The Effect of Cognitive Strategies on Endurance Performance

A Thesis
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Peter J. Oswald

Department of Physical Education & Recreation
Faculty of Human Development
Victoria University of Technology

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DEDICATION

This work is dedicated to Ben,
spirit brother and friend,
whose support and energy
give meaning to a difficult journey.

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To all those who showed immeasurable patience, I say thank you.

It is done!

I would especially like to thank my advisers, Professor Jeff Summers, Dr. Tony Morris and Dr. John Carlson, for their particular efforts and their belief (hope?) in the fact that one day I would complete this work. My special thanks also to two of my esteemed colleagues, Mick McCoy and Con Hrysomallis, whose friendship and constant nagging did provide me with the grass roots support we all need. A further thanks is extended to Sherry Newsham who gave that important little nudge when all seemed futile - an Hawaii Ironman inspiration!!

ABSTRACT

Subjectively perceived pain or effort is a major factor which limits endurance performance. It has been claimed that cognitive strategies can mediate perceived effort and enhance endurance performance (Morgan & Pollock, 1977). These authors have suggested that association, focusing on bodily sensations and race related stimuli, is the most effective strategy for elite marathon runners. On the other hand, Pennebaker and Lightner (1980) found a dissociative strategy, distracting attention from bodily signals, to be more effective with college students. The purpose of the present study was to examine the effect of association and dissociation on rated perceived exertion and subsequent performance on an endurance activity.

Subjects were 33 male volunteers, aged 17 to 34 (mean=23.0, SD=4.39), who were involved in regular aerobic exercise from jogging to marathon and triathlon. Maximal aerobic power (MAP) was determined for each subject by a treadmill run to exhaustion. Subjects subsequently completed two further treadmill runs to exhaustion, with the treadmill set at a pace equivalent to 80% MAP. For the first of these runs, subjects were simply instructed to run to exhaustion, producing baseline measures. For the second run, subjects were randomly assigned to an associative, dissociative or control group, from triads matched for MAP. Associative condition subjects were given instructions that drew attention to bodily signals and they were asked to report on these at random intervals. Dissociative condition subjects watched a video as they ran and were asked questions about it and other non-run-related matters at random intervals. Control subjects ran as for the baseline condition. At the end of each run global rated perceived exertion (RPE) was elicited for the run and subjects completed a Cognitive Strategies Questionnaire (CSQ), while their run time was noted.

Mean cognitive strategy scores indicated that the manipulations were successful. Subjects' strategy scores moved in the direction consistent with their group membership. Results show that the associative group reported experiencing significantly more effort (RPE) during the experimental run than the baseline run ($F_{2,30}$=9.6, p<0.05). Neither the dissociative nor the control subjects reported a significant change in RPE. Run time to exhaustion for the association group declined significantly in comparison to dissociative and control subjects ($F_{2,30}$=10.12, p<0.05).

It was concluded that an internal focus of attention enhanced perceived exertion and resulted in a deterioration in performance. The potential for pace adjustment is acknowledged as an essential feature of association. The use of an associative cognitive strategy, when pace adjustment is not possible, as on a fixed workload treadmill run, may lead to an increase in perception of effort or pain and a consequent reduced performance. This result has implications for inexperienced runners who do not know how to vary pace in response to bodily signals. The measurement of association and dissociation remains problematic.

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CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

This thesis addresses the basic question faced by athletes who push themselves to their physical limits: How to best cope with the pain and discomfort of an endurance activity? The subject of this inquiry is not only the elite athlete, but also the novice and recreational athlete. Each of these athletes has physiological limits that are different in absolute quantity, but each shares the qualitative experience of pushing themselves to transcend these limitations.

The degree of success enjoyed by the athlete in breaching his or her upper limits is in no small part due to the motivation and mental skills required to tolerate physical discomfort. As Morgan (1981) suggested, while much of the variability in performance is "due to differences in physiological capacity it also appears that a runner's willingness or ability to endure the discomfort...is also quite important. Indeed, the decision (cognition) to slow down, accelerate, maintain pace or discontinue is based largely on the runner's perceived exertion" (p.414).

1.2 PERCEIVED EXERTION

Perceived exertion is a global measure based on the sensory cues emanating from the working joints, muscles and cardio-respiratory system during exercise (Borg, 1982). At low levels of activity the inputs from these physiological sites cause little distress, hence the athlete reports a low perception of effort. At the more stressful levels of activity, the considerable increase in physiological functioning gives rise to stimuli of such intensity that they are perceived as noxious. Here is the athletes' source of pain and discomfort. The athlete now reports a higher level of perceived exertion.

The physiological cues associated with perceived exertion are integrated into an overall effort sense at the cognitive level (Morgan, 1973; Rejeski, 1981; Robertson, Gillespie, Hiatt & Rose, 1977). Cognitive variables, such as past experiences, personality type, expectations and mental strategies, may affect the perception of physical work.

1.3 MENTAL STRATEGIES

Morgan and Pollock (1977) investigated the role of cognitive strategies in enhancing endurance activity. Based on the extant knowledge, they hypothesised that athletes would dissociate from pain signals during performance. However, as a result of their observations they concluded that there were two essentially different types of cognitive strategy. Elite athletes, they argued, associate or constantly monitor bodily signals and adjust performance accordingly, on the other hand, novice performers dissociate by cutting themselves off from any pain sensation.

Subsequent research on cognitive strategies attempted to confirm Morgan and Pollock's (1977) dichotomy. Survey research results were equivocal, suggesting that, whereas many elite athletes used an associative strategy, so too did novice athletes. Nor was dissociation found to be the sole province of the novice athlete. Experimental research aimed at demonstrating the effectiveness of one strategy over the other in enhancing performance has also been inconclusive.

To date much of the research is not without limitations. Primarily there is considerable confusion in the definition of cognitive strategies. Much of the research material reflects different nuances in the operationalised definitions of various cognitive strategies, rather than differences in the use or effectiveness of the strategies themselves. A clearer definition of cognitive strategies emerges when the purpose and characteristics of the strategy are considered. The measurement of cognitive strategies has also presented methodological problems. The resolution of these problems is not made any easier when the two principal techniques of measurement, retrospective and simultaneous, both have their advantages and disadvantages. In experimental research, the manipulation of cognitive strategies presents several practical dilemmas. These require that careful controls are incorporated into experimental design.

1.4 ATTENTIONAL FOCUS

Pennebaker and Lightner (1980) manipulated the attentional focus of subjects engaged in an endurance activity. Subjects in this study performed better when using an external focus than when using an internal focus. If an 'external focus' is the essential feature of dissociation and an 'internal focus' is a major component of association, then, it would appear that, Pennebaker and Lightner's (1980) conclusions are in contention with those reported by Morgan and Pollock (1977).

1.5 CURRENT STUDY

Accepting the notion that cognitive strategies can influence the experience of pain and effort and subsequently affect endurance performance, the observations of Morgan and Pollock (1977) and Pennebaker and Lightner (1980) create a dilemma of application. Morgan and Pollock suggested that association facilitates superior performance at endurance tasks. Monitoring of bodily sensations is an essential component of this process. On the other hand, Pennebaker and Lightner suggested that when subjects use an internal focus, such as monitoring bodily sensations, they do not perform to their full potential.

The present study aims to clarify the conceptual definition of cognitive strategies and to further investigate the effect of association and dissociation on performance in an endurance activity.

Knowledge of the mechanism and effectiveness of cognitive strategies will help novice and elite athletes reach their full performance potential. Further, this knowledge will be of benefit to recreational performers, who, although not looking to reach their highest potential, are nevertheless looking to participate in physical activity with the minimum of pain and discomfort while maximising their enjoyment.

CHAPTER 2. LITERATURE REVIEW

2.1 INTRODUCTION

An athlete's ability to tolerate pain has long been recognised as a decisive factor in sporting success. Ryan and Kovacic (1966) have shown that athletes have a higher pain tolerance than non-athletes, and that the highest pain tolerance can be found amongst participants of contact rather than non-contact sports. Taylor (1979) found that the stress of a noxious stimulus could be important in limiting human strength and endurance. Morgan (1981), when discussing differences in marathon performance, notes that "a runner's willingness or ability to endure the discomfort associated with this arduous event is also quite important" (p.414).

Understanding how pain is processed and how people cope with pain would be valuable for the athlete involved in endurance activity (or indeed any sport that has a disturbing pain aspect). It would seem that developing a high degree of pain tolerance is important for athletes who wish to challenge the limits in their chosen sport.

On the question of pain tolerance, Gelfand (1964) has argued that psychological variables play an integral and critical role. Research has shown that a variety of cognitive processes can be used to alter a person's level of pain tolerance (Scott & Barber, 1977). Early pain research has established that distraction strategies are effective in increasing pain tolerance levels (Blitz & Dinnerstein, 1971).

