The Use of Mental Imagery

to Improve Sporting

Performance

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DEDICATION

To my wife Lise and my family, Michael, Monique, Marc, Madeleine and Oliver. Thank you for your support, love and understanding during the seemingly endless years of study.

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ABSTRACT

The purpose of this study was to examine the effect of mental imagery training on the serving performance of elite junior tennis players. A multiple baseline across subjects design was utilised. Four junior tennis players from the Wellington Regional Tennis elite training programme carried out 29 trials in which twenty serves were observed for accuracy. Baseline measures of tennis serving accuracy were obtained. Consistent with a multiple baseline design, the intervention was introduced at different times for each subject. The baseline measures of tennis serving accuracy were then compared with tennis serving accuracy following the mental imagery intervention. Serving accuracy was then plotted for each trial and subjects' graphs were visually inspected for intervention related change against the baseline performance level. A significant improvement in tennis serving accuracy following intervention was demonstrated for all subjects by statistically significant t-tests ($p < 0.05$). These results supported the experimental hypothesis that mental imagery training would be effective in improving physical performance of elite junior tennis players. It addition to its usefulness in improving physical performance, mental imagery has the advantages of having no risk of injury and is able to employed outside of normal practice sessions.

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THE USE OF MENTAL IMAGERY TO IMPROVE

SPORTS PERFORMANCE

Researchers and athletes have long recognised the performance benefits of physical practice. However, the latter part of the twentieth century has seen a broadening acceptance of alternative methods to improving physical performance. This change is, due in part, to a philosophical move away from strict Watsonian and operant behavioural theories towards more cognitively orientated theories. Yuille (1983) argues that the decline of behaviourism as the predominant psychological school of thought began in the 1940's when North American psychology began to embrace unobservable cognitive constructs, such as drives and habits. From this time on, behaviourism became a loose set of assumptions about psychology rather than a solitary theoretical stance. With this change in philosophy, came an increase in the importance of cognitive theories. Subsequently greater attention has being paid to, for example, the effects of mental imagery on physical performance.

Since the 1960's mental imagery has been given considerable attention in the sports psychology literature, as evidenced by the number of reviews on the subject (Corbin, 1972; Feltz & Landers, 1983; Feltz, Landers & Becker, 1989; Grouious, 1992; Janssen & Skeikh, 1994; Murphy, 1990; Oxendine, 1968; Richardson, 1967a, 1967b, 1980; Singer, 1972; Weinberg, 1982). The majority of these reviews have concluded that mental imagery, especially when combined with physical practice, facilitates motor performance. In addition, meta-analytic studies on this topic have provided consistent

empirical support for the beneficial effects of mental imagery on physical performance (Feltz & Landers, 1983; Feltz, Landers & Becker, 1988).

The following sections will introduce the purpose and hypotheses of the current study, provide clarity regarding definitional terms, and review, firstly, literature on the efficacy of mental imagery on physical performance and secondly, literature on the efficacy of mental imagery as specifically related to tennis performance. The theoretical basis for mental imagery, followed by an investigation of mediating variables, then provides a rationale and justification for the experimental design.

PURPOSE OF STUDY

The primary intent of this study was to investigate the efficacy of mental imagery on physical performance among a group of elite junior tennis players (aged 14 –16). While a number of previous studies have also utilised tennis for investigating mental imagery training, none have specifically focussed on junior elite tennis players. Furthermore, few previous studies have utilised a single subject multiple baseline across subjects design, as is used in this study. By using a multiple baseline design it was hoped that analytic and methodological limitations would be reduced, and that a clearer demonstration of the impact of mental imagery training in an applied setting would be achieved. To maximise this impact, the mental imagery training utilised a broad range of cognitive mechanisms, including kinesthetic, visual, tactile and emotional dimensions.

HYPOTHESES

The experimental hypothesis is that mental imagery training will improve the accuracy of subject's tennis serves. The null hypothesis is therefore, that there will be no improvement in physical performance (as measured by the accuracy of tennis serving) following a period of mental imagery training. By virtue of the research design, these hypotheses were operationalised in terms of a difference in the accuracy of tennis serving pre and post mental imagery training.

DEFINITION OF TERMS

In discussing mental imagery it is important to firstly define the term *cognition*. For the current purposes a broad functional definition of cognition is posited. Cognition is defined as "the mental processes involved in the acquisition of knowledge" (Weiten, 1992). This definition therefore assumes little distinction between the terms 'mental' and 'cognitive' - and as such, they are used interchangeably in the current thesis.

Mental imagery refers to the cognitive rehearsal (i.e. mental processing) of a task in the absence of overt physical movement. Richardson (1967a, p.95) provided the standard definition of mental imagery as "the symbolic rehearsal of a physical activity in the absence of any gross physical movements". This approach has also variously been labelled *imagery practice* (Perry, 1939), *covert rehearsal* (Corbin, 1967), *symbolic rehearsal* (Sackett, 1934), and *introspective rehearsal* (Egstrom, 1964). Richardson (1969, p. 2-3) further expanded his definition of mental imagery to the following:

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"(a) All those quasi-sensory or quasi-perceptual experiences which (b) we are all self-consciously aware, and which (c) exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts, and which (d) may be expected to have different consequences from the sensory or perceptual counterparts."

Richardson (1983, p. 15) subsequently refined this definition to exclude the fourth criteria ('d' above), stating that "there is increasing evidence that self-initiated thought imagery ... can have consequences that appear indistinguishable from their genuine sensory counterparts". It is this refined definition that is adopted for the current study.

For the current purposes it is perhaps most pertinent to attempt to differentiate the meaning of mental imagery from the broader term of mental preparation. Mental preparation refers to a variety of disparate techniques that share a common goal of enhancing performance, including attention focusing, relaxation, 'psyching-up', self-efficacy statements and other forms of cognitive and emotional preparation *directly* prior to performance (Hardy, Jones & Gould, 1996; Richardson, 1983). However, this distinction remains rather simplistic. Despite considerable effort, the mental imagery literature remains contentious with respect to more precise distinctions between mental imagery and mental preparation (Murphy & Jowdy, 1992; Suinn, 1983). In reality, it would appear that the term's mental imagery and mental preparation are virtually indistinguishable, however for the sake of clarity the term *mental imagery* will be primarily used in the current discussion[1].

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[1] It should be noted that the term's *mental practice* and *mental imagery* are often used synonymously in the literature, however where possible the single term of mental imagery will be employed.

RESEARCH INVOLVING IMAGERY AND PERFORMANCE

The origins of mental imagery can be found in the early writings of Washburn (1916, cited in Weinberg, 1982). She contended that slight muscle movements were made when a person imagined himself/herself to be engaged in activity. In addition, she proposed that the muscular movements produced through imagery were identical, except on a smaller magnitude, to the muscular movements of the actual activity. The first empirical support for Washburn's hypotheses came from Jacobson (1932). Jacobson was able to show, through the use of electromyography, that actual muscle contractions occurred only in the muscles that were involved in the imagined activity. For example, if the subject was asked to imagine lifting a weight with their arm, only those muscles involved in the physical task (i.e. arm, shoulder, neck, and chest) were stimulated. This therefore suggests that cognitive processes, and specifically mental imagery, can affect physical performance. While not yet directly addressing the issue of whether mental imagery can *improve* physical performance, Jacobson did provide important information about the inter-relationship between practicing a skill mentally and the concomitant muscular reactions produced by this activity. As will become apparent, this finding has significant theoretical implications.

Sackett (1934) was the first to specifically test the effect of mental imagery against physical practice. Utilising a maze retention task, Sackett found that physical practice was superior to mental practice, but that mental practice was nonetheless effective in improving performance (as measured by accuracy). Similarly, Vandall, Davis and Clugston (1943) investigated the role of mental imagery on the accuracy of dart

throwing performance and concluded that mental imagery improved performance almost as much as physical practice.

In 1967, Richardson conducted the first extensive review of the research examining the effects of mental practice on performance. He concluded that, overall, mental practice was effective in improving performance. For example "the trend of most studies indicates that mental practice procedures are associated with improved performance on a task" (Richardson, 1967a, p. 102). Corbin (1972) also reviewed the mental imagery literature and reached the more tentative conclusion that mental practice was preferable to no practice at all. In 1982, Weinberg found that the majority of studies showed that mental practice was an effective means of increasing performance. In Martens (1982) review, 30 studies were cited in which mental imagery improved motor performance, whereas only 4 studies showed no improvement.

Feltz and Landers (1983) undertook the first comprehensive meta-analytic review. From the review of 60 studies (yielding a total of 146 effect sizes), they obtained an average effect size of 0.48. This suggests that mentally practicing a motor skill improves performance better than no practice at all. Additional analyses carried out by Feltz, Landers and Becker (1988) showed that mental imagery effects were much larger for tasks that possessed a major cognitive component than they were for motor or strength related tasks. A more recent meta-analysis undertaken by Driskell, Copper and Moran (1994) concluded, "mental practice has a positive and significant effect on performance" (p. 481).

