The Effects of Three Different Types of Distraction on Pain Induced by the Iontophoretic Administration of Potassium Ions

A thesis presented in partial fulfilment of
the requirements for the degree of
Masters of Arts in Psychology
at Massey University

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1992

ABSTRACT

Distraction of attention away from painful sensations is a widely accepted technique for reducing both clinical pain (Copp, 1974; Turk, Meichenbaum, & Genest, 1983), and instances of experimentally induced pain (Fernandez & Turk, 1989; McCaul & Malott, 1984). However there is little research regarding the relative efficacy of different types of distracters.

According to a model proposed by McCaul and Malott (1984), distraction is thought to modify pain perception by competing with pain-sensory information for limited attentional resources. Extending this model to accommodate the multiple resource model of attention (Wickens, 1984), suggests that somatic distraction may be analgesically more potent than visual distraction, while a recent meta-analysis (Fernandez & Turk, 1989) suggests that imagery may be the most effective form of distraction.

The present study examined the effects of three different distracters on pain induced by the iontophoretic administration of potassium ions. 20 subjects underwent four conditions of a repeated measures experimental procedure: somatic distraction; visual distraction; imaginal distraction; and no-distraction control conditions. It was hypothesised that under these conditions; (1) the distracters would raise pain threshold when compared to no-distraction conditions, and (2) that either pain threshold would be raised more or distracter performance would be lowered more (or both) under somatic conditions than under comparable visual conditions.

Findings revealed that all three distraction conditions significantly raised pain threshold when compared to no-distraction control. Of all the distracters, the imaginal task was found to be least effective in raising pain threshold, and despite predictions the somatic distracter was not demonstrated to be any more effective than its visual counterpart. Additionally, the prediction that somatic task performance would be lowered more than visual performance was not confirmed.

These findings were discussed in relation to research by Riley and Levine (1988), and the value of the multiple resource model for extending McCaul and Malott's (1984) information processing model for distraction analgesia was also discussed.

ACKNOWLEDGEMENTS

I would like to thank Malcolm Johnson for his supervision and guidance on this project.

I also wish to acknowledge Steve for his patience in programming the software for the experiment, and Richard for his last minute proofreading and editing of the manuscript.

Finally, and certainly not least, thanks Mandy for your encouragement and support throughout.

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CHAPTER ONE

Introduction

An Historical Perspective

Historically, pain was viewed as a purely sensory phenomenon. This perspective was provided as early as 1694 by Descartes (cited in Melzack and Wall, 1982) who constructed a model which pictured the pain system as a simple straight-through projection between the site of injury and the brain. Pain has therefore tended to be regarded as an experience determined solely by the quality and intensity of its underlying noxious stimulus. Although there does tend to be a relationship between the severity of pain and the extent of its underlying tissue damage, the vast evidence showing instances where this relationship breaks down demonstrates a need for an alternative pain model.

Beginning with Descartes and prevailing till recently, the simplistic sensory models of pain have tended to obscure other essential components of the pain experience. Their inadequacy is reflected in their failure to account for many of the experimental and clinical findings in the pain literature.

For example, one obvious assumption derived from the sensory approach is that pain can be eliminated by somehow blocking or severing the pathway before pain impulses reach the brain. However, there are many cases where pain is reported to persist even after standard pharmacological and medical treatments are used to block or disrupt pain pathways (Melzack & Wall, 1982; Toomey, Ghia, Mao, & Gregg, 1977; Turk & Rudy, 1986; Wynn Parry, 1980).

Other research by Beecher (1959) revealed that (contrary to the predictions of the sensory models) the context and meaning of the injury can affect pain perception more than the degree of tissue damage. In this now classic study soldiers severely wounded in battle were compared with civilians with surgical wounds which produced a similar degree of tissue damage. It was demonstrated that, in contrast to 83% of the civilians, only 32% of the soldiers complained of enough pain to require morphine.

Additional factors found to influence pain perception have included: social variables such as culture (Clark & Clark, 1980; Sternbach & Tursky, 1965), and group identification (Buss & Portnoy, 1967); as well as cognitive variables like anxiety (Martinez-Urrutia, 1975), sense of control (Copp, 1974; Rosenbaum, 1980), and attention (Beales, 1979; Hodes, Howland, Lightfoot & Cleeland, 1990).

In summary, pain theory has traditionally held that a direct invariant relationship exists between the psychological perceptual dimension of pain and its corresponding physical stimulus dimension. However, this assumption is regarded as a problem in the literature because it fails to account for the many factors outside of tissue damage which may impact on pain perception (Leventhal & Everhart, 1979; Melzack & Wall, 1982). The pain experience is a variable phenomenon - not necessarily having direct correspondence with tissue damage - and is very much determined by emotional, physical, social and cognitive influences (Beecher, 1959; Leventhal & Everhart, 1979; Melzack & Wall, 1965,1982; Melzack, Wall, & Ty, 1982).

The Gate Control Theory

An alternative to the traditional sensory models of pain, together with a warning of their inadequacy, was proclaimed with the initial formulation of the gate control theory. Essentially, Melzack & Wall (1965) synthesised the critical ingredients from both traditional pain theories as well as neurophysiological and clinical literature into a theory that was compatible with research regarding pain perception available at that time.

Their theory holds that a spinal gating mechanism exists in the substantia gelatinosa of the dorsal horns (in the spinal cord): which acts to either increase or decrease the flow of nerve impulses between the peripheral nerve fibres and the central nervous system. This aspect of the theory means that the pain transmission system can no longer be viewed in terms of a simple one-to-one relay between primary afferents and central pain processes. The gating mechanism is said to be influenced from the "bottom-up" by the relative amount of activity in the large and small diameter fibres. Activity in the large fibres tends to close the gate, whereas activity in the small fibres tends to open the gate; thus either inhibiting or facilitating synaptic transmission to more central cells. The gating mechanism is also said to be influenced by descending impulses from the brain, thereby accommodating the substantial evidence regarding psychological factors and their effects on pain.

In contrast to other models of pain, Melzack and Wall's gate control theory (Melzack & Wall, 1965, 1982) provides a good framework for considering the complexity of the pain experience and the role of various cognitive and affective influences on pain. Moreover, although some of the details of the theory have required modification over time, it still serves as an excellent first approximation of the neural mechanisms underlying pain transmission (Price, 1988) as well as being generally accepted as the best model to explain the complexity of the pain experience (Weisenberg, 1987).

The gate control theory offered scope for the recognition of the many potential psychological factors which may impact on the pain experience. Since its conception many studies have confirmed that psychological interventions such as hypnosis (Miller & Bowers, 1986), relaxation training (Clum, Luscomb & Scott, 1982) and cognitive-behavioral therapy (Holmes, Hekmat, Mozingo, 1983; Turner, 1982) all effect pain perception. One factor common to such manipulations is the distraction of attention.

The Distraction of Attention

Common belief suggests that, if one's attention is focused on a painful stimulus, the pain will be perceived more intensely than if one's attention is distracted away from it. Indeed, people required to evaluate pain coping strategies tend to rate distraction as highly effective when compared to other coping techniques (Ahles, Blanchard, & Leventhal, 1983; Corah, Gale, Illig, 1979; McCaul & Haugtvedt, 1982). This common-sense belief in distraction is not isolated to the opinions of lay individuals only, but extends also, to the writings of researchers who widely accept the pain-controlling effects of distraction, both in instances of clinical pain (Copp, 1974; Turk, Meichenbaum & Genest, 1983), as well as in experimentally induced pain (Fernandez & Turk, 1989; McCaul & Malott, 1984).

The biological significance of attention

The biological importance of attention in the pain experience needs to be seen in the context of the adaptive and survival functions that pain itself serves. Wall (1979) argued that pain was a need-state which serves to promote healing and recuperation. He went on to propose that the period after injury should be divided into the immediate, acute, and chronic stages reflecting the different behaviours which accompany each phase. In the later acute and chronic phases, attention tends to be directed towards the injury and rest and recuperation is the primary aim of the organism. However, in the immediate phase, it may not be adaptive to focus on, or even experience pain because more important behaviours may be required. Attention may be required to deal with more salient issues such as fighting or escaping to prevent further injury. This may explain anecdotal findings that a pain free period often follows injury in life threatening situations in which pain has no real survival advantage (Wall, 1979). The distraction of attention may also partly explain why rugby players and boxers are said to be able to sustain substantial injury and experience little pain while still competing (Melzack & Wall, 1982). Not only may the distraction of attention be seen as a mechanism by which pain may be decreased, but also by attending to pain a person may serve to raise its intensity (Pennebaker, 1982). Fields (1988) speculated that an attentional mechanism may be a contributing factor in chronic pain, where pain often persists even after injury has healed. He suggested that by focusing on minor pain a person may actually increase its intensity through central mechanisms that activate the neural transmission of pain.

Attention redirection strategies

Researchers exploring the impact of attention redirection strategies on pain have explored a variety of pain stimuli along with a wide variety of distracting tasks. These studies typically examine some form of pain (experimentally induced or otherwise) and compare the impact of distraction with control conditions using some form of pain outcome measure. These outcome measures are commonly: pain threshold (the point at which the noxious stimulus is first experienced as painful); pain tolerance (the level at which subjects are unwilling to continue); and pain reports (which usually involve rating a particular dimension of pain). Other less common outcome measures of pain include behavioural observation, electrophysiological correlates of pain, crossmodality matching measures, as well as reports on the emotional/distress response to pain.

The present study will focus on the general area of pain and distraction. The literature review intends to provide a good representative sample of the research in this area. However, because emotional and stress related responses may be indicative of other issues such as anxiety, rather than pain, studies which used these measures exclusively will not be reviewed. Following the review some unanswered issues will be raised and further research will be proposed in order to address them.

CHAPTER TWO

Pain and Distraction

This chapter reviews the majority of the pain and distraction literature. It initially looks at two recent reviews which have contributed to our knowledge about the efficacy of distraction techniques (McCaul & Malott, 1984; Fernandez & Turk, 1989). Then the types of noxious stimuli that have been attenuated by distraction will be considered. This will be followed by a brief outline of the attentional mechanisms believed to subserve distraction related analgesia. After this the various experimental distraction techniques which have been used in order to control pain shall be examined, and an attempt made to categorise these techniques in a manner consistent with an attentional paradigm. Finally, some additional issues are considered.

Reviews of the Distraction Literature

McCaul and Malott (1984) employed a narrative approach to investigate studies using distraction based techniques for the control of pain. They concluded that distraction was generally more effective than "no treatment" and placebo controls for the management of acute laboratory pain. However, they emphasised a need for further investigation using chronic and clinical pain. This review has received some criticism because of its non-uniform sampling of studies for the analysis, and because of the inclusion of studies which used emotional/distress outcome measures rather than pain as such (Fernandez & Turk, 1989). However, despite such limitations, McCaul and Malott still provide a good general overview of the distraction and pain literature, as well as pursuing their primary intention of exploring some important conceptual issues regarding the efficacy of distraction analgesia.

In an attempt to achieve greater objectivity than previous reviews, Fernandez and Turk (1989) used the meta-analysis procedure to evaluate cognitive strategies for controlling pain. The investigation sampled studies involving cognitive strategies for modifying pain published after 1960, but excluded studies using packages of more than one cognitive intervention, as well as studies in which stress or discomfort outcome measures were used. Cognitive strategies were divided into a taxonomy of 6 general categories: (1) external focus of attention (eg. viewing slides); (2) dramatised coping (eg. imagining one's self in a desert and the cold pressor as refreshing); (3) rhythmic cognitive activity (eg. counting backwards); (4) pain acknowledging (eg. concentrating on the painful stimulus); (5) pleasant imaginings (eg. imagining oneself in a comfortable situation); (6) and neutral imaginings (eg. imagining a lecture).

Fernandez and Turk (1989) found that out of 61 independent investigations, 85% of the strategies used were successful in enhancing either pain tolerance or threshold and reducing pain ratings when compared to no-treatment control conditions. Moreover, the authors concluded that, when compared to other techniques, those involving imagery techniques were the most successful in attenuating pain -- with the highest effect being produced by neutral imaginings, followed by pleasant imaginings, and the lowest effect resulting from using pain acknowledging as a coping strategy.