Researchers working in the area of effort perception during physical activity have arrived at similar conclusions. It is argued that a person's perception of effort or work is a *gestalt* of the noxious stimuli emanating from the working body. This *gestalt*, however, can be influenced by the individual's mental set (Borg, 1982). Indeed, it is suggested that an individual can alter his or her perception of effort (tolerance of pain) through the use of particular mental processes called cognitive strategies. The use of cognitive strategies in enhancing endurance performance is the focus of this thesis

The following review begins with a brief survey of the early research on pain coping strategies. This research identifies the importance of specific cognitive strategies in altering pain tolerance. The role of pain tolerance in the performance of physical activity, especially endurance activities, has also been emphasised in research relating to perception of effort. A review of the research on perception of effort indicates the importance of a number of psychological variables in modifying effort perceptions and the effect on subsequent performance. More particularly the use of cognitive strategies suggests that a person can engage in specific mental activities that modify the influence of physiological stimuli.

Research on the use and relative efficacy of two popular cognitive strategies (association and dissociation) is reviewed next. Survey research suggests that athletes use various combinations of these two strategies. However, with support from experimental research, it has been argued that elite athletes predominantly use an associative strategy, whereas novice athletes tend to use more dissociative strategies.

At this juncture research in a related area is considered. Studies of attentional focus indicate the importance of distraction from noxious stimuli as a means of enhancing performance. Further, it is argued that an internal focus of awareness will be detrimental to performance. These findings appear to be in opposition to those of cognitive strategy research.

The review finally discusses some of the major conceptual and methodological problems associated with the research to date. A redefinition of cognitive strategies emerges and becomes the basis for the experimental research that follows.

2.2 PAIN RESEARCH

Much of the research on pain tolerance has investigated the effectiveness of particular mental strategies in reducing perception of pain. The pain stimuli utilised in the research are from a single defined source (e.g., cold, pressure) and are of relatively short duration, in the order of several minutes. The most effective mechanism to deal with these types of pain sensation appears to be the use of those strategies that distract the person from the stimulus.

Blitz and Dinnerstein (1971) were able to increase pain tolerance by using distraction strategies. Subjects with their hand in $0^{o}C$ water were told to either concentrate on the task (as opposed to the pain) or associate the pain with pleasant non-aversive feelings. Both groups showed an increase in pain tolerance. A similar study by Spanos, Horton, and Chaves (1975) found subjects reported a reduction in pain if they imagined the water as cool and refreshing on a hot day. Distraction was also used by Barber and Cooper (1972) to reduce the effect of pain. Here subjects were required to listen to a story or add aloud a series of numbers while undergoing a painful stimulus. Under both strategies, subjects effectively increased their pain tolerance.

The use of multiple strategies is particularly effective. Scott and Barber (1977) tested subjects experiencing pain from ice water or local tactile pressure. For each group a significant reduction in pain was noted if subjects combined the following strategies: 1) attempting not to be bothered by the pain, 2) concentrating on other things, 3) dissociating from the pain, 4) reinterpreting the sensations as not painful, and 5) imagining the pained areas as numb or insensitive.

Much of the laboratory research on pain tolerance relates to the pain experience generated at a given instant in time and as the result of a specific noxious stimulus. However, many of the painful experiences in life, and especially in sport, often result from the action of a number of stimuli and over an extended period of time. Most sporting activities require an athlete to cope with a variety of noxious stimuli arising from within the body, for example, lactic acidosis, muscle and joint pain, increased cardiac demand, forced respiratory action. Further, the action of these stimuli does not cease after a few minutes, but in response to the time element of the activity, increase in strength as the activity proceeds.

Cautela (1977) has argued that the pain response can be characterised by one or two of the following: 1) verbal report of pain, 2) behaviour such as moaning, groaning, or grimacing, and 3) avoidance of the stimuli perceived as noxious. Clearly, the discomfort associated with many sporting endeavours fits the above criteria to be classified as pain. However, avoidance of the noxious stimulus is, on most occasions, inconsistent with the goals of sporting achievement. When an athlete chooses to persist with an activity and not avoid the associated pain, there must exist mechanisms whereby the athlete can over-ride or somehow modify the need to avoid any noxious stimuli.

Generally, it appears that mental strategies are effective in pain reduction if they direct attention away from the painful stimuli (Blitz & Dinnerstein, 1971; Spanos, Radtke-Bodorik, Ferguson & Jones, 1979). In painful situations, such as hard physical work or endurance activities, termination of the activity would effectively avoid any painful stimuli. However, a decision to continue the activity suggests that the person can effectively modify the experience of pain. Directing attention away from the source of pain has been established as a potent way of increasing pain tolerance. Morgan (1981) has suggested that the perception of the intensity of pain is a cognitive process that involves both physiological and psychological variables. Ultimately the experience of pain depends on one's perception.

2.3 PERCEIVED EXERTION

Borg (1962) introduced the concept of perceived exertion as a simple measure of exercise intensity. Important in this idea was not so much the absolute measure of physical strain, but rather, what this physiologically based information ***meant*** to the individual, how did the person ***perceive*** the concomitant biological indicators of their effort. Morgan (1973) has also stressed the importance of the processing of perceptual information when making decisions about intensity and continuation of work.

Borg (1982, 1985), in a later refinement of the concept, suggested that perceived exertion refers to a general or overall perception of effort and exertion. This perception represents a *gestalt* of signals from the body: local muscles and joints, cardiovascular and respiratory organs, as well as emotional and cognitive factors. The relative influence of 'local', 'core' and 'overall' physiological inputs as determinants of perception of effort has been a contentious issue. However, the role of specific physiological cues appears to be a function of their salience during the course of a particular physical activity. (For an extensive review see Pandolf, 1982).

Much of the research regarding the determinants of rated perceived exertion has been influenced by the researchers' academic discipline (Pandolf, 1983; Rejeski, 1981). Hence, physiologists have sought to determine the physiological parameters contributing to perceived exertion, whereas psychologists have looked to the cognitive factors that may play a crucial role. However, Morgan (1981) has suggested that the investigation of perceived exertion has done much to stimulate inter-disciplinary (psychophysiological) research.

2.3.1 Physiological Determinants of Perceived Exertion

Borg (1970, 1978) used a fifteen point graded category scale as a measure of perceived exertion (Appendix 1). The scale has values in the range 6 to 20. This, Borg suggested, matches the variation in heart rate from 60 to 200 beats/min. Verbal descriptions corresponding to the increasing levels of effort are provided at equidistant intervals on the scale. These range from "very, very light" at a numerical score of 7 up to "very, very hard" for a score of 19.

Using this scale Borg (1970) was able to demonstrate a linear relationship between ratings of perceived exertion (RPE), workload on a bicycle ergometer, and heart rate (HR). Borg (1973) has suggested that "...for healthy middle-aged men doing moderate to hard work on a bicycle ergometer or treadmill, the heart rate should be about ten times the RPE value" (p.91). To further examine this proposed relationship Morgan, Raven, Drinkwater and Horvath (1973) presented subjects with random workloads while they were pedalling a bicycle ergometer. Again, the linear relationship between RPE and HR was demonstrated. However, Morgan (1981) offered a caution. He suggested that the linear relationship between RPE and HR is only observed when incremental work intensity is varied. In the case of steady state work loads, a different relationship is observed. Here the mean RPE measures were lower than HR in the early stages of performance. After approximately ten minutes of steady state work, the mean RPE progressively exceeded HR response. Morgan (1981) concluded that "heart rate is not correlated with effort sense under these circumstances since, by definition, HR remains relatively constant" (p.405).

In contrast to Borg (1970), the primacy of the circulatory system as the cue to RPE, has been disputed by Ekblom and Goldbarg (1971). By manipulating subjects' heart rate with autonomic nervous system blocking agents, they were able to alter the correlation between HR and RPE. They concluded that HR is not a primary factor in setting RPE. Ekblom and Golgbarg (1971) have argued that an individual will evaluate perceived exertion based on two factors: a local factor, strain in the working muscles, and a central factor, perceived tachycardia (rapid heart rate) and tachypnoea (rapid breathing). They further argued that, during work involving smaller muscle groups, local factors will dominate perception, whereas during work involving large muscle groups, information from the circulation and respiration will dominate perception. Ekblom and Goldbarg (1971) supported this view with evidence that RPE was higher for arm work than leg work, and that cycling elicited higher RPE than running or swimming.

A plethora of research has been conducted to investigate the importance of central factors, such as heart rate, ventilation and respiration rate, and potential local factors including, lactate concentration, proprioceptive responses, general muscle sensations, catecholamines, and skin and core temperatures. Extensive reviews of this material are presented by Mihevic (1981) and Pandolf (1983). Neither of these reviews offers support for central factors being the primary physiological determinant of RPE. However, Pandolf (1983) argued that ventilatory sensations may play a role.

