Mental rehearsal and skill acquisition in sports

Jim Sheedy

University of Wollongong

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MENTAL REHEARSAL AND SKILL ACQUISITION IN SPORTS

A thesis submitted in fulfilment of the requirements for the award of the degree of

MASTER OF ARTS (HONOURS)

from

The University of Wollongong

by

Jim Sheedy BA (Hons)

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ABSTRACT

Mental rehearsal is thought to have positive effects upon the learning and retention of gross motor skills such as those demanded in many sports. A field study using 30 participants from the sport of lawn bowls failed to demonstrate a statistically significant benefit from the use of mental rehearsal in the performance of their skill. As minimal instruction, training and control accompanied the field experiment a more stringently run study was conducted to establish the extent to which mental rehearsal may effect the acquisition of motor skills.

A laboratory experiment using 61 subjects revealed significant positive effects from mental rehearsal prior to the first overt attempt at a novel psychomotor task. Theoretical and methodological considerations were examined in relation to these two experiments and their conflicting results. Additionally, several implications for the practical application of mental rehearsal techniques for coaches and athletes were discussed. Following the success of the laboratory study future research needs to establish the type of instruction and control necessary for mental rehearsal to be effective in naturalistic settings (i.e. the sports field), where research concerning applied sport psychology should be encouraged.
CHAPTER ONE

INTRODUCTION
INTRODUCTION

1.

Mental rehearsal has long been considered an effective technique to enhance sports performance (Egstrom, 1964; Martens, 1981; Orlík, 1980; A. Richardson, 1969; Sheedy, 1982; Singer, 1975a). Research evidence as well as anecdotal and coaching reports suggest significant benefits from mental rehearsal for various aspects of motor performance relevant to sport (Cratty & Pigott, 1984; Furlong, 1976; Hall & Erffmeyers, 1983; Rushall, 1980; Straub, 1978; Suinn, 1976, 1980). Despite the wide variety of findings in the area of mental rehearsal in sport, the processes involved remain unclear (Clark, 1960; Corbin, 1967; Feltz & Landers, 1983; Minas, 1980; Wrisberg & Ragsdale, 1979). This thesis attempts to clarify some of the factors that contribute to the apparent effectiveness of mental rehearsal for sports performance.

For the purpose of this thesis the following (layman's) interpretation of what constitutes sport will be used: a semi-organized competitive activity involving various forms of skill and physical attributes (Best, 1978; Thomas, 1983). The term "athlete" applies to people engaged in sport and covers both elite and recreational participants.

Scientists and laymen use a variety of terms to refer to mental rehearsal (Egstrom, 1964; Hall & Erffmeyers, 1983).
Whatever the term used it appears that athletes and coaches may utilize some significant components of mental rehearsal in their mental preparation (Sheedy, 1982; Wood, 1981).

The following list provides a sample of the many terms used to describe techniques incorporating mental rehearsal in sport as well as synonymous labels frequently encountered in the research literature (Egstrom, 1964; Lane, 1980; Singer, 1975a).

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To avoid confusion, only two terms from the above list, "mental imagery" and "mental rehearsal", will be used throughout this thesis except in direct quotes from the relevant literature. Both terms have a long history of research and frequent use. Both terms are accepted referents to the phenomenon under investigation by scientists and laymen alike (Feltz & Landers, 1983).

"Mental rehearsal" implies the use of an established motor-plan in memory to enhance motor performance, based on the memory of an overt performance (Jones, 1965). The more specific term "mental imagery" implies the utilization or development of a motor plan without the experience of any overt performance at the desired task (A. Richardson, 1969). It is to the latter issue, mental imagery prior to overt practice, that the major portion of the original research work of this thesis was addressed, rather than the more restrictive term mental rehearsal alone.

Restrictive in that to mentally rehearse tends to imply the practice of something already physically performed at some time in the past, whereas imagery encompasses the practice of creating new, previously unexperienced performances in the mind which forms part of the experimental design pursued in this thesis. Etymological arguments concerned with differences in terminology between mental rehearsal and mental imagery (and the other terms listed above) would be inappropriate here since throughout this thesis they are used inter-changeably, except with the distinctions previously made. The attempt to reduce the number of terms used here to describe similar mental activities was made
to facilitate clarity. Thus, for the reasons stated above, only the terms "mental imagery" and "mental rehearsal" are used in attempts to describe the following phenomena: "The covert or 'imagined' rehearsal of physical activity in the absence of gross muscular movements". (Minas, 1978, p.102). "When a high jumper is waiting for his turn to jump and in imagination 'sees' and 'feels' himself going through the run up, roll over and landing he is engaged in mental practice" (A. Richardson, 1969, p.56).

Although the adherents of many specific types of techniques utilizing mental rehearsal in sport may consider their methods radically different, an investigator may conclude that mental imagery is an element common to all of the foregoing methods listed (Devore et al., 1981; Egstrom, 1964; Lane, 1980; Orlick, 1980). Physiological responses may well be similar regardless of the technique employed although the physiological factors, such as electroneurophysiological activity below the movement threshold, are as yet unclear (Davis, 1932; Egstrom, 1964; Meaney, 1984). Future research of a physiological nature into such factors as electromyograph (EMG) responses, biofeedback measures, biochemical changes and energy exchange at the actin-myosin interface may clarify this issue (Carlile, 1982; Feltz & Landers, 1983).

A number of researchers have described four major types of mental imagery of which brief descriptions follow:

**Visual after image.** Often a colourless image of an internal perspective, such as the "spots before the eyes" phenomenon
reported after close or intense visual concentration with a fixed gaze (A. Richardson, 1969).

**Eidetic imagery.** Usually a positive colour image with external localization, often described in present tense, such as "photographic" memory (Haber & Haber, 1964; Miller & Peacock, 1982; Singer, 1974).

**Memory image.** The replication of a previous performance or experience. Such imagery may be the basis of much of the mental rehearsal in sport (Klavora & Daniel, 1979).

**Imagination imagery.** The creation of images never overtly experienced. This form of imagery has been used in attempts to influence performance positively (DeVore et al., 1981; Pylyshyn, 1981).

The distinction between memory image and imagination imagery as it is described above, is important with reference to the perspective athletes have reported when "viewing" in their mental rehearsals. For example, it has been suggested that athletes may "recall" previous performances from an external perspective indicating imagination, rather than the reportedly more effective, internal perspective (Egstrom, 1964; Meaney, 1984; Rushall, 1980; Sheedy, 1982; Suinn, 1980). The implications of such internal and external imagery will be discussed in subsequent sections of this thesis.

To summarise, mental rehearsal has been variously described in esoteric, scientific and laymen's terms. Similarly mental rehearsal has been deployed in diverse settings. For the purpose of consistency and to reduce confusion, wherever possible only
the terms mental rehearsal or mental imagery will be utilized in this study. The aim of this experimental undertaking is to help clarify the factors necessary for the effective use of mental rehearsal; to explore interpretations that seek to explain the diversity of results reported in the literature concerning the employment of mental rehearsal in acquiring motor skills. In order to clarify the effect of mental rehearsal both naturalistic and laboratory experimentation will be utilized and described in the following chapters.
CHAPTER TWO

REVIEW OF RESEARCH AND RELATED LITERATURE
2. REVIEW OF RESEARCH AND RELATED LITERATURE

2.1 The mechanisms of mental rehearsal

There is still no consensus concerning the nature of the underlying mechanisms of mental rehearsal's apparent positive effects on skill acquisition (Cratty & Piggott, 1984; Davis, 1932; Feltz and Landers, 1983; Minas, 1980; J. Richardson, 1967; Wrisberg & Ragsdale, 1979). A number of theories have been postulated.

2.1.1 Neurophysiological

It has been suggested that the neuromuscular system is activated at a measurable level during mental rehearsal, but insufficiently to cause gross muscular movements (Jacobson, 1932; Start & Richardson, 1964; Wrisberg & Ragsdale, 1979). Electromyograph research has indicated such actual, though minimal, innervation of the muscles used in the imagined task (Jacobson, 1932; Start & Richardson, 1964).

Egstrom (1964) reported that Jacobson (1932) and Shaw (1938) obtained the following differing results when measuring EMG output with mental rehearsal: Jacobson indicated localized EMG activity whereas Shaw found no such localization. Therefore, considering such conflicting results, it remains unclear as to the role neurophysiological activity initiated by mental rehearsal played in motor skill performance (Meaney, 1984). Improvements in technology and precision of instrumentation may assist in clarifying this issue.
2.1.2 Symbolic

It has also been suggested that mental rehearsal assists in entrenching the symbolic, or cognitive, aspects of motor skills (Feltz & Landers, 1983; Rawlings et al., 1972; Wrisberg & Ragsdale, 1979). Symbols for success such as scores flashing on electronic scoreboards simultaneously with direct hits (e.g. in fencing) and vision/sound of a golf ball disappearing down a hole in a putting green also exemplify such symbolic components.

Some theorists suggest that motor skills with limited symbolic components may benefit less from mental rehearsal than those with more symbolic components. However, it should be noted, more recent research indicates this may not be the case. See for example, research reported by Feltz and Landers (1983) and Minas (1980). Hence, symbolic theories have not as yet proved conclusive indicators of the function of mental rehearsal in motor performance (Kosslyn, Pinker, Smith & Shwartz, 1981).

2.1.3 Other theoretical possibilities

Mental rehearsal may assist the encoding of information relative to motor responses in some form of mediational process (C. Hall, 1980; Minas, 1980). This mediational activity may give the athlete a better opportunity to organize motor plans in memory (Jones, 1965; Start & Richardson, 1964). Mediational theories may find some support in the reported benefits of mental rehearsal by athletes in such aspects as concentration and attention to task relevant cues (Bond, 1984; Clark, 1960; Klavora
& Daniel, 1979; Orlick, 1980). Moreover, as mediational effects may occur at an unconscious level the difficulties of isolating the mechanisms responsible for mental imagery's apparent benefits to motor performance are increased (Barratt, 1953; C. Hall, 1980; Lee & Hirota, 1982; Singer, 1974; Sweigard, 1974).

It is now evident that a physical skill may be "learned" without any overt physical practice being involved. It remains to be established whether this "learning" is habit reinforcement at a subliminal level in the neuromuscular system as the studies in Electromyograph and muscle tension might suggest, or whether it is a purely cortical phenomenon either one of "grooving" the ability to concentrate on the task and establish a favourable "set" or of establishing neurological pathways in the higher centres associated with proposed physical skill. (Start & Richardson, 1964, p.280)

Additionally, it has been suggested that the brain, via mental rehearsal, works on developing and refining motor plans in memory for future use (DeVore et al., 1981; Green & Green, 1977; Jones, 1965). This "work" of mental rehearsal may occur unconsciously thus preparing the athlete for future performances.

In summary, various theories have been suggested to account
for the reported benefits of mental rehearsal to motor performance (Lang, 1977), but as yet the underlying mechanisms remain unclear (Block, 1981; Brown & Herrnstein, 1981; Dennett, 1981a, 1981b; Fodor, 1981; Kosslyn et al., 1981; Kosslyn, 1981; Landers, 1981; Meaney, 1984; Pylyshyn, 1981; Schwartz, 1981). As research on the theories remains inconclusive, researchers need to consider all the theoretical possibilities when undertaking research on mental rehearsal.

In this thesis an attempt is made to shed further light on the theoretical possibilities as outlined above. Equally important are the practical implications of the use of mental rehearsal for the immediate benefit of athletes. It is by no means suggested that one research project is likely to determine conclusively the theoretical "laws" of the mental rehearsal phenomenon. Conclusive research may take many years to accumulate and require a variety of innovative methodologies (Moriarty, McCabe & Prpich, 1979; Sidman, 1960).
2.2 Mental rehearsal in Australian sport

In order to appreciate the social and political forces likely to influence local empirical research, its interpretation and likelihood of publication (Barratt, 1953; Feltz & Landers, 1983), a brief outline of the current Australian perspective relevant to mental rehearsal is appropriate.

Australian journals that specialise in sports science publications appropriate for mental rehearsal either for academics or laymen are of recent origin. Research articles on mental rehearsal related to sport have in the past appeared mainly in sports magazines or found occasional acceptance in professional psychological journals.

Although many Australian athletes and coaches have a rudimentary understanding of mental rehearsal, sound application of the technique does not appear to be widespread (Hall & Erffmeyers, 1983; Sheedy, 1982). The slow rate of growth of Australia's National Coaching Accreditation Scheme and its acceptance here may serve as an illustration of this point (Woodman, 1984). The scheme is one of the few avenues for the education of coaches in psychological techniques. A major recommended text (Pyke, 1980) makes specific reference to mental rehearsal. The accreditation scheme was implemented during 1980 in an effort to standardize and upgrade coaching in all sports throughout Australia.

Despite the recently improved standing of sport psychology (Blundell, 1984), it may well be many years before the majority
of Australian coaches have a basic understanding of the use of mental rehearsal in sport. Additionally, there is a dearth of appropriately qualified, experienced sport psychologists in Australia to train athletes in the effective use of mental imagery (Bond, 1981; Lee & Owen, 1984; Salmela, 1981; Sheedy, in press a; Sheedy, in press b; Titley, 1980). Hence, the quality and effectiveness of what is being taught as mental rehearsal, under whatever term used, remains questionable.

Further, few Australian coaching manuals thoroughly cover the topic of mental rehearsal for the practicing coach and athlete (Davey, 1981; Nettleton, 1980a; Pyke, 1980; Wood, 1981). Therefore, the majority of Australian coaches and athletes may have little knowledge of the application or effectiveness of mental rehearsal in sport.

There is a need in this country for empirical research concerning mental rehearsal in sport to be undertaken and for relevant findings to be published in appropriate coaching manuals and journals. Research in both laboratory and naturalistic settings should be encouraged by tertiary institutions, government and private funding sources as well as individual sporting organizations.
2.3 Relaxation as a Factor in Mental Rehearsal

An athlete's ability to relax, and to monitor and control arousal levels, has long been shown to influence sporting performances and various mental strategies such as mental rehearsal (Arend, 1980; Bahrke & Morgan, 1981; Berger & MacKenzie, 1981; Fucini, 1979; Landers, 1981; Ravizza, 1982; Sugarman, 1977; Suinn & Richardson, 1971; Weinberg, Chan & Jackson, 1983; Wilson & Bird, 1982). Hamberger and Lohr (1980) suggest that it is typically presumed that relaxation will facilitate imagery by reducing distracting stimuli, aiding recall, or clarifying the visual representation of experiences. "While imagery vividness and clarity are not related to degree of relaxation or effectiveness of systematic desensitization, it is hypothesized that controllability of imagery is facilitated by relaxation" (Hamberger & Lohr, 1980, p.103).

Much of the research concerning mental rehearsal in sport has incorporated some form of relaxation, often under the above assumptions (Feltz & Landers, 1983; Hall & Erffmeyers, 1983). Athletes have used various forms of relaxation techniques to assist their performance or to move into an altered state of consciousness (ASC).

These ASCs have usually been described by the methods used to produce them or by their characteristics, for example, meditation, hypnosis, trance, drug-induced, psychadelic, sensory deprivation, sensory overload,
ecstacy, prayer, dreams, daydreams, fugue, dissociation, hypnogogic, creative, transcendental, biofeedback, progressive relaxation, autogenic training, relaxation response, alpha state, and theta state.

(Korn, 1983, p.25)

Athletes and coaches have also used audio tapes of relaxation, hypnotic induction, music, and the like to aid the effectiveness of mental rehearsal (Nathan, Nathan, Vigen & Wellborn, 1981; Unestahl, 1982). It has been suggested that such relaxation techniques have positive effects on a person's ability to concentrate and focus attention on relevant cues in the sporting environment (Bird, 1981; Israel & Beiman, 1977; Pelletier, 1974; Singer, 1974; Spink, 1984; Suinn & Richardson, 1971; Widmeyer, 1983).

Research evidence supports the view that states of relaxation may have positive influences upon psychophysiological activity and motor performance. These influences are illustrated in the following list of studies covering a diverse range of sport-related activities: pain management (Ahsen, 1981); flexibility (Bird, 1981); motor tracking tasks (Ehrlich, 1964); controllability of imagery (Hamberger & Lohr, 1980); flexibility (Holt, Travis & Okita, 1970); concentration (Pelletier, 1974); thermal regulation (Piedmont, 1983); vividness of mental imagery (Quittner & Glueckauf, 1983); reaction time (Smith & Whitley, 1964); psychomotor skills (Start, 1964a); fine motor skills
(Williams, 1978); fine perceptual motor skill (Williams & Herbert, 1976); state of muscle tension and active imagery (Wolpin & Kirsch, 1974). The literature indicates that some sports, such as those requiring fine motor skills or high levels of precision, demand low levels of physiological arousal for success (Oxendine, 1980; Singer, 1975a). Therefore, self-control and relaxation techniques in such sports as pistol shooting and archery are often part of the training procedures of elite performers (Landers, 1978; Layman, 1978; Orlick, 1980; Oxendine, 1980; Stanton, 1983).

The above findings suggest that relaxation is a useful technique in many sporting situations, and may well enhance the effectiveness of mental rehearsal (Hall & Erffmeyers, 1983; Orlick, 1980; Syer & Connolly, 1984). The quality or absence of relaxation techniques may in some instances account for the variety of findings in research concerning mental rehearsal and skill acquisition in sport.
2.4 The Place of Anecdotal Reporting in Mental Rehearsal

Hall and Erffmeyers (1983) have suggested that much of the information concerning mental rehearsal in sport is in the form of anecdotal or personal accounts. For example, the golfer Jack Nicklaus is reported to have attributed 50% of his success on the day of events to mental rehearsal (Klavora & Daniel, 1979). Suinn (1976) reported his experiment on the effect of mental rehearsal had to be abandoned because the coach of the U.S.A. Winter Olympic Team was so convinced of the effectiveness of the imagery that he was willing to use only the experimental group (mental rehearsal group) and excluded the control (no mental rehearsal group) in Olympic Team training.

In order to gain a more comprehensive view of the use and abuse of mental rehearsal in sport, researchers may need to consider examining a sample of anecdotal reports, rather than relying solely on laboratory work or publications conforming to the "Laboratory" model (Landers, 1981; Martens, 1981; Start, 1964b). Anecdotal examples also provide insight into improper use and failure rates of mental rehearsal in sport (Sheedy, in press, b). Material of this nature is unlikely to be published in either journals of psychology or coaching. Whether or not it is overtly acknowledged, every practising psychologist and every known psychological technique is likely to have a casualty or failure rate (Sheedy, in press, b). Sport psychologists may be reluctant to draw attention to their casualty rate, nor are reports relating to such failures likely to be published, since they may tend to diminish the public image of the practice of psychology.
The interrelation of relaxation and mental rehearsal may be seen in five case studies which follow. Anecdotal reports such as these may provide insight into the complex mechanisms of mental rehearsal which seems to have perplexed researchers and obscured the relevant factors for mental rehearsal's effectiveness.

2.4.1 Case 1

A Canadian sport psychologist working with an elite female swimmer incorporated the use of mental rehearsal into training. Daily sessions of approximately 3 hours of mental rehearsal were undertaken. The result, in the opinion of the athlete and psychologist, was that the imagery training dramatically impeded performance and probably cost that swimmer the National Championship (B. Rushall, personal communication, July 1982).

Research has suggested that approximately 20 minutes of mental rehearsal daily gives substantial results (Sheedy, 1982; Suinn, 1972b; Twining, 1949). However, it is still unclear what factors contribute to performance decrements of the above type as referred to B. Rushall (personal communication, July 1982).

2.4.2 Case 2

An Australian psychologist attempted to manipulate the imagery of Australian Rules Footballers by instructing them to slow down their mental rehearsal (G. Jones, personal communication, 1983). This version of imagery was designed to allow more time for the athlete to "see" what was to be done in
imagery. Similar methods have been suggested by DeVore et al. (1981) and this manipulation also relates to capacity loading strategies sometimes used by sport psychologists (Glencross, 1981).

Unfortunately, the result was performance decrement in the form of "slow-motion" athletes (which is in contrast to reports by Suinn, 1972b). Although some use of high or low speed mental rehearsal may be beneficial (Chenery, 1984), it has been suggested that the majority of the mental rehearsal should be at the desired achievable speed of performance for the individual athlete (Rushall, 1981; Sheedy, 1982).