Pain Stimuli

Every day experience may include mild burns, stubbed toes, injections and many other instances in which pain may be encountered. Types of pain produced in these circumstances are usually brief, intense, localised, and may or may not involve tissue damage (Price, 1988). These types of pain occur in the transient and acute categories of pain as described by Melzack and Wall (1982). In contrast to acute pain, which is usually associated with the hope of recovery, chronic pain is more persistent, and often accompanies feelings of helplessness and distress (Melzack & Wall, 1982; Keefe & Williams, 1989). Chronic pain may be acute and intermittent, as in the case of migraine headaches, or may be present most of the time and vary in intensity, as in chronic low back pain (Turk et al., 1983). A further difference between acute and chronic pain is that the former generally serves a function in motivating the individual to avoid activity and recuperate from injury (Melzack & Wall, 1982). However, the latter is often seen to be dysfunctional because the pain often persists long after healing has taken place (Weisenberg, 1987). In instances of experimental pain, subjects tend to be assured that the stimuli will not cause harm and that they will not have to endure the burden of pain over time -- both of which are concerns that play a prominent role in the perception of chronic clinical pain (Price, 1988). For these reasons, experimental pain tends to reflect more closely instances of acute clinical pain.

The following section will briefly overview some examples of experimentally induced pain stimuli that have been used in distraction research. This will be followed by studies looking at the impact of distraction on acute clinical and chronic pain.

Experimental Pain Stimuli

Lavine, Buchsbaum, and Poncy (1976), using pain elicited by electric shock, demonstrated that when subjects were distracted, they exhibited lower psychophysical responses to pain, and required greater levels of electric shock to elicit discomfort ratings compared to those who were not distracted. Another study demonstrated that distraction significantly reduced acute ischemic pain induced by applying a blood pressure cuff (Clum et al., 1982). Other studies causing pain by applying a heavy weight to the index finger have also demonstrated a pain reduction associated with involvement in distracting tasks (Barber & Cooper, 1972; Chaves & Barber, 1974; Scott & Barber; 1977).

Perhaps the most commonly used experimental procedure for inducing pain is the cold pressor, which requires that participants immerse their hand or arm in an ice water bath until they experience pain threshold or tolerance (or rate the pain experienced over some period of cold pressor endurance). In reviewing eight cold-pressor studies, McCaul and Malott (1984) concluded that threshold and tolerance were uniformly raised by a variety of distracter tasks when compared to no treatment-conditions. One finding contrary to their conclusion (Scott & Barber, 1977) was treated as an anomaly on the grounds that control subjects in this study tolerated cold water for an exceptionally long time.

Acute Clinical Pain

In addition to research studying experimentally induced pain, a variety of studies have been concerned with the impact of distraction on acute clinical pain. As with studies using experimentally induced pain, the research in this area generally supports the pain-controlling effects of distraction.

For example, one study involving subjects following gallbladder surgery found a brief intervention emphasising attention-redirection (distraction) significantly reduced post surgical anxiety when compared to relaxation training, relaxation information, and no-treatment conditions. Furthermore, the same attention-redirection intervention was associated with lower ratings of pain obtained on the fifth postoperative day (when it was at its worst) (Pickett & Clum, 1982). Another study using children receiving immunisation injections found that music distraction significantly decreased pain ratings compared to expectancy control conditions. (Fowler-Kerry & Lander, 1987).

Focusing attention on pain

In a study of children attending a hospital casualty ward with trauma, it was observed that the words and actions of medical staff served to direct the child's attention to, or away from, pain. These differences in attention were considered to increase or decrease pain responding accordingly. Based on this investigation, it was recommended that distraction should be used as a means of countering pain in children, and that serious attempts should be made to avoid focusing children's attention on pain (Beales, 1979). Similarly, a study by Levine, Gordon, Smith, and Fields (1982), of people who had four wisdom teeth extracted demonstrated that individuals who rated pain more often (and presumably attended more to their pain) also had higher levels of reported pain. Together these two studies suggest that not only does distraction reduce pain, but also that the more attention is directed towards pain, the greater the pain experienced: a belief supported by other researchers (Fields, 1988; Pennebaker, 1982). However, this is not always the case, as some other research has shown that pain outcome measures may be lowered by attending to the painful stimulus (Ahles et al., 1983; Cioffi, 1991; Leventhal, Brown, Sacham, & Engquest, 1979).

Chronic Pain

In contrast to research exploring acute clinical pain, investigations into the effects of distraction on chronic pain have proven equivocal in their outcomes. Some research suggests that distraction strategies may have counterproductive effects, and that people who use distraction may actually experience more intense pain.

Rosenstiel and Keefe (1983) developed the Coping Skills Questionnaire (CSQ) to assess the types of cognitive pain coping strategies used by chronic low back pain sufferers. They found that chronic low back pain individuals who scored high on a factor measuring attention diverting and praying and hoping tended to report more pain and functional impairment. This attention diversion factor, involving an attentional focus on issues perceived to be external to pain, was found to be predictive of adjustment even when patient history variables and patient's tendency to somatise were controlled for (Rosenstiel & Keefe, 1983). Other research using the CSQ has found that high scores on the scale measuring the use of attention diversion coping strategies to be similarly predictive of higher pain, functional impairment, and psychological distress (Keefe, Crisson, Urban, & Williams, 1990; Turner & Clancy, 1986).

In contrast to research investigating chronic pain using the CSQ, Rybstein-Blinchik (1979) in a study set in a physical rehabilitation unit, found that chronic pain patients given a treatment package involving distraction showed decreased pain behaviour and demonstrated significant reductions in rated pain.

In summary, distraction has been shown to be effective in the management of experimental and acute clinical pain. However, research viewing the effects of distraction on chronic pain has shown equivocal findings. This suggests a need for further research concerning the impact of distraction on chronic pain (McCaul & Malott, 1984). Prior to reviewing the variety of distracting techniques that have been used, the attentional mechanisms believed to be responsible for distraction analgesia will next be discussed.

The Attentional Mechanisms Subserving Distraction Analgesia

McCaul and Malott (1984) recently proposed a model to explain the analgesic property of distraction. Their model borrows heavily from the attention literature, and proposes that an information-processing mechanism is responsible for the workings of distraction. Based on the notion that pain perception, as well as distracter task performance, both consume one's limited attentional capacity, they proposed that distraction "works" by competing with the processing of pain sensory information for this limited attentional capacity. In other words, they claimed that distraction impacts on pain perception by competing with the processing of pain sensory information for a limited "pool" of attentional resources. Clearly this model holds that before pain can be modified by some form of distraction, two assumptions must be valid: (1) pain perception must require some form of central processing; and (2) attentional capacity must be somehow limited.

Early structural theories of selective attention reasoned that this capacity limitation was due to some structure like a bottleneck or filter occurring either earlier (eg Broadbent, 1958, cited in Broadbent, 1971) or later (eg Deutch & Deutch, 1963) in perceptual processing. Subsequent approaches have tended to view selective attention more in terms of one or more "pools" of limited capacity resources available to be allocated at the different stages of perceptual processing (Wickens, 1984). This limitation on selective attention has led to the notion that "attentional resources" can be used up by one task and so diminish the resources available to process a secondary task. Similarly, McCaul and Malott (1984) reasoned that if a distraction task was adequately salient and demanding it would use up the resources needed to process pain information.

Forms of Distraction

Considering the attentional mechanisms that are believed to subserve distraction, it would seem that a review of the distraction strategies that have been used in experimental pain management should be grouped in a manner that is logically consistent with the attention literature. However, reviews thus far have tended to be either arranged to explore a particular set of research questions (McCaul & Malott, 1984) or have categorised the literature with little regard to the issue of attention (Fernandez & Turk, 1989).

In the following review an attempt will be made to categorise distraction strategies in a manner consistent with an attentional paradigm. Distinction will be drawn between those strategies which rely on internal cognitive processes (in order to distract attention away from pain) and those which demand that attention be focused on external distracting stimuli. The former research may be divided into those studies in which subjects are distracted by executing repetitive mathematical tasks or those studies using imagery techniques as distracters. Traditionally, imagery techniques have been dichotomised according to their emotional content as being either positive or neutral imagery. However, these categories say little in terms of attention about the types of imagery they contain. This point is reflected by Fernandez and Turk (1989) who, under the category of "pleasant imaginings" included studies in which subjects were instructed to partly attend to the painful stimulus (ie "imagine it's a nice day and the cold-pressor is pleasantly cool") and other studies whose subjects were instructed to imagine scenes totally unrelated to the painful stimulus (ie listening to an orchestra). From a selective attention view point instructions requiring subjects to partly attend to the pain stimulus may be serving to "prime" them for cognitive schemas which bias the perception of incoming sensory events (Pennebaker, 1982).

Schemata (otherwise called scripts, sets, expectancies, or working hypotheses) are deemed by contemporary perceptual theorists to be hypothetical knowledge-based structures which are somehow specific to what is being perceived; and when activated serve to organise incoming sensory information (Becker, 1987; Neisser, 1976; Norman & Bobrow, 1975; Pennebaker; 1982). Furthermore, schemata, if activated by priming (or instructions or prior information), tend to render schema consistent information easy to attend to and difficult to ignore (Johnston & Dark, 1986; Bargh, 1982; Gleitman & Jonides, 1978). In other words, incoming information may be unattended to or rejected from further processing due to a lack of fit with an active schema (Dowd & Pace, 1989). Accordingly, schemata may serve to direct attention toward or away from particular bodily sensations, and may serve to bias the way incoming information is interpreted (Pennebaker, 1982). Schemata could thus be seen to attenuate pain perception by directing attention towards particular aspects of the noxious stimulus only (such as the thermal or numbing aspects of cold-pressor), and so distract from the pain sensations themselves.

In the present review distraction research will be divided into studies using internally generated cognitions, and those using external stimuli as distracters. The former will include studies using repetitive mathematical tasks and imagery-based tasks. Further, imagery studies will be divided into two types; those studies in which subjects may be seen to be completely distracted by the processing of their own internally generated cognition, and those studies in which attention is partially directed towards the pain stimulus, but may be guided by a schema which directs attention away from the pain sensations themselves. In contrast to those studies which require subjects to be distracted by their own internally generated cognitions, other studies require that attention is directed towards external distracting stimuli. Research of this kind will be divided into studies using distracting visual stimuli and those using distracting auditory stimuli.

Distraction by Internally Generated Cognition

Distraction by repetitive mathematical tasks

Findings from studies using repetitive mathematical tasks as a distraction have been equivocal. Some studies have demonstrated significant reductions in pain-outcome measures, while others have revealed (at best) directional, but non-significant findings.

Beers and Karoly (1979) found that counting backwards from 1000 by 3's was associated with significant increases in reports of pain tolerance and threshold but had no effect on discomfort ratings of cold-pressor pain.

One recent study (Hodes, Howland, Lightfoot & Cleeland, 1990) required subjects to perform both easy and difficult mental arithmetic on a string of serially presented numbers. Findings revealed that, relative to baseline measures, subjects in both distraction conditions had reduced pain ratings obtained earlier during cold pressor exposure, but distraction tended to have no effect in the later stages of immersion. Neither did distraction have any effect on pain tolerance measures. Furthermore, no difference in pain outcome was demonstrated between the easy and difficult distracter tasks.

Other studies have revealed only directional, but non-significant findings. For example, in another cold-pressor study, it was found that a group required to count backwards from 1000 demonstrated only directional (but not-significant) improvement in tolerance when compared to controls (Horan & Dellinger, 1974). Similar directional but non-significant findings were produced in a study by Barber and Cooper (1972) who investigated the effects of adding multiples of 7 on ratings of finger pressure pain.

Distraction by imagery

As previously mentioned, the success of imagery techniques is supported by Fernandez and Turk's (1989) recent meta-analysis which concluded that, when compared to other cognitive coping strategies, those involving imagery were the most effective in attenuating pain. However, the diversity of the imagery techniques used in these studies makes it difficult to determine the processes underlying the pain reduction associated with these techniques. In some instances subjects may be seen to be completely distracted away from the noxious stimulus, and involved in the processing of their own internally generated cognitions. In other studies attention is not completely directed away from the noxious stimulation, but instead active schemata may serve to orient attention away from the painful aspects of the noxious stimulus. Emotional confounds and suggestabilty may further serve to complicate the processes behind imaginal distracters.