Following Ekblom and Goldbarg's (1971) two factor, local and central, model of rated perceived exertion, Robertson (1982) advanced an integrated model to account for these two factors. Robertson suggested that central factors act, not as the primary cue for effort sense, but as "an amplifier or gain modifier that potentiates the local signals in proportion to the aerobic metabolic demand" (p.390). Robertson suggested that during the initial 30 secs. of activity only the local cues are salient. From 30 secs to 180 secs. the central sensory cues begin their potentiating effect. The variance in time for these effects reflects the differences in cardiovascular and/or ventilatory adaptation to varying degrees of exercise intensity.

This potentiating relationship between central and local factors differentially influences the perception of effort at low, moderate and high levels of metabolic intensity. No matter what the level of intensity, local signals will dominate perception of effort. The role of central cues (V_E, minute ventilatory volume and VO_{2max}, maximal oxygen uptake) is only relevant at the higher levels of metabolic demand. At all three levels (low, moderate and high) of metabolic intensity, VO_2 reflects the relative oxygen requirement of the exercising tissue. Hence the effect of VO_2 as a cue for effort sense will be proportional to oxygen demand from the exercising tissue. The role of V_E also reflects definite changes in metabolic demand. The strength of the V_E signal increases as the body approaches and passes the lactate threshold through to the later stages of metabolic acidosis.

Contrary to the idea of local sensory primacy, Horstman, Morgan, Cymerman and Stokes (1979) suggested that local factors are salient in determining RPE only at low to moderate exercise intensity. At high intensity levels, central factors become dominant and hence the primary source of information in the perception of exertion. Studies by Young, Cymerman and Pandolf (1982) offer support for this contention. Differentiated RPE, local, central, and overall, was measured in subjects exercising at sea level, and after acute (less than two hours) and chronic (18 days) exposure to high altitude. When exercise of the same relative intensity is performed at sea level and at high altitude, certain physiological responses to exercise, such as lactate accumulation, V_E, VO_2 and VO_{2max} are altered. At sea level local RPE was found to be the primary determinant of effort sense. However, at high altitude there is a marked reduction in lactate accumulation and a much higher ventilatory equivalent for oxygen. Under these conditions central RPE dominated the measures of perceived exertion.

It appears that the contribution of physiological cues to perceived exertion is determined by the relative strengths of the signals emanating from the various local and central sites. The work of Young et al. (1982) and Horstman et al. (1979) suggests that "when a particular cue, either local or central, is accentuated over others it can dominate the overall perception of effort" (Pandolf, 1983, p.143). This view is supported by Mihevic (1981) who commented "rather than a single primary cue, multiple sensory inputs of local and central origin are integrated and weighted by the individual to arrive at an evaluation of overall perceived exertion" (p.161). The integration and weighting means that those factors sending out the strongest signals are automatically weighted highest in perceived intensity (Borg, 1985).

2.3.2 Psychological Determinants of Perceived Exertion

Notwithstanding the importance of physiological variables in determining RPE, Morgan (1973) has suggested that these physiological factors account for only 66% of the variance in RPE measures, and that much of the shortfall may be due to psychological factors. Rejeski (1981) has gone further to suggest that in non-laboratory experiences of physical activity, subjective assessment of effort may be more influenced by motivational and situational factors than by physiological factors, local or central. These views have also been supported by Borg (1977) who suggested that although the determination of perception of effort was based on physiological inputs, psychological factors such as information processing, learning and motivation must also be involved.

Research supporting the role of psychological variables in determining perceived exertion is extensive. Psychological factors have included personality variables, hypnotic suggestion, meditation, past experiences, motivation and task aversion, social perceptions and cognitive strategies.

2.3.2.1 Personality Variables

Morgan (1973) investigated the relationship between a number of psychological traits and ratings of perceived exertion. In this study a range of psychometric variables was measured in each of fifteen subjects. The traits assessed were: extroversion - introversion and neuroticism - stability using the Eysenck Personality Inventory (Eysenck & Eysenck, 1962); trait anxiety using Spielberger's State - Trait Inventory (Spielberger, Gorsuch & Lushene, 1969); somatic perception with the Somatic Perception Questionnaire (Landry & Stern, 1970), and depression using Lubin's Depression Adjective Check List (Lubin, 1967).

Subjects in the study were required to estimate the magnitude of the workload at which they were exercising. The experimental workloads were increased at random levels rather than being linearly increased. Of the seventy-five possible judgements (15 subjects x 5 loads), eight of the subjective estimates were not in accord with the actual loads. Of those subjects who made errors all but one were neurotic or anxious. The subject making the most errors scored highly on the neurotic, anxiety and depression measures. In reviewing this study Pandolf (1983) suggested that the rating of perceived exertion was in some way influenced by psychopathology.

In a second experiment, the subjects pedalled a bicycle ergometer at various loads for one minute intervals. Subjects' perceived exertion ratings were found to correlate with introversion-extroversion measures. Results showed that extroversion correlated negatively with rated perceived exertion. This suggests that when extroverts and introverts work at the same level of power output, extroverts perceive the work as requiring less effort (Morgan, 1973).

Results from this study also showed that ratings of perceived exertion correlated positively with measures of anxiety (r = 0.56), somatic perception (r = 0.75), and depression (r = 0.71). Interestingly, these correlations were only noted at the higher workloads. Morgan (1981) argues that perception of effort may well be influenced by personality structure, albeit in a complex way. He suggests that the influence of personality variables would be most potent when the experience of pain or discomfort is greatest.

2.3.2.2 Hypnotic Suggestion

Morgan et al. (1973) investigated the effect of hypnotic suggestion on perceptual and metabolic responses to work on a bicycle ergometer. The induction technique utilised eye fixation and suggestions of relaxation (cf. Friedlander & Sarbin, 1938; Barber, 1966). Subjects were required to exercise at a constant intensity of 100 Watts. On each of the experimental trials subjects were administered suggestions of light (50W), moderate (100W), and heavy (150W) workloads. In preliminary trials subjects actually experienced the effort involved at each of the suggested workloads. Effort sense during the experimental trials was assessed using the Borg Scale. Results of the study showed that although subjects were exercising at the same intensity (100W), the perception of effort was dependent on the experimental condition. Under the suggestion of 'light work', subjects had a mean rated perceived exertion score of nine, under 'moderate work', the mean rating was eleven and for 'heavy work' the mean rated perceived exertion was fourteen. In each of these cases the mean ratings were significantly different.

Similar results were noticed by Morgan, Hirota, Weitt and Balke (1976). Non-hypnotised and hypnotised subjects were asked to pedal a bicycle ergometer for twenty minutes at a resistance of 100 Watts. Under the experimental condition, subjects were asked to imagine they were cycling up hill and then back to a level grade at the 11 -15 minute and 16 - 20 minute marks respectively. Rated perceived exertion was seen to increase linearly for both subject groups. However, at the suggestion of uphill work, the hypnotised group recorded a significantly higher mean RPE than the non hypnotised group. At the suggestion of level grade, the hypnotised group mean RPE score decreased to a value similar to that of the non-hypnotised group.

Suggestions of heavy work not only affected rated perceived exertion but also the physiological parameters associated with physical output. Carbon dioxide production, respiratory exchange ratio and ventilatory minute volume, all increased when the subject was exercising under conditions of suggested heavy load (Morgan et al., 1973; Morgan et al., 1976). When exercising under suggestions of light load, the ratings of perceived exertion decreased but the physiological indices mentioned above remained similar to subjects under control conditions. Morgan (1981) suggested that there may be a lower limit to which physiological patterns of work can be reduced, even though the work is experienced as easier.

Based on the physiological and perceived exertion data from these studies, Morgan (1981) concluded that "perception of effort is a complex psychophysiological process, and furthermore, simplistic models involving a single variable (e.g., heart rate) or system (e.g., respiratory) will not prove to be fruitful in attempting to understand effort sense" (p. 395)

2.3.2.3 Social Influence

Defining 'social influence' as "the alteration of one's behaviour, feelings or attitudes by what others say or do" (p.90), Hardy, Hall and Prestholdt (1986) investigated the effect of social influence on rated perceived exertion (RPE).

Subjects exercised on a bicycle ergometer at moderate intensity (50% of subject's VO_{2max}). On each of the experimental trials, the subject exercised in the presence of a co-actor (experimenter's confederate). The confederate worked at either 25% VO_{2max} (low intensity information) or 75% VO_{2max} (high intensity information). Naive subjects were informed they were of the same physical condition as the confederate, hence they could be tested together at the same intensity.

Results of this study showed that for low intensity information, the subject suppressed RPE relative to that reported when exercising alone. For high intensity information, RPE remained consistent with the exercising alone condition. Hardy et al. (1986) argued that these results illustrate the combined effects of the self-presentational and social comparison motives. When these forces act in concert, as in the low intensity cue condition, RPE is biased in the direction of information (i.e., low intensity). However, when these motives act in opposition, as in the high intensity cue condition, they effectively cancel each other, consequently RPE does not change significantly from the alone condition. Hardy et al. (1986) concluded that cognitive social psychological variables can play a significant role in the perception of exertion.