2.4.3 Case 3

The 1984 Australian Women's Judo Champion (under 61 kg) was won by an athlete coached by the author. After debriefing, the two major factors identified in this successful performance, as compared to the previous year's second place, were:-

(a) quality of physiological preparation;
(b) self control (relaxation) techniques.

The self control techniques had been specifically worked on for three months before this event. The athlete reported that mental rehearsal was avoided on the day of the event until directly prior to competition (Sheedy, in press, b). She felt that self control techniques must be emphasised and the mental rehearsal minimized or else performance would have been poor. This example might reflect the need to tailor-make programs to suit individual athletes and not to impose the same mental rehearsal program on all athletes (Landers, 1981; Oglesby, 1981; Sheedy, in press, b; Sugarman, 1977).
Telford (1984) also provided objective evidence to support the view that judo players (such as the one mentioned above) undergo great physiological and emotional stress prior to performance as reflected in increased lactic acid content in blood samples. Blood testing of this nature can be carried out in naturalistic settings. One advantage of such testing is the opportunity it affords for usable feedback to be obtained and incorporated into the overall coaching plan.

2.4.4 Case 4

It appears that there are complex but subtle differences between athletes and their ability to visualise images. These differences may include the ability to visualize only in black and white rather than in natural colour as well as individual differences in clarity, quality and speed of visualizing task. Anecdotal material from two sources will help illustrate this point. L. Zaichkowsky (personal communication, April 1984), a sport psychologist working with the 1984 United States Olympic Gymnastics team, reports that athletes who mentally rehearsed in black and white were unable to obtain images as clear as athletes who imaged in colour. Suinn (1976) has reported similar experiences with swimmers who mentally rehearsed in colour.

Such reports reflect the marked individual differences possible in imagery and the necessity to design specific (tailor-made) programs of mental rehearsal for individual athletes (Hall, 1980; Sheedy, in press, b; Turner, Kohl and Morris, 1982).
2.4.5 Case 5

Members of the 1978 Australian Commonwealth Games Swimming Team were instructed to perform relaxation techniques immediately prior to competition. The team had an unexpectedly poor result in relation to pre-competition training times and expectations leading some sport psychologists to express the opinion that the relaxation procedure was detrimental to the swimmers' performances (B. Rushall, personal communication, July 1982). Research findings and coaching experience would suggest that at such a vital pre-game point in competitive preparation, mental rehearsal, warm-up and attentional cueing would be more appropriate than deep states of relaxation (Bond, 1984; McArdle, Katch & Katch, 1981; Pyke, 1980).

2.4.6 Summary

The examples provided above help indicate possible flaws and limitations in the theoretical explanations discussed in the introductory chapter. Symbolic theories in relation to sports such as judo (Feltz & Landers, 1983), and the type of colour positive imagery reported by gymnasts and swimmers (Richardson, 1969) do not seem to conform to the theoretical models. Empirical research reconciling the above anecdotal reports with the current theoretical perspectives needs to be implemented and duly published. The above examples afford some indication of the complexities involved in mental rehearsal usage, complexities that may lead to confusion as reports in the relevant research literature concerned with mental rehearsal effect on motor performance make clear.
2.5 **Skill Acquisition**

2.5.1 **Introduction**

As previously indicated mental rehearsal is reported to have a strong influence on human performance especially applicable to sporting skills (Meaney, 1984; Richardson, 1969; Rushall, 1980; Sheedy, 1982). Furthermore, examination of the literature indicates that some forms of mental rehearsal have been reportedly successful with many athletes at elite levels (Bond, 1984; Klavora & Daniel, 1979; Suinn, 1980). Various authors have reported significant results with mental rehearsal in many sports, e.g. squash (DeVore et al., 1981), basketball (Hall & Erffmeyers, 1983), tennis (Noel, 1980), swimming (Yamamoto & Inomatta, 1982), karate (Weinberg, Seabourne & Jackson, 1981).

The following section of the thesis presents a description of some of the major factors that influence skill acquisition as they may be related to the processes relevant to mental rehearsal's effect on motor performance.

2.5.2 **A Paradigm of Skill Acquisition**

Skill learning tends to be the theoretical realm of both psychologist and physical educationalists (Singer, 1975a). Much research has been undertaken and published on many aspects of human motor learning (Drowatzky, 1981; Fitts & Posner, 1967; Glencross, 1978; Legge & Barber, 1976; Marteniuk, 1976; Newell, Sparrow & Quinn, 1985; Singer, 1975a). To establish a basis for discussing the interrelationship between mental rehearsal and skill acquisition a brief outline of some of the major factors involved in skill acquisition is presented in Figure 1.
Display situation
Mechanics of the skill
Similarity to the learner
Readiness

MODEL

Verbal instructions
Physical manipulation
Method of presentation
(whole or part)

Feedback
Schedules
Type (proprioceptive, 
(relevant, visual, 
verbal)
Intrinsic/extrinsic

Meaningful/useful
(intermittent)

PRACTICE

DISTRIBUTION

Massed
Distributed
(quality of practice, 
(planning of training)
work-rest ratios)

Early emphasis

SPEED AND

ACCURACY

Respective importance

Mental imagery
techniques

MENTAL REHEARSAL

AND PRACTICE

Forward/backward
chaining
Full and correct
repetitions

Refine competition
motor plans

STRESS

Simulate competition
situation

Personal factors
eg sense-acuity
past injuries

INDIVIDUAL

Personalized style

Figure 1. A paradigm of skill acquisition
adapted from Treble (1979).
2.5.3 The Model

Prior to presenting a model the coach should have decided which method of presentation is the most appropriate for the particular skill and the individual involved (Ford, 1983; Singer, 1975a; Suinn, 1977). The choice (between "whole" method or "part" method) is likely to be made on the basis of the complexity of the skill. The "whole" method (performance of the whole task at desired speed) may be appropriate for skills that are not complex (Clark, 1960; Nettleton, 1980a, 1980b; Singer, 1975a). Evans and Waites (1981) suggest the whole method of instruction is appropriate for students with high intelligence. Both Nettleton (1980b) and Singer (1975a) suggest the "part" method (breakdown of the task into slower speeds or static parts) could be beneficial for skills involving more complex tasks. A variation on the part method, suggested by Treble (1979) involves a combination of whole-part-whole processes. The whole-part-whole method involves an initial demonstration of the whole task at the desired speed followed by a breakdown of the important segments of the task into slower speeds or static parts and ending with a reversion to the whole task (Singer, 1975a; Treble, 1979). It is considered advantageous to the athlete for the coach to keep the number of parts shown the athlete small in order to optimise learning and retention (Hulse, Deese and Egeth, 1975; Lawther, 1972; Singer, 1975a).

A model of the desired skill may best be presented after the learner has acquired a basic understanding of the skill and
exhibits a readiness to attempt the tasks to be performed (Nettleton, 1980b; Singer, 1975a). The most appropriate models are assumed to be people similar to the learner, that is, of the same sex, same age, etc (Bandura & Walters, 1963; Gould & Weiss, 1981; Teasdale, 1976). The model for the skill should be seen to be performing at the level of competence of the learning observer (DeVore et al., 1981). The presentation demonstration of the model allows for motivation to be enhanced by the display of the skills to be mastered (Lane, 1980; Pyke, 1980; Rothstein, 1980).

A number of devices and conditions may go towards enhancing the display situation to facilitate the learning process, such as mirrors and artificial devices (Singer, 1975a). Clear verbal instructions and explanations of the biomechanical factors of the performance are assumed to aid retention (Pyke, 1980; Singer, 1975a; Treble, 1979). Physical manipulation, for example, actually placing the learner's body in the desired position, can also have positive effects upon skill acquisition (Treble, 1979). To reinforce the skill (and its image) to be immediately practiced, a number of demonstrations of the full and correct technique are then presented (Nettleton, 1980b; Treble, 1979).

Some types of skills, such as a kata in judo (Jacks & Carter, 1979) contain large numbers of components or sequences of movements. In such cases, it has been suggested that manageable segments may be taught leading to the composition that is the whole or desired object modulation (Legge & Barber, 1976; Nettleton, 1980b; Singer, 1975a). For more detailed descriptions
of the types of motor skills and explanations of information processing the reader may wish to consult such writers as Drowatzky (1981), Fitts and Posner (1967), Legge and Barber (1976), Marteniuk (1976), Newell, Sparrow and Quinn (1985), Newell, Walter, Quinn and Sparrow (1983), and Singer (1975a).

2.5.4 Feedback and Reinforcement

Feedback can come from any of the senses, visual, tactile, kinesthetic, olfactory and auditory (Annett & Kay, 1957; Hayes & Reeve, 1980; Pyke, 1980; Singer, 1975a; Vattano, 1964). As skills improve more of the useful feedback will become of an intrinsic nature, accompanied by a greater automation of the skills (Pyke, 1980; Singer, 1975a). Feedback is internal or external information of the correctness or incorrectness of responses and generally needs to be augmented by useful and positive means to enhance skill acquisition (Glencross, 1978; Newell et al., 1985; Singer, 1975a). It is suggested that more positive remarks rather than criticism (punishment) enhances the feedback situation between coaches and athletes (Aksamit & Husak, 1983; Pyke, 1980; Rushall, 1982). In the early stages of learning, verbal feedback is perhaps of greatest importance in most sports (Nettleton, 1980b). However, as skill improves more visual and proprioceptive feedback may be appropriate (Rothstein, 1980; Singer, 1975a). Whatever type of feedback is used it should be meaningful to the learner and given as soon after the
performance as the athlete is receptive; for example, after the recovery from fatigue (Coaching Association of Canada, 1979; Hulse et al., 1975; Mixon, 1975; Singer, 1975a).

Reinforcement is defined according to the behavioural outcome related to the presentation or withdrawal of various stimuli seen as aversive or pleasant by the individual (Dunham, 1977; Mixon, 1975). For example, a presentation of a positive stimulus resulting in an increase in the desired behaviour is termed positive reinforcement (Mixon, 1975; Singer, 1975a). Research has clarified that where possible the reinforcement should be positive, paired closely with the desired response and seen as specifically rewarding to the individual (Dunham, 1977; Hulse et al., 1975; Mixon, 1975; Rushall, 1980). In the early stages of learning it is postulated that there should be a great deal of positive reinforcement for reasonable approximations of the desired task, as in shaping behaviour by reinforcing successful approximations of the desired response (J. Adams, J., 1976; Gagne, 1965; Hulse et al., 1975). Once the basic skill has been established the reinforcement can then become intermittent, and to maintain effectiveness the reinforcers can be varied and novel (Rushall, 1980). It is at this stage that intrinsic reinforcement may become more salient for the athlete (Oglesby, 1981).
2.5.5 **Practice Distribution**

Practice distribution refers to the schedule of performance rehearsal of skills (Drowatzky, 1981; Singer, 1975a). It has been suggested that in general, distributed practice tends to show superior results in skill learning when compared to massed practice (Lawther, 1972; Marteniuk, 1976; Singer, 1975a). Distributed practice refers to practice repetitions spread over time (e.g. days), whereas massed practice refers to practice repetitions undertaken in large single units (Singer, 1975a). For the athlete this knowledge can influence both single training sessions as well as the long-term training program (Nettleton, 1980b; Worthington, 1980). For example, training sessions can be arranged so that in cases where skill work puts demands on the lactic energy source, work-rest ratios of approximately 1:5 to 1:10 are provided (McArdle et al., 1981; Pyke, 1980). This may allow for longer sessions of quality practice (Pyke, 1980) and for mental rehearsal during the athlete's physical recovery period. The long term plans of the coach or athlete may provide for a series of session plans on specific skills to be developed rather than massed practice of the desired task (Worthington, 1980). Mental rehearsal may also need to adhere to the principle of distributed practice to maximize results.
2.5.6 Speed and Accuracy

Either, or both, speed and accuracy of performance are important factors in many sports (Pyke, 1980; Singer, 1975a). It appears that if speed is the more important factor in a particular sport then concentration on this element in the early or associative stages of skill acquisition may prove advantageous (Lawther, 1972; Singer, 1975a). Later, accuracy can be given more attention (Legge & Barber, 1976).

On the other hand, if accuracy is the most important aspect of a given skill, early concentration on accuracy should be encouraged (Singer, 1975a) and subsequently speed can be given more emphasis. In activities where both factors are seen as equally important then speed and accuracy need to be nurtured together for best results (Lawther, 1972; Singer, 1975a). The mental rehearsal accompanying this type of skill development pattern may need to adhere to the same basic principles of speed and accuracy enhancement.

2.5.7 Mental Rehearsal and Practice

Mental Rehearsal

Mental rehearsal and techniques utilizing various aspects of mental imagery have been shown to assist the acquisition of many skills (Feltz & Landers, 1983; Pulos, 1979; Singer, 1975a). Elsewhere in this thesis some of the research and its
implications have been briefly discussed and need not be reviewed here. However, before giving a brief survey of some of the factors relating to overt practice a few basic aspects of the practice procedures of mental rehearsal and its role in motor learning may be of value.

Mental rehearsal could feasibly be considered a skill in itself, therefore the mastery of mental rehearsal may conform to the basic principles of skill acquisition (Legge & Barber, 1976; Singer, 1975a). For children or athletes at the cognitive stage of skill acquisition mental rehearsal is not thought to greatly enhance motor learning (Minas, 1980; Rarick, 1980; Rushall, 1982; Sheedy, 1982; Singer, 1975a). Furthermore, it has been suggested that mental rehearsal of performance well beyond the current capabilities of the athlete may not be particularly effective (Rushall, 1980, 1982; Sheedy, 1982). To gain optimal benefits from mental rehearsal it has been suggested athletes may need an established motor plan in memory (DeVore et al., 1981; Jones, 1965; Sheedy, 1982). The internal perspective known as the "through-your-own-eyes" image (as distinct from a projected image passively observed) has been reportedly effective in mental rehearsal to enhance sports performance (Meaney, 1984; Rushall, 1982; Sheedy, 1982). Mental rehearsal of the full and correct successful task has been suggested as an effective method of practice (Rushall, 1980; Sheedy, 1982). It has also been postulated that to incorporate cues from the olfactory, kinesthetic, and auditory receptors may enhance the mental rehearsal (Lee & Hirota, 1982; Meaney, 1984; Wolpin & Weinstein, 1983; Sheedy, 1982). For example, a yachtsman wishing to make
his mental rehearsal as vivid as possible may incorporate such sensations as the feel of the rope in his hands, the sounds of the pulleys, ocean, wind, breakers, the smell of salt-air, the taste of salt-water spray, plus kinesthetic feedback of performing the movements efficiently.

Although some benefits have been reported from mentally rehearsing the performance in either slow motion or at higher than normal speed, in general it appears that rehearsal at an obtainable desired speed is most beneficial (Chenery, 1984; DeVore et al., 1981; Rushall, 1982; Suinn, 1972b). Control of the speed of what is mentally rehearsed may need to be emphasised to the skill-learner to maximize benefits.

To follow the overt practice of quality performances with mental rehearsal of the skill in question has been suggested as an aid to imprinting the needed motor plans (Rushall, 1982; Sheedy, 1982). Additionally, recalling one's best performances, via mental rehearsal, is reported to assist motor learning and performance (Hickman, 1979; Klavora & Daniel, 1979; Railo & Unestahl, 1979; Sheedy, 1982). Visual aids, such as videos of "ideal" models of performances have been used to enhance mental rehearsal (Hall & Erffmeyers, 1983; Hongfei, 1984; Rikli & Smith, 1980; Rothstein, 1980). To maximize the effectiveness of such visual aids it has been suggested that the model (if not the athlete) should be similar to the learner (Bandura & Walters, 1963; Hall & Erffmeyers, 1983; Oglesby, 1978).

A 10 to 15 minute daily session of mental rehearsal appeared sufficient time to obtain good results according to Hickman (1979), however optimal rehearsal time may be a highly
individualized variable (C. Hall, 1980). Mental rehearsal has been coupled with the athlete's relaxation, self-control and flexibility training to assist performance (Holt, Travis & Okita, 1970; Lang, 1977; Pelletier, 1974; Shapiro, 1983; Smith & Whitley, 1964). Mental rehearsal is also seen as another form of reinforcement and feedback for athletes (Bernheim, 1957; Nideffer, 1976; Sheedy, 1982; Suinn, 1977; Vattano, 1964).

It has been reported that numerous mental and tactical strategies have been successfully incorporated into athletes' mental rehearsal, such as segmentation of tasks, "mood" words, positive self reinforcement, secondary and coping strategies (Coaching Association of Canada, 1981; Klavora & Daniel, 1979; May, 1980; Nideffer, 1980a; Ogilvie, 1980; Salmela, 1979; Sheedy, in press, b; Singer, 1975a; Straub, 1978; Suinn, 1978; Weinberg et al., 1983).

Although its effects are not clear at present, mental rehearsal may well have significant positive effects on many of the major factors contributing to motor learning as briefly described in this chapter (Bugelski, 1982; Cratty & Pigott, 1984; Drowatzky, 1981; Singer, 1975a; Sweigard, 1974). Unfortunately the diversity of results reported in the literature concerning the influence of mental rehearsal on skill acquisition indicate that its exact effects remain unclear.

Practice

Skill can be enhanced by maximizing the overt practice of full and correct repetitions of the desired task (Singer, 1975a). To enhance full and correct repetitions, the majority of
skill practice should be performed in low stress situations. For example, low states of fear, fatigue, anxiety, interference, information overload, together with minimal demands for information processing, have been found to maximize the value of practice sessions (Legge & Barber, 1976; Pyke, 1980; Singer, 1975a).

The question of whether to teach or practice skills by forward or backward chaining (i.e. teaching the components of a skill from the beginning to the end, or from the desired end position to the beginning position) has recently drawn debate in Australian sporting circles (Ford, 1983). The effectiveness of backward chaining appears to be not widely known to Australian coaches or sports scientists as is indicated by its absence in Australian coaching manuals (Nettleton, 1980a; Pyke, 1980). Traditionally Australian athletes have tended to be taught and practice their skills by forward chaining (Martin & Pear, 1978; Singer, 1975a). Recent research evidence and coaching experience suggests that for some skills backward chaining is far superior in terms of speed of learning, retention, safety and minimization of errors while learning (Ford, 1983; Martin & Pear, 1978). In some instances, once the basic skill is automated, forward chaining can become the dominant practice method (Ford, 1983). Other types of skills appear to benefit most from backward chaining for all stages of skill development and practice, but as yet the reasons underlying these issues remain unclear (Coaching Association of Canada, 1979; Ford, 1983; Martin & Pear, 1978; Singer, 1975a; Suinn, 1977). The author believes that the question of what types of skills, and individuals, gain more
benefit from either forward or backward chaining is an issue for future research into motor learning. From the point of view of coaching skills, safety and kinesthetic awareness, backward chaining has a great potential for the practicing coach and athlete (Coaching Association of Canada, 1979; Ford, 1983).

2.5.8 Stress

Although it has been established that factors such as fatigue and information overload generally tend to have detrimental effects on skilled performances, many sports demand skills to be exhibited in situations where various degrees and forms of stress are present (Legge & Barber, 1976; Oxendine, 1980; Singer, 1975a). In this instance, "stress" is defined as a behavioural response to the individual's interpretation of a given situation (Dickinson, 1976; Drowatzky, 1981; Fuccini, 1979; Lang, 1977). Hence, some of the athlete's preparation should be concerned with the application of skill in settings similar to the stressors present in competition (Singer, 1975a; Treble, 1979).

Since it appears that numerous motor plans relating to the same task being performed in different situations or states of fatigue are established and stored in memory (Ehrlich, 1964; Jones, 1965; Treble, 1979), use of the motor plans in actual contest situations would require a sufficient amount of retrieval and refinement of the various plans (Singer, 1975a; Treble, 1979). It is generally asserted that the relationship between arousal (stress in some cases) and performance takes the form of
an inverted "U" (Carrón, 1980; Nettleton, 1980b; Singer, 1975a). However, recently some doubt has been expressed on the reliability of this well established model as a result of examining elite athletes with highly automated skills (Carrón, 1980; Gotts, 1982). For the highly skilled and experienced athlete in some sports high states of arousal may not interfere with or be detrimental to performance (Gotts, 1982). The results of future research in this area may influence coaching methods for such performers if the inverted "U" hypothesis proves not to hold for elite athletes.