Imagery tasks requiring a focus completely away from pain have been used in numerous studies with demonstrated success in reducing pain. For example, Chaves and Barber (1974) found that subjects instructed to imagine pleasant events (such as going out for a meal, relaxing on a beach, or listening to a symphony orchestra) exhibited significantly lower verbal reports of finger pressure pain when compared to baseline measures. A study by Clum, Luscomb and Scott (1982) required individuals to imagine themselves going outside into a bright sunny day and away from the room where they were experiencing acute ischemic pain. They found that individuals undergoing such procedures experienced lower pain as measured by cross modality matching. Research using cold-pressor by Grimm and Kanfer (1976) compared the effects of pleasant imagery (related to planning a party or going on a trip with a friend) with a relaxation group, an expectancy group, and a no-treatment control group. Findings demonstrated that imagery was the most successful of all conditions in raising pain tolerance, reducing heart rate, and lowering discomfort ratings. Another cold-pressor study demonstrated that subjects required to imagine events related to their graduation experienced lowered pain threshold when compared to baseline threshold measures (Jeremko, 1978).

Moreover, numerous other studies have been successful in raising tolerance to cold pressor pain. For example, a study by Avia and Kanfer (1980) instructed subjects to imagine a trip with a friend or good movie; Rosenbaum (1980) required subjects to imagine a pleasant relaxing situation; and in a study by Worthington (1978) subjects were required to generate their own imagery.

Despite the general support for the efficacy of imaginal techniques, 2 of the 27 imagery studies meta-analyzed by Fernandez and Turk (1989) failed to produce significant reductions in pain. One study by Ladouceur and Carrier (1983) found instructions to use positive and pleasant imagery to have no effect on cold-pressor tolerance. In another study encouraging subjects to imagine a blank wall, there was no resultant effect on the duration that a painful radiant heat stimulus was tolerated (Neufeld, 1970). When viewed in terms of McCaul and Malott's model (1984), it may well be that the imagery required in these two studies was not particularly distracting or demanding -- thus it may have only partially used the subject's limited attentional capacity (allowing for the remaining attentional capacity to be focused on pain). This argument would be particularly appealing in view of the Neufeld study. Requiring subjects to imagine a blank wall would seem to be a particularly undemanding task.

Imagery involving partial distraction

Studies using imagery which partially distracts tend to encourage an attentional focus towards the non painful aspects of noxious stimulation (such as the thermal or numbing aspects of cold-pressor), and away from the actual sensations of pain. In this way the instructions given may serve to activate a schema which is incompatible with pain sensory information. Schema-directed search for sensations other than pain may thus be seen to distract attention away from pain (Pennebaker, 1982).

As with the imagery studies encouraging an attentional focus completely away from pain, those imagery studies in which attention is partially distracted have achieved similar pain reductions. Research of this kind tends to encourage subjects to focus on the non-painful aspects of noxious stimulation, such as the thermal or numbing properties of cold-pressor. For example, Thelen and Fry (1981) demonstrated that subjects requested to imagine it was a hot day and the water was pleasantly cool experienced significantly greater tolerance to cold-pressor than controls. Spanos, Horton, and Chaves (1975) demonstrated that subjects in a group instructed to imagine themselves in a desert, and to interpret the cold water as refreshing, tended to have a greater pain threshold than baseline comparison. Similarly, Beers and Karoly (1979) demonstrated raised cold pressor threshold and tolerance measures after instructions to imagine a pleasant warm scene. Other research requiring individuals to focus on the numbing properties of cold water has also demonstrated improved pain measures. For example, instructions to imagine the immersed arm as "numb and insensitive" during cold pressor exposure have been associated with significant reductions in pain report among those high in hypnotic susceptibility (Stam & Spanos, 1980; Spanos, McNeal, Gwynn, & Stam, 1984). However, another study demonstrated no effect on tolerance to finger pressure pain following instructions to imagine that the exposed index finger was numb (Scott, 1978). Perhaps suggestibility or hypnotic susceptibility may also be an important moderator of the effectiveness of these sort of techniques.

There is also some evidence indicating that imagined behavioural contingencies may be effective in helping individuals to cope with pain. Blitz and Dinnerstein (1968) found that subjects instructed to imagine that they will receive $1000 for every second longer that the pain stimulus is endured were able to tolerate greater levels of electric shock. However, whether the effect was related to attentional or motivational factors remains uncertain.

Other research investigating schema directed distraction

In addition to merely distracting attention from pain, active schema may also be seen to guide attentional focus both towards or away from pain. Anderson and Pennebaker

(1980) set out to test if identical sensory data could be interpreted as either painful or pleasurable depending on the schema held by the individual. In this experiment, the participants were essentially primed to expect either "painful" or "pleasurable" sensations from an ambiguous stimulus (a 1 second exposure of the finger to vibrating emery board). Findings showed a highly significant difference between the post exposure ratings of the two groups. That is, those given the "pain prime" saw the stimulus as painful and those given the "pleasure prime" saw the stimulus as pleasurable. In a subsequent interview, it was also found that the subjects felt that the stimulus could not have been perceived in any way other than the way they perceived it: a finding that testifies to the power that schemata have over the perception of pain.

Similar findings were found in another study using a known pain stimulus. Friedman, Thompson, and Rosen (1985), in a study ostensibly exploring the impact of perceived threat on cold-pressor pain, inadvertently showed evidence for a schematic effect. A group believing they were participating in an experiment involving the perception of novel stimuli showed greater tolerance and reported less pain than did other subjects who believed they were participating in a study on pain perception.

Similarly, Leventhal et al. (1979) found that subjects who heard the word "pain" in the instructions given prior to cold pressor exposure tended to report greater distress and reported stronger pain sensations than did subjects who received instructions which excluded the word "pain".

Taken together, such research indicates that an active pain schema may serve to focus attention towards painful sensations, and so increase the amount of pain perceived. Conversely, an activated schema which is inconsistent with pain may serve to decrease pain by distracting attention away from it (Pennebaker, 1982).

Distraction From Focusing on External Stimuli

Visual stimuli

Research using visual distraction has typically instructed subjects to view slides in order to distract attention away from pain. Instructions to view slides have been shown by numerous studies to be associated with raised tolerance to cold pressor pain (Berger & Kanfer, 1975; Kanfer & Seider, 1973; Greenstein, 1984; McCaul & Haugtvedt, 1982). Raised pain threshold has also been found in research using cold pressor (McCaul & Haugtvedt, 1982). Kanfer and Goldfoot (1966) found that viewing and describing slides was the most effective of four strategies for increasing cold pressor pain tolerance. There is also some indication that slide content may influence distracter efficacy. Greenstein (1984) found that "unpleasant slides" significantly increased the number of subjects who could endure cold pressor for the maximum time when compared to "pleasant slides" and control conditions.

Auditory stimuli

Distraction through auditory channels has also been demonstrated to alleviate pain both experimentally and clinically. One study using cold pressor by Melzack, Weisz, and Sprague (1963, cited in Melzack & Wall, 1982) found pain tolerance was increased when subjects were given the opportunity to listen to music and white noise. Other research by Lavine et al. (1976) showed increased tolerance to electric shock and decreased EEG measures of pain were associated with listening to loud but comfortable levels of music.

Similarly, Spanos, McNeal, Gwynn, & Stam (1984) demonstrated that pain ratings were significantly lower than baseline measures when subjects were required to listen to (and repeat back) strings of serially presented words. However, in terms of attention, it is difficult to determine whether the processing of auditory inputs or the processing of verbal responses interfered with pain in this particular study.

Other research using children experiencing pain during immunisation injections demonstrated that music distraction significantly decreased pain reports when compared to control and expectancy conditions. Moreover, the same study found that a combination of distraction plus expectancy was no better than distraction alone in decreasing pain (Fowler-Kerry & Lander, 1987).

Somatic stimuli

The literature has given little regard to external distracting stimuli presented in the somatic modality. The impact on pain perception caused by the simultaneous presentation of somatic stimuli has typically been considered within the context of counterstimulation rather than distraction. Counterstimulation will be dealt with in a subsequent section.

Other Research on Distraction and Pain

Effects of Distraction on Electrophysiological Correlates of Pain

Additional support for the involvement of selective attention in pain perception has been provided by recent research viewing event related potentials (ERPs) as physiological correlates of pain. Several studies have demonstrated that specific components of pain-evoked somatosensory ERPs were correlated with subjective pain reports, and that analgesics reduce the amplitudes of these ERPs (Chapman & Jacobson, 1984). A recent study investigating the effects of attention on such pain-evoked ERPs demonstrated that (when compared to subjects who attended to pain) ERP amplitudes were significantly lowered if subjects were distracted by a task involving a difficult word puzzle (Miltner, Johnson, Braun & Larbig, 1989).

Animal Studies

Research using animals has also demonstrated the effects of distraction on electrophysiological pain correlates. A series of studies on monkeys showed reduced neuronal responses in medullary dorsal horn cells to noxious thermal stimuli when the animals' attention was distracted by a visual stimulus (Hayes, Dubner, & Hoffman, 1981; Bushnell, Duncan, Dubner & He, 1984). Additionally, these studies also demonstrated the same neurons to be more responsive when attention was directed towards the noxious thermal stimulus. Together these findings seem to suggest that selective attention may differentially excite or inhibit nociceptive pathways depending on whether attention is focused towards, or away from, the site of noxious stimulation (respectively).

Other animal research using behavioral pain measures has also implicated the pain-controlling effects of distraction. For example, Casey and Morrow (1983) demonstrated that cats are less likely to react to painful stimuli when they were eating (and presumably distracted) while painful stimuli were presented. They argued that this finding was attributable to central neural mechanisms related to attention.

Alternative Explanations for the Analgesic Effects of Distraction

Keeping in mind the complexity of the pain experience, it is probably naive to stipulate any single way in which attentional processes have their effect on pain. In fact, it may well be that selective attention operates via several mechanisms at different levels of perceptual processing to modulate pain. The previously introduced animal research by Hayes et al. (1981) and Bushnell et al. (1984) suggests that nociceptive pathways may be differentially excited or inhibited by attentional mechanisms. This is reflected by other studies demonstrating the pain enhancing and controlling effects of respectively attending to, or away from, pain (Kanfer & Goldfoot, 1966; Pennebaker, 1982; Pennebaker & Lightner, 1980).

In a study using cold-pressor pain, Bandura and colleagues (Bandura, O'Leary, Taylor, Gauthier, & Gossard, 1987) demonstrated raised cold pressor tolerance consequent upon using a cognitive intervention involving distraction. However using the same package combined with the opiate antagonist naloxone (but not saline) was associated with lessened pain tolerance. This suggests that endogenous opiates may have been involved in producing the analgesic effects demonstrated in this study. But, because the intervention used by Bandura et al. included more than one manipulation the exact processes remain unclear. Although it is tempting to speculate that perhaps an endogenous opiate mechanism may subserve the analgesic effects produced by distraction, this issue certainly would require further clarification.

The Issue of Expectancy

In considering the preceding section on distraction and pain, the issue of potential expectancy effects needs to be addressed. An alternative hypothesis to the role of distraction, may be that an expectancy effect caused by a belief in distracter efficacy may also be in operation to reduce pain. However, there is little evidence that expectancy (alone) is able to account for the outcomes surrounding studies on distraction. Studies contrasting distraction with expectancy control conditions indicate the superiority of distraction in alleviating experimental pain (Beers & Karoly, 1979; Chaves & Barber, 1974; Fowler-Kerry & Lander, 1987). Moreover, meta-analysis of 9 investigations showed positive expectancy to be no better than no-treatment conditions in attenuating pain (Fernandez & Turk, 1989). Such findings were also endorsed by

McCaul and Malott (1984) who considered that the effects produced by distraction were beyond any potential pain controlling effects produced by expectancy.

Summary

Generally, distraction has been demonstrated as an effective means of countering pain when compared to "no instructions" and expectancy control conditions. This holds across various pain stimuli, experimental settings, and distracters, in both human and animal subjects.

CHAPTER THREE

Towards the Proposed Research

Increasing our understanding of distraction techniques and determining which have the greatest impact on pain, may potentially advance new ways of assisting those who suffer pain. However, the literature has generally failed to generate rules for determining appropriate distracting strategies (Riley & Levine, 1988). Few studies have set out specifically to compare the relative effectiveness of different types of distraction tasks, and consequently there is little evidence to show which distracter tasks have the greater impact on pain. Perhaps this is because most researchers have failed to account for the underlying mechanisms responsible for distraction-related pain reduction (Tan, 1982).

