of hypnosis, the process of hypnosis and hypnotic analgesia is fundamentally different from the processes involved in (nonhypnotic) cognitive-behavioural strategies, and (2) unlike proposed by the dissociated-control model of hypnosis, hypnotic analgesia appears to require high-level cognitive effort and demand attentional and disattentional allocations.

Future studies of the mechanisms underlying hypnotic analgesia would be enhanced by combining the relative strengths of various studies. They could employ direct assessment of brain activity using PET measures of rCBF to examine differences in information processing between subjects that were accurately differentiated on hypnotisability and received a pure method of pain stimulation (e.g., potassium iontophoresis) while attending to a secondary task proven to require high-level attention-demanding effort (e.g., maze task or a properly configured tracking task).

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Appendix 1

SUBJECT INFORMATION SHEET

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FACULTY OF SOCIAL SCIENCE
DEPARTMENT OF PSYCHOLOGY

ASSESSMENT OF HYPNOTIC SUSCEPTIBILITY, ABSORPTION, AND ALEXITHYMIA

Our names are Louis Smeets and Blair Vernall and we are graduate students at the Psychology Department. As part of our research projects we are conducting studies on the attentional demands of hypnotic analgesia, and the relationships between hypnotic susceptibility, absorption, and alexithymia. The projects are supervised by Malcolm Johnson, a senior lecturer at the Psychology Department.

The studies involved require that a large pool of potential subjects will be screened for their ability to become involved in hypnotic suggestions. It is for this reason that we are asking for your assistance by volunteering to:

(1) firstly complete the Tellegen Absorption Scale and then the Toronto Alexithymia Scale, two short questionnaires assessing absorption (a disposition for having periods of 'total' attention) and alexithymia (difficulty in understanding and expressing ones emotions), and
(2) secondly have the Harvard Group Scale of Hypnotic Susceptibility administered to you.

The Harvard Group Scale of Hypnotic Susceptibility is a widely used standardised measure of ones level of responsiveness to hypnotic suggestions, which can be administered to large groups of people. After a brief introduction to hypnosis you will receive a standard hypnotic induction which will take approx. 10 min. Following this you will be given a number of hypnotic suggestions. Both the hypnotic induction procedure and the hypnotic suggestions are recorded on audio tape by Dr Bill Zika who is experienced in using clinical hypnosis.

The hypnotic suggestions do not require you to do anything unusual or unpleasant. You will simply be instructed to become relaxed and imagine a certain situation, e.g. holding your hands straight in front of you and imagining a force pulling them together. You will record your own responses to these suggestions in a response booklet which will be provided.

The entire assessment will take approx. 80 min. It should be fun to do and will give you a personal experience of the hypnotic process and a useful indication of your own hypnotic ability.

Please turn page over

You have the right to refuse to answer any particular question, and to withdraw from the study at any time. Any information obtained will be completely confidential. Once the data is obtained, and before it is analysed, all names will be removed and the data will be coded by numbers only to ensure your total anonymity.

On the basis of your hypnotic susceptibility score you might be asked to volunteer to participate in a second assessment of your hypnotic susceptibility.

Louis Smeets

Blair Vernall

Queries about the research can be addressed to: Malcolm Johnson (Psychology Clinic)
ph [redacted]

MASSEY UNIVERSITY
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ASSESSMENT OF HYPNOTIC SUSCEPTIBILITY ABSORPTION, AND ALEXITHYMIA

Consent Form

I have read the Information Sheet for these studies and have had the details of the studies explained to me. My questions about the studies have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I also understand that I have the right to withdraw from the studies at any time, and to decline to answer any particular questions in the studies. I agree to provide information to the researchers on the understanding that it is completely confidential.

I wish to participate in these studies under the conditions as set out on the Information Sheet.

I also give my consent to being contacted by phone should I be selected for any of the further stages of the studies.

Subject name: .....

Signature: ..... Date: .....

Phone number: .....

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FACULTY OF
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DEPARTMENT OF
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SUBJECT INFORMATION SHEET

ASSESSMENT OF HYPNOTIC SUSCEPTIBILITY (PART 2)

My name is Louis Smeets and I am a masters student at the Psychology Department. As part of my thesis project I will be conducting a study on the attentional demands of hypnotic analgesia. The project is supervised by Malcolm Johnson, a senior lecturer at the Psychology Department.

The study involved requires the prior assessment of the hypnotic susceptibility of a large group of potential subjects using two indexes of hypnotic ability. You have already completed an initial assessment using the Harvard Group Scale of Hypnotic Susceptibility and on the basis of your response to that measure you are now invited to participate in a second assessment of your hypnotic susceptibility.

This second assessment involves completing the Waterloo-Stanford Group C Scale of Hypnotic Susceptibility. This is a more sensitive, and somewhat more challenging, measure of a person's responsiveness to hypnotic suggestions. This measure will be given in smaller groups (up to 12 participants) and will be conducted in a smaller, more comfortable room. You will listen to a tape recording which will guide you through a hypnotic induction and then gives you a series of hypnotic suggestions. Again you will be instructed to become relaxed and imagine certain situations or actions which will not involve anything unusual or unpleasant. Following this you will record your own responses to these suggestions in a response booklet, and the session will finish with a short debriefing. The entire procedure will take about 1 hour and 15 minutes.