2.3.2.4 Motivation

Attribution theory is a cognitive model used to explain an individual's motivation to perform. "It assumes that people strive to explain, understand, and predict events based on their cognitive perception of them" (Cox, 1990, p.228). In achievement/performance situations, an athlete attempts to find some explanation for any perceived success or perceived failure. The nature of these causal attributions in terms of their locus of control, stability and controllability will influence the athlete's feelings toward the outcome and consequent expectations about future performance. When such expectations are negative (future success not assured or future failure expected), then there is a concommitant loss of motivation. On the other hand, when expectations are positive, then motivation is enhanced. Attributions used by athletes to explain the outcomes of their performance can include effort, task difficulty, luck and ability (Weiner, 1972, 1985). Attribution research has shown that causal attributions to 'effort' are more salient when performance is inconsistent with past behaviour (Spink, 1978). Further, ratings of effort as the main attribution are higher after conditions perceived as successes as opposed to failures (Scanlan & Passer, 1980). The underlying explanation is that athletes aim to protect their self-concept. In circumstances of perceived failure, a reduced attribution to effort allows the athlete to provide a face-saving explanation of the outcome (e.g., "I didn't really try hard enough").

Rejeski (1981) argued that in sporting situations athletes' reports of effort may be motivated by self presentational needs. Under these circumstances, exertion is perceived as an ability. The need to appear able to tolerate pain and persist through hardships, "tough-minded", may strongly influence the perception of exertion and its subsequent reporting (Rejeski & Lowe, 1980). Borrowing from the work of Covington and Omelich (1979), Rejeski (1981) suggested that "the direction of one's self presentation is problematic" (p.314). If an athlete fails and claims he did not try his hardest then he is chastised, if, however, he fails and claims he did try then his ability is in doubt.

Rejeski (1981) has suggested that, "in the field, where a myriad of social psychological forces impinge on the performer, the role of physiological feedback to RPE may well be reduced" (p.312). It is reasonable to assume, therefore, that past experiences, present outcomes and underlying motives will combine to have some influence on the perceived, and reported, degree of effort put into a particular activity.

2.3.2.5 Cognitive Strategies.

Cognitive strategies, be they dissociation, self-focus, external cue utilisation, self-talk, or goal setting, are potential psychological mediators of perceived exertion, over which the athlete can exercise conscious control. As such, cognitive strategies provide ways that an athlete can actively modify perceived exertion and hence influence performance of a physical activity. The role of cognitive strategies, especially dissociation strategies and self monitoring techniques, as mediators of rated perceived exertion and their subsequent effect on endurance performance is discussed in detail below.

In a real life situation, personality and psychological variables may have a far greater influence than physiological feedback in determining perceived exertion (Rejeski, 1981). The relative influence of psychological variables is, to a degree, dependent on the person and the situation. Morgan (1981) suggested that personality variables would be most salient at higher exercise intensities. On the other hand, cognitive psychological factors: cognitive strategies, past experience, motivation and social influences are more salient at lower and moderate levels of exercise intensity (Hardy et al., 1986; Rejeski, 1981,1985). At high exercise intensity levels, the strength of physiological cues is of such magnitude that they would dominate perception, thereby reducing the mediating effect of any cognitive psychological variable (Rejeski, 1981).

Notwithstanding the above comments, the role of psychological variables in determining the subjective experience of effort and subsequent performance is obviously important. Were athletes able to manipulate these psychological variables, then they would perhaps have more control over the quality and outcome of their performance. An athlete's ability to consciously and purposefully direct cognitions could provide the athlete with a means to modify the experience of effort and hence the outcome of physical endeavour. Such is the rationale for the use of cognitive strategies.

2.4 COGNITIVE STRATEGIES AND PERCEIVED EXERTION

The athlete's decision to adjust pace, continue or withdraw from an endurance activity is to a large extent based on the athlete's perception of effort (Morgan, 1981). In broad terms there are two ways an athlete can influence perceived exertion.

First, the source of noxious physiological signals can be modified. In the longer term, this is the rationale for physical training. Through constant use the muscles, joints, vascular and respiratory systems undergo adaptation to the increased demands placed on them during endurance activity. With this adaptation there is a lessening of the sense of discomfort during prolonged activity.

Alternatively, the athlete may utilise psychological variables to bring about a change in perception. This would be especially viable at low to moderate intensity activity (Rejeski, 1981). A number of psychological variables have been found to influence perceived exertion (Morgan, 1981; Pandolf, 1983; Rejeski, 1981). However, drawing on results from the pain research literature, it may be argued that athletes would be best served if they utilised cognitive strategies that distract from pain and discomfort. Such strategies are the most practical way for an athlete to deal with the intermittent and/or acute discomfort developed during an ongoing endurance activity.

2.4.1 Association - Dissociation

The pivotal research on the role of cognitive strategies in modifying perceived exertion during endurance activity was reported by Morgan and Pollock (1977). Based on reasoning similar to the above, it was generally accepted that athletes would practise pain distraction techniques known as dissociation (Morgan, 1978). When given the opportunity to test elite middle distance and long distance runners, Morgan and Pollock (1977) did indeed hypothesise that "dissociation of sensory input would represent the principle cognitive strategy employed by world class distance runners during competition" (p. 385).

Morgan and Pollock (1977) conducted clinical interviews with 19 world class middle to long distance runners, of which 8 were marathoners who were able to complete the marathon distance in a time of less than 2 hr. 20 min. The interview protocol included the following question:

> "Describe what you think about during a long distance run or marathon. What sort of thought processes take place as a run progresses?" (p.382)

Based on the analysis of interview data, Morgan and Pollock (1977) rejected their initial hypothesis. Rather, they concluded that elite marathon runners use an associative strategy. More particularly elite runners reported that:

> 1. they paid very close attention to bodily input such as feelings and sensations arising in their feet, calves and thighs, as well as their respiration,
> 2. whereas they paid attention to time, pace was largely governed by reading their bodies
> 3. they identified certain runners they would like to stay with during a given race if possible
> 4. during any given marathon they constantly reminded or told themselves to 'relax', 'stay loose'
> 5. they typically did not encounter 'pain zones'
>
> (p.390)

Morgan and Pollock (1977) pointed out that the subjects in earlier work with marathoners were average runners who completed the marathon distance in three to four hours. These non-elite runners used cognitive strategies designed to dissociate from painful input. However, with the elite performers they observed a strategy that was essentially different. The elite runner *associates* and "attempts to process this information and modulate pace accordingly" (p.399)

Morgan and Pollock (1977) argued that the elite athletes' physiological superiority allowed these athletes the pleasure of running at a greater percentage of maximum effort before encountering severe pain. By associating (i.e. monitoring bodily sensations) the athletes were able to make fine adjustments to pace, respiration and/or technique thereby avoiding pain. As a result of these findings Morgan and Pollock (1977) concluded that:

> "on the basis of our interviews it seems reasonable to propose that marathoners might adopt what appears to be two rather divergent coping strategies" (p.400)

This comment in the literature gave rise to a number of studies designed to confirm the strategies used by endurance athletes of various skill levels and to determine therelative efficacy of dissociation and association in enhancing performance in endurance events.

After Morgan and Pollock (1977), the research literature took two directions. A number of researchers conducted surveys similar to that of Morgan and Pollock (1977) to determine the types of and self-reported efficacy of strategies used by endurance performers. Other researchers set up experimental studies in which cognitive strategies were manipulated and consequent changes in performance assessed. The general aim of these studies was to determine if one or the other of these strategies was better suited to enhancing performance. Indeed Morgan (1978) had given some fillip to these endeavours after he suggested that :

> "the average jogger...would be well advised, whenever he can, to imitate the elite runner's associative strategy. In doing so he might improve his competitive performance..." (p.49)

2.4.2 Survey Research

Survey research has generally concentrated on one or more of the following broad categories: comparison of strategies used by novice (sub-elite) and elite athletes; the strategies used in training as compared to those used in competition; and the relationship between strategies and subsequent performance. Some survey research has taken the form of survey questionnaires. These use either open-ended type questions or alternatively, a number of descriptive strategy items are presented which the athlete must rate in some way. Other researchers have opted for a clinical interview style.

As a note at this point, the classification of runners as elite or non-elite has presented difficulties. Several authors have accepted marathon performance in less than some specified time as indicating elite status (Durtschi & Weiss, 1986; Morgan & Pollock, 1977; Schomer, 1986). Others have defined elite athletes as those who compete at international or national level (McDonald & Kirkby, 1989). Houseworth (1990) has developed a complex system of rating athletes based on competitiveness (i.e., level of competition) and running time relative to age.

2.4.2.1 Elite versus Non-elite Strategy Use

In their original research Morgan and Pollock (1977) argued that elite athletes used a type of cognitive strategy that the authors termed association. Although subsequent survey research has found support for the predominant use of association by elite performers, there has been no support for the exclusive use of this strategy by the elite performer.