Attentional Demand as an Indicator of Distracter Potency

Based on their model for the workings of distraction analgesia, McCaul and Malott (1984) were able to predict that highly demanding distracters would be more potent because they would require more of the limited attentional resources needed to process pain perceptual inputs. In other words, distracter tasks demanding the greatest attentional resource capacity would be expected to have the greatest effect on pain. McCaul and Malott (1984) tested this prediction by reviewing those studies using different distracters which presumably had different demands on attentional capacity, and compared the relative analgesic potency of these different distracter tasks.

For example, Barber and Cooper (1972), in a study using finger pressure pain, found that ratings of pain obtained during the first minute of stimulation tended to be lower when subjects were instructed to listen to a story or count serially by 7's. However, no comparable distraction effect was demonstrated when subjects were instructed to perform the (presumably) less demanding task of counting by 1's.

Horan and Dellinger (1974) compared the effects of relaxing imagery with counting backwards by 1's on cold pressor tolerance. Although the effect was insignificant, they demonstrated that individuals in the highly demanding imagery group tended to have twice the tolerance of those in the presumably less demanding counting group.

Another finding consistent with predictions of distracter potency is that many imagery studies have found that greater reported involvement in imagery strategies corresponds to greater pain reductions (Chaves & Barber, 1974; Marino, Gwynn & Spanos, 1989; Spanos et al., 1975).

Although such studies provide evidence that highly demanding distracters are more potent, McCaul and Malott (1984) emphasised that the evidence should be interpreted with some caution. This was because the emotional content of the distracters (eg. telling a story, or relaxing imagery) potentially confounded the results. An additional reason for caution was because comparison of the distraction strategies tended to be post hoc and relied on rather indirect measures of attentional demand (ie. involvement in imagery strategies is difficult to measure objectively).

In fact, McCaul and Malott (1984) believed that only one of the studies they reviewed adequately tested their proposal. Brucato (1978, cited in McCaul & Malott, 1984) compared distraction tasks demanding three levels of attention (high, medium and Low). He found that tasks consuming high and medium amounts of attention were the most effective in raising tolerance to cold pressor (this was consistent with the prediction that the low demand distraction would have relatively little impact on pain). However, contrary to expectations, the greatest pain tolerance was not found to be associated with the highly demanding task, but with the moderately demanding distracter. This led Brucato to reason that distracter tasks which are too demanding may cause subjects to give up and so abandon the potential benefits of distraction. This being the case, it seems that there may be an optimal level of distracter difficulty.

Contrary to McCaul and Malott's (1984) predictions, one recent study by Hodes et al. (1990) requiring subjects to perform both easy and difficult mental arithmetic on strings of serially presented numbers, found no difference in pain outcome between these two tasks. However, the authors suggested that the findings may also be partly attributable to subjects giving up on the difficult distracter task.

Although there are indications that there may be an optimal level of distracter difficulty, the preceding research provides some preliminary evidence in support of McCaul and Malott's expectation that high demand distracters are more potent. Given the attentional mechanisms believed to underlie distraction analgesia, it follows that the attentional literature may possess a framework from which further predictions concerning distracter potency can be made.

Task Similarity as an Indicator of Distracter Potency

Examination of attention research using the dual-task paradigm shows that it is impossible to predict the interference between tasks on the basis of their individual attentional demands alone, but task similarity also needs to be considered (Kahneman, 1973). Dual-task research demonstrates that similar tasks (requiring the processing resources of the same modality) become disproportionately difficult when performed together, whereas tasks involving different modalities can be performed together with relatively less performance decrement (Kahneman, 1973; Segal & Fusella, 1970; Treisman & Davis, 1973). Such findings have led to suggestions that attentional capacity is not undifferentiated and freely interchangeable between tasks, but rather that central processing is somehow modality specific (eg Martin,1980; Wickens, 1984).

The multiple resource model

The multiple resource model (Wickens, 1984) claims that there is no single attentional resource but multiple attentional resources -- the allocation of which appear to be (at least partly) modality dependent. According to this model, simultaneously performed tasks interfere less with each other if they involve perceptual processing in different modalities because they are inclined to use separate resources. In contrast, tasks using the same sense modality are more likely to be competing for the same "pool" of modally distributed resources. Consequently, when these tasks are concurrent, the performance in one or the other task (or both) will suffer more than if the tasks used separate resources.

Based on the notion that competing resources are believed to be the underlying principle by which distraction impacts on pain (McCaul & Malott, 1984), it follows that the multiple resource model may possess a framework from which predictions concerning distracter potency can be made. Wickens' (1984) model holds that attentional resources tend to be distributed according to sense modality, and that competition between tasks will tend to be greater when they share the same pool of resources. It follows that somatic distracters would be analgesically more potent because they would be more inclined to be competing with the modally-distributed resources needed to process pain sensory inputs. However, as mentioned previously, the impact on pain perception of simultaneously presented somatic stimuli has typically been considered within the context of counterstimulation rather than distraction. Despite this there is still some indication that somatically presented counterstimuli are analgesically more potent than counterstimuli presented via other modalities.

Counterstimulation

Counterstimulation typically involves presenting some form of somatic stimulus in conjunction with pain as a means of controlling it. Within the literature on this topic there is some suggestion that these somatically presented counterstimuli are more effective in reducing pain than counterstimuli presented via other modalities. For example, Eriksson, Rosen, and Sjolund (1985), using thermal sense as a model of nociception, found that transcutaneous nerve stimulation (TNS) reduced sensitivity to thermal stimuli, but photic stimulation did not.

Riley and Levine (1988) compared the effects of somatic versus auditory counterstimulation on cold pressor pain. Based on an information-processing conception of distraction analgesia, they proposed that the greatest interference would occur between the processing of pain and a simultaneously presented somatic stimulus, and so lead to a greater pain reduction under somatic counterstimulus conditions. Accordingly, it was demonstrated that subjects receiving somatic stimulation exhibited lower pain ratings than did those in the auditory condition (who did not differ significantly from the no-treatment controls). Further, not only was the heightened interference effect (under somatic conditions) predicted to alter pain perception the most, but this same effect was also predicted to alter the perception of the somatic counterstimulus more than visual counterstimulus. This prediction was confirmed -- even though both counterstimuli were rated as equally aversive prior to experimentation, the counterstimulus ratings obtained during cold pressor exposure demonstrated that somatic counterstimulation was considered less aversive than its auditory counterpart. The authors argued that these results support an information-processing conceptualisation of pain modulation (McCaul & Malott, 1984), and based on these principles, they assumed that somatically presented distracters are analgesically more potent. However, despite Riley and Levine's claims of their study being congruent with an information-processing view of distraction analgesia, there is reason to suggest that their results may have been confounded by a different analgesic mechanism.

Analgesic mechanisms subserving counterstimulation

Although the effects of distraction may account for a component of counterstimulation analgesia, the underlying mechanisms are believed to be different to those thought to underlie the pain controlling effects of distraction (Melzack & Wall, 1982). Essentially, counterstimulation is believed to reduce pain by three different mechanisms depending on the physical qualities of the counterstimulant as well as its location relative to the site of pain (Favale & Leandri, 1984; Fields, 1987). Firstly, peripheral mechanisms such as decreased nociceptor excitability and fatigue of peripheral nerve fibres may potentially occur when the counterstimulus is positioned close to the site of pain. Secondly, low-level stimulation positioned in a site anatomically related to the site of pain may operate by selectively stimulating the large low-threshold fibres to close the spinal gating system (Melzack & Wall, 1982). This pain inhibitory effect has been proven electrophysiologically, behaviourally and clinically (Woolf, 1989). Thirdly, intense stimulation (or hyperstimulation) is believed to activate brainstem inhibitory mechanisms which in turn exert their control over pain transmission (Fields, 1987; Melzack, 1989).

In Riley and Levine's (1988) study the relative superiority of the somatic stimulus may not be attributable to competing resource demands, as outlined by McCaul and Malott (1984), but rather a counterstimulant effect present under somatic conditions but not in operation under the auditory conditions. The nature and placement of the electrocutaneous counterstimulus used in their study, permits such an alternative explanation. The somatic stimulus used was an aversive electrocutaneous counterstimulus situated close to the site of painful stimulation. This suggests the possibility that a spinal or a brainstem inhibitory mechanism (or both) as proposed by Favale and Leandri (1984) may have been operating to achieve the associated analgesic effects.

Moreover, the finding that the perception of somatic counterstimulus was altered in the presence of cold-pressor stimulation, whereas perception of the auditory stimulus was not, may also be explained by an alternative mechanism to that assumed by Riley and Levine (1988). Consistent with Riley and Levine's findings, a recent study also found that the perception of an aversive somatic stimulus was altered in the presence of cold-pressor stimulation. However, no similar perceptual alteration was associated with a visual task (Talbot, Duncan, Bushnell, 1989). Instead of attributing this to an information-processing mechanism, Talbot et al. attributed the effect to a brainstem inhibitory mechanism (similar to that proposed by Favale and Leandri, 1984) which was set up by cold-pressor stimulation to inhibit the conduction of the secondary somatic stimulus in the dorsal horn of the spinal cord.

There is further reason to doubt that the effects achieved by Riley and Levine were related to an underlying distraction effect as proposed by McCaul and Malott (1984). The experimental protocol followed by Riley and Levine (1988) did not manipulate attention away from the painful stimulus and towards the "distracting" counterstimuli, as do typical investigations viewing the effects of distraction on pain. In fact, instead of distracting subjects away from pain, they were instructed to rate it at regular intervals throughout the cold-pressor procedure: a protocol reasoned by other investigators to manipulate attention towards the pain rather than distract from it (eg Levine et al., 1982). If subjects were instructed to attend to the auditory counterstimulus in the Riley and Levine study perhaps there would have been an associated analgesic effect. However, no such effect was found. This is in contrast with other investigations which have found that pain was attenuated when attention was distracted towards auditory stimuli (Fowler-Kerry & Lander, 1987; Lavine et al., 1976; Melzack, Weisz & Sprague, 1963, cited in Melzack & Wall, 1982).

Summary

In summary, some important conceptual difficulties arise when attempting to generalise the findings of Riley and Levine's (1988) research to the distraction literature -- particularly when these findings are related to McCaul and Malott's (1984) model. Even though counterstimulation is comparable to some forms of distraction in that it involves the simultaneous presentation of an alternative stimulus to pain, the mechanisms underlying counterstimulation analgesia are believed to differ from those thought to underlie distraction analgesia. Thus, it is plausible that a simple information-processing explanation would not be sufficient to account for Riley and Levine's (1988) finding demonstrating the superiority of somatic counterstimulation when compared with an auditory stimulus. Moreover, counterstimulation studies do not tend to impose the same attentional demands as do typical distraction studies. This gives further reason to doubt the involvement of an attentional resource mechanisms in counterstimulation-related analgesia.

Even though there is reason to suggest that somatically presented counterstimuli may not achieve their analgesic effect by a distraction related mechanism, the question of distracter potency still remains. If counterstimulant effects are controlled for, will somatically presented distracter tasks be analgesically more potent than distracter tasks presented via other modalities?

CHAPTER FOUR

The Proposed Research

It has been suggested in a prior section that distracter tasks are thought to modify pain perception by competing with the processing of pain sensory information for limited attentional resources (McCaul & Malott, 1984). Moreover, the attentional literature suggests that this competition between pain sensory processing and the distracter may be greater if the distracter task involves the processing of somatic sensory information (Wickens, 1984). Based on these principles it seems that somatic distracters would be analgesically more potent. A counterstimulation study by Riley and Levine (1988) set out to explore this issue and found that somatically presented counterstimulation was superior to comparable auditory stimulation in reducing pain. However, it appears that these findings could have been confounded because other processes beyond the information processing mechanisms outlined by McCaul and Malott (1984) may have been operating to determine the analgesic superiority of the somatic counterstimulus.