In summary, there exists a considerable wealth of empirical data to support the suggestion that training via mental imagery is a valid and reliable way to improve physical performance. This has been demonstrated across a variety of physical performance tasks, including a multitude of sporting tasks as diverse as ski racing (Suinn, 1972), basketball (Shambrook & Bull, 1996: Zeigler, 1987), rugby (McKenzie, 1989) and tennis (Noel, 1980).

Given the focus of the current study, the following section will review the mental imagery literature pertaining specifically to the sport of tennis.

IMAGERY TRAINING AND TENNIS

Over the last two decades the production of sports psychology literature on improving tennis performance has been prolific (Weinberg, 1988). A number of explanations exist as to why tennis has received so much attention in the mental imagery literature. Weinberg (1988) identifies three major explanations; firstly tennis is a very precise game that requires an exacting combination of timing, co-ordination, agility, stamina and judgement (for example, Weinberg (1988) states that in the average tennis match, players will make approximately 900 – 1000 decisions, each of which have to be made in fractions of a second). Secondly, from a biomechanical perspective, contact between the tennis racket and the ball requires a sophisticated level of precision, where fractions of a degree make the difference between a 'winner' and a bad shot. Thirdly, the intermittent nature of tennis, whereby players stop between each and every point distinguishes it from other 'constant' sports such as basketball and soccer. This 'down-time' presents the player with ample opportunity to both mentally review and preview

aspects of their game, which may of-course have either positive or negative consequences. For the unsophisticated or cognitively naïve player, this thinking time may allow distraction and irrelevant thoughts to enter the mind, thereby disrupting timing and co-ordination and ultimately, success. Given tennis' intrinsic vulnerability to mental influence, it quickly becomes apparent that to achieve optimal physical performance, tennis players must also maximise their cognitive ability. As a final point, it is important to acknowledge that the sheer popularity of tennis and the large financial benefits enjoyed by tennis players (over other similar sports which may also lay claim to similar attributes (e.g. squash), makes it a very fashionable sport, not only for participation, but also for research.

There exists a large body of literature on the effects of various cognitive strategies and techniques on the tennis player - whether it be a first time junior school player, or the top ranked seasoned professional. This literature is unanimous in emphasising the significant contribution that mental phenomenon play in the game of tennis (Gallwey, 1974). Take for example the titles of some recent tennis coaching books; *Smart Tennis: How to play and win the mental game* (Murray, 1999), *Mental training for tennis* (Sailes, 1995), and *Visual Tennis: Mental imagery and the quest for the winning edge* (Yandell, 1990). These books all emphasis the vital role that cognitive preparedness, and particularly mental imagery, play in the development and maintenance of superior tennis skills. Similarly, many professional tennis players accent the importance of mental aspects in successful tennis. For example, Jimmy Conners stated that he felt tennis was 95% mental at the professional level (Weinberg, 1988). Similarly, Chris Event, in the forward to James Loehr's book *The New Toughness Training for Sports* (1994)

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espouses the vital contribution that mental strategies played in her winning 21 Grand Slam titles.

Loehr (1994) has written extensively on the application of mental imagery strategies to the game of tennis. Simply put, Loehr's techniques revolve around teaching players "mental toughness". To do so he employs various mental imagery techniques, mental rehearsal techniques, and self-motivation techniques. Loehr's approach to mental imagery is broadly consistent with the attention / arousal set theory (see following section), in that he emphasises the importance of player's finding their own 'Ideal Performance State'. Loehr believes that this optimal state of arousal facilitates performance by reducing the disruptive influence of unwanted emotions and cognitions. Unfortunately Loehr's writings, while having widespread popular appeal, are not backed by empirical evidence. Similar limitations restrict other popular authors, including Terry Orlick and his seminal publication, *In Pursuit of Excellence: How to win in sport and life through mental training (1990)*. Nonetheless, this popular-branded literature does provide a useful introduction to the application of mental imagery techniques to improve tennis performance.

A limited number of scientific studies also support the application of mental imagery training to tennis. Defrancesco and Burke (1997) examined the training strategies employed by a large sample of professional tennis players. Results indicated that higher ranked players attributed more of their performance to psychological variables than lower ranked players did. For example, 93.8% of the highest ranked players employed the mental strategy of imagery, 100% employed mental preparation, and

93.8% relaxation. This compares with 85.4%, 95.1% and 82.9% respectively, for the lowest ranked players.

Noel (1980) provided one of the first empirical studies of imagery training using tennis players. Noel compared the additive effects of imagery training, utilising the VMBR (visuo-motor behavioural rehearsal) paradigm, against the effects of regular physical practice. Noel observed an interaction effect, with higher ability players improving with the VMBR training, but lower ability player's performance declining with VMBR training. No change pre to post were observed for the control (physical practice) group. This study therefore provided qualified support for the hypothesis that mental practice improves physical performance in the sport of tennis. As Noel (1980, p. 225) concluded "...mentally rehearsing the tennis serve while relaxed may facilitate serving performance under actual tournament conditions, but only for high-ability players". Unfortunately Noel fails to make comment on whether his definition of "high-ability" extends to elite junior tennis players.

Additional support for the efficacy of mental practice on tennis performance is provided by Atienza, Balaguer and Garcia-Merita (1998). These authors compared 3 groups of junior tennis players who were exposed to (1) physical practice only, (2) physical practice plus video modelling, and (3) physical practice, video modelling and imagery training. Results indicate that the physical practice group did not improve pre to post test, whereas both the experimental groups showed statistically significant improvements on tennis performance with the mental imagery group improving the most. This result therefore suggests that imagery efficacy is dependant on more than

just ability per se. It also provides support for the use of an imagery intervention with junior tennis players.

However not all studies have unanimously supported the efficacy of mental practice in tennis performance. Daw and Burton (1994) concluded that while players subject to a psychological skills training programme (goal setting, imagery, and arousal regulation) reported feeling as though their game had improved, they could not detect any statistically significant difference on quantitative measures.

Other studies have investigated the performance relationship of such diverse factors as self-talk (Van Raalte, Brewer, Rivera, & Petitpas, 1994), coaches' use of metaphor (Efran, Lesser, & Spiller, 1994), coaches' use of self-efficacy building strategies (Weinberg, Grove, & Jackson, 1992), and advanced relaxation strategies (REST environments: McAleney et al., 1990).

Conclusion

The majority of top level players agree that mental imagery training improves their tennis performance. Take for example this quote from tennis legend Billie Jean King "I see one coming and visualise where I'm going to hit it, and the shot's perfect – and I feel beautiful all over" (Murray, 1999, p. 71). However despite substantial anecdotal evidence and limited empirical support, there is still much to be researched regarding mental imagery training and tennis. The current study hopes to make a contribution to the knowledge regarding the efficacy of mental imagery training in improving physical performance of tennis players. Firstly however, it is necessary to review theoretical

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approaches to mental imagery and to examine mediating variables on the effectiveness of mental imagery training.

THEORIES OF IMAGERY: How Does Imagery Affect Behaviour?

Despite robust support for it's efficacy, there is little understanding of how exactly imagery affects behaviour. In the following section the various theories and research pertaining to how imagery influences performance behaviour will be reviewed. The four major theories that dominate the literature are first reviewed, followed by a discussion of other, less well validated theoretical considerations.

Symbolic Learning Theory: A Mental Blueprint?

The symbolic learning theory posits that movement patterns are symbolically coded into the central nervous system (Sackett, 1934; 1935). Keele (1977) stated that an integral component of this theory is the concept of propositional networks. Propositional networks refer to information, including image-based information, that is coded in memory in an abstract form rather than as a separate mental picture or verbal representation (Bird & Cripe, 1986). These propositional networks thus create a mental blueprint of the required motor task. The more automated the recall of this blueprint the better the execution of the task. Support for the symbolic learning theory is taken from those studies that show greater efficacy of mental practice for cognitive tasks as opposed to motor tasks. For example Hird, Landers, Thomas, and Horan (1991) found, after imagery, greater gains on a peg board task (defined as cognitive) than a pursuit rotor task (defined as motor). Feltz and Landers (1983) and Feltz et al. (1988) reached

similar conclusions in their meta-analytic studies, which demonstrated that effect size was larger in studies that used cognitive rather than motor or strength tasks. Feltz and Landers (1983, p. 45) conclude "...the distinction between symbolic and motor aspects of motor skill learning are very robust and provide very strong support for the symbolic learning explanation". According to Driskell, Copper and Moran (1994) the weight of evidence firmly supports the symbolic theory, at least to the extent that skills requiring less physical effort benefit more that those requiring greater effort and presumably entailing more muscular movement (and hence possessing a more complicated mental blue-print).