In many sports where interaction with an opponent or opponents is required such skills as feinting, combinations and counters are necessary (Legge & Barber, 1976; Singer, 1975a). Many of the skills of this type take advantage of the opponent's psychological refractory period to out-manouver the opponent (Legge & Barber, 1976; Marteniuk, 1976). Therefore, practice under stress is essential to establish and refine such competitive skills (Treble, 1979).

An important consideration to be addressed by future researchers in mental rehearsal as it relates to stressful sporting situations is the possible benefits of rehearsal from an external perspective (as a passive observer). It may be the case that some mental rehearsal in the external perspective can help reduce perceived stress and anxiety in the athlete, thus bringing benefits specific to some individuals (e.g. reduced tension via detachment imagery). However, such a claim will need to be reconciled with the general view that imagery of the internal perspective is the most appropriate, as suggested by such
researchers as Meaney (1984) and B.S. Rushall (personal communication, July 1982).

2.5.9 The Individual

Once the basic pattern of the desired task has been established performers often tend to develop and exhibit an individualized style of the technique (Treble, 1979). Recently there has been a trend in Australia for athletes and coaches to be more innovative and accepting of individuality (Blundell, 1983). The trend may have been due to an effort to gain or maintain success or perhaps to maximize uncertainty in the opposition which in itself can be an effective tactic (Spink, 1982).

Coupled with the above is the need to consider learners in the context of their social and physical environment as well as personal factors which may be brought to the learning situation and which also are important elements (Dennett, 1981b; Singer, 1966; Singer, 1975a; Turner et al., 1982). Each athlete lives in a cultural environment with peer, parental and social sanctions that influence behaviour (Cantelon & Gruneau, 1982; Carron, 1980; Harris, 1973; Mihalich, 1982; Yiannakis, 1974). Some of the numerous personal factors which can influence the acquisition of motor skills include "personality, age, sex, previous experiences, physiological abilities, sense-acuity, motivation, emotions, level of aspiration and socialization" (Lawther, 1972; Oxendine, 1980; Singer, 1975a).

Literature indicates a need for specific individualized
coaching for maximizing skill development (Landers, 1981; Leonard, 1983; Singer, 1975a; Treble, 1979). Similarly, mental rehearsal programs may need to be highly individualized to maximize effectiveness and safety for specific performers. The acquisition of motor skills in sport is a complex process, not all factors of which are understood at this time (Drowatzky, 1981; Legge & Barber, 1976; Newell et al., 1985; Singer, 1975a).

The foregoing description is not meant to be exhaustive; the intention has been to examine some of the known and suspected factors in the skill acquisition process (Legge & Barber, 1976; Treble, 1979). Nonetheless, a brief review of a paradigm of skill acquisition has been considered essential for the development of a basis for the empirical studies and practical implications to be explored in this thesis. At this point it may be suggested that mental rehearsal could adhere to the basic principles of motor learning as mental rehearsal itself may be considered a skill. Mental rehearsal may also influence motor performance at various stages of skill acquisition as suggested above, but further research is necessary to clarify the suspected influences.

2.6 SELECTED VARIABLES OF SPECIFIC RELEVANCE TO MENTAL REHEARSAL

All of the factors that influence mental rehearsal are not as yet clearly established (Feltz & Landers, 1983; Meaney, 1984; A. Richardson, 1967). Nevertheless, the following review represents some of the major factors researchers have found that influence mental rehearsal as it applies to the acquisition of
sports skills. In addition the list of possible advantages may aid the reader's appreciation of the complexity of mental rehearsal and its appropriateness to sport.

2.6.1 Practical Implications of Mental Rehearsal in Sport

On the basis of the research evidence, published coaching reports, and personal experiences it can be suggested that the positive and practical benefits of mental rehearsal for athletes may include the following:

1. Tension reduction
2. Concentration
3. Reduction of external interference
4. Coping with unexpected occurrences
5. Appropriate arousal levels at the optimum time
6. Instill confidence and enhance motivation
7. Initiate "free-flowing" skills at appropriate stages of performance
8. Initiate appropriate biochemical activity and adjustments in the body
9. Facilitate the utilization of appropriate motor plans: speed of recall, restructure or creation of new plans for maximizing performance.
10. Detection of anxiety or motor problems prior to performance (e.g. new, dangerous or difficult skills can be mentally rehearsed before physical practice reducing the likelihood of injury)
11. Facilitate detachment of mental state
12. Initiate desirable physiological state and an awareness of the body's biofeedback (to arouse or calm as necessary)

13. Facilitate storage and retrieval of secondary or coping strategies (motor plans) to cope with error, change in environment or unpredicted variables

14. Facilitates shifts in states of awareness to assist the focus of attention to important variables

15. Facilitate the maximising of recovery during and between events (e.g. removal of lactic acid, reduction of heart rate)

16. Facilitate the efficient use of the body's available energy, psychic and physical (e.g. via biomechanically efficient actions)

17. Facilitate the recovery from sports injuries (e.g. maintain skills during lay-off; aid physiological recovery, blood flow to injured site)

18. Facilitate skill retention (and development) during periods when physical practice is not possible

19. Facilitate the imprinting of quality performances in (motor) memory

20. Facilitate mental strategies such as segmenting tasks, positive self-reinforcement, enhancing physiological capacities (e.g. strength and flexibility).

2.6.2 **Body Image**

The athlete's body image may intrude on the effectiveness of mental rehearsal since it involves both physiological and social
components which influence the athlete's self perceptions (Brawley, Landers, Miller & Kearn, 1979; Goldberg & Folkins, 1974; Harris, 1973). As mental rehearsal requires the athlete to visualize her/himself performing the task from either an internal or external perspective, body image is considered to be an important factor (Harris, 1973; Oglesby, 1978). If an athlete has a poor body image mental rehearsal may not be the optimim aid to use since to the athlete the procedure may not necessarily be seen as positive reinforcement (Goldberg & Folkins, 1974; Fisher, 1973; Lang, 1977). For example, an overweight athlete may not want constant reminders via mental rehearsal of what may be a problem for performance (Bailey, Shinedling & Payne, 1970; Harris, 1973; Rowan, 1978). The same may be said for the aged or injured athlete (Sacks & Sachs, 1981; Unestahl & Stanley, in press).

Social variables have been found to be strong influences on body image and athletic achievement (Ball & Loy, 1975; Carron, 1980; Lenney, 1977; Martens, 1975). If, for example, a female athlete's body image did not fit the current social stereotype mental rehearsal may prove to be aversive despite successful athletic performances (Bastide, 1973; Bolotti, 1976; Coles, 1980; Sheedy, 1983). Social learning of this type is thought to mainly take place in childhood when sport is a strong socializing agent and the rewards are often immediate and easy to visualize (Brawley et al., 1979; Cheffers, 1973; Maehr, 1974; Schembri, 1981; Yiannakakis, 1974).

It has been suggested that for mental rehearsal to have maximal benefits the athlete needs to be comfortable with his/her
body image while visualizing movement patterns compatible with the desired motor responses of the sport (Harris, 1973; Sheedy, 1982; Unestahl & Stanley, 1983). Others have suggested cultural and media-portrayed stereotypic body images for athletes in specific sports may influence an athlete's mental rehearsal and motivation in visualizing the desired skill (Bolotti, 1976; Coles, 1980; Cratty & Pigott, 1984; Edwards, 1973; Mehrabian, 1971; Singer, 1974; Singer, 1975a, 1975b) As the preceding makes clear, body image is a factor to be taken into account in the design, implementation and interpretation of empirical research into mental rehearsal.

2.6.3 Vision

Visual input is reported to be important in many sports and necessary for optimising performance (Neil, 1981; Singer, 1975a, 1975b). It has been postulated that some information may be registered at an unconscious level and used to refine motor plans in memory. If this is the case it may help to account for some of the reported positive effects of mental rehearsal (DeVore et al., 1981; Feltz & Landers, 1983; C. Hall, 1980; Jones, 1965). Furthermore, according to Neil (1981) sport specific drills are needed to assist visual development to aid athletic performance. Such skills may be incorporated in, and possibly improved by, mental rehearsal (Bugelski, 1982; Gross, 1984; Neil, 1981).

It has been shown that stress can effect visual perception
and may have detrimental effects on performance (Arend, 1980; Carron, 1980; Fucini, 1979). For example, anxiety and nervousness can significantly reduce peripheral vision (Carron, 1980). Stress also effects many other aspects of performance and health (Kretch & Wolowski, 1980; A. Ryan, 1962). In view of these findings and since relaxation is often paired with mental rehearsal (Lane, 1980; Suinn, 1972a) consideration of the reported attentional focusing benefits attributed to the technique appears warranted. At the same time such findings support use of the technique to assist sports performance (Lane, 1980; Pelletier, 1974; Spink, 1984). Thus it may be suggested that vision and variables which influence visual input are relevant factors of concern to research into mental rehearsal.

2.6.4 Ritualistic Behaviour

Many aspects of human behaviour have appeared to lose their original meaning and become rituals (Berger & Luckman, 1966; Goffman, 1967). In sport, forms of meditation, prayer and redundant movements may have some benefit as mental strategies (Metzner, 1971; Singer, 1975a, 1975b; Widmeyer, 1983). Ritualistic behaviour has been observed at many sporting events where athletes may resort to breathing exercises, prayer, ceremonial preparation habits (Massimo, 1981; Nideffer, 1976; Schembri, 1978). Some of these rituals are said to be significant socializing agents which often contain religious
metaphors, coaching cliches, and many non-verbal signals that may have positive influences on mental rehearsal (Blundell, 1983; Edwards, 1973; Eitzen & Sage, 1983; Mehrabian, 1971; Segrave & Chu, 1981; Suinn, 1976). It has also been suggested that such rituals may assist spontaneous and efficient skilled performances since they allow the intuitive mind to take control at appropriate times (DeVore et al., 1981; Kroll & Lewis, 1978).

"The body will do what you tell it, if you learn how to tell it. The way of telling involves a period of quietness plus a visualization of what you want the body to do" (Green & Green, 1977, p.11). Mental rehearsal is often used in conjunction with such states of quietness or calm of the body (Feltz & Landers, 1983; Lane, 1980; Singer, 1974; Suinn, 1972a). For these reasons ritualistic behaviour deserves the attention of researchers investigating the influences of mental rehearsal on sports performance.

2.6.5 Physiological Aspects

Physiologically there appears to be some form of priming of neural pathways with the use of mental rehearsal, although this function is still to be clarified (Feltz & Landers, 1983; A. Richardson, 1967). Suinn (1976, 1980) reported physiological activity that included slight physical movements of athletes engaged in mentally rehearsing sporting performances. It is also suggested that the benefits of mental rehearsal may be enhanced by physiological self-control skills (Chenery, 1984; Orlick, 1980; Solomon & Bumpus, 1981; Spinelli & Barrios, 1980). In a
similar vein the efficient use of energy has been seen as an important aspect of skill acquisition and peak performances (Carlile, 1982; McArdle et al., 1981; Singer, 1975a). Suggestions that anger, tension and fear may expend energy better utilized for task execution have been put forward by Orlick (1980), Ravizza (1982) and Rowan (1978). The breakdown of adenosine triphosphate to produce the energy would be a Kreb's Cycle activity, activity that may rob the body of oxygen better used in athletic performance (Carlile, 1982; McArdle et al., 1981; Pyke, 1980).

Thus mental rehearsal may help to alleviate negative physiological effects and so benefit human performance (Green & Green, 1977; Orlick, 1980; Meaney, 1984; Riggs, 1981; Singer, 1974; Suinn, 1976). An appreciation of such physiological effects is a valuable part of acquiring an insight into the complexities of mental rehearsal.

2.6.6 The Brain

The brain's physiological and biochemical activity is thought to have an interrelationship with mental rehearsal and skilled performances (Biersner, McHugh & Rahe, 1981; Davidson & Schwartz, 1977; Davis, 1932; Green & Green, 1977; E. Hall, 1981; Meier, 1964; Ogilvie, Hunt, Tyson, Luacescü & Jeakins, 1982; Quittner & Glueckauf, 1983; A. Richardson, 1967; Riggs, 1981; Shaw, 1938; Thompson, 1973). The interaction and function of the brain's hemispheres and the frequencies of brainwave activity have been suggested to be related to the function and effect of
mental rehearsal (Ahsen, 1981; Chenery, 1984; Green & Green, 1977; Oglesby, 1981; Prigatano, 1983; Saparina, 1974; Short, 1953; Singer, 1974).

2.6.7 Socio-cultural Effects

As has been noted earlier, social and situational factors create sanctions and social reinforcers that may influence the learning of motor skills and its related imagery (Borger & Seaborne, 1977; Carron, 1980; Hoch, 1972; Maehr, 1974; Segrave & Chu, 1981; Singer, 1966; Widmeyer, 1983). Further, it has been suggested mental rehearsal may be part of ritualistic behaviour performed by many athletes (Bastide, 1973; Berger, 1974; Clark, 1960; Edwards, 1973; Martens, 1975; McMurtry, 1974; Treble, 1984; Yiannakis, 1974). Such socio-cultural effects may well influence the results of research into mental rehearsal through the varying social structures that surround the experimental situation and the subjects.

2.6.8 Relaxation

The athlete's ability to relax, monitor and control arousal levels has been shown to influence sporting performances and various mental strategies such as mental rehearsal (Arend, 1980; Bird, 1981; Fucini, 1979; Ravizza, 1982; Sugarman, 1977; Wilson & Bird, 1982). It has been suggested that relaxation enhances the
effectiveness of mental rehearsal in certain circumstances as when the rehearsal follows a "detachment" phase thus allowing the effect to occur in a relaxed state (Green & Green, 1977; Hall and Erffmeyers, 1983). Additionally the body's need for homeostasis should be considered in all sports settings for possible interaction effects it may have with the reported positive effects of mental rehearsal (Chenery, 1984; Wilson & Bird, 1982). In view of the pairing of relaxation with mental rehearsal further research investigating the influence of mental rehearsal on sports performance seems appropriate.

2.6.9 Learning and Skill

Along with skill acquisition athletes may learn various responses in sports settings (Dickinson, 1976; Hulse et al., 1975). Vicarious learning, conditioning and modelling effects may influence mental rehearsal in any of the many situations in which they are present (Bugelski, 1982; Rushall, 1980). Mental rehearsal may represent a significant form of feedback, reinforcement or punishment which athletes may respond to in competition or practice (Annett & Kay, 1957; Butt, 1979; Crocker & Stortz, 1982; Ende, 1984; Gerler & Nelson, 1982; Lang, 1977; Lee & Hirota, 1982; Minas, 1978; Yamamoto & Inomata, 1982).

In addition to the factors already discussed in the section on skill acquisition the nature and performance characteristics of the skill may need to be considered (Singer, 1975a). The
athlete's genetic and physical parameters may well affect mental rehearsal of various skill demands (Singer, 1975a) such as an individual's height in relation to high jumping performance. Additionally, the type of skill itself may well influence the nature of the mental rehearsal (Davis, 1932; A. Richardson, 1967; Singer, 1975a). For example, closed and open skills may require different forms of mental rehearsal, in order for individuals to gain optimum benefit.

Factors influencing learning and skill need to be considered in the design and implementation of research into mental rehearsal and sports performance. Failure to appreciate learning and skill factors may in part account for some of the diversity of findings in the literature concerning mental rehearsal and skill acquisition.

2.6.10 Biofeedback

Athletes have long been aware of the importance of "listening" to their own biofeedback (Chenery, 1984; Suinn, 1980). Recently technology has provided numerous devices to aid the athlete's biofeedback and mental rehearsal training (Calhoun, 1977; Chenery, 1984; Lang, 1979; O'Leary & Wilson, 1975). For example, Chenery (1984) used biofeedback equipment to indicate an athlete's alpha state in order to have it coincide with the practice of mental rehearsal of fencing skills. Both the use of physiological functions, such as heart rate and skin temperature, and performance feedback, such as the angle of a limb or the level of a scull, have been used in attempts to enhance sports
performance (Hatfield & Landers, 1983; Wenz & Strong, 1980). Such biofeedback may be incorporated into both experimental and practical applications of mental rehearsal to expand our understanding of this phenomenon.

2.6.11 **Sport**

The demands, history, expectations and constraints of each individual sporting activity may have influences on the athletes' use of mental rehearsal (Duquin, 1978; Smith, 1974). The type of skills needed along with the opportunity and sanctions for the use of mental rehearsal may also affect the athlete's approach to using mental imagery in attempts to enhance performance (Botterill, 1980; Duquin, 1978; Hongfei, 1984; Kirschenbaum & Bale, 1980; Phipps & Morehouse, 1969; Smith, 1974). Researchers into mental rehearsal and motor performance in sport need to appreciate the possible influence the specific sport may have on experimental findings.

2.6.12 **Other Suspected Variables**

Numerous variables, not as yet clearly understood, may influence the effectiveness of mental rehearsal in sport (Meaney, 1984; Roberts & Russel, 1977; Ryan & Simons, 1982; Singer, 1974). Further research with diverse and innovative methodologies are necessary to clearly establish all the factors influencing mental rehearsal and skill acquisition including...
1. Attributions, Heider (1958);
2. Belief strength, Sheedy (1982);
3. Body awareness, Leonard (1983);
4. Hypnosis, Bernheim (1957);
5. Hypnotic state, Pressman (1980);
6. Ideokinetic facilitation, Sweigard (1974);
7. Imagery, Pylyshyn (1973);
8. Imagery types, Cranney & McConkey (1980);
9. Personality, Hall & Lindzey (1978);
10. Psychological health, Cratty (1978);
11. Psychological preparation, Zaremski (1980);
12. Psychological state, Roberts & Russel (1977);

The preceding review of selected variables thought to influence mental rehearsal has been necessary prior to undertaking the research question pursued in this thesis. However, it is not meant to be exhaustive, but rather to call attention to the complexities of mental rehearsal in relation to existing and future empirical research.

2.7 PRELIMINARY FIELD STUDY: LAWN BOWLS

Prior to developing an hypothesis to be tested in a laboratory setting a field study was undertaken. In agreement with Clark's (1960) view on the inability of any one experiment to adequately cope with all the variables affecting any one motor
performance, it is suggested that such a study would add to the overall scope of the thesis. The general evidence concerning mental rehearsal presented thus far establishes a base from which to undertake such research. The fieldwork aims:

(a) to establish a familiarity with mental rehearsal research;
(b) To explore some of the theoretical views of mental rehearsal in a practical setting;
(c) to contribute to the data base concerning the use of mental rehearsal for specific sports;
(d) to establish a working relationship with the field of study and subject responses to mental rehearsal prior to embarking on a major empirical project.

The preliminary study may highlight any shortcomings or specific needs in the experimental design which is to become the major empirical research of this thesis.

A quasi-experimental design was implemented with participants in the sport of Lawn Bowls to investigate the effectiveness of mental rehearsal on sports skill. The sport of Lawn Bowls is widely played and understood in Australia (Smith, 1974). It does not appear a physically demanding activity but does utilize skills that are relatively easy to visualize. Furthermore, it provides an objectively measurable criterion for skill: that is, the distance of the bowl at rest from the "jack", the white target ball (Australian Bowls Council, 1982).

On the basis of previous research (Feltz & Landers, 1983; Hall & Erffmeyers, 1983; Meaney, 1984) and anecdotal experiences in mental rehearsal, the following four hypotheses were examined:
1. Bowlers will not significantly change in their skill over a period of two weeks in the absence of both physical practice and mental rehearsal (Group 1: control).

2. Bowlers who combine physical practice and mental rehearsal will show a greater degree of skill improvement over two weeks than bowlers using only mental rehearsal, or only physical practice, or in the absence of both physical practice and mental rehearsal (Group 2: P+M).

3. Bowlers who participate only in physical practice for two weeks will show a greater degree of skill than bowlers who participate in only mental rehearsal, or in the absence of both physical practice and mental rehearsal (Group 3: PP).

4. Bowlers who participate only in mental rehearsal for two weeks will show a greater degree of skill than bowlers who do not participate in either physical practice or mental rehearsal over a two week period (Group 4: MR).