The Current Study

The primary undertaking of the current research is to compare a purely somatic distracter task with a similar visual distracter task which provides comparable demands on attention. This study intends to use similar logic to that of Riley and Levine (1988). However, in order to determine if the potential difference is achieved by competing attentional resources, the experimental protocol will be fashioned more after typical distraction research by instructing subjects to focus their attention on the required distracter tasks. Moreover, in order to lessen the likelihood of confounds due to counterstimulant mechanisms it was decided that the nature and the placement of the somatic distracter used in this study will differ substantially from the electrocutaneous counterstimulus used by Riley and Levine. In order to lessen the likelihood of hyperstimulation effects (Favale & Leandri, 1984) the proposed somatic distracter task will involve detection of just noticeable changes in a low base level thermal stimulus (set just above body temperature). Further, to lessen the likelihood of segmental counterstimulation effects (Favale & Leandri, 1984) placement of the somatic distracter will be at a site anatomically unrelated to the site of painful stimulation.

In order to equate the attentional demand of visual and somatic distracters both will be required to be comparably difficult and have similar task requirements. Thus, both tasks will be required to have similar performance error rates and execution of both will require the detection of just noticeable changes in a low level base stimulus.

Given the apparent superiority of imaginal distraction techniques in the attenuation of pain (Fernandez & Turk, 1989) this study shall also include an imaginal distracter task. However, because of the uncertainty of how imagery impacts on attention, no predictions were made concerning the relative potency of the imagery distracter in comparison to the other distracter tasks.

In summary, it is predicted that all three distracter tasks (somatic, visual and imaginal) will be effective in attenuating pain. Moreover, based on the multiple resource model of attention, it is assumed that the resources available for simultaneously processing pain and a somatic task will be fewer than those available to simultaneously process pain and a visual task. Therefore, because of these greater constraints on resources under dual pain and somatic task processing conditions, it is predicted that either pain will be attenuated more, or performance of the somatic task will suffer more (or both), than when compared to pain perception and distracter performance under visual conditions.

Therefore, the specific hypotheses to be tested are:

(1) All three distracter tasks will be effective in raising pain threshold when compared to no distraction conditions.

(2) The somatic distracter will be more effective in raising pain threshold than the visual distracter.

or

(3) Performance errors will be greater for the somatic distracter than the visual distracter in the presence of the pain stimulus.

or

(4) Both the somatic distracter will be more effective in raising pain threshold than the visual distracter, and performance errors will be greater for the somatic distracter than the visual distracter in the presence of the pain stimulus.

CHAPTER FIVE

Method

Subjects

The subjects were 20 volunteers (12 males, 8 females) who agreed to participate in an experiment on pain perception. The mean age was 27 (range 21-34). Prior to participation subjects were required to read and complete a brief document containing: (a) an outline of the nature of the experiment, (b) a consent form, and (c) a short medical check-list to ensure the avoidance of any contraindicating conditions (see appendix A, B, & C).

Apparatus

All experimental pain stimuli as well as the visual and somatic distracting stimuli were controlled by an IBM PC computer. All subject responses were recorded by the same computer

The Pain Stimulus

The noxious stimulus was potassium ions delivered through the skin iontophoretically. This procedure (iontophoresis, or ion transfer) occurs when an electrical current is passed through a solution containing an ionised species in order to facilitate the migration of these ions (Tyle & Kari, 1988). The pain producing qualities of potassium ions have been recognised by a number of researchers (Benjamin & Helvey, 1963; Iggo, 1974; Ong Singer & Wallace, 1981). Their iontophoretic administration through the epidermal barrier has been used in some research as a way of inducing experimental pain (Benjamin & Helvey, 1963; Voudouris Connie & Coleman, 1985). Pain produced in this way is thought to be linear in nature -- there being a correspondence between amperage and pain experienced (Benjamin & Helvey, 1963; Humphries & Johnson, 1990; Voudouris, 1981, cited by Voudouris et al, 1985). Although differences between subjects may be large, there is relatively small intra subject variability (Benjamin & Helvey, 1963). The intra subject reliability of response to iontophoretic potassium stimulation, as well as its ability to be presented repeatedly and rapidly, makes it particularly useful for repeated-measure experimental designs.

The iontophoretic pain generator

The pain stimulus was delivered by an iontophoretic pain generator designed and developed in the Massey University Psychology Department. This device consisted of a constant-current power source, and was designed to deliver a selected current ranging between 0 and 25 milliamps -- beyond which an automatic cut-off switch terminated the stimulus.

Electrode placement

Electrode placement was similar to that of Benjamin and Helvey (1963) and Voudouris et al (1985), with the cathode attached to the volar surface of each subject's right forearm, and the anode situated directly opposite on the dorsal surface of the forearm. Two elastic straps were used to secure the electrodes next to each subject's arm.

The anode consisted of a plastic ring which converted into a bowl using the volar surface of the subjects arm as a base. Once filled with a potassium chloride solution (3 % w/v), there was a surface area of 12.5 square centimetres of solution in direct contact with the subject's skin. To reduce seepage of the solution between the arm and the bowl, 1 gram of agar was added per 100 mls of potassium chloride solution.

The cathode consisted of a 4cm x 13cm silver plate covered with several layers of saline-saturated medical gauze (4% w/v sodium chloride).

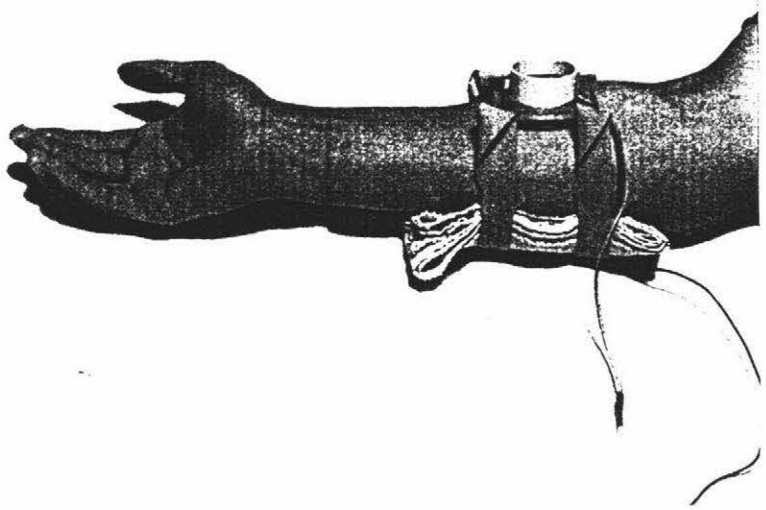


Figure 1. Electrode placement. Anode bowl visible on the volar surface of subject's arm and saline saturated gauze on the dorsal surface of the forearm.

Delivery of the pain stimulus.

The stimuli were presented in 5 trial blocks which were identical in configuration across all subjects and experimental manipulations. The iontophoretic trials within each block differed in the rate of increase in current (ramp rate), and in the delay before the stimulus began (for details see Table 1.). Ramp gradient's as well as stimulus onset were varied to avoid the anticipation of pain sensation. The current was ramped to avert the sensation of electric shock associated with sudden current changes (Balogun, 1986).

TABLE 1. Detail of stimulus configuration for each iontophoretic 5 trial block -- Showing ramp rates and the period prior to the onset of each stimulus.

TRIAL	STIMULUS INTERVAL (seconds)	RAMP RATE (milliamps per second)
1	15	1.0
2	20	0.5
3	20	0.7
4	30	0.4
5	15	0.5

Pain threshold measurement

Throughout stimulation the subject's hand rested on a switch (threshold detection switch) which allowed stimulation to continue as long as it remained depressed. In order to obtain a pain threshold measure the subjects were instructed to lift their hand at the point when they first felt the stimulus was painful. Lifting of the hand stopped stimulation and recorded pain threshold in milliamps.

The Distracters

Both the light and thermal probe were driven by the same computer- controlled stimulus generator designed and developed by the Massey University Psychology Department. The visual (light) and thermal (heat) distracters used in the experimental session were identical in terms of their stimulus configuration. Both consisted of pulses which would peak after 1 second, and then slowly fade over a 2-5 second period back to a low level base stimulus intensity. A variable delay ranging between 7 and 13 seconds occurred between pulses to minimise anticipation of each delivery. Subjects responded by pressing a button each time they detected a stimulus pulse and the responses were recorded. The intensity of the light and heat pulses was chosen for each individual on the basis of jnd (just noticeable difference) data obtained from the familiarisation session. Pulse intensities during the experiment proper were varied around each individual's jnd for that particular stimulus.

Three forms of distraction were used:

(a) a somatic (thermal) distracter
(b) a visual (light) distracter
(c) an imagery distracter (engaging in neutral imaginings)

(a) The somatic distracter.

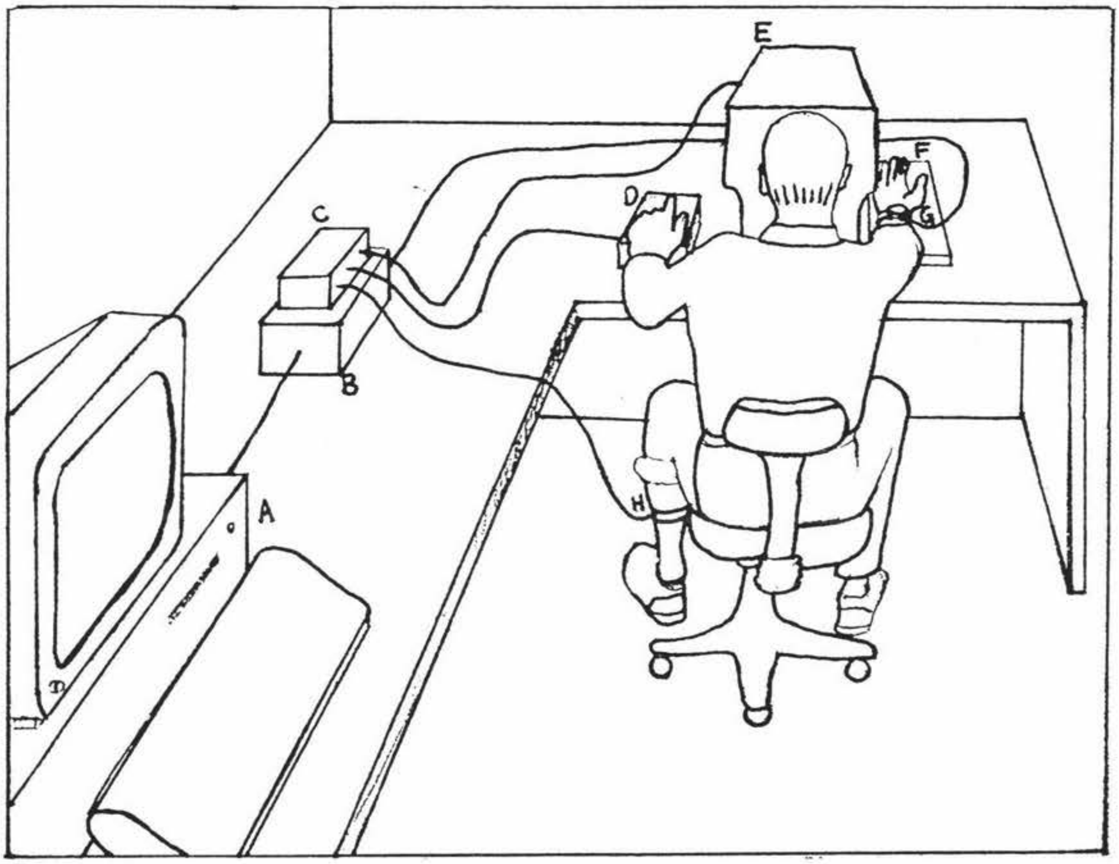
This distracter was produced via the use of a circular, 9mm diameter copper plate set at a base temperature of 38.6 degrees celsius, and attached to the lateral aspect of each subject's left calf by a velcro strap. This thermal probe was designed to deliver 1 second heat pulses which would increase, and then cool back to the base temperature setting. Heat pulses delivered during the experiment ranged no more than 2 degrees above the base setting and varied around each individual's jnd. The probe was placed on the leg contralateral to the arm receiving the pain, and low level non-painful heat stimuli were used to avoid potential confounds related to segmental counterirritant effects on pain (Favale & Leandri, 1984).

(b) The visual distracter.

The visual distracting apparatus used a circular 15mm diameter red light positioned at the end of a 610mm long (250 mm wide by 300 mm high) darkened tunnel. The light was designed to deliver 1 second light pulses which would brighten and then fade back to the base light intensity of 3.0 NITS (candellas/m^2; as measured by a Tetronix J 6523-2 f° Narrow Angle Luminance Probe). Subjects were seated in front of the tunnel with their head resting in the entrance.