Freischlag (1981) surveyed the perceptions and running strategies of 55 marathoners prior to their competing in a marathon run. Responses relating to cognitions during a marathon were grouped into five focus groupings: personal affairs, finishing the race, position in the race, body, and finally mechanics of running. Following Morgan and Pollock's (1977) description of association and dissociation, the 'personal affairs' focus can be considered to be dissociative whereas the remaining foci would fit with the notion of association. An important observation made by Freischlag (1981) was the "increased reliance on body functioning to cope with episodes of stress" (p. 286) by all athletes.

Durtschi and Weiss (1986) presented athletes with a *Running History Questionnaire* in which they were asked questions concerning "..the thought processes during race competition" (p.74). The results of this survey showed that all four groups (male, female, elite and non-elite) used some form of association. The non-elite athletes, however, were more likely to report using dissociative strategies.

Silva and Appelbaum (1989) surveyed the association-dissociation cognitive patterns of 32 US Olympic marathon trial contestants. On the basis of data analysis the athletes were separated into groups of top- and lower- place finishers. Silva and Appelbaum concluded that top finishers were more likely to use both associative and dissociative techniques. Lower finishers indicated a response pattern that suggested an early adoption of dissociative strategies that was maintained throughout the race. McDonald and Kirkby (1989) asked young athletes to describe "three or four of the most important things you concentrate on when it is difficult to continue in a race or in hard training"(p.4). The athletes were given a list of ten associative and ten dissociative items from which to choose. The response pattern showed that more associative items were chosen by athletes performing at the elite level. McDonald and Kirkby (1989) have cautiously suggested that the use of associative strategies may increase with age (and commensurate maturity and competitive experience). At the other end of the age scale, Ungerleider, Golding, Porter and Foster (1989) surveyed 587 masters' track and field athletes. Of those surveyed 76% reported using associative techniques during competition. A combination of both cognitive strategies was more likely to be used by the younger athletes in the group.

Sachs (1984) had sixty runners from the Florida State University complete a questionnaire in which the runners were asked about their cognitive strategy use. Results of this survey prompted Sachs (1984) to comment that "simple categorisation of runners as associators or dissociators may not be meaningful" (p.291). Survey results showed that 68% of the subjects reported using a dissociative strategy most of the time, 25% predominantly used an associative strategy and 7% used an equal mix of the strategies. However, all runners indicated that they used both strategies with, "frequent shifts during the run from association to dissociation and back again" (p.291)

Schomer (1986) has argued that novice and superior athletes do not differ in terms of the amount of associative and dissociative strategy they use during endurance performance. Rather, these groups differ on the quality of the strategies used. Based on Nideffer's (1981) concepts of attentional style, Schomer developed a more extensive classification system of cognitive strategies. Associative strategies were sub-classified as: Feelings and Affects, Body Monitoring, Command and Instruction (to self), and Pace Monitoring. Dissociative strategies were further sub-classified into six categories. In an elaborate study, Schomer (1986) recorded the verbalisation of athletes' cognitions during a marathon run. These verbal reports were then content analysed and classified into one of Schomer's categories. Results indicate that all runners employed associative strategies. However, superior athletes had a higher representation of 'body monitoring' cognitions whereas the novice athlete centred more on the 'feelings and affect' aspects of associative thinking.

Houseworth (1990) surveyed the attentional style of runners competing in a ten mile road race. The survey items were "written to reflect associational, dissociational and meditational focus specific to an endurance event" (p. 3). Subjects were classified according to competitiveness and running time relative to age. For example, "the first woman 45-49 year old finisher placed second overall for women in 1:06:58, only 3:55 slower than the second placer for men 20 years younger. Thus, she was classified in Class I [Superior] while the second finisher in this age category (1:18:55 and eleventh overall for women) was classified in Class II [average]" (p.3). The third class of runner was classified as Recreational. Data analysis showed no significant difference between groups in terms of cognitive strategy use. Overall, Class I, Class II and Recreational runners did not differ in their use of association, dissociation or meditation. Analysis of the pattern of strategy use during the event indicates that all runners shifted attention continuously throughout the race.

There is some support for the position that elite performers predominantly utilise an associative strategy during competition and that the novice athlete invokes more of the dissociative style. However, neither class is restricted to the sole use of one or other of the strategies. There is considerable evidence to suggest that runners of all classes use a mix of the two strategies. A number of authors have suggested that this mix is determined not only by the status of the athlete but also by the context in which the athlete is performing. Different strategy balances may result depending on whether the athlete is in competition or training, the nature of the event, or the elapsed period of the event.

2.4.2.2 Context Variables and Cognitive Strategy Use

Morgan, O'Connor, Sparling and Pate (1987) surveyed female runners involved in three levels of endurance activity: 1500m-3000m competitors, 10000m distance runners, and marathoners (42km). Athletes were asked to detail the types of thoughts they experienced during a training run as well as competition. Analysis of the survey responses showed that significantly more runners used association (56%) than dissociation (22%) during competition. This situation was reversed during training when 56% of subjects reported using predominantly dissociation and none of the respondents considered association their preferred strategy.

Similar results have been reported by Summers, Sargent, Levey and Murray (1982) and Sachs (1984). Results from the Summers et al. (1982) survey showed that, although 63% of respondents reported using both association and dissociation during competition, dissociation was the preferred strategy for 69% of the athletes during training. Sachs' (1984) survey results indicated that dissociation is the predominant strategy employed during training with association being employed by a lesser number and the use of both strategies being reported by the least number of respondents. As Sachs (1984) pointed out, however, many runners find it difficult to classify themselves as dissociators or associators. Although they can nominate the strategy they use most of the time, the athletes report that they often shift back and forth between the two styles.

Masters and Lambert (1989) asked 30 competitors to complete a Race Diary within 24 hours of competing in a marathon. Runners were asked to report what they thought about during the marathon. The report was divided into 5-mile sections (except the last which was 6.2 miles). Responses were content analysed and categorised according to Schomer's (1986) classification system. The number of dissociative and associative type statements was expressed as a proportion of the total number of statements. Scores were calculated for the race as a whole and for each separate section. Results indicated that association was the preferred strategy used by the runners over all sections of the race. The authors reported from other material gathered in this study that the use of dissociation or both strategies was preferred to association during training runs. A detailed analysis of the use of dissociation during the race has shown that there was a significantly higher use of this strategy in Section 4 (15 to 20 miles) than in the final section. Masters and Lambert pointed out that this section of the course traversed a long downhill stretch. They suggested that because the runners didn't have to physically push themselves they could comfortably indulge in dissociation.

Newsham, Murphey, Tennant, O'Toole and Hiller (1991) have also suggested a patterning of strategy use dependent on the type of activity and the length of competition. Thirty four athletes from the 1989 Hawaii Ironman Triathlon were asked to complete the *Cognitive Coping Strategies Questionnaire* (CCSQ). The CCSQ, developed by Newsham et al., is a questionnaire that assesses the ratio of associative/dissociative thoughts used during performance. The item content is based on Schomer's (1986) definitional system. Respondents indicate the use of a particular strategy using a five point Likert scale ranging from "not used" to "used a great deal".

In the Newsham et al. (1991) study the scale contained three sub-sections each containing eight statements relevant to the swim, bike or run portion of the course. Analysis of event and strategy data revealed significant interaction effects. Subjects used the most association during the bicycle section of the race with least association being experienced during the swim. The use of dissociation increased in a linear fashion throughout the race, with the greatest use of this strategy during the run. Newsham et al. (1991) argued that the use of association is influenced by the degree of task-related concentration required in a particular sport or activity while the use of dissociation is affected by the length of competition and feelings of fatigue.

Sachs (1984) reported changes in cognitive strategy mix depending on temporal or 'locative' factors. Examples given include the shift in emphasis to associative strategies when running in hot and humid weather or running on an uneven surface in order to maintain a safe pace, careful footing and appropriate form. Runners in Sachs' (1984) study reported a different strategy mix at different stages of the activity. "Many runners indicated a tendency to associate more during the early and late parts of the run and to dissociate during the rest of the time" (p. 293). At the end of the run athletes concentrated more on assessing fatigue and maintaining form.

Sachs' (1984) observations appear to differ from those of Newsham et al. (1991) that triathletes use more dissociation towards the closing stages of their event. However, the realities of fatigue at the end of an Ironman competition (Newsham et al., 1991) are quantitatively and perhaps qualitatively different from a training run (Sachs, 1984) and a marathon (Masters & Lambert, 1989). Further, in each of the studies where temporal changes in strategy use has been noted (Masters & Lambert 1989, Newsham et al., 1991; Sachs, 1984) the authors pointed out that these shifts in emphasis are not exclusively in the direction of one strategy as opposed to the other.

Rather, the mix of strategy use tends to draw more from one class of strategy than the other.