2.7.1 Method

Subjects

Eighteen male and 14 female participants from the sport of Lawn Bowls voluntarily participated in this experiment. Of the original 32 subjects, two females withdrew from the mental rehearsal group (Group 4), leaving 30 subjects to provide the research data. The age range of the subjects was approximately 15 to 70 years.
2.7.2 **Apparatus**

Each subject used his or her own set of bowls, individually weighted and carrying personalized insignia. Bowls mats, jacks and greens were regulation dimensions (Australian Bowls Council, 1982). Bowls equipment such as shoes, hats and bowls lotion, were supplied by the subjects and used at their own discretion.

One 3-metre metal tape measure, sufficient recording sheets, instruction sheets and post-test evaluation sheets were provided by the experimenter (see Appendices A to E respectively).

2.7.3 **Procedure**

The experimenter gave a brief explanation of the nature of the experiment and guaranteed confidentiality of results. The introduction read:

This research is designed to look at the effectiveness of various methods of developing skills. Lawn Bowls is an easy-to-measure skill, as you can measure how far from the jack the bowl stops. Firstly we will test your bowling accuracy, then give you a two week skill-development program. After this two weeks we will retest you to see if your bowling skill has improved or not. Your names will not be recorded in the final analysis. You will be one of four
groups involved in the research. Thank you for participating in this experiment.

The thirty two subjects were randomly assigned to the four experimental groups, eight to each group. The subjects were asked to play one "end", consisting of four shots, as warm-up. They were then required to play four "ends" of four shots, for each of which the distance of the bowl from the "jack" was recorded. The distance between the edge of the bowl and the edge of the "jack" for each of these shots was measured individually. The subjects played forehand or backhand shots at their own discretion. "Ends" were played alternatively from one end of the rink at a time. Therefore, two "ends" from each end of the green were recorded.

Each subject was given written instructions for their particular experimental group. The experimenter also read the instructions to the subjects, asked for questions, and clarified any points raised by the participants. The subjects retained their individual instruction sheet and were asked to re-read it if necessary or to contact the experimenter if any problems occurred.

At the end of the two week experimental program the four groups were re-tested in the same manner. That is, they played one end of four shots as warm-up, followed by four ends of four shots which were recorded. The subjects were then asked to complete the post-experiment questionnaire.
2.7.4 Results

As some shots either exceeded 3 metres from the jack or landed in the gutter, the mean of the best eight shots of each subject was used as the research data (Table 1 and Figure 2). This eliminated the difficulty of assigning scores to "dead" shots. However, "dead" shots were recorded and appear in Figure 3 as a post-hoc indicator of accuracy as well as utilizing the "missing" data.

No statistically significant differences existed using a one-way ANOVA at the 0.05 level of probability, between the groups at the pre-test stage of experimentation [d.f. = 3, 26; Calculated F = 1.38; Significant F > 2.98]. A one-way ANOVA was administered on the post-test scores and no significant differences were found at the 0.05 level of probability (d.f. = 3, 26; Calculated F = 1.97; Significant F > 2.98). Therefore, on the basis of this experiment, hypothesis one was supported while hypotheses two, three and four found no support. No significant difference was established between the skill exhibited in the four experimental groups.
Table 1

Mean of Best Eight Shots of the Four Experimental Groups
on the Post-Test Results (decimeters)

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>P+M</td>
<td>PP</td>
<td>MR</td>
</tr>
<tr>
<td>7.7</td>
<td>10.1</td>
<td>9.1</td>
<td>9.1</td>
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<tr>
<td>10.3</td>
<td>6.2</td>
<td>8.8</td>
<td>14.9</td>
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<tr>
<td>14.6</td>
<td>9.3</td>
<td>12.0</td>
<td>13.6</td>
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<tr>
<td>10.9</td>
<td>5.7</td>
<td>7.2</td>
<td>9.4</td>
</tr>
<tr>
<td>12.2</td>
<td>10.1</td>
<td>9.2</td>
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<td>13.5</td>
<td>9.1</td>
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<td>13.7</td>
<td>12.1</td>
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</tr>
<tr>
<td>11.5</td>
<td>8.8</td>
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</tbody>
</table>

Summary of Responses to Post-Experiment Questionnaire

Total number of subjects = 30; Response rate = 12.

Response rate per group: Group 1, Control = 2
                      Group 2, P+M = 6
                      Group 3, PP = 1
                      Group 4, MR = 3

Question 1: Effectiveness of mental rehearsal; Undecided = 2
           Effective = 7

Question 2: Clarity of image; Clear = 9
Question 3: Type of image; Through-own-eyes = 6
Television image = 3

Question 4: Previous use of mental rehearsal Yes = 9
(Generally as part of thinking about the game, what shot to play).

Question 5: Factors affecting the experiment No = 12
(All respondents indicated that they did not feel that any extraneous variables contaminated the experiment).

Question 6: Frequency of practice. An average of six sessions between the pre- and post-tests were conducted.

Question 7: Practice of mental rehearsal by subjects not required to do so.

Group 1, Control: Both respondents indicated no.
Group 3, PP: The respondent indicated no.
Figure 2. Pre- and post-test means of best 8 shots per group.

Figure 3. Total number of “dead” shots of the 16 trials per subject.
2.7.5 Discussion

The statistical analysis showed no significant difference between the four groups (ANOVA at 0.05). However, in Group 2 bowlers who combined mental rehearsal and physical practice showed an apparently appreciable change in the predicted direction even though not reaching statistical significance. Moreover, due to several flaws in the experiment the results can not be considered conclusive, although they do warrant further, more stringent research.

"Dead" shots (Figure 3) may well reflect another criterion of skill for it is the case that as accuracy improves one would expect the number of "dead" shots to decrease. All groups except the physical practice group (Group 3) decreased the number of dead shots from Test 1 to Test 2. Future researchers may wish to include "dead" shots as a measure of skill independently of or in conjunction with distance from the jack. Such a pre-determined design may produce valuable results concerning "dead" shots or other factors influencing bowls skills.

In retrospect the study highlighted the need to exert more control over extraneous confounding variables in mental rehearsal research. In particular, control of the subjects' practice was not sufficiently tight.

More time and effort may be needed to demonstrate and practice the skill of mental rehearsal in order to obtain significant results in a two-week period. Belief strength may also be enhanced by such endeavours. That two subjects withdrew from the mental rehearsal group may reflect low belief strength in the technique of mental rehearsal.
Two weeks of training at mental rehearsal may not be sufficient to produce a positive effect, although it should be noted Hall and Erffmeyer (1983) report positive findings with basketball foul shooting on a similar training period. Relaxation training may need to be incorporated into the mental rehearsal program to enhance effectiveness.

The social nature of Lawn Bowls is not always conducive to experimentation, since such factors as alcohol consumption are difficult to control. Furthermore, adherence to instructions, along with the quality of practice could not be tightly controlled. This may partially be reflected in the low response rate of the post-experiment questionnaire and the differential mortality of subjects.

In general, responses to the questionnaire indicated subjects felt that mental rehearsal is effective and that they had had previous experience with the technique (albeit rudimentary). No separation can be made between those with low belief strength in mental rehearsal who may have dropped out of the experiment and those who failed to respond to the questionnaire. All respondents in groups not required to perform mental rehearsal indicated that they did not (consciously) engage in such practice.

A number of considerations concerning the interaction between mental rehearsal and overt performance raised in this quasi-experimental study have still to be clarified and deserve further investigation. A number of recommendations and issues surfaced as a result of the study. The main points are summarized below to assist the future researcher:
(a) Provide clear written and verbal instructions to all subjects.

(b) Ensure control over practice conditions (e.g. alcohol consumption, physical environment, quality of motor practice, aerobic fitness, flexibility and relaxation training).

(c) Tailor-make mental rehearsal programs (taking care to incorporate the metaphysical beliefs of the subjects, their personal style of skill execution).

(d) Establish whether sex and age of the subject or experimenter affects results.

(e) Enhance belief strength in mental rehearsal (e.g. biofeedback demonstrations, coach and peer participation, provide examples from sport).

(f) Increase precision of skill measurement (e.g. only backhand shots, quantify "dead" shots, play short ends).

(g) Attempt to control more subject variables (e.g. match subjects on initial skill level, age, sex, idiosyncratic behaviours, differential mortality, diminishing returns in exhibited skills by the better performers).

(h) Increase the development of mental rehearsal skill in the subjects.

(i) Increase the duration and quality of the experimental training program.

(j) Carry out thorough debriefing and follow-up.

(k) Establish in the experimenter(s) a sound knowledge and understanding of Lawn Bowls.
Be vigilant for other unspecified variables that might influence mental rehearsal and the acquisition of gross motor skills in Lawn Bowls.

It becomes evident that to control or avoid the influence of extraneous variables of the type described above, more stringent control of the experimental situation of subjects and the environment is needed. In addition, the experience of the preliminary field study reinforced the author's awareness (and interests as a coach) that the effects of mental rehearsal and its testing in the field requires a number of conditions that are difficult to meet for experimental research. Such unresolved conditions do not allow the practical utility of mental rehearsal to be made clear in fieldwork (Meaney, 1984).

The field study fails to support previous findings by such authors as Feltz and Landers (1983), Hall and Erffmeyers (1983) and Meaney (1984) who have reported that mental rehearsal generally has a positive influence on motor performance. However, no detrimental effects of incorporating mental rehearsal into the bowler's programs was evident. To overcome some of the experimental difficulties mentioned above and to eliminate previous experience at the task by the subjects, an experiment designed to test the effect of mental rehearsal prior to the first overt attempt at a novel motor task is suggested. A more clearly defined and controllable aspect of mental rehearsal may prove more fruitful than the field study with Lawn Bowls.

In conclusion, the field study provides some preliminary results as well as testing a methodology concerning the use of mental rehearsal to enhance skill acquisition in sport. It is
recommended that further research, with greater experimental control and a narrower focus of attention, be undertaken on mental rehearsal's apparent influence on motor performance.

2.8 SELECTING A METHODOLOGY

Many forms of research methodology have been suggested as valid for mental rehearsal experimentation (E. Ryan, 1983; Sidman, 1960). For example single subject research of mental rehearsal offers a methodology that may provide valuable insight into the complexities of motor learning effects that group experimentation may obscure (Corbin, 1967; Landers, 1981; Zaichkowsky, 1980). Corbin (1967) also refers to the problem that can arise as a result of taking data from a few subjects. In his view data from a few subjects can affect the mean of the group thereby making interpretations of mental rehearsal's effects difficult.

It has been suggested that the problem of irreversibility creates possible confounds experienced in baseline experiments such as have been reported in investigations into mental rehearsal's effects on skill acquisition (Sidman, 1960). Where irreversibility is met, there is no individual curve that can answer the questions one may put to the group curve, or vice versa. The student should not be deceived into concluding that the group type
of experiment in any way provides more adequately controlled or more generalizable substitute for individual data. (Sidman, 1960, p.53)

Despite weaknesses in group design the decision was made to use group research to examine the influence of mental rehearsal prior to the first physical practice on skill acquisition. In addition to its possible value for motor performance in general, this type of design may have wide practical implications, such as for the primary prevention of sports injuries. The use of group research in studies concerned with mental rehearsal is well established and reported by such authors as Corbin (1967), Hall and Erffmeyers (1983) and Rawlings et al. (1972).

2.8.1 Generalizability

Neufeld (1970) suggests that it is not feasible to undertake statistical provision for the entire complex incidental conditions prevailing during experimentation. From this it would seem to follow that considerations must be employed in generalizations of results beyond the experimental context. Not all independent variables or variable conditions can be controlled (Neufeld, 1970). Among these unbalanced independent variables or incidental conditions are such things as time and locations. Neufeld (1970) also feels it is up to the experimenter to validate the logic of generalizations to reality.
A combination of both actual sports skills as well as novel highly controllable experimental tasks may be appropriate for mental rehearsal research (Hall & Erffmeyers, 1983; Jones, 1965; Rawlings et al., 1972). No one design, experiment or methodological approach has so far been devised that caters for all the possible factors involved in mental rehearsal's apparent effects on motor skill acquisition (Campbell & Stanley, 1966; Clark, 1960; Davies, 1982; Dethier, 1962; Hoff, 1954; Landers, 1981; Martens, 1981; McKAgnew & Pyke, 1978; Neale & Liebert, 1973; Sidman, 1960; Singer, 1974; Todd, 1959; Zaichkowsky, 1980).

That the coach or athlete may want to generalize to specific sports skills, while the researcher may be primarily concerned with the phenomenon of mental imagery per se adds to the difficulties persons interested in mental rehearsal in sport encounter. In an attempt to provide the scientific generalizability desired in this thesis a novel experimental task performed under laboratory conditions was undertaken.

2.8.2 Pursuit Rotor Research

Pursuit rotor tasks have frequently been used in studies concerning motor performance and mental rehearsal (Feltz & Landers, 1983; Marteniuk & Wegner, 1970; Oxendine, 1969). "These instruments are used to test a person's ability to perform a task which requires concentration and motor coordination" (Ferslew, Manno, Manno, Vekovius, Hubbard & Bairusfather, 1982,
Rawlings et al. (1972) suggest that pursuit rotor tasks are appropriate for experimentation with mental rehearsal for a number of reasons. Firstly, because pursuit rotor tasks are said to have few symbolic components, such experimentation may help clarify previous suggestions that imagery is mainly effective with highly symbolic skills (Feltz & Landers, 1983; Rawlings et al., 1972; Wrisberg & Ragsdale, 1979).

It has also been suggested that often when investigating mental rehearsal experimenters have failed to control for the amount of prior experience with the task as for example in the use of basic sports skills (Clark, 1960; Rawlings et al., 1972). Therefore, the use of a novel skill such as the pursuit rotor task may help validate the effectiveness of mental rehearsal in learning new motor skills (Jones, 1965; Rawlings et al., 1972). In this connection Ferslew et al. (1982) relate that a person's ability to perform a pursuit rotor task is said to be correlated to such everyday tasks as driving, flying or complex machine operation. Hence, such experimentation may have valid generalizability to many of the types of psychomotor skills performed in various sports (Rawlings et al., 1972). Singer and Witker (1970) used pursuit rotor tasks as novel psychomotor skills to investigate at what point introduction of mental rehearsal may best facilitate skill acquisition. In their study it appeared that the early introduction of mental rehearsal in conjunction with overt practice may facilitate learning (Singer & Witker, 1970). Elsewhere, using a pursuit rotor task, Oxendine
(1969) found that "Up to 50% of the practice time (or trials) in mental practice can be as effective as 100% of the same time in physical practice, for subjects within the normal intelligence range" (Oxendine, 1969, p.755).

The foregoing few examples indicate the justification for the use of pursuit rotor tasks in research on mental rehearsal and psychomotor tasks as undertaken in this thesis.
In order to appreciate the flavour of the previous research on mental rehearsal (and some related variables) a brief review of the relevant research literature is appropriate. The following sample of studies reflects the nature of the research published in scientific journals. Interpretation, criticism or support for the cited works is provided where appropriate.

2.9.1 An Overview of the Research

Most (but not all) of the published research has indicated that mental rehearsal has positive effects, of varying degrees, upon skilled performance (Feltz & Landers, 1983; Meaney, 1984). Egstrom (1964) suggested that published thoughts and research on mental rehearsal go back to 1899 in the literature. "This introspective rehearsal has been variously called mental practice, imaginary practice, imaging, and conceptualizing" (Egstrom, 1964, p.472). In the same study Egstrom notes that Shaw and Jacobson found differences in EMG output with mental imagery. Jacobson indicated localized EMG activity whereas Shaw found no such localization (Egstrom, 1964). Such conflicting observations do not confirm the role of neurophysiological activity as one of the apparent benefits of mental rehearsal (Feltz & Landers, 1983; Meaney, 1984).

In Egstrom's study mental rehearsal lasted 5 minutes. The subjects were asked to report their mental rehearsal technique verbally on a tape recorder. However, this may present a
difficulty in that some subjects may be intimidated by the recorder's microphones or they may find it a problem to verbalize imagery skills, as other researchers such as Start and Richardson (1964) have reported. An additional finding was that even with only 5-minute mental rehearsal periods some subjects reported a tendency to become distracted (Egstrom, 1964). The subjects were also asked not to contaminate the study by discussing the procedures with others. Egstrom found that knowledge of results seems important to enhancing mental rehearsal effects, and that mental rehearsal may need overt practice to obtain best results as suggested by authors such as Feltz and Landers (1983), Sheedy (1982), and Singer (1975a). In the study by Egstrom (1964) physical practice was shown to be more useful than mental rehearsal of the task. Since the 1930s according to Feltz and Landers (1983) over 100 research studies on mental rehearsal have been presented under various guises and they conclude that the findings remain unclear and they feel the issue of reviewer bias needs to be considered. That the majority of published works may reflect the views of the people vetting publications in this area has been suggested by Feltz and Landers (1983). In general, psychology is not known for its publication of non-results or alternative research designs (E. Ryan, 1983; Sidman, 1960). Feltz and Landers have also expressed concern for differences between the findings of the published works and unpublished post-graduate research, an issue that E. Ryan (1983) also raises. Feltz and Landers (1983) go on to question the effect of the type of skill involved and the subject's previous knowledge of the skill as possible influences on results. They suggest
that if the subject "knows" the skill then mental practice may be easier and more effective. However, research has also shown mental rehearsal to be effective with beginners and performers of novel tasks (Feltz & Landers, 1983; Minas, 1980). The brain may form a motor plan based on either previous experience or it may "invent" one according to similar task experiences in attempts to deal with the problem (Legge & Barber, 1976).

The issue of whether people in mental rehearsal groups become more "ego involved" or motivated via mental imagery of the task also has been raised by Feltz and Landers (1983). Sheedy (1983) suggests that ego involvement makes sporting situations appealing as research environments when compared to artificial laboratory settings. Other researchers have used feedback of results or appeals to become highly involved in the imagery to enhance motivation of mental rehearsal groups (Lang, 1977; Twining, 1949). Shorter sessions of about 10 minutes have been found to be effective in mental rehearsal research (Feltz & Landers, 1983), a finding that may be due to several factors such as short concentration spans; the nature of the research task; lack of training and guidance in mental rehearsal skills (Feltz & Landers, 1983; Sheedy, 1982).

Mental rehearsal has also been used to aid physiological attributes such as strength (Feltz & Landers, 1983). It has been suggested that for strength tasks more time on quality mental imagery is required in order to gain beneficial effects for the athlete (Feltz & Landers, 1983). For high performance athletes maximum benefit may be the result of many years of practising
mental rehearsal, as is similarly evident for perfecting other types of motor skills (Singer, 1975a). Feltz and Landers (1983) note that mental rehearsal may be effective at more than one stage of learning. The authors also maintain that a paucity of evidence exists in some areas of mental rehearsal such as in sex differences, although according to J. Richardson (1976) there may be no significant differences between females' and males' ability to image.

The relationship between imageability and concreteness of tasks also needs consideration by researchers (C. Hall, 1980; J. Richardson, 1976). Although it appears that the use of internal imagery perspectives elicit better EMG recordings, it has not yet proved convincingly superior in actual motor performance (Feltz & Landers, 1983; Meaney, 1984).

In addition to symbolic and neurophysiological theories, Feltz and Landers (1983) suggest that mental rehearsal may enhance optimal tension levels of performance, or prepare a psychological "set" enhancing motor responses. Certainly, on the basis of Feltz and Landers' (1983) review of the research the underlying mechanisms of mental rehearsal remain unclear.

2.9.2 Some Methodological Considerations

While looking at the relationship between imagery and thinking, Barratt (1953) conceded that mental imagery is a very subjective experience. Nevertheless he expressed concern for the "scientific" approach that avoids imagery studies because they present many experimental difficulties. Perhaps because of these difficulties some researchers have not persisted in this field of research (C. Hall, 1980). Barratt (1953) finds the following:
(a) the drive for "objectivity" has led to the rejection of "subjective" processes as imaging; (b) attempts to find some reliable method of examining the extent and role of imagery in thinking have proved so difficult that recourse has been had to the expedient of "quitting the field". (p.154)

Barratt notes the hazards of defining imagery, operationally or otherwise, since it is unavoidably tied to the subjective estimates of subjects. For instance, if the researcher asks a subject to rate their imagery on a scale, the imagery rating cannot be compared to another subject's (Short, 1953). For these and other reasons, Barratt (1953) suggests that it has been difficult to confirm or infer the effects of imagery. Many of the research findings may be indeterminate if one considers the possible interaction between imagery (A. Richardson, 1969), relaxation (Feltz & Landers, 1983) and belief strength (Sheedy, 1982). Barratt also sees imagery as important to some forms of thinking and problem solving, a view shared by various authors such as Crocker and Stortz (1982), Gerler and Nelson (1982), Ware and Hesse (1982) and Wrisberg and Ragsdale (1979).