(c) The imagery distracter.

Instructions promoting neutral imagery were similar to those used by Spanos, Horton and Chaves (1975), whose subjects were encouraged to imagine a lecture situation. These were used because the relative effect associated with the neutral-imagery condition in the Spanos et al. study was among the highest of those evaluated by Fernandez and Turk (1989).



A = Computer; B = Iontophoretic pain generator; C = Distracter stimulus generator; D = Finger on distracter pulse detection button; E = Darkened tunnel containing light; F = Hand rested on threshold detection switch; G = Iontophoretic electrodes positioned on subject's forearm; H = Thermal probe attached to lateral aspect of subjects calf.

Figure 2. Experimental layout. Demonstrating the subjects position relative to the distracter detection button; the iontophoretic electrodes; and the visual and somatic distracting stimuli.

Procedure

Experimental Design

A repeated measures design was used to reduce the impact of inter- subject variability known to be associated with the pain producing properties of iontophoretically delivered potassium ions (Benjamin & Helvy, 1963). Each of the 20 subjects were randomly assigned to their own treatment order to avoid potential sequence effects.

Pilot Study

A pilot study was run using three subjects. Information obtained from this study was used to make some minor modifications to the experimental instructions to ensure greater clarity. In addition it was found that each individual's performance on the light detection task was superior to their heat detection performance. Thus, in order to better equate the tasks in terms of difficulty, the base brightness of the light stimulus was raised slightly to make changes in the light stimulus more difficult to detect. This was in accordance with Weber's law which suggests that people notice small changes in a weak stimulus but that changes in a stronger stimulus are more difficult to detect (Weber, 1834, cited in Bootzin, Bower, Zajonc & Hall, 1986).

Main Study:

All subjects were required to attend two sessions of approximately 30 minutes duration:

1. Familiarisation session
2. Experimental session

1. Familiarisation Session

The purpose of this session was: (a) to decrease anxiety related to experimentation and the anticipated pain stimulus; (b) to familiarise the subjects with the tasks required in the experimental session; and (c) to determine the smallest change in both the light stimulus and the heat stimulus (respectively) needed to produce a just noticable detection response (these jnd estimations were obtained for each subject).

The protocol for the familiarisation session was the same for all subjects. Following an overview of the experiment (where each subject was told that the purpose of the familiarisation session was to decrease anxiety related to the experimental manipulation and to acquaint them with the tasks to be used in the experimental session), (1) the light detection preparation exercise was conducted, followed by the light jnd calibration exercise, then (2) the heat detection preparation exercise was conducted followed by the heat jnd calibration exercise, and (3) the iontophoretic preparation protocol and familiarisation exercise.

To obtain each individual's jnd for the light and thermal detection tasks, subjects were first presented with a series of stimulus pulses which could be detected with relative ease. This was to "cue them in" to the task that would be required. Following this initial preparation exercise the subjects were then presented with a series of 10 stimulus pulses of ascending intensity. Heat pulses ranged from a base level of 38.6 to peaks as high as 39.5 degrees celsius; while the light pulses ranged from a base level of 3.0 NITS to peaks as high as 4.7 NITS. For each type of stimulation the minimum point past which a subject could consistently detect changes was defined as their jnd for that particular task. These jnd estimates were then used to determine the intensity of the distracter stimuli in the experimental session.

(1)light detection and jnd calibration procedure

In the case of light stimulation each subject was seated comfortably in front of a darkened tunnel which contained the red light. They were then read instructions which were repeated if the subject appeared unsure of the task:

> "What I want you to do is focus on the red light in front of you. The light is going to brighten and then fade back to its current brightness. Each time you detect an increase I want you to press this detect button with your left hand (subjects were shown the detection button). Is that clear ?"

Subjects were then presented with the series of stimuli used for the light preparation task. After a 2 minute resting period they were presented with the ascending series used for the light calibration task.

(2) Heat detection and jnd calibration.

Prior to thermal stimulation the thermal probe was attached to the lateral aspect of each subject's left calf, and he/she was then required to resume their position with their head in the darkened tunnel. They were then read instructions, which were repeated if the subject appeared unsure of the task:

> "What I want you to do this time is focus on the thermal device attached to your leg. The temperature of this device is going to increase and then fade back to its current temperature. Each time you detect an increase I want you to press the detect button with your left hand. Is that clear ?"

Subjects were then presented with the series of stimuli used for the thermal preparation task. After a 2 minute resting period they were presented with the ascending series used for the thermal calibration task. The thermal probe was then removed and a mark was drawn in its place to ensure the correct placement of the probe in the experimental session. Subjects were instructed not to erase the mark until after the experimental session on the following day.

(3) iontophoretic preparation protocol and familiarisation.

Prior to the application of the electrodes the volar and dorsal surfaces of each subject's forearm was cleaned by briefly rubbing with distilled water, followed by an 80/20 solution of alcohol and acetone, and then another brief cleaning with distilled water. This ritual was performed as an aid to lowering and stabilizing skin resistance -- in order to allow for more consistent pain responding. Additionally, a block of 5 iontophoretic trials comprised of 3 tolerance and 2 threshold trials was initially given (but not utilised for experimental purposes) to ensure optimal lowering and stability of skin resistance. This was performed because repeated iontophoretic stimulation has been found to lower skin resistance, which in turn leads to optimal pain responding (Humphries, 1989).

In anticipation of this preparation block of trials subjects were given the following instructions:

> "These first few trials are primarily to lower your skin resistance, and to allow you to become acquainted with the pain stimulus. What I want you to do is to rest your hand on the pressure switch until the stimulus reaches a point you are not willing to tolerate any longer. Then you are to lift your hand and the pain will immediately cease. After each trial rest your hand back on the switch so another trial may begin. Is that clear?" (the instructions were read again if the subject appeared unsure of the task).

Subjects then underwent 3 tolerance trials after which they were given the following instructions:

"OK now, rather than letting the pain run up until it becomes intolerable, what I want you to do for the remainder of this session is lift your hand when you first feel that the stimulus is painful."

The subject then underwent the remaining 2 trials of the preparation block and their skin resistance was checked (measures were taken using a Data Precision 936 resistance meter). Based on prior research (Humphries, 1989) a rejection level of 7000 ohms was set; however no subjects were rejected from the study.

Each subject received two blocks of 5 trials in the familiarisation session. The first block was performed as part of the preparation protocol, and the second block of threshold trials was to familiarise subjects with the threshold responding required during the experimental session.

Following the preparation trials the experimenter proceeded with the second block of 5 threshold trials. The experimenter reminded subjects of the task by saying: "lift your hand when you first feel the stimulus is painful"; or "same again" prior to each of the 5 trials.

2. Experimental Session

Prior to receiving the different experimental manipulations each subject under went the standard preparation protocol involving: forearm scrub; electrode placement; and preliminary block of iontophoretic trials (This was performed according to the procedure outlined in the familiarisation session).

The delivery of the pain stimuli was the same across all subjects. After receiving a preliminary block of trials (conducted in conformity with the iontophoretic preparation protocol), each subject then received 4 blocks of 5 trials. The 4 blocks of iontophoretic trials were delivered in conjunction with 4 different treatment conditions: (1) visual distraction; (2) somatic distraction; (3) imaginal distraction (4) control (no- distraction), (see Table 2). The ordering of these conditions was randomly varied between subjects to control for the possibility of sequential effects.

Table 2. Research format.

SESSION	PROCEDURE
Familiarisation Session	Experimental outline Consent Form Medical Checklist Light detection preparation exercise and light jnd calibration. Heat detection preparation exercise and heat jnd calibration. Iontophoretic preparation protocol. Block of threshold trials.
Experimental Session (the day after familiarisation session) ** note:the order of experimental conditions was randomised across subjects	Iontophoretic preparation protocol. Visual distraction in conjunction with 5 iontophoretic trials. Somatic distraction in conjunction with 5 iontophoretic trials. Imaginal distraction in conjunction with 5 iontophoretic trials. 5 iontophoretic trials (no-distraction).
Follow-up	study review sent to subjects

There was a 20 second delay between each trial and a 2 minute delay between each block of trials. These delays allowed time for the subjects to be instructed about the required tasks and reduced the potential for habituation or sensitisation to the pain stimulus. In addition to the periods between trials there was also a within-trial period ranging from 15 to 30 seconds before the onset of iontophoretic stimulation (for details see Table 1.). This allowed time for the subjects to engage in the stipulated distracter tasks before the onset of iontophoretic stimulation. The procedure for the 4 different experimental conditions will follow:

(1) Visual distraction.

Before commencing this block of trials subjects were given the following instructions:

> " OK, for this block of trials I want you to continue performing the same task you have been doing with your right hand, and lifting it each time when you first feel the stimulus is painful. However, instead of focusing on your right arm, I want you to focus your attention on the red light before you -- this is going to brighten then fade back to its current brightness. Each time you see it brighten you are to press the detection button with your left hand."

The instructions were read twice to all subjects, and when the experimenter was sure the instructions were clear he said, "ready", and started the first of the 5 trials.

Prior to each subsequent trial the experimenter said either: "same again", or "continue pressing the detect button each time you see the light brighten".

(2) Somatic distraction.

Prior to commencing this block of trials the thermal probe was attached to the same spot that was used during the familiarisation session, and the subject was given the following instructions:

> " OK, for this block of trials I want you to continue performing the same task you have been doing with your right hand, and lifting it each time when you first feel the stimulus is painful. However, instead of focusing on your right arm, I

want you to focus your attention on the thermal device attached to your leg -- this is going to heat up and then fade back to its current temperature. Each time you feel it increase you are to press the detection button with your left hand."

The instructions were read twice to all subjects, and when the experimenter was sure the instructions were clear he said, "ready", and started the first of the 5 trials.

Prior to each subsequent trial the experimenter said either: "same again", or "continue pressing the detect button each time you feel the thermal device increase in intensity".

(3) Imaginal distraction.

Prior to commencing the block of trials subjects were given the following instructions:

" OK, for this block of trials I want you to continue performing the same task you have been doing with your right hand, and lifting it each time when you first feel the stimulus is painful. However this time I want you to perform an imaginal task. Firstly I want you to pick a lecturer you are familiar with and venue where you have seen that person speaking."

Once the subject acknowledged this had been done the experimenter read the following instructions:

"Instead of focusing on your right arm, I want you to focus your attention on imagining yourself in that familiar venue with this person as he or she is speaking. I want you to picture all the ideas and images related to you being in that place and listening to that person speaking."

The instructions were read twice to all subjects, and once the experimenter was sure the instructions were clear he said: "ready" and started the first of the 5 trials.

Prior to each subsequent trial the experimenter said either: "same again", or " remain in role and continue to imagine yourself in that place and all the pictures and images related to that person speaking".

Five of the subjects were not currently attending lectures, so they chose to imagine a work colleague in a staff meeting situation or to visualise a public speaker with which they were familiar.

(4) Control (no-distraction).

Prior to commencing this block of trials the subjects were given the following instructions:

> " OK, for this block of trials I want you to continue performing the same task you have been doing with your right hand and lifting it each time when you first feel the stimulus is painful."

The instructions were read twice to all subjects, and when the experimenter was sure the instructions were clear he said: "ready" and started the first of the 5 trials.

Prior to each subsequent trial the experimenter said either: "same again", or "continue to lift your hand when you first feel the stimulus is painful."

Follow-Up

A review of the study's aims and its findings was sent out to all of the subjects (see appendix D).

CHAPTER SIX

Results

To compare the effects across different experimental conditions, the threshold data were averaged for every 5-trial-block -- thus generating a mean threshold score for the somatic, visual, imaginal and no-distraction conditions for each of the 20 subjects. This data is presented in Table 3.

Table 3.

Overall means and standard deviations of pain threshold (as measured by milli-amps of current) for different conditions of distraction.

TREATMENT CONDITION	PAIN THRESHOLD (mA)	
	Mean	Standard Deviation
No Distraction	5.036	2.906
Imaginal Distraction	5.432	2.986
Visual Distraction	6.225	3.701
Somatic Distraction	6.362	3.525

Pain Threshold

To compare the effects of the 4 distraction conditions (somatic, visual, imaginal and no-distraction) on pain threshold, a repeated measures multivariate analysis of variance (MANOVA) was performed using SPSS/PC as analysis of the data suggested that the assumptions for this procedure were met.