However the symbolic learning theory leaves a number of questions unanswered. It adequately explains how early skill acquisition is enhanced by the coding of movement patterns through imagery, but the theory does not explain how performance is enhanced in experienced athletes who already have the movement pattern (and hence propositional network / blue-print) well established (Murphy, 1990). Janssen and Sheikh (1994) also correctly state than it is tenuous to classify a movement as purely cognitive or motor, rather they should be considered to be on a cognitive-motor continuum.

Psycho-neuromuscular Theory

The psycho-neuromuscular theory is based on Carpenter's (1894) ideomotor principle. Carpenter posited that low level nerve impulses are produced during imagined movement, and furthermore, that these neuromuscular movements are identical to those of the actual movement but reduced in magnitude. Thus although no overt

movement takes place, the minute intervention, as evidenced by electromyographic action potentials, is presumed to transfer to the physical practice situation. As previously reviewed, Jacobson's (1932) results provided the first firm support for the presence of this effect. Additional support has since been accumulated by Bandura (1986), Bird (1984), Harris and Robinson (1986) and Suinn (1976, 1980). Suinn (1980) tested the theory, using the imagery training technique he developed called visuo-motor behaviour rehersal (VMBR). By attaching an EMG to the legs of a skier and having him imagine skiing a downhill race, Suinn (1980) discovered that the recorded pattern of muscle movements was almost identical (although obviously at a smaller intensity) to the muscle patterns obtained when actually skiing the course. Bird (1984) conducted a similar study using athletes involved in various sports (riding, rowing, swimming, water skiing, and basketball) and she also found that the EMG pattern recorded during imagery was very similar to that obtained during the actual sporting activity.

However Feltz and Landers (1983) and Hecker and Kaczor (1988) criticised the psycho-neuromuscular theory on the basis that most studies have lacked a control group and thus the quantitative effects are minimised. Furthermore, Hecker and Kraczor claim that the psycho-neuromuscular theory is deficient in explaining the general increase in muscle action potentials that occur throughout the body rather than just in a particular muscle (for example as report by Shaw, 1938; MacKay, 1981; Suinn, 1967). Despite these criticisms, limited evidence such as documented by Hale (1982), suggests that imagery, when *appropriately applied*, may in fact produce localised neuromuscular activity, however such findings are definitely in the minority. In short, further support for the ability of mental imagery to localise neuromuscular activity is required for the psycho-neuromuscular theory to continue in its present form.

Bio-informational Theory

A third possible explanation of how imagery works is Lang's bio-informational theory (1977, 1979). This theory holds that each cognitive image is composed of a set of organised propositions that is stored in the brains long-term memory (Vealey and Greenleaf, 1994). These propositions are divided into stimulus propositions and response propositions. Propositions are neural representations of the stimuli and responses associated with an action. Lang (1979) directs that stimulus propositions transmit information about the imagined environmental stimuli, while response propositions relay information regarding the behavioural activity. For example, imaging shooting a basketball free throw would involve the stimulus propositions of the feel of the ball in the hand, the sight of the basket and the sound of the crowd. The response propositions for this image might include muscular tension in the shooting arm, increased perspiration, feelings of anxiety, and the joyous sight of the ball swishing through the net. According to bio-informational theory, for imagery to facilitate sport performance, response propositions must be activated so that they can be modified, improved and strengthened. By repeatedly accessing response propositions for a particular stimulus situation and modifying these responses to represent perfect control and execution of the skill, imagery is hypothesised to enhance performance.

The thesis of Lang's argument is that imagery is a process that strengthens the links between these two types of propositions. Most simply, all imagined behaviour potentiates stimulus propositions and subsequent reaction by response propositions.

Vivid images allow for a greater detail of stimulus and response propositions to be processed (Suinn, 1994; Budney, Murphy & Woolfolk, 1994).

Prominent among the response propositions are emotional and physiological responses such as fear, excitement, elation, fatigue, perspiration and tension. It is believed that by modifying responses to given situations (i.e. altering the response proposition) through imagery, that the athlete gains more control and hence improves performance. An expanding body of research exists to support the bio-informational theory. Considerable support is taken from the finding that the more personally intensive the imagery (i.e. actually imagining doing the task rather than just watching it), the greater the subsequent improvement in performance (Hale, 1982; Mahoney & Avener, 1977). In addition, the bio-informational theory is bolstered by the finding that experienced athletes benefit more from imagery that do novice athletes (Feltz & Landers, 1983; Weinberg, 1982). It is expected that experienced athletes have a well-established behavioural prototype of a muscle movement. Imagery improves performance by accessing the prototype information and activating the desired response proposition. A novice athlete would presumably have a less well defined behavioural prototype allowing extraneous and deleterious response propositions to be processed and rehearsed in imagery, which of-course would have the over-all effect of interfering with desired performance. This finding is obviously of relevance to the current study, which in attempting to maximise the experimental effect, has employed a sample of elite tennis players, who would therefore be expected to have well defined behavioural prototypes for the desired activity.

An important implication drawn from the bio-informational theory is that sports psychologists and coaches involved in imagery training should include many response propositions when using imagery (Issac, 1992). Simply, the mental imagery training environment should be as realistic to the actual physical environment as possible. Images should contain not only the conditions of the situation (e.g. swimming in a pool, water conditions, crowd behaviour), but also the athlete's behavioural (e.g. swimming strongly, right on pace), psychological (e.g. feeling confident, focusing on the race), and physiological (e.g. feeling energised) responses to the situation. By including these positive responses the image will be more vivid and should thus result in improved performance.

Attention / Arousal Set Theory

A less sophisticated explanation postulated to account for the learning of motor skills through imagery is the attention/arousal set theory. This theory suggests that (1) attentional processes facilitate imagery practice (Vealey & Greenleaf, 1994) and that (2) imagery helps the athlete to set the optimal arousal level and focus attention on the relevant aspects of the task (Janssen & Sheikh, 1994). As previously noted, low muscle innervations (movements) have been observed to accompany imagery training. Schmidt (1982) maintained it is possible that these general minimal tension levels are generated by the athlete as a means to "get prepared for a good performance" (p. 520). Furthermore Schmidt argues that extended imagery training allows athlete's to focus their attention onto task relevant factors; reinforcing specific details, and consequently eliminating disruptive thoughts – thus creating a narrowed, specific course of attention. In this way imagery acts to screen out potential distractions allowing the athlete greater

control and energy to be directed towards the ongoing priming of muscles for action (Feltz & Landers, 1983, Grouios, 1992).

The fundamental weakness of the attention / arousal set theory is that it does not specifically explain how imagery optimises arousal and attention. However from an intuitive perspective, it is obvious that using productive imagery prior to competing can serve to facilitate performance. Thus while there is little direct support for the attention / arousal theory, Feltz and Landers (1983) state that its role can be implied from the types of psychological states that have been found to be most conducive to producing mental practice effects on performance. Muscle action potentials, for example, are enhanced when the subjects are allowed to select scenes with which they are most familiar (Hale, 1981). It is assumed that familiar surroundings allow the athlete to concentrate more attention on to the imagery task, without disruptive or intrusive thoughts.

Other Theoretical Approaches

A number of other theoretical applications have received less widespread attention. These include the ISM triple-code theory, motivational theory and the self-efficacy theory.

Ashen's (1984) ISM triple-code model of imagery specifies three essential parts of imagery. The first part is the *Image* (I) itself, the second part is the *Somatic* (S) response to the image (i.e. that the act of imagination results in psycho-physiological changes in the body (see the section describing the psycho-neuromuscular theory).

The third aspect of imagery, most often ignored by other models, is the *Meaning* (M) of the image. According to Ashen, every image imparts a definite significance or meaning to the individual. Further, every individual brings his or her unique history into the imagination process, so that the same set of imagery instructions will never produce the same imagery experience for any two persons. While theoretically promising, Ashen's ISM model has produced little empirical evidence in its support. Until such time it is obviously limited in its applicability, yet it is fair to say, offers promise for the future.

The motivation theory supposes that performance differences between mental practice and control groups might reflect differing levels of motivation between the groups (Grouios, 1992). Specifically, attention to verbal instructions, demonstrations, or practical help creates an elevated level of motivation in the performer. As identified by Perry and Morris (1995), the mental practice group would have a greater desire to successfully complete the activity because they had prior exposure (through imagery) to the activity. The self-efficacy model also refers to the experimental nemesis, the Hawthorne Effect. The Hawthorne Effect is the experimentally demonstrated tendency for peoples performance to improve, not because of the independent variable, but simply because they know they are being observed or because a change has taken place. This effect is inherent in the vast majority of experimental designs and remains a threat to the validity of the present experiment.