2.9.3 Mental Rehearsal and IQ

Start (1964a) states that mental rehearsal has long been used by top performers in many sports. His research, reported in 1964, found a nonsignificant negative correlation between skill
performance after mental practice and intelligence. The results, along with the reliability and validity of IQ tests have often been questioned (Calhoun, 1977; Hilgard, Atkinson & Atkinson, 1975; Sternberg, 1985). However, mental rehearsal may relate to a different form of intelligence than "academic" IQ which tests used by Start (1964a) may have reflected, and this view finds support in the work of Calhoun (1977), Hall and Lindzey (1978), and Hilgard et al. (1975). Start's (1964a) study incorporated the use of a gross motor skill that the subjects were unfamiliar with and could not physically practice outside of the experimental situation. In contrast to the reports of Carron (1980) that top athletes tend to have a higher than average IQ, Start (1964a) found no such relationship in his experiment.

Since high level athletes are thought to be exponents of mental imagery, as suggested by such authors as Hongfei (1984), Klavora and Daniel (1979) and Meaney (1984), it may be the case that the reliability and validity of IQ testing needs further investigation (Evans & Waites, 1981; Hall & Lindzey, 1978; Hilgard et al., 1975).

It could be suggested that an athlete may approach motor skill tasks differently from intellectual tasks despite the fact that both tasks are multifactorial; but as Start (1964a) postulated, motor skills are capable of providing numerous alternative, yet contradictory, avenues for success.
Wrisberg and Ragsdale (1979) accept that, in general, mental rehearsal has a positive transfer to physical practice. However, they concede that due to the wide variety of findings in mental rehearsal research the processes of transfer remain unclear. For example, Clark (1960) found mental rehearsal to be as effective as physical practice. Wrisberg and Ragsdale (1979) report mental rehearsal to be most effective on motor tasks at the cognitive stage of development when used in conjunction with skills of high cognitive demands. In a related finding Minas (1978) has reported that mental rehearsal facilitates sequential learning in motor tasks.

Wrisberg and Ragsdale's (1979) experiment involved a stability platform task with high and low cognitive demands. "The results indicated that mental rehearsal was as effective as physical rehearsal only during the early performance on the task having high cognitive demands." (Wrisberg & Ragsdale, 1979, p.201). Wrisberg and Ragsdale (1979) reflect upon what they consider to be the two main theories that attempt to describe mental rehearsal's effectiveness. One of these theories, they claim, is that mental rehearsal results in actual, though minimal, innervation of muscles used in the activity that is, a psychoneuromuscular orientation. The other theory they propose is that mental rehearsal primarily serves to establish the symbolic or cognitive aspects of the task. According to this theory motor skills with few symbolic components would benefit little from mental rehearsal. The same authors have suggested that mental rehearsal may be more beneficial at the cognitive
stage of skill acquisition (Wrisberg & Ragsdale, 1979), a suggestion endorsed by Minas (1980). Despite this apparent convergence of views subsequent work by Feltz and Landers (1983) and Meaney (1984) indicate that there is still great variety in results with motor tasks of various degrees of symbolic components. Thus the symbolic theory remains unclear (Feltz & Landers, 1983; Meaney, 1984).

As athletes reach the peak of their learning and performance curve, objectively measurable increments will be smaller, as is consistent with virtually all types of learning, thus increasing the difficulty experimenters into mental rehearsal effects have of producing statistically significant results (Dethier, 1962; Singer, 1975a). Another aspect of mental rehearsal's role in skill acquisition is that it may serve an important motivational role in providing performance information and hence reinforcement (Rushall, 1980; Sheedy, 1982). Considering the numerous self reports of the positive influence of mental imagery (Klavora & Daniel, 1979; Meaney, 1984), it cannot be discounted that its use at the autonomous stage of skill acquisition is of significant practical benefit to highly experienced elite performers (Singer, 1975a).

2.9.5 Bizarre Imagery

DeVore et al. (1981) have proposed the use of bizarre imagery to enhance athletic performance and to aid self doubt problems. They suggest the use of such strategies as mentally enlarging the sports equipment (e.g. bats, ball, goal areas) and enlisting the aid of bizarre characters in mental rehearsal to
assist performance (DeVore et al., 1981). Senter and Hoffman (1976) have pointed out that bizarre images may need more time to be created than "normal" images. Whether or not bizarre imagery is an aid to recall is still unclear (Hauck, Walsh & Kroll, 1976; Senter & Hoffman, 1976). While the use of images may assist subjects in differentiating everyday occurrences or reality (Hauck et al., 1976), the DeVore et al. (1981) suggestion for the use of bizarre imagery in mental rehearsal needs further investigation and support before its use can legitimately be recommended for enhancement of elite performance.

2.9.6 Memory and Learning

Start and Richardson (1964) report that mental rehearsal in sport is thought to be of considerable benefit to subsequent performance. Although they suggest performance benefit may be due to habit reinforcement "learning" at a subliminal level or to a neuromuscular system, Start and Richardson (1964) find with Feltz and Landers (1983) improvement may derive from some as yet undetermined system. Start and Richardson (1964) further suggest that mental rehearsal often relates to the performer's introspection of the task at hand. According to Crocker and Stortz (1982) most mental rehearsal research is in short term memory tasks. A study by these authors on long-term memory, reported in 1982, used a linear positioning task and showed positive results for mental rehearsal. "These findings provide preliminary evidence that the covert rehearsal increases the retention of movement in motor long-term memory" (Crocker & Stortz, 1982, p.934).

Memory was also involved in explaining the results of
research by Lee and Hirota (1982) which indicated that subjects who could not see the actual task, in this case a distance linear positioning task, reproduced the task as well as subjects who could see it. "The results of the present study substantiate and extend a previous study (Lee and Hirota, 1980) which concluded that active and passive movement information is not differently encoded in memory" (Lee & Hirota, 1982, p.183).

Mental imagery may be an important factor in these situations, aiding in the development of an appropriate motor plan based partly upon proprioceptive feedback (Jones, 1965; Singer, 1975a). Lee and Hirota (1982) also report that Marteniuk's 1976 study found blindfolded subjects more accurately remembered the extent of a movement when the criterion was actively generated by the subject, as opposed to the subject being passively moved by the experimenter. This finding suggests the existence or action of mental imagery's effects at unconscious levels as postulated by C. Hall (1980) with the possibility they may be related to motor memory. "A classic finding in the literature is that mental imagery can be an effective technique for improving memory performance of to-be-remembered words" (Gerler & Nelson, 1982, p.1111). However, in the study by Gerler and Nelson (1982) imagery was not found to be an effective mnemonic technique on a word colour memory task.

Minas (1978) relates that in sport many skills demand the learning of a sequence of movements as well as the motor components. This view may help support the suggestion others have put forward that athletes often need to acquire precise
timing of muscle motor unit firing in correct sequences in order to master motor skills (Fox & Mathews, 1981; Singer, 1975a). Mental rehearsal may have positive influences on memorising such sequences if correctly administered (Sheedy, 1982).

In her study on ball selection and throwing Minas (1978) found that:

Mental practice under certain circumstances facilitates acquisition of the sequential components of a complex motor skill. ... The beneficial effect of mental practice, however, depends on the presence of feedback information during training, for subjects receiving mental practice in the absence of feedback were worse than those receiving no practice. (p.106)

C. Hall (1980) voices his concern (shared by Barratt, 1953) about criticisms and opposition to imagery in psychology, criticisms which indicate that imagery's popularity tends to waver. In relation to memory, C. Hall (1980) identifies three ways in which imagery may affect encoding systems:

(1) as a mediational process;
(2) as a stimulus characteristic;
(3) as individual differences in imaginal abilities.

The notion of individual differences has far-reaching implications for coaching since it suggests specifically designed programs may be needed to maximize an athlete's benefits from mental rehearsal. Furthermore, individual differences may exist in type or strength of imagery, in such aspects as internal or
external perspectives, positive or negative colour images, and vividness (Meaney, 1984; Suinn, 1976; Weinberg, Chan & Jackson, 1983).

C. Hall's three possible effects of imagery on memory refer to the dual coding model (Pavio, 1971, cited in C. Hall, 1980) which postulates that verbal and non verbal information may be represented and processed independently but interconnected symbolically (C. Hall, 1980). Additionally, C. Hall (1980) suggests that these encoding functions, including the "work" of mental rehearsal, may not be conscious activities. C. Hall found that imagery ability did not interact with concreteness of words as would be predicted by the dual coding theories (C. Hall, 1980). In summary, C. Hall (1980) makes the following three statements concerning imagery:

1. Conditions that encourage nonverbal imagery, such as instructions to image, generally result in higher levels of recall memory for movements.

2. Movement patterns can be scaled on imagery and recognition memory for movement patterns in direct function of the imagery value associated with a pattern. The higher the imagery value, the better the pattern is remembered.

3. Imagery ability appears to have a functional significance as a mediator for behaviour; however, effects of imagery are less predictable when this process is defined
by individual difference measures than when it is defined by stimulus characteristics or instructional sets. (p.262)

On the basis of the majority of research findings it appears that mental rehearsal can have positive effects on learning and memory relevant to motor tasks provided such variables as augmented feedback are present. However, the exact functions or mechanisms by which such learning is facilitated at this time remain unclear and require further research.

2.9.7 Combining Mental Rehearsal and Overt Practice

An elaborate study by Oxendine (1969) examined the effect of mental rehearsal on the learning of three motor skills. The total number of subjects were 212 junior high school students from three (U.S.) high schools. Each school group, subdivided into four, undertook one motor skill: pursuit rotor, soccer kick accuracy, basketball jump shot.

The pursuit rotor ran in a circular clockwise pattern at 45 RPM with the task requiring 15 second tracking periods interspersed with 15 second rest periods. A 5 second warning signal was given before each trial. The subjects practised in four groups for 3 weeks: (i) eight overt practices and no mental rehearsal, (ii) six overt practices and two mental rehearsals, (iii) four overt practices and four mental rehearsals, (iv) two overt practices and six mental rehearsals of the skill. The results showed no significant differences between the four groups.

The group performing the soccer kick for accuracy used their
non-dominant foot. In this case the four experimental groups performed (i) 12 practice kicks, (ii) nine practice kicks and three mental rehearsals, (iii) six kicks and six mental rehearsals, (iv) three kicks and nine mental rehearsals. Statistical analysis showed no significant difference in skill on post test scores, a result similar to the pilot study on Lawn Bowls cited earlier in this thesis (page 50).

For the jump shot skill no backboard was used as in normal basketball games. The same organization of physical practice and mental rehearsal as in the soccer task was used. No significant results were found, but Oxendine suggests that poor learning confounded this part of the experiment as little improvement in this skill was acquired by any of the subjects. Such difficulties may also be encountered when using elite performers as subjects since only small increments in performance can be expected. Additionally, it could be suggested that insufficient covert and overt learning trials were used to adequately facilitate improved motor performance of this skill.

The overall results indicated that as much as half the time, or trials performed as mental rehearsal may be as effective, or as ineffective, as purely overt practice. Oxendine also suggests that tasks may be learnt more rapidly if a more effective way of combining mental rehearsal and physical practice were found.

"The proportion of time which might be profitably devoted to mental practice appears to be dependent upon the nature of the task, i.e., its complexity, familiarity, and whether the learner has the physical abilities to perform the activity" (Oxendine, 1969, p. 762).
An interesting observation in Oxendine's study is that in each of the subgroups whose task was predominantly mental rehearsal subjects gave the most negative reports about the use of mental rehearsal (e.g. boredom). "When used to excess (up to three-fourths of the practice time) some students became impatient with the technique" (p.755). Such reports are consistent with numerous self reports by athletes who perform mental rehearsal for long lengths of time (Meaney, 1984; B. Rushall, personal communication, July 1982; Sheedy, 1982).

2.9.8 Evidence from Particular Applications of Mental Rehearsal

In addition to the aspects of mental rehearsal discussed so far a number of examples from the literature in which mental rehearsal has been applied in a variety of ways may serve to develop a basis for the empirical research pursued in this thesis. This section of the literature review will attempt to lay a foundation upon which to formulate a sound research hypothesis that may contribute to and possibly clarify the influence mental rehearsal may have in the acquisition of the motor skills of sport.

2.9.9 Bilateral Transfer

Turner et al. (1982) found that mental rehearsal aided bilateral transfer (i.e. dominant to non-dominant hand) on a pursuit rotor task. A rotor speed of 60 RPM was used for fifteen 30-second trials with 30 seconds rest between each trial. The subjects observed a 30 second demonstration of the task prior to overt attempts. Turner's findings support previous views that
individual differences exist and may affect mental rehearsal and motor performance in various ways (Feltz & Landers, 1983; C. Hall, 1980; Rawlings et al., 1972). "There are individual differences in competency to generate mental imagery that may affect acquisition of skill when imagery of one skill is used, specifically in ability to image vividly and control one's images" (Turner et al., 1982, p.771).

The ability to transfer skills from one limb to another has practical application potential for a wide variety of sports and for sports medicine (Glencross, 1981; Singer, 1975a; Unestahl & Stanley, in press). Research such as Turner's supports the view that mental rehearsal can have positive influences on bilateral transfer, a finding that deserves further investigation for the practical implications it may have for improving motor performances needed in sport.

2.9.10 Balance

Roehrig (1964) in a study that required subjects to learn a difficult balancing task involving the whole body, found perfect retention after 50 weeks of no overt practice. These subjects were reportedly intelligent, and were also highly motivated to acquire the co-ordination necessary to the balancing task. However, Roehrig (1964) appears not to have considered the possible effects of mental rehearsal in retaining skills when overt practice is not possible (Rushall, 1982; Unestahl & Stanley, in press). The fact that subjects in Roehrig's experiment knew that they were to be retested may have meant that they consciously or unconsciously employed mental rehearsal to retain their skill levels (C. Hall, 1980).
Replication of Roehrig's experiment with the added inclusion of a post test mental rehearsal questionnaire may help clarify why perfect retention of skill was achieved. The research design incorporated in this thesis in part attempts to pursue the question of retention of skill without overt practice.

2.9.11 Pursuit Rotor Tasks

Rawlings et al. (1972) suggest that pursuit rotor tasks have few symbolic components, a quality that makes them appropriate for experimental use with mental rehearsal. The authors also question the generalizability of past findings in mental rehearsal, this they do on the basis of the types of tasks investigated. They suggest that often the amount of prior experience has not been controlled, as for example in the use of sports skills, to investigate mental rehearsal. They attempt to validate the use of pursuit rotor tasks in their experimentation.

As it has been suggested that symbolic tasks have been more effectively aided by mental rehearsal, the use of a novel task with few symbolic aspects, such as pursuit rotor, may be appropriate in an attempt to overcome such confounds (Feltz & Landers, 1983; Rawlings et al., 1972; Wrisberg & Ragsdale, 1979). An additional confound, noted by Rawlings et al., is that the control groups may be different from the experimental subjects as the latter have more "contact" with the experimental environment (i.e. in physical or mental practice). Future researchers may attempt to cater for this possible limitation in their experimental designs.

Rawlings et al. devised two experiments using pursuit rotor
tasks and both showed positive results. "In both these studies mental rehearsal was operationally defined by having S mentally picture the apparatus (which was not in view) and imagine themselves performing the task without actually making the motor movements" (Rawlings et al., 1972, p.71).

The design of the empirical research undertaken in this thesis attempts to cater for the confounds suggested by Rawlings et al. of (a) differences in contact by the subjects with the experimental environment, (b) prior experience at the experimental task, and (c) the use of a task with few symbolic components.

2.9.12 Ring Tossing Tasks

Twining indicated in 1949 that it is unclear how much is physical and how much is mental in learning motor skills. He makes clear how difficult it is to isolate and measure mental activities. Nonetheless, Twining maintains that mental rehearsal can be as effective as physical practice in some circumstances.

Twining's study of the skill used in ring throwing included some interesting components. The subjects were divided into three groups: Group 1 only engaged in the pre and post test measurements; Group 2 engaged in pre and post test measurements with intervening physical practice; Group 3 engaged in pre and post test measures with intervening 15 minute mental rehearsal sessions. There was a total of 3 weeks practice between recorded tests. There was an attempt to influence the subjects' motivation by having them self record their scores after every seven shots (on the assumption that knowledge of results could be
expected to positively influence subsequent effort at the experimental task). Procedures such as this have implications for skill enhancement and the increase of possible benefits of mental rehearsal by the use of performance feedback (Rushall, 1980; Singer, 1975a). The experimental design utilized in this thesis incorporates the procedure of giving subjects immediate knowledge of performance results in an attempt to enhance motivation and maintain interest in the experimental task.

An important observation by Twining (1949) was the subjects' reports that of the 15 minutes mental rehearsal only about 5 minutes were quality efforts of imagery. After this time it was reportedly difficult to concentrate. However, this concentration could improve with practice, motivation or feedback of positive results (Sheedy, 1982; Singer, 1975a). The mental rehearsal skill of elite athletes may perhaps be superior to the average performer, but such a suggestion needs to be investigated and duly confirmed by research specifically designed to clarify the issue. The difficulty reported by Twining's subjects' presumptive inability to sustain prolonged concentration on imagery may also support B. Rushall's (personal communication, July 1982) statement of "overuse" problems in mental rehearsal. The current research thesis attempts to provide for the difficulty in subject concentration span by keeping the imagery time short for all subjects.
2.9.13 **Golf Putting**

Aksamit and Husak (1983) found no significant difference between subjects who were asked to watch the ball or watch the target compared to those who were blindfolded when performing the task of golf putting. It appeared that the strategies of watching the ball or watching the target were equally effective with golf putting skill.

However, if a difference does exist it offers practical implications for coaching such as undertaking to influence attentional focus and direction of concentration (Cotton, 1964; Daish, 1972; Nicklaus, 1968; Nideffer, 1980a; Nideffer, 1980b; Spink, 1984). In addition, mental rehearsal instructions may need to be directed towards the most appropriate focus of attention in the sporting or experimental situation to optimize results.

Aksamit and Husak (1983) also report that the no vision (blindfold) group had fewer errors than the two vision groups (ball watchers, target watchers), although not significantly fewer. They suggest their result may be due to information overload. The result could also be due to the effect of mental imagery, with the subjects forming an appropriate motor plan for the task before the blindfold was applied, as others have suggested (Jones, 1965; and Singer, 1975a). All subjects are reported to have received visual feedback after the task was performed, a possible influence on mental rehearsal of the skill according to Rushall (1980) and Sheedy (1982). Proprioceptive feedback is another factor that may have a significant effect on influencing subjects skill processes (Singer, 1975a). Motor
learning theory suggests that information overload would be unlikely on such a simple, closed, discrete skill as golf putting (Legge & Barber, 1976; Marteniuk, 1976; Pyke, 1980; Singer, 1975a).

Future research of this nature may benefit from self reports of what subjects imagined in each experimental situation. Such information may lead to a better understanding of the type of focused imagery likely to produce optimum results in physical activities such as golf putting.

2.9.14 Gymnastics

A research project by Start (1964b) employed 21 male subjects in 5 minute daily mental rehearsal sessions over 6 days. Subjects were asked to mentally rehearse a novel gymnastic task. The aim of the research was to examine mental rehearsal's effect on kinesthesis, which Start (1964b) suggests "provides information to an individual about his body movement and this is subconsciously integrated with other cues to enable him to move smoothly and accurately" (p.317).

Start supports views expressed by others that mental rehearsal may "work on" motor plans in memory or foster the development of motor plans designed to solve problems (DeVore et al., 1981; Saparina, 1974; Segrave & Chu, 1981). This possible interrelationship or transfer effect may be an important factor in the apparent positive function of mental rehearsal in motor performance. Future researchers may wish to determine whether kinesthetic, visual, or a combination of the two types of imagery is most effective for enhancing skill acquisition (Davis, 1932; Nettleton, 1980b; Singer, 1975a).
In a study by Clark (1960) it was shown that in basketball one-hand foul shot mental rehearsal was nearly as effective as physical practice. In accounting for the general knowledge coaches and physical educators have of the importance in sport of mental aspects such as imagery, Clark suggests it is based on intuition rather than awareness of research evidence. He also suggests that it is still uncertain how much of motor learning is mental and how much is physical, as stated by various authors such as Singer (1975a) and Twining (1949). In relation to his own experimental results Clark (1960) feels "It is folly to attempt to evaluate accurately in one experiment all the variables affecting any motor skill" (p.560).