It would appear from the above review that the use of a particular strategy or mix of strategies is dependent on the context in which they are used. Dissociation is arguably the preferred strategy during training, irrespective of the strategy choice during competition. Schomer (1986) has suggested that "dissociative thinking permits the runner to negotiate temporary pain zones and distract from the monotony of the running process" (p.42). It is during the training stage that the runner chalks up the miles, so it is not necessary at this stage for the athlete to be predominantly task-focused. During competition (and training), a number of variables may influence the mix of strategies used. The degree of concentration required during the activity, the length of competition and environmental changes have been posited as triggers to alter an athlete's cognitive strategy use.

2.4.2.3 Cognitive Strategies and Performance

The effect of cognitive strategies on performance has been investigated in a small number of survey studies. However, results have been equivocal. In a related work, Summers et al. (1982) investigated the use of cognitive strategies and the experience of hitting-the-wall. Hitting-the-wall has a number of popular explanations, but essentially it is that point in an endurance activity when the athlete feels she or he has run out of reserve energy. Morgan (1978) explained that "it is the point that a runner's homeostasis, or internal function, begins to break down. The breakdown is associated with depletion of glycogen supplies in the working muscles, there is a loss of blood volume, core or rectal temperatures sometimes rise to 106 or 107 degrees, and the body starts to dehydrate" (p. 40). Morgan and Pollock (1977) have suggested that the use of an associative strategy by an endurance performer allows for adjustment of running pace and subsequent efficient utilisation of fuel, hence their observation that elite runners do not report hitting-the-wall. Summers, et al. (1982), however, found that 56% of runners reported an encounter with "the wall". Within this group, there was no significant relationship between experiencing "the wall" and the type of cognitive strategy used.

Okwumabua (1985) surveyed 90 middle aged male marathoners. Included in the general questionnaire were items regarding cognitive strategies used during performance. Run time for each of the subjects was also recorded. Results indicated that finish time was a function of three variables: training, past performance and self-efficacy. Cognitive strategy use, as reported, was not significantly related to marathon performance. These results are consistent with those of Newsham et al. (1991). Competitors in the Hawaii Ironman Triathlon reported various combinations of cognitive strategy use during each of the three events that constitute the race. However, Newsham et al. (1991) found that there was no relationship between the use of an associative strategy and performance times for the event.

Masters and Lambert (1989) reported results that conflict with the observations cited above. These authors found that association was the predominant strategy used by 93% of the runners sampled. A comparison of strategy use with performance time indicated a significant negative correlation between association and time to complete the marathon [$r(46) = -0.30$, $p<.05$]. These results suggest there is some substance to Morgan's (1978) view that runners' performance would benefit from the judicious use of association.

As a general conclusion, there appears to be considerable support for Morgan and Pollock's (1977) conclusion that elite athletes predominantly associate, whereas those of a lesser standing place more emphasis on dissociative techniques. Notwithstanding this, there is sufficient support for the notion that all athletes use a mix of association and dissociation. When training, athletes use dissociation as the predominant cognitive strategy. The reduced level of necessary task focus gives the athlete time to dissociate. However, when engaged in competition, strategy use is moderated by a number of factors. The mix or balance between strategies can vary depending on the athlete's skill level, the nature and duration of the activity, and environmental demands. Schomer (1986) has further shown that the difference between elite and sub elite athletes in their use of association is in the qualitative nature of the cognitions used by each of the groups.

2.4.3 Experimental Research

An underlying assumption in much of cognitive strategy research relates to the performance of elite athletes. If elite athletes associate, then association must enhance winning performances. The survey literature is divided on this issue. A number of studies have found no relationship between cognitive strategy use and performance. On the other hand, Masters and Lambert (1989) demonstrated a significant relationship between the use of association and better performance.

The notion of a causal relationship between cognitive strategy use and performance suggests two alternatives: either elite athletes use association because they are elite, or they are elite because they associate. Morgan (1978) took the view that elite runners' use of association is a consequence of their "phenomenal physical structures"(p.46). Association is a strategy available to these athletes because their physical systems are developed to such a point that they suffer less during a race. They are elite "not because they have learned to associate, but because they can afford to associate" (p.46). This view is supported by Okwumabua (1985) who concluded that performance is *inter alia* a function of training and not cognitive strategy use. The opposing view that the use of association contributes to successful performance has been indirectly supported by Schomer (1986). As part of his conclusion, Schomer (1986) expressed the view that training an athlete to adopt associative coping strategies will enable a high effort training schedule "aimed at the optimisation of the runner's output during a marathon race" (p. 56). The resolution of this dilemma has been the aim of the experimental research literature.

The general aim of experimental research in the area of cognitive strategies and endurance performance has been to establish which of the two strategies, association or dissociation, is more effective in enhancing performance. Because of the limited number of studies results have been equivocal. The greater proportion of research effort has been concentrated on survey research of cognitive strategy use.

Spink and Longhurst (1986) manipulated the cognitive strategies used by 400m individual medley swimmers. Subjects in this study were state and national level swimmers. Subjects swam a 400m individual medley time trial to establish a baseline condition. Three days later subjects were randomly allocated to groups receiving either association or dissociation strategy training. During a 15 minute session, subjects were provided with instructions on how to employ a particular strategy and the appropriate rationale for its effectiveness. Subjects then completed another 400m individual medley. Analysis of the effect of cognitive strategies on the change in performance time showed a significant main effect. Subjects utilising an associative strategy swam significantly faster than those who used a dissociative strategy. Spink and Longhurst in their discussion cautioned against overgeneralisation of their results and suggested that any future experiments utilise a control group condition.

Morgan, Horstman, Cymerman and Stokes (1983) reported a study designed to test the efficacy of a dissociative strategy. Subjects were assigned to one of three groups: a control group, a placebo (lactose capsule) group, or a dissociation group who employed a relaxation technique (Benson, Dryer & Hartley, 1978). Each subject was pre-tested by walking on a treadmill to exhaustion at 80% VO_{2max}. On a second occasion subjects were again tested using the same protocol but under their respective experimental conditions. Results indicated that the group employing the dissociative strategy took a longer time to exhaustion than the other two groups. Morgan et al. (1983) argued that "...dissociation of sensory input by means of a simple distraction strategy enabled subjects to tolerate greater discomfort" (p.254).

Morgan et al. (1983) reported a second study designed to evaluate the use of a dissociative cognitive strategy to facilitate physical performance. Subjects were required to exercise to exhaustion at 80% MAP. The time taken to exhaustion provided baseline data. At this pre-test level subjects did not differ on any of the physiological variables measured nor on mean performance times. Subjects were then randomly assigned to a dissociation group (N=14) or a control group (N=13). After a period of 48 hours rest, maximal endurance times were again tested using the same procedures. However, on this occasion subjects in the dissociation group were presented with a narrative that contained a rationale for the use of the dissociative strategy, techniques for implementation of the strategy and finally a short description of how and why a dissociative strategy would be effective in facilitating endurance performance. The dissociation strategy involved the subject focusing on a fixed point directly ahead and with each leg movement saying the word *down* to themselves in a rhythmical fashion. The control group were given the same instructions they had received at the baseline trial.

The mean endurance time for the dissociation group (M=21.5 min.) was significantly greater than that of the control group (M=14.5 min.). Morgan et al. (1983) suggested that the observed performance gain is mediated by a cognitive perceptual process based upon distraction (pseudo-mantra, synchrony, narrow focus) thereby ignoring or suppressing sensory input (working muscles, metabolites, ventilation). Morgan et al. (1983) in their discussion made no mention of any limitations in this study. However, the improvement in performance in the experimental (dissociation) group may reflect the influence of demand characteristics. The narrative presented to the subjects in the dissociation group contained a specific request: "Please go as long as you can in order to make our experiment a success" (p.258). It is possible that those subjects in the dissociation group, who were so inclined, put all other considerations aside and extended their efforts to comply with this request and keep the experimenter happy.

Okwumabua, Meyers, Schlesser and Cooke (1983) investigated the effects of training in the use of either an associative or dissociative strategy on novice runners' performance. Thirty-one undergraduate students were assigned to one of three jogging classes: association instruction, dissociation instruction, or control. As a pre-test condition all subjects completed a timed run over 1.5 miles and completed a cognitive strategy questionnaire. The strategy questionnaire consisted of a number of association and dissociation items which the subject checked off if these were applicable to their personal style. A cognitive strategy score was obtained by dividing the number of associative items by the total number of associative and dissociative items checked. Hence, a score of less than 0.5 indicated a predominantly associative style, whereas, a score greater than 0.5 was considered predominantly dissociative.

Over a five week training period subjects met for a three hour session each week during which they were given a ten minute instruction on how to implement the relevant strategy and a positive rationale for the intervention. The associative group were instructed to monitor body signals in respect to the demands of the running task. The dissociative group were taught to focus attention on non-run-related thoughts and to repeat a rhythmic phrase (mantra). The control group were introduced to a number of relaxation exercises. All groups were instructed in the skills and proper techniques of jogging. In the third and final (fifth) weeks, subjects completed a timed run over 1.5 miles and completed the cognitive strategy questionnaire.