The self-efficacy model (Bandura, 1982) proposes that imagery heightens an athlete's expectation and desire for success, which in turn enhances performance. The additional attention paid to experimental groups (the imagery groups) is one mechanism that may spuriously inflate self-efficacy. Thus the mental practice group would surpass

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the control group because of increased self-efficacy (and hence motivation) to actually succeed at the skill that was imagined. This theory is supported by numerous informal comments made by experimental subjects, such as, that they feel more confident about performing skills following mental practice (see for example Callery & Morris, 1993 and Lee, 1990). Further support is also provided by Weinberg, Grove and Jackson (1992) who studied the frequency of self-efficacious statements made by successful tennis coaches. As they concluded "...before players can feel confident about their strokes during a match, they need to feel confident about them in practice and in simulated competition" (p. 9).

This section has considered a number of attempts to explain the process through which imagery effects motor performance. Despite the large amount of information presented, no single theory stands out as conclusively explaining the mechanisms by which imagery works. Given the huge diversity of evidence that has been adduced for imagery training effects it may be unrealistic to expect one single theory to comprehend all the results obtained. Methodological and analytical limitations have also precluded conclusive support for any single theory. Practical considerations mean that the current experiment does not seek to resolve this ambiguity, however, it is hoped that suggestions and areas for future investigation can be offered. As Perry and Morris (1995, p.355) conclude in their recent evaluation "...research must continue to seek a well-substantiated theoretical basis for the imagery phenomenon".

Despite the uncertainty regarding the exact mechanics of imagery training, one theme continues to dominate the literature - *Imagery training is an effective tool for improving physical performance of an activity.* Thus in an area where results are measured by

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physical performance, this consistent finding has meant that mental imagery continues to be employed as a tool for increasing sporting success. Apparently, understanding exactly why, is a secondary consideration. Driven largely by the demands of sports persons and institutions, researchers have therefore begun turning their attention to determine which specific aspects of imagery are most effective in enhancing physical performance. Based on the inconsistencies across studies in terms of effect size (see for example Feltz & Landers, 1983; Feltz, Landers, & Becker, 1988), it appears that there may exist several factors that mediate the effectiveness of imagery training. The following section will review these mediating factors. This in turn will provide a rationale for why the experimental problem was investigated in the selected manner. Where possible, those aspects that have received the most consistent empirical support (i.e. consistently demonstrated improvement in physical performance efficacy) have been incorporated into the current experimental design.

MEDIATING VARIABLES FOR THE EFFECTIVENESS OF MENTAL IMAGERY TRAINING

Imagery Ability

Intuitively it would seem that mental practice is most effective for those athletes who are well skilled and versed in the actual techniques of imagery training (i.e. they perform the imagery tasks well). Good imagery has been defined by two primary characteristics – vividness and controllability of the image (Start & Richardson, 1964). Vividness relates to the athlete's self-report of the clarity and reality in the image. Controllability is an individual's ability to influence the content of image (Naito, 1994). Start and Richardson

found that subject's who had high vividness and high control improved performance the best. They were followed by those with low vividness and high control, then by those with low vividness and low control and finally by those with high vividness and low control (which may actually be detrimental to performance). Start and Richardson suggested that uncontrolled images lead the mind and body to rehearse movements and situations that may have negative consequences (for example, failure to perform the physical activity as well as desired); therefore it is important for athletes to learn to control their images. For example, an athlete shooting a free throw in basketball may be able to see the image very vividly in his mind, he may picture clearly the backboard and the rim, may feel the texture of the ball in his hand, hear the crowd in his ears, but then mistakenly imagine the ball missing the basket. In this example the inability of the athlete to control this image will have obvious detrimental effects on self-efficacy, self-confidence and ultimately, performance.

Despite early progress in researching this topic, few studies have recently been offered (Budney, Murphy & Woolfolk, 1994). Most support is gained from anecdotal studies which report that skilled athletes have both better control and better vividness than less skilled athletes. So while common-sense supports the pivotal role that imagery ability has in determining the effectiveness of imagery training, little empirical support exists.

Imagery Perspective (Internal verses External)

Mahoney and Avener (1977, p.137) defined imagery perspective as follows;

"In external imagery, a person views himself from the perspective of an external observer (much like in home movies). Internal imagery, on the

other hand, requires an approximation of the real life phenomenology such as that the person actually imagines being inside his/her body and experiencing those sensations which might be expected in the actual situation."

In their study, Mahoney and Avener reported that successful gymnasts used a higher frequency of internal images than less successful gymnasts. Jacobson as long ago as 1932, postulated that internal imagery was more effective than external imagery. Jacobson (1932) suggested than internal imagery elicited more muscle activity than external imagery, and furthermore that internal imagery created localised muscle activity. Similarly, research by Davidson and Schwartz (1977) showed that internal imagery produced "greater somatic arousal and less visual activity" (p.201) than external imagery.

However other studies have failed to replicate these results. The current state of research is far from unanimous in support for the greater efficacy of internal over external imagery. Meyers, Cooke, Cullen, and Lilies (1979) found no relationship between imagery perspective and performance in their study of highly skilled racketball players. More recently, Harris and Robinson (1986) found that internal imagery did produce more muscle efference than external imagery, and that the efference was localised in experienced athletes. Yet somewhat surprisingly they concluded that "the influence of internal/external imagery perspective is unclear" and warrants further discussion (p. 109). They acknowledged that a person's image perspective is extremely dynamic and can not be adequately controlled to yield conclusive results. Janssen and Sheikh (1994) suggest that the choice and ability to adopt a particular perspective may be related to how well the skill is learned. Beginners may rely more on external images;

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whereas, experienced performers may utilise predominantly internal images. The external perspective is probably easier for beginners to master since they have little idea of the mechanics of the movement. Experienced athletes have actually performed the skills or a variation of them and this prior experience can be more easily transferred to internal imagery (Hale, 1994; Mumford & Hall, 1985). As Murphy (1994, p. 490) concludes, "Research that attempts to show internal imaginal rehearsal is better than external imaginal rehearsal is probably fruitless". He suggests that researchers are best advised to investigate whether internal and external imagery training have different associated features such as generating different levels of self-confidence, or having differential effects on identification of technique mistakes.

Positive verses Negative Imagery

The vast majority of mental practice studies have examined the effects of positive imagery, or have at least assumed that subjects were imagining successful outcomes (Moritz, Martin, Hall & Vadocz, 1996). However a small number have examined for the influence of image polarity. Powell (1973) in an experiment with dart throwing discovered that positive, success orientated images improved performance, while negative images adversely affected performance. Gould, Weinberg and Jackson (1980) and Woodfolk, Parrish and Murphy (1980), both concluded that negative imagery rehearsal inhibits performance. In addition Janssen and Sheikh (1994) suggested that the detrimental effects of negative imagery were stronger than the advantages of positive imagery, although they offered no empirical evidence to support this position.

Imagery theories have been slow in their attempt to explain how negative imagery might degrade performance (Bugelski, 1983; Suinn, 1985). Suinn suggested that negative mental practice interferes with the subject's motor program (mental blueprint), thus causing a decline in performance. This proposition is certainly consistent with Start and Richardsons (1964) suggestions on the effect of poor controllability and low vividness as mediating factors in mental imagery efficacy. It is also possible that negative mental practice affects performance through its impact on subject variables such as confidence, motivation, attention and concentration. This would also be consistent with Bandura's (1982) self-efficacy model and the related concept of the Hawthorne Effect.

Role of Relaxation

Considerable effort has been directed towards clarifying the role of relaxation in imagery training (see for example Orlick, 1986). Relaxation is often recommended prior to imagery training. In fact, Suinn's VMBR method (1985) requires beginning each and every imagery session with a relaxation induction. Suinn (1985) and Weinberg et al. (1981) both document considerable evidence that relaxation preceding imagery is more effective than just imagery training alone. Suinn suggests that relaxation aids imagery by reducing somatic tension, eliminating cognitive distractions, and focussing attention. In addition relaxation provides a peaceful state which would seem conducive to producing vivid and controllable mental images. This view is supported by McAleney, Barabasz and Barabasz (1990), who using an experimental Restricted Environmental Stimulation (REST) procedure demonstrated an improved efficacy of mental imagery for the enhancement of physical performance. McAleney et al. argued that the REST

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procedure was instrumental in improving participants relaxation state, and subsequently the vividness and accuracy of the imagery training.

However a number of studies of imagery and relaxation have not found any significant benefits from using relaxation (Murphy, 1994). For example Qualls (1982: cited in Janssen and Sheikh, 1994) suggests that relaxation is inherently in conflict with the response propositions that imagery training is trying to create. The body therefore becomes physiologically confused due to conflicting directions. Similarly Hinshaw (1991) suggests that relaxation may have a negative effect on performance because it inhibits the possible transfer of mental practice to physical performance. Transfer is inhibited due to the differences in physiological state between when the image is rehearsed mentally (relaxed) and when the behaviour is physically completed (aroused).

A small number of authors have also suggested that the advanced relaxation state of hypnosis may be employed to facilitate sports performance (see for example, Morgan, 1996; Robazza & Bortoli, 1994; Stanton, 1994). Unfortunately research on the effects of hypnosis are largely limited to single case study designs. The applicability of such results is therefore questionable given the small effect sizes typically obtained. Significant methodological advances must be made in hypnosis research before the much vaunted effects of hypnosis on sports performance (see Stanton, 1994) can be described as any thing more than exploratory.