The difficulties of conducting research concerned with mental rehearsal have been commented on by a number of authors among them are Barratt (1953), Feltz and Landers (1983), A. Richardson (1967), and Twining (1949). In Clark's (1960) experiment intelligence was used as one measure, although no significant relationship was found between motor skill, mental imagery and I.Q. It has been suggested that such group tests for I.Q. do not tend to be accurate (Calhoun, 1977; Clark, 1960; Evans & Waite, 1981; Hall & Lindzey, 1978).

A factor of special interest in the 1960 experiment by Clark was the finding that some subjects were "contaminated" by facetious and deprecating remarks by their coaches concerning the effectiveness of mental rehearsal. If subjects are to be kept as free as possible of this type of external interference future researchers need to be aware of such influences on outcome
together with such factors as the attitude of some coaches towards all areas of sports science. In the same experiment some of Clark's subjects reported hallucinations such as the basketball sticking to the ground. In such cases of reported difficulty in positive sports imagery, coaches and sports psychologists have suspected problems in skill, readiness, or lack of confidence in performers (B. Rushall, personal communication, July 1982; L. Zaichkowsky, personal communication, 1984). Subconscious problems of this type may be exhibited via such hallucinations or imagery according to Green and Green (1977) and Stanton (1984). Various hallucinations were reported by the subjects in Clark's basketball experiment. This phenomenon may also relate to the types of imagery dominant in the subjects (e.g. imagination or memory imagery) as referred to by A. Richardson (1967, 1969).

Such hallucinations could indicate insufficient or incomplete motor plans in memory for the experimental basketball task (Jones, 1965; Singer, 1975a). Pre-performance imagery of the type described may have utility, as B. Rushall (personal communication, July 1982) suggests for preventing injuries by not permitting athletes to attempt the desired task until clear successful positive imagery is obtained.

The introspective reports by the subjects, though not "scientific" as Clark himself notes, nevertheless provide the reader with valuable information. This view is supported by Meaney (1984) and Suinn (1976) who note the importance of introspective reports, anecdotal reports and the experience of coaches as valuable sources from which to gain insight into
certain aspects of mental imagery in sport. Clark (1960) comments that "it appears that mental practice has great potential for sharpening perceptual skills" (p.568). Clark also indicated that mental rehearsal was not as effective with novice performers as with the more experienced. This is in direct contrast to results reported by other researchers including Minas (1980) and Wrisberg and Ragsdale (1979) who showed the cognitive stage of skill acquisition as most influenced by mental rehearsal. It should be noted, however, that coaching experience tends to confirm the view of Clark (B. Rushall, personal communication, July 1982; Sheedy, 1982).

In the experiment by Clark all subjects who undertook mental rehearsal of the basketball skill, reported subjectively an improvement in their ability to visualize the task. This may indicate that mental rehearsal is a skill in itself and will improve with consistent correct practice and augmented feedback (DeVore et al., 1981; Singer, 1975a). On the basis of Clark's (1960) study it appears that subjects who were better at visualizing imagery and more experienced basketballers profited most from the mental rehearsal, a finding that is consistent with the reported results of Rawlings et al. (1972).

2.9.16 Swimming

Yamamoto and Inomata (1982) using 36 subjects divided into three groups, looked at the effect of mental rehearsal on backstroke swimming with progressive part modelling or whole demonstration modelling, as described in detail by Singer (1975a) and others. Their experimental design used a film to show the
task being demonstrated by models, and a variation of Bett's imagery questionnaire (A. Richardson, 1969) was administered to the athletes at the conclusion of the experiment.

These results support the following conclusions: (1) Physical practice as well as mental rehearsal increases vividness and accuracy of imaging swimming the backstroke. (2) The relationship of mental rehearsal to vividness of imaging is significant for scores on vividness of general motor imagery. (3) Initially in learning the backstroke or crawl, the effect of mental rehearsal on motor performance is related to the learner's general ability for motor imagery under the whole but not the progressive part modelling. (Yamamoto & Inomata, 1982, p.1070)

The third conclusion could relate to the nature of whole learning to the function of the right hemisphere and mental imagery (E. Hall, 1981). The success of visual aids, such as film and video, to assist mental rehearsal is also supported by authors such as DeVore et al. (1981), Hall and Erffmeyers (1983), and Suinn (1976).

The apparent interrelationship between imagery accuracy and both mental rehearsal and overt practice deserves further consideration by researchers in the field of sport psychology (Yamamoto & Inomata, 1982). Another consideration in Yamamoto and Inomata's research is the 2 hours of physical practice that
all of the athletes undertook. A resulting confound could be improvements in Krebs Cycle functioning affecting the subject's swimming performance. Physiological rather than psychological variables may have influenced the research results (Carlile, 1982; Pyke, 1980). Future research can employ experimental designs to control or account for such physiological changes as influences on performance outcomes and post-test results.

2.9.17 Mental Rehearsal Prior to Overt Practice

The following cited works further develop and narrow the theme for the experimental direction of this research project. The sampled literature indicates the need for further research and clarification of the effect of mental rehearsal prior to the first overt attempt at a novel psychomotor task.

A study by Ware and Hesse (1982) failed to show mental rehearsal as beneficial to perceptual accuracy. The experiment used 10 minutes of mental rehearsal contrasted with a control group employing 10 minutes of relaxation. Subjects in both groups were shown the visual-kinesthetic positioning task prior to their first overt attempt at performance, and prior to either experimental or control group procedures.

Start and Richardson in a 1964 study looked at subjects' ability to both control and change their imagery. They used a gymnastics skill that the subjects were not able to physically practice away from the gymnasium where the appropriate apparatus was established. The subjects mentally rehearsed for 5 minutes per day for 6 days prior to their first overt attempt at the skill. Results were positive but also provided indications that
vividness of imagery did not relate to performance scores. This finding appears to support the view of Green and Green (1977) and C. Hall (1980) that mental rehearsal has subliminal effects and may be working on an unconscious level. The control of imagery may be part of a general ability to ignore irrelevant or extraneous stimuli as Start and Richardson (1964) suggest. Such a theory may help to account for the elite performers' outstanding attentional abilities and concentration in many sporting situations as reported by Nideffer (1976) and Spink (1984). Start and Richardson (1964) also postulate that the subjects may report imagery in terms that best suit their verbalizing rather than in terms of what images they actually used or imagined. People may tend to say what is easy to verbalize or communicate in "logical" terms, although they may in practice form images in a manner not totally conscious or images that are very difficult to explain through the medium of spoken or written language (Start & Richardson, 1964).

Minas (1980) refers to mental or symbolic practice in reference to her research on hop-scotch sequence skills. She reports that there is still little consensus about the nature of the underlying mechanisms of mental rehearsal's apparent effect on skill as suggested by such authors as Feltz and Landers (1983), Minas (1980) and A. Richardson (1967). Of interest is the point Minas makes about the subjects, when she considers the importance of the athletes' "gestalt" framework of the skilled task. If established this has implications for coaching athletes
at the cognitive stage of learning in that the use of mental rehearsal in conjunction with physical practice may facilitate skill acquisition (Pyke, 1980; Singer, 1975a).

The Minas (1980) study revealed significant beneficial effects which she attributed to mental rehearsal prior to the first physical attempt at performance. In her experiment the independent variables controlled for were speed, quality and correct sequence of the hop-scotch task. Minas suggests that the reported benefits of mental rehearsal could be attributed to the subjects having a better opportunity to organize a movement plan. If Minas' reflection is correct it supports postulations by Fitts and Posner (1967) that the cognitive stage of learning may be enhanced by mental rehearsal.

An earlier suggestion by Legge and Barber (1976) supports the Minas' 1980 view that the demands placed on the executive system during overt practice of a new skill do not allow time or space to establish or refine motor plans. Minas (1980) suggests mental rehearsal may provide just such a cognitive opportunity to enhance skilled performance.

Singer and Witker (1970) looked at what point the introduction of mental rehearsal might best facilitate the acquisition of a novel motor task. In their study the psychomotor task used was pursuit rotor. The study involved two sessions per week for 4 weeks: 15 seconds tracking time at 60 RPM with 10 seconds rest between trials. No significant differences were found between groups that were contingent on the order of
addition of mental rehearsal to physical practice. However, there did appear to be a trend that suggested early mental rehearsal may facilitate learning when used in conjunction with overt practice.

With the work/rest ratio used by Singer and Witker (1970) it may be that lactic acid congestion could effect the physical performance of the subjects (Marteniuk & Wenger, 1970; McArdle et al., 1981; Pyke, 1980). Slower rotor speeds or longer rest intervals may overcome this possible confound.

Corbin (1967) used a wand tossing task to investigate the effect of mental rehearsal after an initial period of physical practice. The subjects were given 5 days of physical practice of 30 tosses per day, before being assigned to one of three groups: physical practice, mental rehearsal or control. The subjects then spent 13 days in their groups.

The fact that the paired + score of 1.6 was nearly significant might indicate that for full effect, mental practice need not merely be based on experience but also on actual physical practice. This physical practice after mental practice might act as the catalyst to bring out the full effects of this mental practice (Corbin, 1967, p.537).

This apparent effect may be due to a "fine tuning" of the motor plans subconsciously worked on during or via the mental rehearsal, and further enhanced by the feedback from overt practice (Jones, 1965; Singer, 1975a).

Vattano (1964) suggests that in tracking performance visual
and kinesthetic feedback (intrinsic) operates independently of knowledge of results provided by external (extrinsic) sources. Suggestions of this type have implications for mental rehearsal using pursuit rotor tasks since subjects may be more motivated if performance feedback is given between each trial (Singer, 1975a). Intrinsic feedback, such as seeing or hearing the time on target score, may be even more beneficial to the subject's performance (Vattano, 1964).

Annett and Kay (1957) indicate that such knowledge of results should encourage both self competition and social competition. They further suggest that lack of, or removal of, augmented feedback may be frustrating to subjects. Annett and Kay (1957) also relate that occasionally withholding knowledge of results may aid learning as the subjects may tend to concentrate on the current task (learning feedback, i.e., what should be done) rather than the next task (action feedback, i.e., what to do next).

It remains the case that no single research design up to now has been able to incorporate or account for all factors, but as Lang (1977) suggests future researchers should perhaps attempt a systematic approach when studying the various influences on mental rehearsal and skill development.

Phipps and Morehouse (1969) designed a study to examine the effects of mental rehearsal on the acquisition of three skills of varying complexity. A hock swing gymnastics skill, a jump foot skill, and a soccer hitch kick were the tasks examined. The
80 subjects were athletes with no prior experience of these skills. After a brief relaxation phase, the subjects performed 10 mental rehearsals of their experimental task. Five days of mental rehearsal preceded the subjects' first overt attempt at the motor skills.

The results of the subjects' first physical attempts at the skills showed mental rehearsal effective for the hock swing; but with jump foot and soccer kick no significant difference from the control group was evident. "It was concluded that the effectiveness of mental practice without prior physical practice is specific to the skill and is more pronounced for simpler skills" (Phipps and Morehouse, 1969, p.773).

The Phipps and Morehouse findings support Corbin's (1967) study but contradict Jones' (1965) experimental results with the same hock swing gymnastics skill. The effectiveness of mental rehearsal with skills new to the learner, and prior to the learner's first overt attempt may be related to the complexity of the task or effectiveness may be specific to certain skills (Feltz & Landers, 1983; Phipps & Morehouse, 1969).

Jones (1965) used the hock swing upstart gymnastics skill to investigate the effect of mental rehearsal prior to the subjects' first overt attempt. A total of 71 male subjects were randomly assigned to two practice conditions: directed and non-directed mental rehearsal. Subjects had no prior experience in gymnastics and performed the mental rehearsal 3 days per week for 2 weeks.
The results indicated that the subjects could perform the gymnastics skill at their first overt attempt and that the non-directed imagery group were superior. This second finding supports suggestions by DeVore et al. (1981) that mental rehearsal may influence or develop appropriate motor plans at unconscious levels. "Research workers are coming to realize more and more that the function of the brain in planning motor acts is a vital part of motor learning" (Jones, 1965, p.270). In tasks such as gymnastics skills, totally naive subjects may be scarce, as motor plans may be built from fragments of other known skills or from vicarious learning experiences (e.g. television coverage of Olympic gymnastics competition). "Previous experiences drawn from memory may also be used as part of the construct" (Jones, 1965, p.271).

Future researchers who wish to investigate mental rehearsal's effects on the acquisition and learning of "new" skills may have difficulty in obtaining totally naive subjects. This is due in part to the influence of the media and to greater opportunities to experience the wide variety of sports that now exists (Edwards, 1973; Meyer, Brightbill & Sessoms, 1969; Zeigler & Spaeth, 1975).

2.9.18 Summary

In summary, the need exists to conduct research utilizing subjects naive to the experimental task which has been chosen because it is objectively measurable and relatively easy to visualize. Thus the influence of mental rehearsal at this initial stage of skill acquisition may be clarified.
Additionally the use of a psychomotor task with reportedly few symbolic components (i.e. pursuit rotor) may confirm or confute symbolic content theories concerning mental rehearsal that have been postulated by various authors (Feltz & Landers, 1983; Rawlings et al., 1972; Wrisberg and Ragsdale, 1979).

The results of the preliminary field study on Lawn Bowls need to be considered as an experiment to test mental rehearsal's effects on motor performance. In particular control of the experimental conditions and quality of mental rehearsal instructions require specific attention in the experimental design.

Considering the above research concerning the influence of mental rehearsal on the subsequent performance of motor skills, the following hypothesis was investigated.

2.9.19 **Hypothesis**

Mental rehearsal prior to the first overt attempt at a novel psychomotor task will significantly enhance early performance compared to a control group.
CHAPTER THREE

METHOD
3. METHOD

3.1 Subjects

Sixty-one subjects voluntarily participated in the pursuit rotor experiment. Initially 52 first year psychology students became the experimental subjects, but in order to increase sample size nine members of the general public were recruited to co-operate in the study. The age range of the subjects was approximately 17 to 50 years. The subjects were deliberately recruited from student populations with little probability of experience with pursuit rotor tasks (e.g. Physical Education and Sports Science students were excluded). Subjects were randomly assigned into two groups. The 30 subjects, 22 female and eight male, in the experimental mental rehearsal group were matched against the control group containing 31 subjects, 18 female and 13 male. In the retest trials attrition accounted for five females in the mental rehearsal group and three female and five male subjects in the control group.
3.2 **Apparatus**

A standard Lafayette pursuit rotor device was set to run clockwise at 60 RPM for six consecutive 30-second trials with 30-seconds rests between trials employing a Digitimer sequence timing apparatus. The shape of the pursuit task was an equilateral triangle with sides 20 centimetres in length. The apex of the triangle was furthest from the subject, the base nearest the subject (see Figure 4). The target light was set at the apex of the triangle before each trial. A signal tone was set to sound for half a second, 5 seconds prior to each trial. The pursuit rotor apparatus was placed on a table so the subject could stand close to and directly in front of the experimental task with uninhibited arm movement for either left or right handed subjects (see Figure 4). The stylus of the pursuit rotor was set so as not to accidentally record time on target during the rest periods. A Lafayette timer was used to record the subject's total time on target for each trial to one hundredth of a second. In order to reduce resistance and noise, the target surface and tip of the stylus were cleaned every day. The speed of the apparatus (i.e. 60 RPM) was also checked every day.

To assist the experimental project a questionnaire (Appendix G) was constructed by the author on the basis of previous research experience and familiarity with the relevant literature and given to the mental rehearsal group subjects. The purpose was to try to determine possible relevant characteristics such as
subject history at the experimental task, belief strength and the effectiveness of the method used. Despite these measures however, the value of such an instrument must depend upon the veracity of the subject's responses (the value and limitations of such questionnaires are discussed by such authors as Clark, 1960; Sheehan, 1967; Short, 1953; and Stacey, 1969). A written set of procedures for the experimenter, including sufficient recording sheets, and mental rehearsal instructions were used throughout the experiment. Pencils and a copy of an extract from a popular novel, with substantial imagery-inducing prose, The hitch hiker's guide to the galaxy (Adams, 1979), was supplied to each of the control group subjects (see Appendix H for the extract). A comfortable lounge chair with arm rests was located in one of two experimental rooms in the Psychology Department. In the other adjoining room the pursuit rotor device with ancillary equipment and furniture was located (see Figure 4).
Figure 4. Plan view of experimental setting (not drawn to scale).
3.3 Procedures

Each subject was led into the experimental room containing the pursuit rotor device. The experimenter gave the following instructions:

This is a simple experiment concerning skill learning. There are no unpleasantly stressful aspects or deception involved in this research. Briefly the experiment consists of four parts: (1) A demonstration of the pursuit rotor task I want you to perform; (2) A short and different task relevant to your performance to be carried out in another room; (3) A recording of your six practice trials of the pursuit rotor task to be performed in this room; (4) A follow-up session in two weeks time on one of the two tasks. I would also ask you please, not to discuss the nature of this research with other people who may be subjects in this experiment until the study is over.

3.3.1 Demonstration

The experimenter then explained the function and mechanics of the pursuit rotor task as follows:

First, I want you to see the equipment and the task you will soon be asked to perform. This apparatus is called a pursuit
rotor. This stylus has a light sensitive tip and registers time-on-target on this stopclock when it is directly over the target light you are asked to trace. The light follows this triangular pattern clockwise. The speed of the rotor is constant, but may appear to change as the light approaches and leaves each vertex of the triangle.

You will be required to track the target light for six 30-second trials. Your task is to maximize your time on target in each trial. Please use your dominant hand throughout the experiment.

Between each trial you will receive a 30-second rest in which you may put the stylus down. Five seconds before each trial you will hear a tone that indicates you should place the stylus on the target light, ready for the trial. At the beginning of each trial, before the 5-second warning tone, the target light will be put at the apex of the triangle.

As I write down your time on target after each trial I will tell you how long you were over the target, and will indicate to you when the fourth and last trial is coming up.

In summary the four main points are: (1)
There will be a 5-second warning tone; (2) 
You must track the target for 30 seconds; (3) 
There will be a 30-second rest period between 
each trial; (4) There will be six consecutive 
trials. I will now show you one trial of the 
task as an example of how to perform the 
skill.

The experimenter then carried out one complete trial in view 
of the subject. This consisted of the apparatus being fully 
switched on (motor running), the warning tone sounding, the 
experimenter tracking the target light and finally the target 
light being reset at the apex of the triangle ready for further 
trials. The subject was then asked if she/he had any questions. 
If there were questions these were answered and the subject was 
then led to the second experimental room.

3.3.2 Experimental Group Instructions

Each of the experimental group subjects was asked to sit in 
the lounge chair while the experimenter gave the following 
instructions:

This part of the experiment involves the 
use of mental rehearsal of the task you just 
saw and will soon be asked to attempt. That 
will be six 30-second trials. Please find a 
comfortable position in the chair; avoid 
constricting yourself by crossing your legs. 
Rest your hands on the arms of the chair. 
During mental rehearsal you will be asked to
keep your eyes closed and signal me by raising your right index finger to avoid breaking your concentration by opening your eyes or speaking. I want you to close your eyes and try to relax as much as possible. Think about your breathing, it should be controlled and rhythmic. In a moment I want you to take 10 controlled breaths, and try to become more physically relaxed as you breathe out each time. When you have completed your 10 breaths and feel relatively relaxed, raise your right index finger. Please start your 10 relaxing breaths now. (SUBJECT'S SIGNAL)

Keeping your eyes closed I want you to imagine yourself performing the pursuit rotor task. Imagine the 5-second warning tone sounding and yourself placing the stylus on the apex of the triangle. Now the rotor starts and you trace the light with the stylus. Think about how you are holding the stylus, imagine how it feels in your hand, how your forearm feels as it moves, the sound of the apparatus. The target light may seem fast at first but you soon adjust to the speed of the rotor, and you can fairly accurately trace the light in the triangle. When you feel the 30 seconds of trial time are up raise your right index finger. (SUBJECT'S SIGNAL)
Good, relax your finger now. You can imagine resting the stylus. Keeping your eyes closed, think about the shape of the task you must trace. (PAUSE)

Now the warning tone sounds again indicating to you to place the stylus at the apex of the triangle ready for the second trial. The rotor starts and you trace the target light even more accurately this time. Think about the task, how it feels, what you see, how you concentrate. When you feel the 30 seconds are up raise your right index finger. (SUBJECT'S SIGNAL) Good, you can rest your finger now.