Analysis of the cognitive strategy data showed that, regardless of group assignment, all runners reported more associative strategy use over the duration of the study. Further it was found that the runners did not employ the cognitive strategies to which they were assigned. In view of this "the original group assignments were disregarded and students were re-grouped according to their report on the final questionnaire of cognitive strategies while running" (p.368). This re-grouping resulted in an associative group (N=16) and a dissociative group (N=15). Using these groups as the data source it was found that both groups improved mean running performance over trials. Subjects using more dissociative strategies showed greater performance improvement than those using predominantly associative strategies. Okwumabua et al. (1983) concluded : "novice runners reported increasingly associative cognitive strategies as they gained running experience and physical proficiency. The performance of novice runners profited from the use of dissociative strategies." (p.368). These results agree with Morgan's (1978) suggestion that novice runners may benefit from the judicious use of dissociative strategies.

Weinberg, Smith, Jackson and Gould (1984) compared the effect of association, dissociation and positive self talk on endurance performance. Sixty male university undergraduates were randomly allocated to one of association, dissociation, positive self-talk or control groups. The association group was instructed to constantly monitor their level of exertion, to pay attention to the body's responses to the running activity. The dissociation group was asked to imagine themselves doing something that was pleasant but unrelated to running. The self-talk group was required to constantly talk to themselves and give themselves positive encouragement. All subjects were then asked to run as far as they could in a thirty minute period

Strategy use during the run was assessed by means of a single question at the completion of the run. Subjects were asked to estimate the percentage of time in the run that they complied with the appropriate strategy instruction. The authors reported that each group had a response rate in the order of 71% usage. Analysis of the performance scores for groups showed there was no significant difference between groups on the number of laps completed.

In their general discussion Weinberg et al. (1984) provided some insights for cognitive strategy research. In particular, the authors suggested that experienced runners have most likely developed their own coping styles. Imposing an experimental strategy on runners may lead to a conflict of strategies and hinder the adoption of the assigned strategy. Secondly, subjects were not specifically trained in the use of a particular strategy rather they were told about the strategy immediately before the run. The authors suggested that "specific training in the use of these cognitive strategies would be necessary before their effectiveness...could be adequately assessed" (p.29). These general comments are similar to those suggestions made by Okwumabua et al. (1983) regarding the refinement of methodologies for cognitive strategy research.

The above experimental research shows conflicting results regarding the effectiveness of associative and dissociative strategies on performance. A number of possible causes may explain the discrepancies. Inappropriate experimental design (lack of control groups, no pre-test data), no clear agreement in the definition of elite and novice level subjects, ineffective manipulation of cognitive strategies (for example, no pre-training or ineffective pre-training), small sample sizes, and demand characteristics are some of the possible limitations of experimental research to date.

2.5 ATTENTIONAL FOCUS RESEARCH

Attentional focus has also been used as a model for research into cognitions and performance at physical tasks. Attentional focus is subdivided into two primary 'directions'. An **internal focus** suggests the individual is making a "concerted effort to pay attention to his or her own thoughts, feelings, and bodily sensations, whereas in an **external focus** the individual attempts to concentrate on objects and events outside the body" (Clingman & Hilliard, 1990, p.25)

A number of researchers have stressed the importance of sensory information processing and focal awareness as determinants of athlete performance. In an exercise setting, both internal and external sources of information are available to the athlete. Pennebaker and Lightner (1980) have argued that, under these circumstances, the processing of one of these sources will restrict the processing of the other, as there is a limit to the amount of information that can be processed at any one time. Further, Pennebaker and Lightner (1980) argued that, where external information is potentially more novel or complex than internal information, there is a higher probability that attention will be directed externally.

Pennebaker and Lightner (1980) conducted two separate but related studies to investigate the notion that "factors promoting external attentional focus will reduce awareness of internal sensations and fatigue" (p.166). They hypothesised that there would be competition between internal sensation and external cues such that "with varying types of external information, individuals should be differentially aware of internal sensations of fatigue" (p.165).

In the first study internal and external attentional focus were directly manipulated during a constant level of exercise. Fifty seven male undergraduates were required to walk on a treadmill at increasing speeds for ten minutes. Subjects were required to wear headphones that were not operative on this occasion. On completion of the walk, subjects responded to a questionnaire to assess self reported fatigue, symptoms, and moods. One week later, subjects repeated the procedure but under one of three experimental conditions. Subjects allocated to the external focus condition were required to listen to tape recordings of novel sounds. These included music, a radio talk show, parts of a lecture, cars driving past. Each sound vignette was no more than 20 secs. duration. Those subjects in the internal focus group were fed back the sound of their own breathing. Subjects in the control group heard nothing over their headphones.

At the end of the walk subjects again completed the questionnaire. Results of this study showed that relative to control subjects, subjects who listened to distracting sounds reported less perceptions of fatigue and negative symptoms. Those subjects who listened to their own laboured breathing reported higher levels of fatigue and symptom rating. These results and the fact that there was no difference between groups on pulse and blood pressure prompted Pennebaker and Lightner (1980) to conclude that "the forced attention to body in an exercise setting results in greater perception of fatigue and symptoms than if attention is directed elsewhere" (p. 169). By way of explanation Pennebaker and Lightner (1980) suggested that while processing external information, the subject has less capacity to process internal sensations to the same degree, hence, there is a reduced perception of fatigue and/or negative symptoms.

In the second study, Pennebaker and Lightner (1980) investigated subject performance in two different running situations. In the first session, and then on every other day, subjects jogged over a cross country course that required close concentration on the external environment. On each alternate day the subjects ran a lap course that required little external focus because of its safe and repetitious design. Both runs were 1800m long. The subjects ran these two courses on alternate days for a ten day period. The time to complete each run was recorded. After finishing each day's run subjects were required to complete a self report of fatigue and symptoms. After the last day's run subjects also completed a questionnaire regarding their attitude to the two courses.

Results of the second study showed that there was no difference in the fatigue and symptom rating for each of the course conditions. However, running times were significantly faster on the cross country course than the lap course. Again there was no difference between conditions on physiological variables. The attitude survey showed that subjects expressed a greater preference for running on the cross country track. The authors conclude that:

> "subjects set and maintained their jogging pace in accord with their perceptions of fatigue related symptoms. Given that subjects were focusing on external factors to a higher degree on the cross country course, their processing of internal sensations was restricted. Consequently they could increase their pace before feeling maximally fatigued" (p.171).

These two studies offer support for the notion that there is differential processing of internal and external information during exercise. An athlete's focus of awareness is to some degree consequent on the salience of various environmental cues and internal sensations. When external factors focus attention away from the body, the perceptions of fatigue and negative symptoms are reduced. On the other hand an internal focus will enhance the cognisance of the fatigue element of bodily sensations. Performance in endurance activity is to some extent based on an athlete's perception of his or her internal state. When an athlete is externally focused, an increased level of performance is observed before the concomitant strength of the internal cues is sufficient to dominate the athlete's focus of awareness.

In a study similar to that of Pennebaker and Lightner (1980), Wrisberg, Franks, Birdwell and High (1988) manipulated the attentional focus of subjects while running to exhaustion on a treadmill. Wrisberg et al. aimed to compare the effect of self focus and external focus on heart rate, endurance time and perceived exertion. Subjects performing in the self focus condition were required to watch themselves in a mirror and listen to their own breathing. Each subject was fitted with headphones, and a microphone that picked up the sound of the their breathing. In the external focus condition, subjects watched a film and listened to the sound track through headphones during their run. Subjects were required to run to exhaustion under each of the experimental conditions. At the completion of each experimental trial, subjects gave an estimate of their perceived exertion using the Borg (1982) scale. The time for the run was calculated from when the subject stepped onto the treadmill to the point when the subject called stop.

Results of a questionnaire to determine the effectiveness of the attentional focus manipulation showed that 19 of the 20 subjects adopted the external focus as required and 16 out of 20 subjects an appropriate self focus. The authors concluded that the manipulation of attentional focus was successful. Analysis of the perceived exertion data showed no significant differences between focus conditions when assessing maximal performance. Analysis of the endurance performance times showed no significant difference between focus conditions.

Gill and Strom (1985) investigated the influence of attentional focus on endurance performance. Based on Nideffer's (1976) framework, Gill and Strom compared the effects of a narrow internal focus to a narrow external focus. Thirty four female subjects performed a leg lift task on a quadriceps machine. On each of two occasions subjects were required to complete as many leg lifts as they could within a fifteen minute period. All subjects performed under each of two experimental conditions. For the internal narrow focus condition, the subject was told to "focus all of her attention on the feelings in her legs while performing the exercise" (p.219). When performing under the external narrow focus condition, the subject was asked to

" focus on a collage fixed 3 ft. in front of her at eye level" (p.219). At the end of the exercise period subjects completed a questionnaire to check adherence to the attentional manipulation and to assess subjective feelings about the two conditions.