In conclusion, support for the effect of relaxation in facilitating physical performance remains equivocal (Janssen & Sheikh, 1994; Murphy, 1994; Perry & Morris, 1995).

While a mild state of relaxation may be useful in precipitating imagery training, total relaxation is likely to impede progress due to poor generalisability of the skills across the differing physiological states.

Open Verses Closed Skills

Poulton (1957) defined closed skills as those performed in a environment where the critical cues for the performance of the skill are static or fixed in one position. Examples of closed skills would include darts, ten-pin bowling, tennis serving or rugby penalty kicks. In contrast, an open skill is one performed in an environment where the conditions are continually changing (Marteniuk, 1976). A tennis rally, boxing, or free flowing play in a game of rugby would be examples of open skills.

The majority of research into the relationship between mental imagery and physical performance has been concern with closed skills. Of the 85 studies that Feltz and Landers (1983) analysed, only ten investigated open skills. Feltz and Landers observed that the trend was towards mental imagery being more effective with closed skills. Closed skills have received the majority of research attention because they are most amenable to experimental manipulation and also to observation and measurement. The confounding influence of such factors as opponent skill, luck, and 'bounce of the ball', are also removed from the situation when investigating closed skills. For these reasons the current experiment investigates the efficacy of mental imagery training on tennis serving, a closed skill.

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Skill Level

According to the bio-informational theory, a higher pre-existing skill level of the participant, is likely to lead to a greater increase in subsequent physical performance attributable to mental imagery training. This is because expert or more skilled athletes are likely to have better developed behavioural prototypes for the desired activity than novice athletes. This finding is supported by Mumford and Hall (1985, p. 176) who concluded that "more experienced athletes are better able to utilise benefits derived from mental imagery because they can internalise a more precise model". Furthermore it could be argued that elite players have greater motivation and commitment to improving their skill level, and thus will show a greater adherence to a regime of mental imagery training than would novice athletes who do not have the same intrinsic motivation to succeed in this particular skill. For these reasons, elite athletes were selected for the current experiment. However, it will be important to monitor for the presence of a 'ceiling effect' on skill performance (i.e. the maximum skill level may have already been obtained). A ceiling effect may preclude physical performance advances for elite athletes (due to mental imagery training) and lead to rejection of the experimental hypothesis.

CONCLUSION

In summary, it is apparent that a number of variables are important in mediating the effects of imagery training. The current study controls for a number of these variables. Firstly, all subjects are elite athletes. According to the bio-informational theory this will increase the efficacy of mental imagery training. Secondly, all subjects will receive

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standardised instructions on mental imagery that reinforces the use of an internal mental imagery perspective. This perspective has been shown to be more effective with elite athletes than an external perspective (which may be more effective for novice athletes). Thirdly, the instructions will emphasise the importance of vividness and controllability of the mental image. Fourthly, a positive success orientated image will be employed. Finally, subjects will be encouraged to use the mental imagery training when in a mild state of relaxation. This is consistent with suggestions advanced by Qualls (1982: cited in Janssen and Sheikh, 1994). Practical limitations prevent a more advanced state of relaxation being induced (for example, as adopted by REST training or saline tanks).

The current study utilises a single case study design to investigate the effect of imagery training on the tennis performance of 4 junior elite tennis players. The independent variable will be an imagery training intervention developed specifically for this task. The dependant variable will be successful first-serves as percentage of total first serves. This variable was chosen because it would appear to be under less influence to external variables (i.e. it is a closed skill).

METHOD

The use of single-case study design in researching the effects of mental practice on sports performance has been strenuously encouraged by Kendall, Hrycaiko, Martin, and Kendall (1990) who utilised a single-case study design to investigate the impact of an imagery intervention on basketball shooting performance. Suedfeld and Bruno (1990) who utilised the Restricted Environment Stimulus Technique, have provided further encouragement for the use of single-case methodology. Shambrook and Bull (1996) employed a similar methodology to that currently presented in their investigation of basketball performance and imagery training.

Subjects

Subjects were four male junior tennis players. Their age ranged from 14 to 16 years, with a mean age of 15. All four subjects were enrolled in the elite tennis programme administered by the Wellington Regional Junior Tennis Association. None of the subjects were familiar with mental imagery techniques prior to the experiment.

Experimental Design

A multiple baseline across subjects design was employed. The imagery intervention was therefore applied to the subjects at different time points across

the investigation. This design eliminates any complication or confounds attributable to the introduction of more than one independent variable for each subject. As Shambrook and Bull (1996) identify, the difficulties of withdrawing a performance enhancing intervention increase the risk that later data will be 'contaminated' by the intervention.

The multiple baseline across subjects design was established using methodology suggested by Cooper, Heron and Heward (1987). Initial trials sought to establish a stable baseline (i.e. a consistent level of performance, reflected by a relatively consistent level of tennis serve accuracy). In line with Cooper et. al.'s recommendation, mental imagery (the independent variable) was not introduced until at least one subject had attained a stable baseline. For subject one, a stable baseline level of responding was judged to have occurred after five trials. The independent variable was therefore introduced between the fifth and sixth trial. Baseline conditions remained in effect for the other three subjects (i.e. no application of independent variable). Once the first subject had achieved stable responding under the new condition (i.e. was applying the mental imagery intervention), the independent variable was applied to the second subject. The second subject to receive the intervention was again determined by the stability of responding. The next most consistent performer (i.e. most consistent baseline) was identified, and the independent variable was introduced for this subject. This occurred after 13 trials. The same process was employed until the intervention had been applied to all subjects. Subjects three and four began the intervention after 18 and 24 trials respectively.

Practical time limitations necessitated that interventions were sometimes introduced before subjects demonstrated complete stability. In this case, the subject judged to be 'most stable' was selected to receive the next intervention. Cooper et. al. (1987) suggest that having baseline conditions of various lengths provides a stronger experimental design as unambiguous conclusions can be drawn as to the effect of the independent variable.

Procedure

The experiment was conducted during the months of September and October 1999. The intervention procedure consisted of a structured consultation with the principal researcher. This consultation was identical for all subjects. It involved the subjects (1) listening to excerpts read by the principal researcher on applying mental imagery (adapted from De Mille, 1977); (2) participating in games designed to increase control and vividness of the subjects imaging ability (also developed by De Mille, 1977); (3) watching an introductory video on imagery training (*'What You See Is What You Get'*, Botterill, 1985); (4) watching a demonstration video on mental imagery as applied to tennis serving (*'The Winning Edge'*, McEnroe, Lendl & Yandell, no date); (5) receiving standardised verbal instructions on how to apply the imagery techniques; (6) completing a practice imagery session, for tennis serving, prior to completion of the consultation. This procedure was designed to maximise subjects understanding and compliance with the procedures and techniques of mental imagery. Upon introduction of the independent variable subjects were verbally encouraged to

repeat the mental imagery technique (step 6 above) in their own time. They were encouraged to do this task for a 10-minute duration on a daily basis, and to ensure that they were in a relaxed and calm state prior to beginning. Each subject was given equal opportunities to seek clarification and assistance from the principal researcher with respect to applying mental imagery.

Over the eight week investigation period, normal tennis practice continued, however no specific coaching on serving was provided. A total of 29 sessions were performed over the duration of the experiment. These sessions were conducted at various times of the day and interspersed through typical practise sessions. The sessions were composed of the subject first being given the opportunity to apply the mental imagery techniques. Subjects then performed 10 first-serves to either side of the court, giving a total of 20 serves per sessions. The principal researcher, aided by a trained assistant, recorded the accuracy of each serve using a standard recording sheet (attached as appendix A).

Treatment of Data

The raw scores were summed to give a trial session score out of 20. The scores for all 29 sessions were plotted for each subject. Each subjects baseline was established by calculating the overall mean performance score for the pre-intervention stage. This score was then compared with the mean score for the post-intervention stage. All data were entered into Microsoft Excel for analysis.

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Statistical significance was tested using t-tests. Analyses were considered significant if above the 95% confidence interval (alpha value of 0.05).

To reiterate the experimental aim, a statistically significant improvement in tennis serving accuracy from pre to post-intervention will support the hypothesised effect of the independent variable, that is, imagery training improves physical performance.