Now I want you to mentally rehearse the rest of the six practice trials as vividly as you can. You have four more trials to imagine. When you have completed the final trial raise your right index finger. Please go ahead with your mental rehearsal. (SUBJECT'S SIGNAL) Good, you can rest your finger now.

Finally, I want you to relax once more before you open your eyes. Take 10 controlled breaths and on the 10th breath open your eyes. (SUBJECT OPENS EYES) Are you O.K.? (SUBJECT'S RESPONSE) Please move slowly, strength and wake up fully before you
attempt to stand. Now we will go back to the pursuit rotor task.

The subject was then led back to the adjacent experimental room which contained the pursuit rotor device.

3.3.3 Control Group Instructions

The control group subjects were asked to sit in the lounge chair. They were given a pencil and a copy of the extract from *The hitch hiker's guide to the galaxy* (see Appendix H). The experimenter gave the following instructions:

This part of the experiment involves performing a simple cognitive task for about 10 minutes. This is an abstract from a popular novel. I would like you to read the material and underline the words, or phrases, that evoke the most imagery for you. When you have completed the task please indicate to me that you are ready for the final part of today's experiment. Do you have any questions? (SUBJECTS INDICATE COMPLETION OF THE CONTROL GROUP TASK) Good, now we will go back to the pursuit rotor task.

The subject was then led back to the adjacent experimental room which contained the pursuit rotor device.

3.3.4 Pursuit Rotor Trials

The subjects stood directly in front of the pursuit rotor device, and the experimenter sat opposite with recording materials. When the subject indicated she/he was ready the six
practice trials were recorded. Hence, the apparatus was started, the 5 second warning tone sounded, 30 seconds of pursuit tracking ensued, followed by the 30-second rest period in which the time on target was recorded and verbally reported to the subject, the stopclock reset to zero, the target light reset to the apex of the triangle, and the beginning of the fourth and last trial were indicated.

At the conclusion of the six consecutive trials the experimental group subjects were asked to fill out the mental rehearsal group questionnaire (see Appendix G). All subjects were asked to set a retest date for the follow-up trial series approximately 2 weeks hence. All subjects were told that full debriefing and explanation of the meaning of the experiment would be given after the retest.

**Follow-up Instructions**

The subjects were led into the experimental room containing the pursuit rotor device, and given the following instructions:

In this final section of the experiment I would like you to again perform six trials at the pursuit rotor task. To refresh your memory these are the four main points, (1) There will be a 5 second warning tone; (2) You must trace the target light for 30 seconds; (3) There will be a 30-second rest interval between each trial; (4) There will be six consecutive trials.

I will now show you one trial of me
performing the task as a reminder of how to perform the skill. (DEMONSTRATION) Do you have any questions?

The subjects then took up their position in front of the pursuit rotor device and when ready began the six practice trials. The procedure for the six recorded follow-up trials was the same as for the initial trial series. At the completion of the final trial the subjects were thanked for their participation and debriefed.
4. RESULTS

A BMDP P2V computer program was used to calculate a Split Plot 2(group) x 2(sex) x 6(trials) ANOVA, with repeated measures on trials for both the initial trial series and the retest series (Winer, 1971).

Test 1 results:

The only significant factor was trials \( (F = 74.41, \text{d.f.} = 1:190, \ p < .001) \) indicating that there was a difference in trial means. None of the other factors approached statistical significance (i.e. grouping, sex, trials by group or trials by sex).

A Dunnatt "t" test (see Roscoe, 1969, p.320) was administered to establish the nature of the trial difference indicated by the ANOVA and to further clarify the results pertaining to the theoretical hypothesis. At the .05 level of probability (\( \text{d.f.} = 290; \text{critical t value of 1.64} \)) the experimental group was found to be significantly better on the first two of the six trials (see Figure 5 and Table 2).
Table 2

Results of Dunnet "T" Test; Initial Trial Series

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<th>TRIALS</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
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<tr>
<td>Means (seconds)</td>
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</tr>
<tr>
<td>Control Group</td>
<td>3.446</td>
</tr>
<tr>
<td>Means (seconds)</td>
<td></td>
</tr>
<tr>
<td>Calculated &quot;t&quot;</td>
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</tr>
<tr>
<td>*p&lt;.05</td>
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<tr>
<td>Critical Value of &quot;t&quot;</td>
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<tr>
<td>at .05</td>
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</table>

Figure 5. Mean time on target per trial; initial trial series.
4.1 Retest Results

Again the Split Plot ANOVA indicated that the only significant factor was trials \( (F = 6.70; \text{d.f.} = 1.125; p < .001) \). None of the other factors approached statistical significance (i.e., group, sex, trials by group or trials by sex).

Similarly, the Dunnett "t" test at the .05 level of probability \( (\text{d.f.} = 225; \text{critical } t \text{ value of } 1.64) \) indicated that the experimental group was significantly better on the first two trials of the retest (see Figure 3 and Table 6). There was a differential mortality of five subjects from the experimental group and eight subjects from the control group for the retest trial series.

Table 3

Results of Dunnet "T" Test; Retest Trial Series

<table>
<thead>
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<th>TRIALS</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Experimental Group</td>
<td></td>
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<tr>
<td>Control Group</td>
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<tr>
<td>Calculated &quot;t&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.22</td>
</tr>
<tr>
<td>*p &lt; .05</td>
<td>*p &lt; .05</td>
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<tr>
<td>Critical Value of</td>
<td></td>
</tr>
<tr>
<td>&quot;t&quot; at .05</td>
<td>1.64</td>
</tr>
</tbody>
</table>
The results of the ANOVA failed to show a significant difference between groups, a finding that fails to support the experimental hypothesis (see 2.9.19). However, the hypothesis was supported on the results of "t" tests on the means of the first two trials of both the initial and retest trial series (raw scores appear in Appendices I, J, K, L).
4.2 Results of the Mental Rehearsal Group Questionnaire (N=30)

Question 1: Prior experience with pursuit rotor tasks
   Yes = 0   No = 30

Question 2: Mental rehearsal of internal or external perspective
   In = 22   Ex = 8

Question 3: Did mental rehearsal help your performance?
   Yes = 24   No = 6

Question 4: Comments on the mental rehearsal (four subjects gave no response to this question).
"Instructions on practice period may possibly be clearer".
"Mental rehearsal helped prepare for the task".
"Relaxation - mind on exercise".
"The mental rehearsal reinforced the task".
"Mental rehearsal made me more aware of the position of the rotor on the triangle".
"Mental rehearsal was both relaxing and served to give an idea of how to approach the task".
"Would have been more helpful after the trial?"
"After visualizing the first four trials, I found the actual task easier to master".
"I felt it could have been longer. Have more breathing time so you can adjust".
"Helped to relax me and got me accustomed to the task without having to do any practice trials".
"I think that it increased the anxiety for the rotor task".
"Could have rehearsed better if I was more familiar with the apparatus, i.e. longer demonstration".
"Led to better preparation for a task which was previously unknown to me".

"Allowed me to gain a mental picture of the task and the warning noise prepared me to pursue the task".

"First attempt at mental rehearsal. Strange feeling".

"Tended to get a bit fanciful about the course of the light and my mind wandered a bit. External thoughts intruded".

"Motivated to improve".

"Tended to concentrate on times taken or to be taken in task rather than actual skill of task".

"My use of the mental rehearsal was slower than the actual performance. I was unable to do it fast".

"Helped to relax and understand more clearly the experiment".

"The mental rehearsal may help the performance of the task because it may also influence the physical fitness of a person".

"When I looked at the pursuit rotor as an image in my mind rather than an object my performance was best".

"I felt a little uneasy when the experimenter asked me to perform the task four times because I wasn't sure if I was taking up too much time or going too quickly with my preparation. Also, I found it a little uneasy trying to relax in a small, sterile sort of room with the experimenter. Otherwise, I felt that the mental rehearsal did help for my performance".

"Got used to it. Felt more relaxed".

"I was better prepared for the experiment".

"I found it relaxed one, and prepared them for the task ahead".
4.3 **Summation of Results**

On the basis of the results of this experiment it appears that mental rehearsal prior to the first overt attempt at a novel psychomotor task does significantly enhance performance, as stated in the hypothesis. However, this tends to be only an initial effect. In summary, these results can be regarded as offering some support for the hypothesis as stated.
CHAPTER FIVE

DISCUSSION
5 DISCUSSION

5.1 Considerations for Interpreting Results

The need to employ caution in interpreting results of mental rehearsal experiments is apparent. Numerous variables influence experimental design and outcome as previous investigators make clear (Dethier, 1962; Neale & Liebert, 1973). The importance of the necessarily subjective nature of mental rehearsal experiences in attempts to evaluate experimental results cannot be overlooked (A. Richardson, 1969). Attempts to generalize on the basis of results obtained in such experiments for purposes of drawing practical inferences should be undertaken with care. Statistical and practical differences may be so markedly dissimilar as to appear, in the case of statistics, to lack significance. This may be especially true of research relating to sport. Yet in sport what may appear a statistically insignificant finding can in fact be of considerable practical value. One centimetre, for example, may fail to reflect statistically the considerable actual value it represents in a sport context (as in the high jump or pistol shooting accuracy). Alternatively, 1 centimetre may prove to be statistically significant (as in a 5 hour canoe race or round the world yachting events) but not worthwhile practically since the time and effort needed to achieve such gains outweigh statistical factors.

As Neufeld (1970) suggests, decisions regarding the usefulness and applicability of research results of the type presented here must lie with the researcher (and reader).
discussing findings in mental rehearsal experimentation the researcher/reader is asked to keep in mind practical as well as theoretical and statistical implications.
5.2 Subjects

The 61 subjects, 21 male and 40 female, were mainly first year psychology students at Wollongong University. No subject claimed to have had previous experience in pursuit rotor tasks or to have used or seen pursuit rotor devices. Two subjects admitted having read descriptions of pursuit rotor devices.

Future researchers may profit from efforts to match subjects on factors that could influence pursuit rotor performance (e.g. reaction time, hand-eye co-ordination, previous experience with similar tasks). The recent advent of computer use and computer games may effect the general population's skills at pursuit rotor type tasks with consequent effects on comparisons to early research results based on (at that time) novel skills.

In the pursuit rotor experiment subjects showed great variation in the time they spent in mental rehearsal. Some subjects' estimation of 30 seconds was far less than the actual time interval. A trend appeared for those subjects who spent the longest times at mental rehearsal to exhibit more signs of "quality" relaxation and imagery. Examples of "quality" relaxation and imagery included deep states of relaxation, watering of the eyes, deep breathing, slight muscle twitches, slight overt hand movements as if tracing the target light, slight head movements as if tracing the target, slight eye and eyelid movements as if tracing the target. Future research may profitably include objective measures of such subject behaviours in an attempt to clarify their possible relationship to mental rehearsal.

The time control subjects spent on their reading and
underlining task seemed more uniform. This could be due to such factors as educational background and reading ease of the task. No record was kept of the underlining responses of the control group subjects. In general the total time of the control group task and the experimental group were approximately the same.

One subject indicated fatigue, possibly as a result of holding the stylus tightly thus causing lactic acid build-up as a consequence of the isometric nature of the clasping task of the hand (Pyke, 1980). Many of the subjects tended to make circular patterns rather than keeping to the triangular shape of the pursuit rotor task. One subject mentioned the clicking of the apparatus as a form of feedback or distraction when the stylus moved on or off target. Future researchers may wish to attempt to alleviate this auditory distraction. Some subjects overtly practiced the pursuit task during their intertrial rest periods. Two subjects asked if the rotor speed was increased on the retest trial series, which may indicate that the rotor seemed faster than they remembered it. However, the rotor ran at 60 RPM for all aspects of the experiment. A few subjects wore glasses, but no record of the use of contact lenses was kept. Future researchers into effects of mental rehearsal may wish to try to match subjects on vision as one of the characteristics that could be controlled in projected studies.

As the majority, 52 of 61 subjects, were first year psychology students care is needed in generalizing these results to athletic populations. Few Australian tertiary institutions provide the type of athletic scholarships offered by the Australian Institute of Sport in Canberra. Therefore, as the
experimental subjects from the University of Wollongong were not athletic scholarship holders or noted athletes they cannot be considered a representative population of elite sportspeople.

Future research may profit from selecting athletic populations for mental rehearsal experimentation using sport specific skills. As noted elsewhere in this thesis diminishing returns of skill improvement can be expected with mental rehearsal as expertise increases; while at the same time the likelihood of achieving statistically significant results decreases. Despite this seeming counter indication, since minute improvement in performance can be shown to be highly significant in practical terms for elite athletes further research in mental rehearsal at elite levels is warranted.
5.3 Experimental Results

The ANOVA found a significant difference only for the trials on the initial series of six 30-second trials. There were no significant sex differences in the subjects' performances. Sex of subject appeared to have little effect on the performance of such a novel and simple psychomotor skill.

The subsequent "t" tests indicated that the mental rehearsal group were significantly better than the control group on the first two of the six initial pursuit rotor trials (Figure 5). These findings support the research hypothesis. Hence, mental rehearsal does appear to show promise as an aid to motor performance prior to the first overt attempt at a movement skill. Such a result has practical implications for coaching and sporting performance, in that mental rehearsal may be a valuable aspect of an athlete's mental preparation program.

Individualized mental rehearsal programs may benefit athletic performance.

The ANOVA on results of the retest trial series similarly indicated a significant difference only for trials. Again no statistically significant sex differences were evident. The "t" tests on the retest trial performances (Figure 6) showed statistically significant differences between the two groups on the first two of the six retest trials. The mental rehearsal group subjects performed better at their initial two attempts at the experimental task in the follow-up trial series, a finding that lends further support to the experimental hypothesis that mental rehearsal has positive effects on the learning and retention of motor skills. A practical implication that follows
from the research result suggests mental rehearsal may enhance the athlete's retention of effects from one training session or athletic performance to another. Theoretical support for the view that mental rehearsal works at unconscious levels is also evident from the retest results as has been suggested by C. Hall (1980). The experimental group in the present research proved significantly better than the control group in the first two of the six follow-up pursuit rotor trials (Figure 6).

Practical applications of mental rehearsal needs the co-operation and support of sporting personnel, such as coaches and managers, to reap full benefits. Interference or lack of confidence in the worth of these techniques, such as the facetious remarks reported by Clark (1960) may undermine the effectiveness of attempts to implement mental rehearsal programs.

Despite some minor methodological problems in the present research project (e.g. not pairing subjects on initial skill level) subject's enhanced performance on the initial trial series can be attributed to mental rehearsal. As it was impossible for the subjects to physically practice the pursuit rotor task between the initial trial series and the retest trial series, mental rehearsal may be considered the main factor in the apparent superior performance of the experimental group subjects over the control group on the retest trial series.

Figures 5 and 6 indicate a tendency for the two learning curves to merge with the two control curves on both the initial and retest trial series after the first few trials. Only the first two attempts of each trial series offer significant differences. The effect of physical practice and performance
feedback (Singer, 1975a) may account for this factor. However imagery between each trial may also contribute to such learning and motor plans may have become refined during the inter-trial rest periods. Future researchers may wish to try to account for imagery during intertrial intervals in order to better appreciate the effect of mental rehearsal on motor skill acquisition.

The results obtained here indicate that an additional practical application of mental rehearsal to sporting situations may be toward the reduction of severity and/or frequency of injuries. This could mean athletes who incorporate mental rehearsal into their training programs may perform better at their first attempt at a new (perhaps dangerous) skill as the research reported here suggests. One may also postulate that during absences from overt practice mental rehearsal may aid in the retention of skill and therefore act as "preventative medicine" when the athlete returns to training or competition. This speculation has some support from the results of the follow-up trial series (Figure 6). Further investigations into the combining of mental rehearsal and overt practice may provide yet greater insight into the possibilities for imagery as preventative sports medicine.

The findings reported here may add support to the postulation made earlier in regard to Roehrig's (1964) results as due, in part, to the influence of mental rehearsal. Subjects in the present study generally improved in their pursuit rotor skill during the two week non (overt) practice period. Similarly, Roehrig found subjects did not decrease in balance skill after 50 weeks of no physical practice. Results such as these
indicate that subjects can apparently benefit from the use of mental rehearsal at the early, or cognitive stage of learning (prior to the first overt attempts), confuting previous suggestions by such researchers as Clark (1960), Minas (1980) and B. Rushall (personal communication, July 1984). At the same time it should be noted that the results presented above appear to confirm Start and Richardson's (1964) findings that mental rehearsal may have positive effects on skill performance when administered prior to the first overt attempt. Phipps and Morehouse (1969) also found similar positive results when applied to a gymnastics skill. At this stage the relationship of mental rehearsal's effectiveness at the cognitive stage of skill acquisition remains unclear but the results indicate promise for future experimentation and practical application.

If one accepts Rawlings et al.'s (1972) postulations that pursuit rotor tasks have few symbolic components, then results of the experiment reported here do not tend to support the symbolic theories relating to the apparent effectiveness of mental rehearsal (Feltz & Landers, 1983; Rawlings et al., 1972; Wisberg & Ragsdale, 1979). The experimenter's observation of the subjects' minute movements during mental rehearsal may indicate some superficial support for the neurophysiological theories cited earlier (Egström, 1964; Jacobson, 1932; Start & Richardson, 1964) but biofeedback evidence is needed to objectively establish such a relationship and its nature.

Mediational and motor plan enhancement theories (C. Hall, 1980; Jones, 1965; Minas, 1980; Start & Richardson, 1964) also merit further consideration. The present experiment provided
ample opportunity to develop and refine motor plans prior to the first overt performance of the pursuit rotor task. In addition it can be suggested motor plans may have been refined during the two week interval between initial and retest trial series (see Figures 5 and 6).

Future researchers may wish to pursue biofeedback information parallel to performance feedback in order to establish further theoretical implications of mental rehearsal's apparent influence on motor performance. Recent improvements in telemetry also provide opportunities for such research to be of a highly practical nature as well as undertaken in applied settings.

The mental rehearsal subjects generally gave positive responses to their questionnaire (Appendix G). No subjects had prior experience with pursuit rotor devices. Of the 30 experimental group subjects 22 indicated that their mental rehearsal was of an internal perspective, which is reportedly the more beneficial type (Meaney, 1984; Sheedy, 1982). To the question of whether they felt the imagery helped their performance on the pursuit rotor task, 24 of the 30 mental rehearsal subjects responded in the affirmative. Such high belief strength may be vital to the success of mental imagery in enhancing motor performance (Clark, 1960; Sheedy, 1982).

In this study guided mental imagery appeared beneficial, an affect in contrast to the findings reported by Jones (1965) where the non-directed imagery group were superior at the experimental gymnastics task. Granted that the two experiments differ so markedly as to rule out effective comparison, the disparity in
findings is nonetheless provocative. Further investigation is warranted because of the particular relevance to applied situations in sport of possible benefits to be derived from guided imagery on the one hand and non-directed mental imagery on the other.

Responses to the open-ended question 4 of the questionnaire (pages 119-120) were mainly supportive of the positive influence of the relaxation and mental rehearsal on performance. Support for theories of refining motor plans (Feltz & Landers, 1983; Jones, 1965) and mediational processes (C. Hall, 1980; Minas, 1980) of mental rehearsal may be inferred from many responses of subjects to this open-ended question. For example, the statement "allowed me to gain a mental picture of the task" may indicate assistance in motor plan utilization as postulated by Jones (1965). Future research could well be structured so as to elaborate on and classify the subjective responses of subjects to their experience of mental rehearsal.