MANOVA results indicated that at least one of the distraction conditions differed significantly from another. Pillais test demonstrated an overall significant effect ($F(3,17) = 5.75$, $p = .007$). Having found an overall MANOVA effect, paired t-tests were performed to compare the differences between each of the distraction conditions. This outcome analysis is presented in Table 4.

Table 4

t and 2-tailed p values obtained from paired t-tests comparing pain threshold across the different distraction conditions

	IMAGERY	VISUAL	SOMATIC
CONTROL	$t = -2.77$ $p = .012$	$t = -3.68$ $p = .002$	$t = -4.35$ $p < .001$
IMAGERY		$t = -2.73$ $p = .013$	$t = -4.04$ $p = .001$
VISUAL			$t = -.63$ $p > .05$

(degrees of freedom = 19)

It can be seen from Table 4. that involvement in all 3 distraction tasks (imagery, visual and somatic distraction) was associated with significant (at .05 confidence level) increases in pain threshold when compared to no-distraction control conditions. Thus supporting the notion that distraction is effective in raising pain threshold. Further, both the visual and somatic distracters were associated with significantly higher thresholds than the imagery distracter; indicating that imagery was the least successful distraction task. Comparing the visual and somatic distracters showed no significant difference between the two -- thus indicating that neither of these distracters was more effective than the other in raising pain threshold.

Making an unmodified Bonferroni adjustment to the acceptable p value (because of the multiple comparisons of the data) means the t-test data would be interpreted more conservatively with a critical p value of .008. Under these constraints the visual and somatic distraction conditions still remained significantly different to the control and the somatic condition remained significantly different from imagery conditions.

Distracter Performance

In order to compare performance in the visual versus the somatic distraction tasks, error rates were calculated by dividing the number of times an individual failed to detect a stimulus pulse by the total number of pulses presented. These ratios were calculated for both the visual and somatic treatment conditions. Furthermore, performance was divided into two additional categories: competition and no-competition conditions. The no-competition condition was defined as distracter performance in the period commencing when each trial began and ending with the onset of the iontophoretic stimulation. The competition condition was defined as the distracter performance in the period commencing with the onset of iontophoretic stimulation, and ending when each individual reached their pain threshold.

Table 5.

Means and standard deviations of performance errors.

TREATMENT CONDITION		PERFORMANCE (% errors)	
		Mean	Std. Dev.
NO-COMPETITION	Visual	32.3	23.2
	Somatic	38.3	25.9
COMPETITION	Visual	33.5	30.3
	Somatic	49.0	28.3

Table 5 shows the means and standard deviations for performance errors in the visual and somatic distraction tasks for the no-competition and competition conditions. It can be seen that the percentage errors for the visual distraction task remained relatively stable across the two treatment conditions, whereas the errors appeared to increase for the somatic distracter task between the no-competition and competition conditions. To assess if this effect was significant a repeated measures MANOVA was performed on the performance data. However no significant effect was found ($F(1,18) = 2.20$, $p > 0.05$).

CHAPTER SEVEN

Discussion

Review of Hypotheses and Findings

The literature generally endorses the efficacy of distraction techniques for the attenuation of a range of experimental pain stimuli (Fernandez & Turk; 1989; McCaul & Malott, 1984). The present study investigated the relative effects of different distracter tasks on pain caused by the iontophoretic administration of potassium ions through the skin. The impact of distraction on pain produced by the iontophoretic delivery of potassium ions has not been tested. Moreover, in contrast to research exploring the analgesic effects of counterstimulation, and despite studies demonstrating that visual and auditory distracting stimuli can be used in controlling pain, there is a gap in the literature with regard to the analgesic impact of low level somatic distracting stimuli. The current study included such a low level somatic distracter along with other distracter tasks.

It was hypothesised that the distracter tasks used in this study would be associated with increased pain threshold when compared to a no-distraction control condition. To test this three distracter tasks were used: engaging in neutral imagery; a somatic task requiring subjects to detect small (just noticeable) changes in a base level thermal stimulus set just above body temperature; and a comparable visual task requiring the detection of just noticeable changes in a low level light stimulus. As predicted, all three distraction treatment conditions produced significantly higher pain thresholds than no-distraction comparisons. The first hypothesis, that distraction "works" to attenuate the pain resultant from the iontophoretic administration of potassium ions was therefore supported.

Once it has established that the distracter tasks "worked" the relative efficacy of the distracters was then tested. This research contained no specific hypothesis about the potency of the imagery distracter, but prior research has suggested that imagery techniques (particularly neutral imagery) are among the most effective in controlling pain when compared to other cognitive coping techniques (Fernandez & Turk, 1989). A comparison was therefore made between this imagery distracter and the other distracter tasks. Findings revealed that, on average, the pain threshold measures associated with both the somatic and visual distracters were significantly higher than those associated with the imagery distracter. Thus, the imaginal strategy was found to be the least effective distracter.

Although there were no predictions concerning the potency of imagery there was a prediction concerning the relative potency of the somatic and visual distracters. Based on the multiple resource model of attention (Wickens, 1984) it was assumed that the resources available to execute a somatic task in combination with processing of pain information would be fewer than those available to execute a visual task in combination with pain processing. Thus somatic distracters would be expected to interfere most with the processing of pain perceptual inputs, and hence the second hypothesis predicted that the somatic distracter would be more effective in raising pain threshold than the visual distracter.

If interference between pain processing and the distracter task is expected to impact on pain perception, it logically follows that this same interference effect may potentially impact on distracter performance. Considering that a greater interference effect is expected in the presence of the somatic distracter, it also seems to follow that performance of the somatic distracter would suffer most. The third hypothesis therefore predicted that a higher performance error rate for the somatic distracter task would occur after the onset of the iontophoretic stimulation than would occur under similar conditions for the visual distracter.

However, despite directional findings, the predictions of the second and third hypotheses were not supported. Pain threshold under somatic conditions did not differ significantly from visual, nor was there any greater performance error rate associated with the somatic distracter.

The fourth hypothesis, predicted that both the second and third hypotheses would be supported. However, this was clearly not found to be the case.

Theoretical Implications

The imagery distracter.

Fernandez and Turks (1989) meta-analysis indicated that neutral imagery techniques were the most effective in attenuating pain when compared to a number of other cognitive pain management techniques. The imagery task used in this study was modelled on the neutral imagery strategy found to be the most effective by Fernandez and Turk (1989). Despite this, the imagery distracter was demonstrated to be the least effective of all when compared to the visual and somatic distracter tasks. This certainly questions the validity of drawing too strong conclusions from Fernandez and Turk's meta-analytic study without direct experimental validation.

In terms of McCaul and Malott's model (1984), it may be that processing of the imagery task required less resources than those needed to process the other distracter tasks, and was thus less likely to impinge on pain perception. However, such speculation is difficult to verify because the exact processes underlying imagery are hard to determine.

The low impact of the imagery distracter could also be attributable to some subjects failing to engage in the stipulated imagery task; a problem also found by other investigators (Avia & Kanfer, 1980; Scott, 1978; Scott & Barber, 1977). Unfortunately, the nature of imagery manipulations makes it difficult to monitor objectively the extent to which an individual engages in such tasks. This is why it has been recommended that studies should include manipulation checks to ensure that subjects use the strategies given by the experimenter (Turk, Meichenbaum & Genest, 1983). In contrast to imaginal conditions, both the visual and the somatic distracter tasks of this study included such manipulation checks by measuring task performance throughout. Because subjects were aware that their performance was being monitored by the experimenter, they would be more inclined to be continually engaged in them.

The somatic and visual distracters.

This study showed some preliminary evidence demonstrating that external stimuli presented via the somatic modality can be used to alter pain perception. However, it is notable that predictions of potency were not supported: the somatic distracter was not seen to inhibit pain response more than the visual distracter. Possible explanations for this unexpected result may be suggested by further examination of the theoretical extensions which produced the initial hypothesis.

In this study dual-task research and specifically the multiple resource model of attention (Wickens, 1984) were invoked to extend McCaul and Malott's (1984) attentional model of distraction analgesia. According to McCaul and Malott, distraction has its analgesic effect by interfering with the limited attentional resources available for pain sensory processing. The multiple resource concept holds that two concurrent tasks interfere with each other only to the extent to which they share the same specialised resources (Navon & Gropher, 1979; Wickens, 1984). Further, Wickens claims that these specialised resources tend to be distributed (at least to some extent) according to sensory modality. This is demonstrated by attentional research showing that tasks involving the same modality become disproportionately difficult when performed together, whereas tasks involving different modalities can be performed simultaneously with relatively less performance decrement (Kahneman, 1973; Segal & Fusella, 1970; Treisman & Davis, 1973). It follows that by assessing wether two concurrent tasks share the same processing modality, the multiple resource model can be used to potentially predict interference between tasks. Dual-task interference will tend to be low when tasks involve processing in different modalities, and (conversely) when tasks involve the same modality, interference will tend to be greater.

Accordingly, in this study the modal differences between the visual and the somatic distracters were expected to impact differently on pain. Because processing of the somatic task and pain-information processing were more likely to be competing for the same modally distributed resources, the somatic task was predicted to be analgesically more potent. In contrast the visual distracter was considered to be more inclined to use separate resources from those used to process pain, and thus was expected to have a lesser analgesic effect.

One reason why the current findings appear to run counter to the assumptions supplied by the multiple resources concept may be partly related to resource divisions in the somatic modality. Wickens (1984) stresses that the multiple resource model was constructed to account for empirical findings of dual-task research. The studies in this area tend to involve tasks executed primarily in the auditory and visual modalities. The Wickens model may therefore require some elaboration if it was to be extended to account for research involving the somatic modality.

Considering the various sensations represented in the somatic modality, logic suggests that resource divisions could perhaps be drawn more finely within this modality. If this were the case it is possible that the somatic distracter and the pain stimulus of this research were not sharing a common "pool" but were, in fact, using separate resources. Consequently, predictions of greater interference between pain processing and the somatic distracter may be invalidated because of such resource splitting. Other researchers have also recognised the predictive limitations of the multiple resource concept as the number of separate resources proliferate (Navon & Gropher, 1979; Wickens, 1984). The unexpected findings of this research may suggest that further exploration in this area may be worthwhile. Wickens suggested that the notion of competing resources is conceptually allied to two tasks competing for the same functional cerebral "space", and proposed that a way of testing this is by comparing brain correlates of different tasks. Perhaps if the iontophoretic stimulation and the heat detection task used in this study were compared in this way, they may be confirmed to be using different neural processing mechanisms.

A second possibility is that salience of the sense modality may also effect a distracter task's ability to captivate attention. Vision is one of our most prominent senses. In fact it is estimated that of all the senses vision provides some 75% of the total input to the brain about the environment (Overington, 1976). It may well be that the analgesic benefits caused by the modal similarity of the somatic distracter were overridden by the superiority of the visual distracter in captivating attention.

The current findings in relation to Riley and Levine's study

Both this study and Riley and Levine's (1988) study predicted that pain would be interfered with most, and thus reduced most, in the presence of another somatically delivered stimulus. These predictions were based on both an information processing conception of pain modulation (McCaul & Malott, 1984), as well as research from the attention literature suggesting that greater interference occurs between tasks when they possess similar sensory features. Moreover, both studies predicted that this same enhanced interference effect between pain processing and the somatically delivered stimulus would lead to a greater alteration in the perception of the somatic stimulus when compared to perception of a stimulus delivered to a different sensory modality. In Riley and Levine's study both of these predictions were supported. In contrast this study supported neither of the predictions.

There could be a number of reasons why this study failed to replicate the findings of Riley and Levine (1988). Although both studies were compatible in terms of their rationale, they both differed in terms of the protocol they used to test their predictions. As outlined in a previous section, the experimental design used by Riley and Levine did not manipulate attention away from the pain stimulus or towards what they saw to be the distracting stimuli -- as does typical pain-distraction research. Furthermore, the nature and the placement of the somatic distracter used in Riley and Levine's study permitted an alternative explanation that a counter-stimulant mechanism (Favale & Leandri, 1984) could well be responsible for the analgesic effects under somatic conditions. In contrast, this study did manipulate the subjects' attention towards the external distracting stimuli, and the nature and placement of the somatic distracter stimulus should have lessened the likelihood that the analgesic effects were achieved via counter-stimulant mechanisms. Thus the analgesic effects produced in the current study could be more reasonably assumed to comply to the attentional mechanisms outlined by McCaul and Malott (1984). Based on this preceding the discrepancies between this study and that of Riley and Levine (1988) may be because different analgesic mechanisms were at work in each study.