RESULTS

In order to evaluate the impact of the imagery intervention, the number of accurate first-serves pre and post-intervention were recorded. This was done using a multiple baseline across subjects design. Figure 1 illustrates the design, the number of accurate first-serves per trial, and the timing of the intervention for each subject.
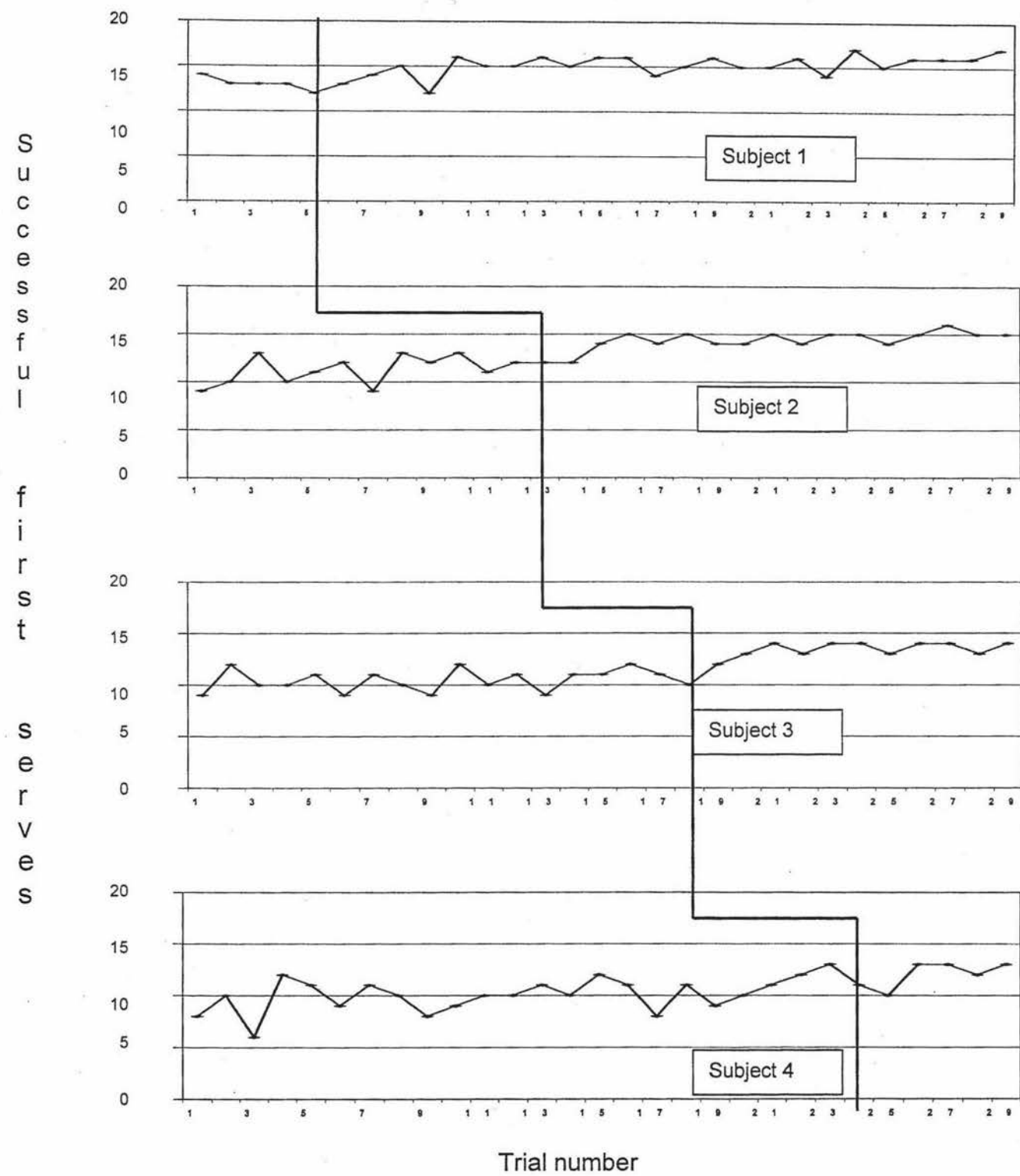

Trial number

Figure 1. Graph to show the multiple baseline design across subjects. Solid lines indicate the staggered implementation of the imagery intervention. As explained in the Method section, the intervention was introduced at trials 6, 14, 19 and 25 for each subject respectively.
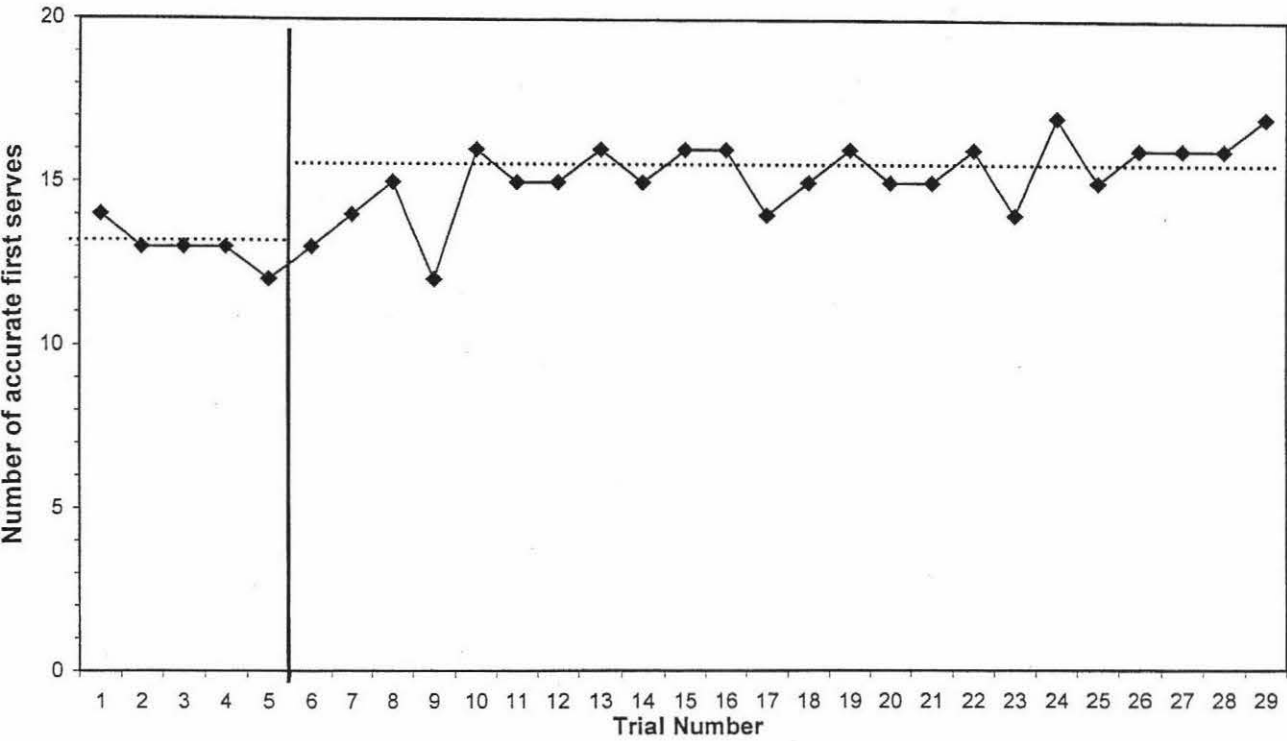
Subject 1

Figure 2. Results for subject 1. Solid vertical line shows point of imagery intervention (after trial 5). Dashed horizontal line shows mean first-serve accuracy pre and post intervention.