Several subjects indicated the positive benefit of enhanced relaxation during the experimental task, which could be due to either the brief relaxation procedures, the mental rehearsal, or interaction of the two. Such subjective reports of improved relaxation and reduced anxiety have practical implications for athletic performance and may reinforce the assertions that relaxation and arousal control techniques should be a fundamental part of the preparation of elite athletes (Orlick, 1980; Suinn & Richardson, 1971; Syer & Connolly, 1984). Responses of this type may also confirm the view that relaxation complements and may assist mental rehearsal of motor performances (DeVore et al., 1981; Suinn, 1972a).
From the responses of subjects to the questionnaire used in this study one can make several suggestions that should improve experimental procedures. Clear instructions coupled with a longer visual demonstration period may enhance performance for both experimental and practical applications of mental rehearsal. Longer periods of relaxation may also lead to more positive results. Furthermore, the use of various forms of relaxation techniques personalized for the individual subject may also enhance results (Ravizza, 1982; Sugarman, 1977).

Use of the raised index finger by the subject to indicate to the researcher progress in the experimental condition was of benefit and adds considerable objectivity to this part of the study. Future researchers may wish to include such feedback to enhance experimental designs. Theories of hemispherical function in mental rehearsal (Chenery, 1984; Green & Green, 1977; E. Hall, 1981) also indicate possible benefits to be derived from such a non-verbal signal as raised index finger used during guided mental imagery as feedback. Additional attempts to further reduce the possible anxiety of subjects during the mental rehearsal phase are also advisable. For example, inhibiting factors to the assigned tasks of concentration and mental rehearsal may have included confinement to a small characterless room with a stranger (the experimenter); the unknown expectations of the subjects as to the "true" nature of the study. More acclimatization time in the experimental setting for the subject may tend to aid in alleviating these problems.

The feedback given subjects between each trial of their time on target may have enhanced motivation and performance as
suggested by authors such as Annett and Kay (1957), Twining (1949) and Vattano (1964). Augmented feedback may prove to be a necessary aspect of maximizing results in such mental rehearsal research, an issue future studies may help to clarify. Reinforcement for effort during the mental rehearsal phase may also positively effect skill acquisition and should perhaps be considered in future research designs. In practical coaching situations feedback and reinforcement should enhance the practice and benefits of mental rehearsal and motor performance (Nettleton, 1980b; Rushall, 1980; Sheedy, 1982; Singer, 1975a). It seems possible that future research may also positively influence subject motivation and concentration by employing an intrinsically more interesting task, such as a computer game. Added interest may aid in the retention of incentive and quality of attention during the latter trials, thus perhaps reducing the plateau effect of the learning curves (Figures 5 and 6).

The six 30-second trials seemed an appropriate experimental task for this particular research study using the pursuit rotor device. Minimal stress or fatigue was evident in the subjects with the work-rest ratios set. Future researchers may wish to investigate whether sex of the experimenter, and consequently the model for skill acquisition, effects the research outcome (Bandura & Walters, 1963; Singer, 1975a).

The 5 second warning signal appeared to be more than adequate for most subjects suggesting that this signal could perhaps be given much closer to the commencement of the task. Perhaps an auditory warning signal presented 3 seconds prior to the task would be more appropriate. The speed and set-up of the
pursuit rotor task appeared to be adequate for the present research as previous studies have also found (e.g. Feltz & Landers, 1983; Rawlings et al., 1972).

The intention of the control group task was to engage the 31 subjects in an activity containing a significant amount of imagery in an attempt, to some extent, to balance the mental rehearsal imagery factor in the two groups. The control subjects were required to physically use their dominant (writing) hand to underline the imagery words, concentrate on the visual (tracking) task of reading and engage in analyzing the quality of invoked imagery. The extract from The hitch hiker's guide to the galaxy (Adams, 1979) was deemed to be both novel and humorous and so aid in maintaining attention and interest in the control group task. Future research may benefit from similar attempts to balance mental imagery research in somewhat the same manner.
5.4 Methodological Considerations

Future researchers into effects of mental rehearsal in acquiring sports skill, especially with elite athletes, may wish to consider the incorporation of single-subject designs with multiple baselines (Sidman, 1960; Zaichowsky, 1980). Approaches of this type could result in numerous theoretical and practical insights into the complex relationship between imagery and motor performance.

Fieldwork and quasi-experimental designs with athletes in actual competitive or performance settings should also be encouraged. Such experimentation may aid in clarifying a
phenomenon that thus far has produced a great variety of results and interpretations (Feltz & Landers, 1983; Meaney, 1984). Greater emphasis on the importance of self-report of subjects may also benefit research, despite apparent difficulties subjects may have in verbalizing their imagery experiences (Start & Richardson, 1964). Important coaching information may well be gained by more systematic approaches to self-report information from mental rehearsal subjects (Clark, 1960; Davies, 1982). In addition, underlying psychic information may present itself which could be beneficial to sport psychologists and athletes for performance enhancement or self understanding.

If mental rehearsal works at unconscious levels as C. Hall (1980) suggests then control subjects in the present study may have been affected by mentally rehearsing the impending trials. When taken in conjunction with the influence of overt practice, this factor may in part be responsible for the merging of the learning curves in the initial trial series (see Figure 5). However, the retest learning curves (Figure 6) indicate that the mental rehearsal group were significantly better at the task after 2 weeks of no practice, which seems to suggest that they profited from the mental rehearsal. Future research is needed to clarify this apparent benefit and also the possible influence mental rehearsal may have had on the control group during the intertrial periods.

Mental rehearsal at subliminal levels to some extent may have influenced both the control and experimental groups during the 2 week interval between the initial and retest trial series (comparison of Figures 5 and 6 would seem to suggest this). The
experimental group showed greater improvement statistically than the control group in the first two pursuit rotor trials on both occasions. Wrisberg and Ragsdale (1979) also found only initial positive benefits from mental rehearsal on cognitive tasks.

Research that compares the mean scores of two or more groups as is the case here presents certain drawbacks. For instance, mean scores can obscure much information of potential practical use. How one should compare groups or match subjects in groups also presents methodological difficulties (e.g. comparison of learning curves, maximizing efforts on future trials, sample size, subject selection, random sampling or incidental samples).

This experiment used a relatively short total time interval of mental rehearsal in an attempt to avoid the possibility of boredom in subjects as reported by Start (1964b) and Twining (1949). No subjects in this experiment reported boredom (pages 119-120) a finding consistent with Twining's (1949) reports that short durations of quality imagery may show significant results and minimize subject boredom. In this connection, the fact that athletes sometimes have only a brief opportunity to practice mental imagery immediately prior to athletic performance may merit special consideration.

The research design attempted to control the possible confound noted by Rawlings et al. (1972) in which the experimental group may have more exposure to, and hence advantages at the experimental situation than the control group. In this study both the experimental and control groups had similar physical exposure to the experimental setting. In addition, since no subjects indicated prior experience with the
use of pursuit rotor devices, the confound of previous knowledge at the experimental task appears to have been controlled for in this study. Thus the concern expressed by Rawlings et al. (1972) regarding this problem in mental rehearsal research seems to have been somewhat resolved.
5.5 Conclusion

The relationship between mental rehearsal and skill acquisition in sport is obviously a complex one. The wide variety of findings in the research support this view as well as reflecting as yet unresolved methodological difficulties. Mental imagery is a variable which, as yet, cannot be directly measured.

The laboratory as a research environment for sport has many obvious shortcomings. Field research with sporting populations should be encouraged despite the fact that this type of experimentation has its own specific methodological problems. Since single-subject designs could produce valuable theoretical and practical evidence for mental rehearsal's apparent influence in athletes' performance such experimentation needs to be actively encouraged. Those who use comparison of group research designs need to consider the methodological implications and possible shortcomings in the work of previous researchers and strive for improvements.

The field study with Lawn Bowls found no statistically significant gain from mental rehearsal, possibly because the experiment had a number of methodological shortcomings. However, coaches and athletes may wish to consider the practical implications of the apparently slight, though not statistically significant, benefit the combined mental and physical practice group seemed to indicate.

Although the pursuit rotor experiment was much tighter experimentally, it was far removed from realistic sporting situations. In this case mental rehearsal showed significant benefit to initial attempts by the subjects at a novel
psychomotor skill. With some reservations, as noted earlier, one can assume such benefits can be expected in actual sporting situations if long term, tailor-made programs were designed for individual athletes.

In summary, anecdotal reports, quasi-experimental, experimental and personal reports indicate that mental rehearsal may aid in the performance of sporting skills if correctly administered. Future research endeavours may clarify the conditions and quality of instructions necessary for obtaining positive results from mental rehearsal to enhance motor performance. In this thesis the field study on Lawn Bowls was not successful in producing a positive outcome, whereas the highly structured laboratory experiment showed significant positive results. The next stage of development would seem to be to encourage further research to establish a method for incorporating mental rehearsal instruction into athletic preparation programs that may positively influence the acquisition of sports skills in naturalistic settings.
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INTRODUCTION

This research is designed to look at the effectiveness of various methods of developing skills. Lawn Bowls is an easy to measure skill, as you can measure how far from the jack the bowl stops. Firstly we will test your bowling accuracy, then give you a 2 weeks skill development program. After this 2 weeks we will retest you to see if your bowling skill has improved or not. Your names will not be recorded in the final analysis. You will be one of 4 groups involved in the research. Thank you for participating in this experiment.

CONTROL GROUP

Your task is to act as the control group, to maintain your present type and level of practice of bowls. All we require of you is to have a second test in 2 weeks time, of your bowling accuracy. Please refrain from any extra practice that may effect this research.
INTRODUCTION

This research is designed to look at the effectiveness of various methods of developing skills. Lawn Bowls is an easy to measure skill, as you can measure how far from the jack the bowl stops. Firstly we will test your bowling accuracy, then give you a 2 weeks skill development program. After this 2 weeks we will retest you to see if your bowling skill has improved or not. Your names will not be recorded in the final analysis. You will be one of four groups involved in the research. Thank you for participating in this experiment.

MENTAL REHEARSAL AND PHYSICAL PRACTICE GROUP

Your task is to improve your bowling accuracy by a combination of mental and physical practice. Mental rehearsal is a very strong aid to learning sports skills. Many top athletes have had great success with it (e.g. Jack Nicklaus - Golf). Mental rehearsal is a skill in itself and you will get better with practice. Correct mental rehearsal involves imagining the full and successful action as if you were looking through your eyes at the green. At each practice session you can combine mental rehearsal with your physical practice. When standing at the mat holding the bowl:

- feel its texture;
- look at the jack;
- imagine the bowl following the correct arc needed to come to rest touching the jack.

When you have had a particularly successful shot, mentally rehearse it a couple of times before you have your next bowl. Recall how it felt, how much effort it took, how it followed the desired arc, and so on.

Even when you bowl a poor shot, mentally rehearse a successful bowl before your next attempt.

During the physical practice, encourage yourself when good shots are made and be positive about your skills. Set yourself realistic goals and strive toward them. Try to get maximum benefit from your practice sessions.

We will retest your bowling accuracy in 2 weeks time.
INTRODUCTION

This research is designed to look at the effectiveness of various methods of developing skills. Lawn Bowls is an easy to measure skill, as you can measure how far from the jack the bowl stops. Firstly we will test your bowling accuracy, then give you a 2 weeks skill development program. After 2 weeks we will retest you to see if your bowling skill has improved or not. Your names will not be recorded in the final analysis. You will be one of four groups involved in the research. Thank you for participating in this experiment.

PHYSICAL PRACTICE GROUP

Your task is to try to improve your bowling accuracy by physical practice. At each practice session constantly try to improve your bowling accuracy. Encourage yourself when good shots are made and be positive about your skills. Set yourself realistic goals and strive towards them. Try to get maximum benefit from your practice session.

We will retest your bowling accuracy in 2 weeks time.
INTRODUCTION

This research is designed to look at the effectiveness of various methods of developing skills. Lawn Bowls is an easy to measure skill, as you can measure how far from the jack the bowl stops. Firstly we will test your bowling accuracy, then give you a 2 weeks skill development program. After this 2 weeks we will retest you to see if your bowling skill has improved or not. Your names will not be recorded in the final analysis. You will be one of four groups involved in the research. Thank you for participating in this experiment.

MENTAL REHEARSAL GROUP

Your task is to improve your bowling accuracy by mental rehearsal. Mental rehearsal is a very strong aid to learning sports skills. Many top athletes have had great success with it (e.g. Jack Nicklaus - Golf). Mental rehearsal is a skill in itself and you will get better with practice. Try to create an image of yourself bowling at the green. Make the mental picture as realistic as possible. Feel the bowl in your hand, watch it move through the correct arc to touch the jack at rest.

Correct mental rehearsal involves imagining the full and successful action as if you were looking through your own eyes at the green.

We will retest your bowling skills in 2 weeks time.
**APPENDIX E**

**POST-EXPERIMENT EVALUATION SHEET**

1. How effective do you feel that Mental Rehearsal is for your bowling skill?

   | Very Effective | Very Uneffective | Uneffective | Undecided | Effective |
---|----------------|------------------|-------------|-----------|-----------|

2. How clear were your images during Mental Rehearsal?

   | Very Clear | Very Unclear | Unclear | Undecided | Clear |
---|------------|-------------|--------|-----------|-------|

3. What type of self images did you use most often?

   - Through your own eyes
   - T.V. Screen

4. Did you use Mental Rehearsal before this experiment. If yes, briefly explain:

   ____________________________
   ____________________________

5. Were there any other factors that may have effected your performance in this experiment?

   ____________________________
   ____________________________

6. How much practice, mental or physical, did you do during this experiment?

   ____________________________
   ____________________________

7. Did you engage in any form of Mental Rehearsal, (non mental rehearsal groups)?

   ____________________________
   ____________________________
APPENDIX F

RECORDING SHEET

Subject's Name: ....................  Sex: .............

Age: ..........  Club: .........................................................

Experimental Group: ............................................................

Four warm-up shots are to be played before recording commences.
The distance will be measured between the jack and the bowl.

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COMMENTS:
MENTAL REHEARSAL GROUP QUESTIONNAIRE FOR PURSUIT ROTOR TASK

1. Have you had any prior experience with pursuit rotor tasks?  YES  NO

2. Was your mental rehearsal of an internal perspective (looking through your own eyes), or an external perspective (like watching T.V.)?  YES  NO

3. In general, did you feel that the mental rehearsal helped your performance on the pursuit rotor task?  YES  NO

4. Please give any other comments concerning the use of mental rehearsal in this experiment:

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
APPENDIX H


Far out in the uncharted backwaters of the unfashionable end of the Western Spiral arm of the Galaxy lies a small unregarded yellow sun.

Orbiting this at a distance of roughly ninety-two million miles is an utterly insignificant little blue green planet whose ape-descended life forms are so amazingly primitive that they still think digital watches are a pretty neat idea.

This planet has - or rather had - a problem, which was this: most of the people living on it were unhappy for pretty much of the time. Many solutions were suggested for this problem, but most of these were largely concerned with the movements of small green pieces of paper, which is odd because on the whole it wasn't the small green pieces of paper that were unhappy.

And so the problem remained; lots of the people were mean, and most of them were miserable, even the ones with digital watches.

Many were increasingly of the opinion that they'd all made a big mistake in coming down from the trees in the first place. And some said that even the trees had been a bad move, and that no one should ever have left the oceans.

And then, one Thursday, nearly two thousand years after one man had been nailed to a tree for saying how great it would be to be nice to people for a change, a girl sitting on her own in a small cafe in Rickmansworth suddenly realized what it was that had been going wrong all this time, and she finally knew how the world could be made a good and happy place. This time it was right, it would work, and no one would have to get nailed to anything.

Sadly, however, before she could get to a phone to tell anyone about it, a terrible stupid catastrophe occurred, and the idea was lost for ever.

This is not her story.

But it is the story of that terrible stupid catastrophe and some of its consequences.
It is also the story of a book, a book called The Hitch Hiker's Guide to the Galaxy - not an Earth book, never published on Earth, and until the terrible catastrophe occurred, never seen or even heard of by any Earthman.

Nevertheless, a wholly remarkable book.

In fact it was probably the most remarkable book ever to come out of the great publishing corporations of Ursa Minor - of which no Earthman had ever heard either.

Not only is it a wholly remarkable book, it is also a highly successful one - more popular than the Celestial Home Care Omnibus, better selling than Fifty-three More Things to do in Zero Gravity, and more controversial than Oolon Colluphid's trilogy of philosophical blockbusters Where God Went Wrong, Some More of God's Greatest Mistakes and Who is this God Person Anyway?

In many of the more relaxed civilizations on the Outer Eastern Rim of the Galaxy, the Hitch Hiker's Guide has already supplanted the great Encyclopaedia Galactica as the standard repository of all knowledge and wisdom, for though it has many omissions and contains much that is apocryphal, or at least wildly inaccurate, it scores over the older, more pedestrian work in two respects.

First, it is slightly cheaper; and secondly it has the words DON'T PANIC inscribed in large friendly letters on its cover.

But the story of this terrible, stupid Thursday, the story of its extraordinary consequences, and the story of how these consequences are inextricably intertwined with this remarkable book begins very simply.

It begins with a house.

CHAPTER 8 (pages 62-63)

The Hitch Hiker's Guide to the Galaxy is a wholly remarkable book. It has been compiled and recompiled many times over many years and under many different editorships. It contains contributions from countless numbers of travellers and researchers.

The introduction begins like this:

'Space', it says, 'is big. Really big. You just won't believe how vastly hugely mindbogglingly big it is. I mean you may think it's a long way down the road to the chemist, but that's just peanuts to space. Listen ...' and so on.
(After a while the style settles down a bit and it begins to tell you things you really need to know, like the fact that the fabulously beautiful planet Bethselamin is now so worried about the cumulative erosion by ten billion visiting tourists a year that any net imbalance between the amount you eat and the amount you excrete whilst on the planet is surgically removed from your bodyweight when you leave: so every time you go to the lavatory there it is vitally important to get a receipt.)

To be fair though, when confronted by the sheer enormity of the distances between the stars, better minds than the one responsible for the Guide's introduction have faltered. Some invite you to consider for a moment a peanut in Reading and a small walnut in Johannesburg, and other such dizzying concepts.

The simple truth is that interstellar distances will not fit into the human imagination.

Even light, which travels so fast that it takes most races thousands of years to realize that it travels at all, takes time to journey between the stars. It takes eight minutes to journey from the star Sol to the place where the Earth used to be, and four years more to arrive at Sol's nearest stellar neighbour, Alpha Proxima.

For light to reach the other side of the Galaxy, for it to reach Damogran for instance, takes rather longer: five hundred thousand years.

The record for hitch hiking this distance is just under five years, but you don't get to see much on the way.

The Hitch Hiker's Guide to the Galaxy says that if you hold a lungful of air you can survive in the total vacuum of space for about thirty seconds. However it does go on to say that what with space being the mind boggling size it is the chances of getting picked up by another ship within those thirty seconds are two to the power of two hundred and sixty-seven thousand seven hundred and nine to one against.

By a totally staggering coincidence that is also the telephone number of an Islington flat where Arthur once went to a very good party and met a very nice girl whom he totally failed to get off with - she went off with a gatecrasher.

Though the planet Earth, the Islington flat and the telephone have all now been demolished, it is comforting to reflect that they are all in some small way commemorated by the fact that twenty-nine seconds later Ford and Arthur were rescued.
It is an important and popular fact that things are not always what they seem. For instance, on the planet Earth, man had always assumed that he was more intelligent than dolphins because he had achieved so much — the wheel, New York, wars and so on — whilst all the dolphins had ever done was muck about in the water having a good time. But conversely, the dolphins had always believed that they were far more intelligent than man — for precisely the same reasons.

Curiously enough, the dolphins had long known of the impending destruction of the planet Earth and had made many attempts to alert mankind to the danger; but most of their communications were misinterpreted as amusing attempts to punch footballs or whistle for titbits, so they eventually gave up and left the Earth by their own means shortly before the Vogons arrived.

The last ever dolphin message was misinterpreted as a surprisingly sophisticated attempt to do a double-backwards-somersault through a hoop whilst whistling the 'Star Spangled Banner', but in fact the message was this: So long and thanks for all the fish.

In fact there was only one species on the planet more intelligent than dolphins, and they spent a lot of their time in behavioural research laboratories running round inside wheels and conducting frighteningly elegant and subtle experiments on man. The fact that once again man completely misinterpreted this relationship was entirely according to these creatures' plans.
### EXPERIMENTAL GROUP RAW SCORES

(SECONDS ON TARGET): TEST 1

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## APPENDIX K

### CONTROL GROUP RAW SCORES

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### APPENDIX L

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