Conceptually it may well be that both studies ask as many questions as they answer regarding McCaul and Malott's (1984) model. Both studies predicted that somatic distracters would be superior to comparable distracters presented via other modalities because they would cause greater interference with the processing of pain perceptual inputs. However, in the current study this prediction was not confirmed, while Riley and Levine's positive findings may have been produced by a confounding element. Clearly further research will be necessary to determine a theoretical basis for predicting analgesically potent distracting tasks.

Methodological Issues

Pain measures

A critical issue in this study was using a pain measure which would be most sensitive to the effects of distraction. Some of the more commonly used measures of experimental pain have been: tolerance; threshold; and intermittent pain ratings. However, there is some indication that tolerance may not be a very sensitive measure of the pain attenuating effects of distraction (McCaul & Malott, 1984), particularly when affectively neutral distracters are used (Hodes, Howland, Lightfoot & Cleeland, 1990).

Hodes et al. demonstrated that distraction lowered pain ratings obtained early during cold-pressor stimulation, but had no effect on tolerance measures. They reasoned that this differential impact on pain outcome measures was because the affectively neutral distracters (doing arithmetic tasks) used in their study were only effecting the sensory, rather than the affective aspects of pain processing.

According to multidimensional models of pain (eg Leventhal & Everhart, 1979), pain processing is believed to involve both sensory, as well as affective/reactive components. Hodes et al. (1990) considered pain ratings to be measures of the sensory aspects of pain, and tolerance more a measure of the emotional/reactive pain system. Thus, it was assumed their findings were because only the sensory components of pain were being altered by the affectively neutral distracters used in their study. On the other hand, they assumed that mood manipulations like positive imagery, would interfere more with emotional/reactive processing and, so impact more on pain tolerance.

Tolerance was not used as a measure in this study, as the distracter tasks were considered to be affectively neutral and more likely to impact on the sensory rather than the affective dimension of pain (Hodes et al., 1990). Further, despite the preceding evidence that intermittent pain ratings are more likely to measure the sensory aspects of pain (Hodes et al., 1990), it was decided that these measures would not be used -- as this procedure appears to manipulate attention towards pain, and has been found to increase reports of pain intensity (Levine et al., 1982). Instead, this study used threshold as a measure because it was also likely to be representative of the sensory dimensions of pain. It was reasoned that threshold would be particularly useful in this study because it allowed for quick simple measurement, and (because prolonged noxious stimulation is not required to make a threshold response) it reduced the likelihood of sensitisation or habituation due to repeated administrations of the pain stimulus.

However, pain threshold may, in fact, not have been the most sensitive measure for all the distracters used. The reason why the imaginal distracter did not prove to be particularly potent in this study may have been because it acted on an aspect of pain processing not represented by threshold response. Given that the required imagery in this study involved reflecting on real life experience, it is not unlikely that this task aroused some emotion (at least more than the other sensory detection tasks). Relating this notion back to the predictions of Hodes et al. (1990), it may be that the imagery task would have impacted more on pain tolerance measures. Perhaps future work in this area would benefit from exploring the relative impact of different distracters on different pain outcome measures.

The distracters

It has been mentioned previously that one possible reason why the somatic distracter did not prove to be more potent than the visual distracter could be related to the salience of the visual modality. This study attempted to equate the visual and somatic tasks in terms of task difficulty, stimulus configuration, and detection responding. However, despite the fact that only a 6% difference existed between the mean performance errors for the visual and somatic detection tasks, and despite the fact that the visual and somatic stimulus presentations were tailored for each subject on the basis of their jnd data -- there was still a great deal of difference between subjects on these tasks. Future research in this area might benefit from finding more effective ways of matching visual and somatic tasks in order to lessen the variability between subjects.

Future Research

Besides the areas of further interest that have already been introduced, a number of other issues may also prove interesting for further exploration. The finding that the somatic distracter was no more potent than the visual distracter not only challenges the predictive utility of the multiple resource model (eg. Wickens, 1984) for distraction analgesia, but also poses some questions regarding the information-processing mechanisms believed to underlie the workings of distraction. Further research might benefit from exploring if endogenous opiate mechanisms are involved in distraction analgesia by testing to see if a naloxone block would reverse the analgesic effects of different kinds of distracters.

While a significant difference was not found, the somatic distraction was demonstrated to be directionally more effective than the visual distracter in attenuating pain. This raises the question of wether the present study yielded sufficient power to test the underlying predictions concerning distracter potency. Future research might clarify this issue by increasing the number of subjects. Perhaps an effect (although probably small) would then be demonstrated.

However, even if a somatic distracter was found to be more potent than a visual distracter, the relative analgesic benefits of this finding would probably not achieve any substantial clinical utility. This would particularly seem to be the case when considering not only that the difference probably would not be that large, but also the practicality of administering a somatic distracter in a clinical setting would be limited. It would be much easier to tell someone to focus on a visual distracting task rather than going through the effort of attaching a thermal device to some part of a patient's body (Unless of course the device was already attached).

Regarding this issue another consideration arises. Given that the analgesic mechanisms of counterstimulation and distraction appear to be different, it may well be that a combined procedure invoking both mechanisms would be analgesically more potent than either process on its own. Further investigations may explore this possibility by comparing the effects of a somatic counterstimulus by itself with the same procedure plus instructions for subjects to focus their attention on the sensations produced by that counterstimulus.

Future research might also explore the utility of the current findings for the management of clinical pain. The iontophoretic administration of potassium ions is more likely to resemble instances of acute clinical pain than that of chronic pain. Moreover Hodes et al. (1990) predicted that affectively neutral distracters (such as the somatic and visual distracters used in this study) would be more inclined to reduce relatively short lived acute clinical pain such as that of lumberpuncture and venipuncture. Accordingly, a study could be designed to test the clinical utility of the present distracters in a clinical setting using injection pain. If (as it was found in this study) there is no difference in potency between somatic and visual distracters, it may be that the latter would be the preferred clinical treatment because of its ease of administration. Subjects would merely be required to watch a screen and respond according to task requirements -- somewhat like the typical video game.

Distraction produced by playing video games has been used with some success in reducing stress during operative dental procedures (Corah, Gale, Illig, 1979). It remains unclear if similar tasks would be useful in controlling pain. Given the reward contingencies, the active participation, and the high attentional requirements of video games (particularly for children), it may be that these would prove particularly useful for the management of acute clinical pain in children during dental procedures, or in instances of post operative pain. However, this speculation would again need to be validated by further research.

Research Summary

This study set out to explore the impact of 3 different types of distraction on pain. Findings demonstrated that all were effective in raising pain threshold. However, despite meta-analytic research (Fernandez & Turk, 1989) suggesting that neutral imagery could be analgesically more potent, this study found imagery to be the least effective distracter. This was discussed in relation to; McCaul and Malott's (1984) model, subjects failing to engage in their stipulated tasks, and the necessity for experimental validation of Fernandez and Turk's findings.

Further, despite prior research by Riley and Levine (1988), as well as predictions derived from the attention literature (eg. Wickens, 1984), the somatic distracter was demonstrated to be no more potent than a comparable visual distracter. This finding was discussed in relation to the analgesic mechanisms believed to be responsible for the outcomes of this study and those of Riley and Levine. Further explanations for this unexpected finding were discussed in relation to visual salience, as well as the possibility of "resource splitting".

Finally some issues related to future research were considered. It was seen that while the threshold pain measure may have been appropriate for this study, further studies could benefit from exploring the effects of different types of distracters on other pain outcome measures. Questions were also raised regarding the exact processes underlying distraction, and some possibilities to explore in a clinical setting were discussed.

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APPENDIX A

Subject Information Sheet

Pain and Distraction

Pain is a complex and poorly understood phenomenon. Obviously, increasing our understanding of how pain works will help to develop ways to assist the many individuals who suffer pain. We know that a number of psychological factors can have an important bearing on the degree and extent of pain experience. The study you requested to participate in is one of a series of studies designed to look at the influence of attentional factors on pain responding and recovery.

The method of stimulation used in this study uses an electric current to administer potassium ions. The procedure does not involve electric shock and is not dangerous in any way. You will simply be asked to remove your hand from a button when the stimulation becomes painful. This will terminate the stimulation. Simultaneously with the pain stimulation you will be required to do three things in turn: to detect the change in a thermal stimulus; to detect the change in a visual stimulus; and to engage in neutral imaginings (this will be explained to you). You will be required on two consecutive occasions, with each session taking about 30 minutes.

Guy Breakwell
Department of Psychology
Massey University

APPENDIX B

Subject Consent Form

I have read and understood the subject information sheet and I understand that my participation in this study will involve some discomfort. I am aware that I can with draw from the study at any time. I am prepared to be a subject in this study.

Signed Date

Witnessed Date

Contact address for results:
(if required)

APPENDIX C

Medical Checklist

Subject name...................................

Please answer the following questions:

1. Have you ever had any form of epilepsy ? yes/no

2. Are you currently using any medication of any type ? yes/no

3. Do you have any known heart or circulatory condition? yes/no

4. Are you in good health ? yes/no

5. In the past 6 months have you suffered from any painful injury or condition lasting more than a week ? yes/no

6. Have you ever had any injury or medical condition that may effect your ability to sense pain ? yes/no

7. Do you suffer from any skin disorders ? yes/no

Signature................................. Date...........

APPENDIX D

Study Review Sent to Subjects

Dear

This letter is firstly to thank you again for your participation in the pain and distraction research you were involved in, and secondly to inform you of the outcomes of the study.

As you are aware, we were looking at different types of distraction and their effects on pain. Three distracter tasks were used: an imagined situation; a light detection task; and a heat detection task.

The reason we used both light and heat detection tasks was to test, and possibly extend, a specific theory about how distraction works. In order to explain this, something must first be said about the nature of attention.

It can be seen from every day situations that people have difficulty in doing more than one thing at once (such as reading a novel and carrying out a serious conversation at the same time). This is because one task tends to interfere with the ability of the brain to process the other. Further, some psychological research has shown that certain tasks tend to interfere more with one another than others, and that the manner by which we process these tasks tends to be a factor in determining the degree of this interference. This principle is reflected by the common observation that we tend to experience difficulty when trying to do two tasks that both involve one of our senses, such as listening to two conversations at once. However listening to a conversation and doing a task that involves our visual sense (like watching a sports match) can be done together far more easily. One theory in the area of cognitive psychology has speculated that these kinds of observations may be explained by the way attention is ordered in the brain. It holds that our attention is divided into different pools for each of our modes of sensing. Thus, when two tasks involve one of our senses they are more likely to be competing for the same pool of attention and consequently they are more likely to interfere with one another.

Similar principles such as those mentioned above are believed by some researchers to effect the way pain is perceived when our attention is focused on some kind of distraction task. If this is the case it may be predicted that distracters presented to our tactile sense would be more inclined to effect pain than distracters presented to our visual sense. This is because (as the theory goes) both pain and a tactile distracter would be more inclined to be competing for the same pool of attention and so be interfering with one another more.

The research in which you participated set out to test this prediction. We compared the effects on pain produced by a light distraction task (using the visual sense) and a similar heat distraction task (using the tactile sense). An additional comparison was also made using an imagined distraction task because some pain researchers have found these types of distracters to be particularly powerful in reducing pain.

We found that all three of the distracter tasks reduced pain when compared to times when distraction was not used. However, contrary to our predictions the tactile distracter was not demonstrated to be any more effective than the visual distracter. Further, despite prior research that has found imaginal techniques to be particularly effective in lowering pain perception, the imagined task was found to be the least effective distraction.

Although the study demonstrated that distraction does, in fact, lower our perception of pain, the specific predictions concerning the potency of the tactile distracter were not supported. This finding challenged the predictions of prior researchers and left some remaining questions regarding theories about the mechanisms of how distraction influences pain.

The outcomes of the study have provided some interesting findings and these could not have been achieved without your participation. Thanks again for your time and help. If there are any further queries you may have about this research, please feel free to contact me.

Regards

Guy Breakwell