Visual inspection of Figure 2 suggests that the accuracy of first-serves did increase following the introduction of mental imagery. This is demonstrated by the greater mean accuracy of first-serves post-intervention (mean=15.21) than pre-intervention (mean=13). The efficacy of the mental imagery intervention for subject 1 is confirmed by a significant t-test result (t [27]=5.56, p<0.05). It can therefore be concluded that the accuracy of subject one's tennis serving significantly increased following the introduction of mental imagery training.
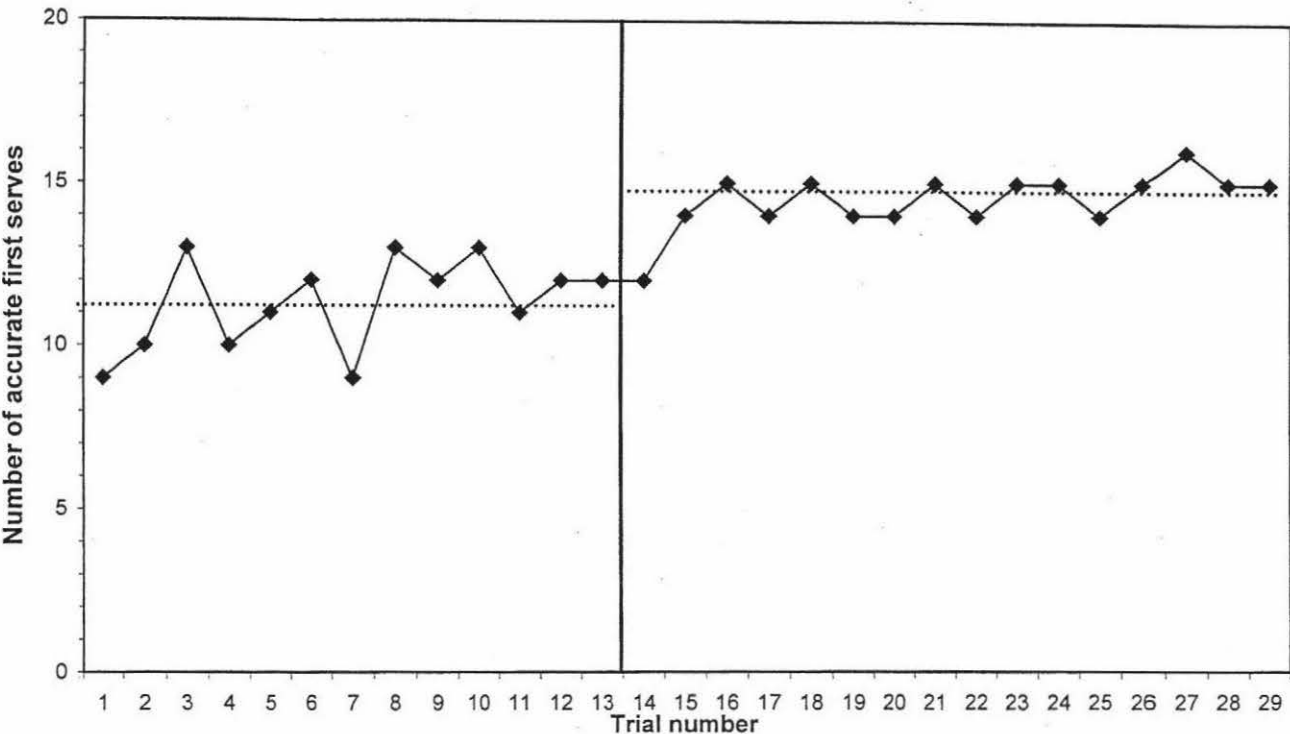
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Subject 2

Figure 3. Results for subject 2. Solid vertical line shows point of imagery
intervention (after trial 13). Dashed horizontal line shows mean first-serve
accuracy pre and post intervention.

Visual inspection of Figure 3 appears to suggest that the accuracy of first-
serves increased for this subject following the introduction of mental imagery.
Again, this is supported by the higher mean accuracy scores of first-serves post
intervention (mean=14.5) than pre-intervention (mean=11.3). Statistical testing
confirms this improvement (t [27]=6.99, p<0.05).

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Subject 3

Figure 4. Results for subject 3. Solid vertical line shows point of imagery intervention (after trial 18). Dashed horizontal line shows mean first-serve accuracy pre and post intervention.

Figure 4 presents a more complicated picture due to the high variability of first serve accuracy pre-intervention. However the post-intervention mean (13.45) is certainly higher that the pre-intervention mean (10.44). Furthermore, t-test results (t [27]=9.37, p<0.05) offer strong confirmation of an intervention effect in the hypothesised direction.
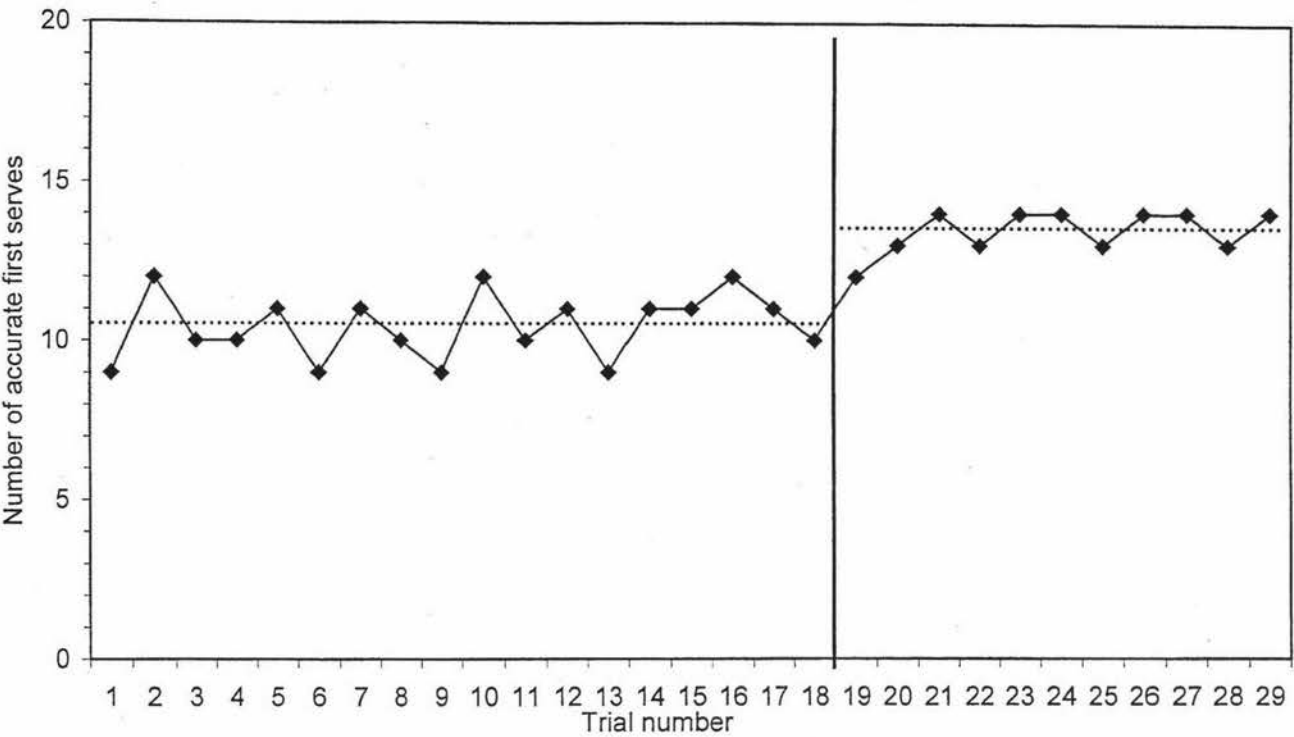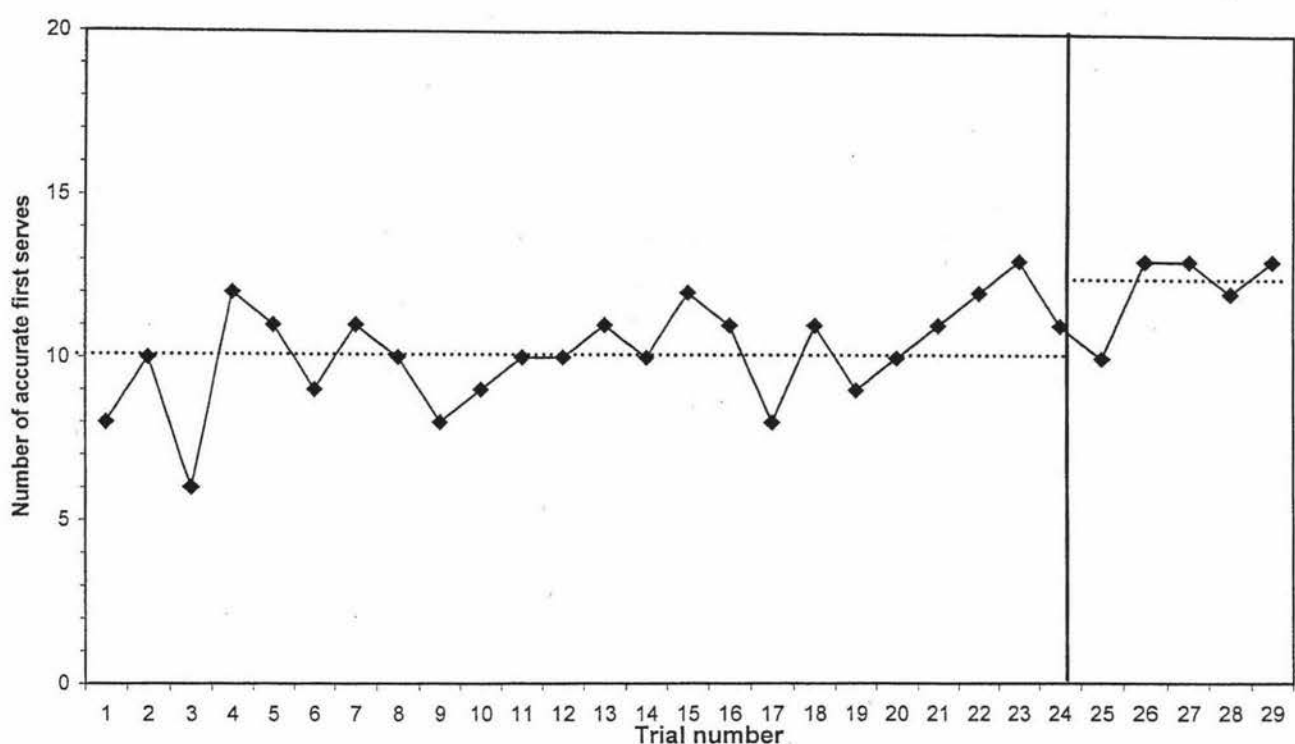
Subject 4

Figure 5. Results for subject 4. Solid vertical line shows point of imagery intervention (after trial 24). Dashed horizontal line shows mean first-serve accuracy pre and post intervention.