You have the right to refuse to answer any particular question, and to withdraw from the study at any time. Any information obtained will be completely confidential. Once the data is collected, and before it is analysed, all names will be removed and the data will be coded by numbers only, to ensure your total anonymity.

On the basis of your score on this measure you might be invited to volunteer as a subject in an experiment on imaginative involvement and coping with pain.

Louis Smeets
contact phone for queries c/o Malcolm Johnson (Psychology Clinic) ph [redacted]

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ASSESSMENT OF HYPNOTIC SUSCEPTIBILITY (PART 2)

Consent Form

I have read the Information Sheet for this study and have had the details of the study explained to me. My questions about the study have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I also understand that I have the right to withdraw from the study at any time, and to decline to answer any particular questions in the study. I agree to provide information to the researchers on the understanding that it is completely confidential.

I wish to participate in this study under the conditions as set out on the Information Sheet.

I also give my consent to being contacted by phone should I be selected for any of the further stages of the studies.

Subject name: .....

Signature: ..... Date: .....

Phone number: .....

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FACULTY OF
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HYPNOTIC ANALGESIA AND COPING WITH PAIN

My name is Louis Smeets and I am a masters student at the Psychology Department. I am asking for your assistance by agreeing to volunteer as a subject in an experiment which is part of my thesis project. The project is supervised by Malcolm Johnson, a senior lecturer at the Psychology Department. Malcolm is leading research into the understanding of pain mechanisms and pain coping strategies and over the years his team at Massey University has built up considerable expertise, especially in the area of using iontophoretic pain stimulation.

Pain is a complex and poorly understood phenomenon that affects most of us at some stage in our lives. Increased understanding of how pain works, and of what are salient elements of effective pain coping strategies, can assist the many individuals who suffer pain. The study you are requested to participate in is one in a series designed to look at the influence of attentional factors of various pain coping strategies.

Potassium iontophoresis, which is the method of stimulation used in this study, involves using a low electric current to administer potassium ions through the skin. The stimulus will be applied to the forearm of your nondominant hand. The procedure does not involve electric shock and is not dangerous in any way. The pain felt is typically reported as a pricking or burning sensation. There will be no unpleasant after effects once the stimulation stops. **You will at all times be able to terminate the stimulation immediately if you desire to do so.**

Your participation in the experiment involves you being exposed to eight blocks of iontophoretic stimulation. Each block consists of 3 stimuli which each last 10 seconds. While receiving this stimulation you will simultaneously perform a tracking task. This task will have you use a sliding potentiometer to control the movement of a cursor so that it tracks a moving waveform on a computer screen. For part of the experiment you will be doing this while having received a hypnotic induction and suggestion for relaxation and analgesia. The entire sessions will take 1 hour and 15 minutes, and participation is subject to meeting the requirements of the Health Check List.

At the end of the study there will be a debriefing and an opportunity for you to ask any questions you may have. Any information obtained will be treated completely confidential. Once the data is collected, and before it is analysed, all names will be removed and the data will be coded by numbers only, to ensure your total anonymity. For those interested a summary of the findings from the study will be available when it is concluded.

Louis Smeets
contact phone for queries c/o Malcolm Johnson (Psychology Clinic) ph 3[redacted]

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FACULTY OF
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HYPNOTIC ANALGESIA AND COPING WITH PAIN STUDY

Consent Form

I have read the Information Sheet for this study and understand that my participation in this study will involve some discomfort. I also understand that I will be required to undergo a hypnotic induction procedure. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any time.

I also understand that I have the right to withdraw from the study at any time, and to decline to answer any particular questions in the study.

I am prepared to be a subject in this study under the conditions as set out on the Information Sheet and agree to provide information on the basis that it is completely confidential.

I consent to filling in the Health Check List on the understanding that this information will be treated confidentially and will be destroyed as soon as the study is completed.

Subject name: .....

Signature: ..... Date: .....

Phone number: .....

If you like a summary of the findings from the study please provide a contact address.

Contact address: .....

.....

HEALTH CHECK LIST

HYPNOTIC ANALGESIA AND COPING WITH PAIN STUDY

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FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF PSYCHOLOGY

This Health Check List has been developed for your safety and should be answered honestly.

Subject name: .....

Please answer the following questions by circling the appropriate answer.

1. Are you in good health? yes / no
2. Do you have any known heart condition? yes / no
3. Have you ever had any form of epilepsy? yes / no
4. Are you currently using medication of any type? yes / no
5. In the past 6 months have you ever suffered from any painful injury or condition that lasted more than a week? yes / no
6. Have you ever had any injury or medical condition that you think may affect your ability to sense pain? yes / no
7. Do you suffer from any skin disorders? yes / no
8. Have you ever had any problems following minor scratches or abrasions? yes / no
9. Are you pregnant? yes / no

This Health Check List is treated confidentially and will be destroyed at the end of the research project.

Signature: ..... Date: .....