Visual inspection of Figure 5 suggests a lower baseline accuracy than that of other subjects. However, it is difficult to determine if there has been a genuine increase in accuracy. This is compounded by the relatively few observations after the intervention (i.e. only 5 trials post-intervention). The mean accuracy pre-intervention was 10.25. This increased to 12.2 following the introduction of mental imagery. This increase is significant at the 5% level of significance (t [27]=3.11, p<0.05). It can therefore be concluded that the accuracy of subject

four's tennis serving significantly increased following the introduction of mental imagery training.

In summary, the accuracy of all subjects' tennis serving improved following the introduction of mental imagery. This is consistent with visual inspection of the presented figures. It is also supported by the increase in mean accuracy scores pre-intervention to post-intervention. Finally, confirmation of the efficacy of mental imagery is provided by t-tests, which demonstrate that the increase following mental imagery training is statistically significant.

DISCUSSION

The accuracy of tennis serving improved for all four subjects following the implementation of mental imagery training. This result was established by statistical analysis and further supported by visual inspection of the data.

This finding provides strong confirmation of the experimental hypothesis; that is, mental imagery training did improve tennis-serving accuracy. The result is consistent with a robust body of literature that substantiates the efficacy of mental imagery training in improving physical sporting performance (Corbin, 1972; Drikell et al., 1994; Feltz & Landers, 1983; and Richardson, 1967). The result is also consistent with previous research using mental imagery and tennis, in which performance improved following mental imagery training (for example, Atienza et al., 1998; and Defrancesco & Burke, 1997). The obtained results are also consistent with the huge body of anecdotal evidence from the vast majority of elite tennis players, which intimates that mental imagery training is a highly effective tool at improving physical performance.

Closer analysis of the results indicates a number of important observations; notably, the possible presence of an ongoing learning trend in the data (i.e. extraneous to experimental manipulation). This effect (i.e. practice effect) exists for all applied research in the area of sporting performance. Subjects are motivated by a variety of contingencies to improve their performance. In the majority of cases (particularly involving developing or junior athletes) it would therefore be expected that a learning trend would characterise their progression. This learning trend is a potential confound in the current experimental design, and one which subsequent studies should pay

additional attention to. From visual inspection of the data no definitive learning trends were noted, however it is possible that the trends were graduated so as not to be easily recognisable (variable baseline periods also complicated visual inspection). It is therefore recommended that future studies utilise a split middle technique or time series analysis to control for the effect of a learning trend in the obtained data.

None-the-less, the obtained change in performance was in the hypothesised direction and was statistically significant. Given the strength and robustness of this result, and of-course the sheer volume of supporting research, attention will naturally turn towards an explanation of *how* the result was obtained. That is, the next logical question will be "*how does mental imagery improve tennis performance?*" Unfortunately a simple answer to this question does not exist. A large proportion of recent literature within the mental imagery realm has been directed towards this very same question (although not necessarily regarding tennis). To date, research on the exact mechanisms that underlie the effectiveness of mental imagery have not been clearly delineated. As the Introduction to this thesis attempted to demonstrate, no single theoretical explanation has yet received consistent empirical support. Unfortunately the scope of the current thesis limits a discussion on the respective merits, and applicability, of each of the major theoretical explanations that were canvassed in the Introduction (i.e. the symbolic learning theory, the psycho-neuromuscular theory, the bio-informational theory, and the attention / arousal set theory). For example, the psycho-neuromuscular theory and the bio-informational theory require specialised apparatus to test muscle innervations. Such complex testing apparatus were not available to the author. Similarly, design limitations mean that the results are not comparable against a control group nor against a group of less experienced tennis players. It would therefore be purely speculative to

comment on the applicability of either the symbolic learning theory or the attention / arousal set theory. Future research designs should attempt to incorporate specialised apparatus, such as EMG recordings, so that more definitive conclusions can be drawn on the relative contributions of different theories.

However, it would be disappointing if the current thesis was not able to offer some exploratory comments, particularly regarding mediating variables for the effectiveness of mental imagery training. The research methodology employed in the current experiment purposely attempted to accentuate the efficacy of mental imagery training. For example, consistent with the research that suggests greater performance efficacy with an internal mental imagery perspective (e.g. Start & Richardson, 1964), subjects in the current experiment were instructed to utilise real life phenomenology (i.e. imagining their movements as felt from the inside, as opposed to an external perspective where subjects would 'view themselves as watched by an observer'). While obviously limited by the lack of a comparison or control group, the current results do support the assertion that an internal mental imagery perspective is effective at improving sporting performance.

Similarly, subjects were encouraged to relax prior to the imagery procedure. The use of relaxation to improve the effectiveness of mental imagery is supported by Mc Aleney et al. (1990), Suinn (1985), and Weinberg et al. (1981). The current results provide further confirmation that relaxation facilitates mental imagery training. It is likely that relaxation reduces muscle tension, eliminates heightened cognitive arousal and focuses attention, all of which would logically improve the efficacy of mental imagery training.

The current experiment also investigated what Poulton (1957) defined as a 'closed skill'. That is, the critical cues for tennis serving are static: the court remains the same; the opposition is generally in the same place, and the serve always begins a point. Furthermore, because of the nature of the game of tennis, accuracy of serving is largely regarded as being under internal control (e.g. it is not dependent on opposition quality or performance: (Weinberg, 1988)). It is therefore well suited to an internal intervention such as mental imagery. In addition the time delay prior to serving, and the stop-start nature of the game allow sufficient periods for which to use mental imagery training. These factors are all likely to contribute to the increased efficacy of closed skills over open skills for mental imagery training (Feltz & Landers, 1983).

The subjects employed in the current experiment were elite junior players. They were some of the most advanced and successful players for their age group in the Wellington region (the majority of subjects had played for approximately 10 years). As suggested by Mumford and Hall (1985), experienced athletes are likely to better utilise mental imagery training. This may be due to a motivational effect (i.e. greater desire to succeed in this profession), or, as suggested by Mumford and Hall, due to having better developed 'behavioural prototypes'. It is significant to note that in this experiment, skilled and experienced players were able to utilise mental imagery training to improve their tennis serving performance. In addition there was no evidence that a 'ceiling effect' was encountered, where-by a peak level of performance was reached, after which no improvement was possible. Unfortunately a control group was not employed. If it had been, then it may have been possible to test some of these assertions regarding level of experience and mental imagery efficacy.

It is perhaps pertinent to identify the major limitations that do exist for the current experiment. An experimental design utilising a control group should be used to confirm the present results. This would aid the generalisability of the research findings. In addition future studies should also take note of previous recommendations regarding utilisation of technology such as EMG recordings.

On a more detailed level, it is important to note that the dependant variable was operationalised in terms of tennis serve accuracy (i.e. whether the ball landed in or not). Accuracy of tennis serves can be varied by player manipulation. For example, accuracy can be increased by slowing the speed with which the ball is served. While neither speed, nor other aspects of 'playability', were measured in the current experiment, it was emphasised to subjects to serve at their normal pace / placement. Thus, while there was no indication that subjects were purposely slowing serves to artificially elevate their accuracy, subsequent studies should be careful to control for this variable.

Despite these limitations, the research methodology that was employed, proved to be simple and effective. The methodology followed a similar design to Cooper et al. (1987). Certainly, the observed intervention effect provides support for the use of a multiple-baseline-across-subject-design. This design allowed sufficient recognition of individual differences while still maintaining experimental integrity and not compromising design validity. A multiple-baseline-across-subject-design allows for meaningful consideration of individual responses, which may otherwise not have been possible in group-averaged data. However, there are few clear-cut rules to follow when choosing methods of analysis for a multiple-baseline-across-subject-design. It is therefore

important that future researchers carefully consider the respective advantages and disadvantages of each analytical method.

In conclusion, mental imagery has proven to be effective in increasing the accuracy of junior tennis player's first serves. The implication for this is a likely overall increase in performance and subsequent success. Because it involves no risk of physical injury, no fatigue factor, and can be practised outside of scheduled training times, mental imagery has a number of advantages over physical practice. For example, injured players may be able to use the technique to maintain their level of physical performance and to facilitate their return to form after recovery. Similarly, mental imagery training can be done when weather conditions prevent physical practice or when fatigue means that physical practice would be detrimental to the player. While not advocating a replacement of physical practice, the results of the current experiment suggest that mental imagery makes an ideal companion to physical practice for improving tennis serving performance.

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