Analysis of results showed that significantly more leg lift repetitions were achieved by the external focus group (M=22.2) than by the internal focus group (M=17.1). Questionnaire responses showed a significant preference for the external focus (28 subjects) over the internal focus (6 subjects). Gill and Strom commented on the inconsistency of their results with those of Morgan and Pollock (1977). They argued that these observed differences are perhaps due to differences in design and subject selection.

Clingman and Hilliard (1990) have argued that enhanced performance may not be simply a question of internal versus external attentional focus but rather the particular attentional details on which the athlete chooses to focus. In a study involving 16 professional walkers, Clingman and Hilliard manipulated the attentional focus during each of four separate half mile walking segments. At the start of each segment the subject was given specific instructions. Two of these segments were completed with an external focus. The subject was told to focus "on something unrelated to walking". However, subjects in this condition were also reminded "to maintain race pace" and to "keep it legal" (p. 28). The authors pointed out that there are strict rules governing technique in walking competition. The internal focus condition was divided into two specific instruction sets. For the 'stride length' condition subjects were told to concentrate only on lengthening their stride. In the 'cadence' condition subjects were told to take as many steps per minute as possible.

Adherence to the attentional focus allocated for a particular segment was determined by questioning the subjects about their cognitive experiences during the preceding section. The authors reported that "all subjects indicated that they had in fact been able to focus as instructed" (p.29). Analysis of performance times showed that there was no significant difference between external focus and internal focus conditions, when the internal conditions were combined. However, comparison of times for external and each specific internal condition showed that when focusing on cadence, subjects covered the set course significantly faster than when they focused externally or on stride length. There was no difference between stride and external focus conditions. Clingman and Hilliard (1990) concluded that an athlete's performance may be enhanced if she or he focuses on specific critical variables. The authors argued that cadence is a critical determinant of success in walking competitions, more so than stride length, hence, the improved performance observed under this condition.

Wrisberg and Pein (1990) conducted a survey, in which they asked 192 university undergraduates to complete an attentional focus questionnaire after a routine jogging session. Data were also collected on the subjects' running experience, including frequency, intensity and past experience. Analysis of the data showed that inexperienced runners focused more on bodily stimuli associated with the activity, whereas the more experienced runners focused on matters that were unrelated to running. These results appear to be in direct contrast to those of Morgan and Pollock (1977). Here, novice runners are using an associative strategy, whereas Morgan and Pollock (1977) suggested that novice runners have a preference for dissociative strategies. Further, the experienced recreational runners in Wrisberg and Pein's (1990) study focused away from the running process because "they are more adept at diverting attention away from unpleasant bodily cues associated with exercise than are the inexperienced runners" (p.430). This apparent conflict between research results may reflect the qualitative differences in the running experience of novice recreational runners and experienced recreational runners compared to novice and elite marathoners.

The research on attentional focus, like the survey and experimental research on cognitive strategies, presents equivocal results regarding the effectiveness of different types of focus in enhancing endurance performance. Closer review of the research material regarding attentional focus and cognitive strategies suggests that there are a number of areas where differences in conceptual understanding and research methodologies might provide possible explanations for a lack of consistent findings .

2.6 ISSUES IN COGNITIVE STRATEGY RESEARCH

The literature relating to cognitive strategy research raises a number of issues regarding classification of cognitions, methodological problems in data collection and experimental manipulation of strategies. The term 'cognitive strategy' has taken on a number of nuances. The dichotomous definition used by Morgan and Pollock (1977) was influential in determining the general understanding of the term and the direction of subsequent research. Another stream of research has chosen to concentrate on an athlete's (subject's) attentional focus. This focus may be directed internally or externally. Proponents do not make any clear theoretical distinction between these two approaches (cognitive strategy and attentional focus) as each uses the other's research results as a basis for further work.

The collection of data in survey and experimental research presents an inherent difficulty. Most research relies on post-performance reports to gain information regarding the cognitions used during performance. However, some authors, and Schomer (1986) particularly, have argued strongly against this method and in favour of an *in vivo* technique of data collection.

In experimental research on cognitive strategies there has been considerable discussion regarding the efficacy of the various techniques used to manipulate strategy use by subjects. The ineffective manipulation of strategies has caused some researchers to redistribute their subject grouping post hoc (Okwumabua et al., 1983), whereas others have been unable to draw conclusions from their study (Sachs, 1984).

In their seminal work, Morgan and Pollock (1977) argued that the use of particular strategies was related to the level of skill and performance of the athlete. This stimulated research to seek a cause-effect relationship between strategy use and performance. Schomer (1987) was even prompted to conduct a training program wherein athletes were being conditioned to use only an associative strategy. More recent studies have, however, questioned the skill-relatedness of strategy use and suggested that athletes at all levels of experience use a combination of strategies (Masters & Lambert, 1989; Sachs, 1984; Silva & Appelbaum, 1989). Indeed Morgan (1984), while advocating association as the preferred strategy for elite and average runners, agreed that there is a place for the judicious use of dissociation.

2.6.1 Classification of Strategies

The term 'cognitive strategies' has both general and specific connotations in the sport psychology literature. As a broad term, cognitive strategies encompasses any mental activity, the object of which is to achieve one's own advantage or aims. In this sense the concept of cognitive strategies includes anxiety reduction techniques, self motivation methods, mental rehearsal techniques, focus and concentration skills and pain coping strategies. Such activities may be carried out before, during or after an event or performance.

On a more specific level 'cognitive strategies' has been used to describe particular mental activities aimed at modifying one's perception of effort while involved in a physically demanding task and consequently improving the outcome of one's performance at that task. There are, at present, three main systems of definition for cognitive strategies or those mental techniques used specifically to modify perception of effort. First, Morgan and Pollock (1977) proposed two types of cognitive strategy: association and dissociation, second, Schomer (1986), provided a system that essentially sub-categorises association and dissociation and, third, attentional focus has been used as a model to describe cognitions used during physical activity. Nideffer's (1981) classification of attentional style has been used to further refine the characteristics of attentional focus. As none of the current definitional systems alone adequately caters for all the potential variations in an athlete's cognitive activity during physical performance, there is a need to clarify and instil some precision into the definition of these cognitive processes.

Morgan and Pollock (1977) distinguished two types of cognitive strategy. When athletes use a ***dissociative strategy***, "they are 'cognitively active' during competition, but this cognitive activity seldom, if ever, relates to the actual running...The cognitive strategy employed by these athletes can best be regarded as 'dissociative cognitive rehearsal'. The various rehearsal themes are rather different, but they all seem to be directed toward the same end - dissociating the painful sensory input." (p.390). On the other hand, athletes who used an ***associative strategy*** reported that they closely monitored and checked their bodily sensations. Although they were cognisant of others in the race, their own pace was largely determined by "reading their bodies" (p. 390).

Schomer (1986) developed a classification system that has brought some order to the categorisation of cognitive strategies. Schomer content analysed the thoughts verbalised by subjects while running a marathon. The theme categories developed to classify the verbalisations "had to manifest a pronounced attentional focus" and were "rigorously rationalised if they did not adhere to the feasibility of exhaustive, mutually exclusive and independent classification" (p.46). Schomer (1986) argued that these sub-classifications represented clear, precise and distinct categories, namely:

"ASSOCIATIVE CATEGORIES

(A) FEELINGS AND AFFECTS
general sensations of the whole body -no mention of specific body parts
["I feel bushed", I'm still feeling fine"]

(B) BODY MONITORING
here and now thoughts containing specific mention of anatomy, body parts, or body physiology
["shoulders are stiff", "left foot is hurting again"]

(C) COMMAND AND INSTRUCTION
emphatic self-regulatory instructions to specific body parts or instructions to whole body functioning distinctly related to the activity and maintenance of running.
["relax the shoulders", "breathe deeply now"]

(P) PACE MONITORING
feedback on current performance with respect to time, distance, speed or any other available form or method of pacing.
["running a bit fast for this section", "three kilometres to go"]

DISSOCIATIVE CATEGORIES

(E) ENVIRONMENTAL FEEDBACK
here an now thoughts on the weather conditions, temperature, light conditions, smell, and noise level.
["clouds building up-might rain", "these car fumes ..."]

(R) REFLECTIVE ACTIVITY THOUGHTS
thoughts on past and future issues related to running.
["I think I'll enter the Peninsula marathon next month", "..how I struggled up this hill last time"]

(S) PERSONAL PROBLEM SOLVING
issues of an intrapersonal and interpersonal nature including reflective introspection, belief system evaluation and modification.
["I wonder how my girlfriend is?", "I feel self conscious about that photo in the paper"]

(W) WORK, CAREER AND MANAGEMENT
thoughts about job, work and career opportunities including thoughts centering around the execution, planning and construction of work
["I'm supposed to cut the lawns tomorrow", "I suspect that patient will need another operation"]

(I) COURSE INFORMATION
thoughts of a descriptive nature about scenery and general whereabouts that are of no consequence to pace.
["Those mountains look great at sunset", "flowers all around me"]

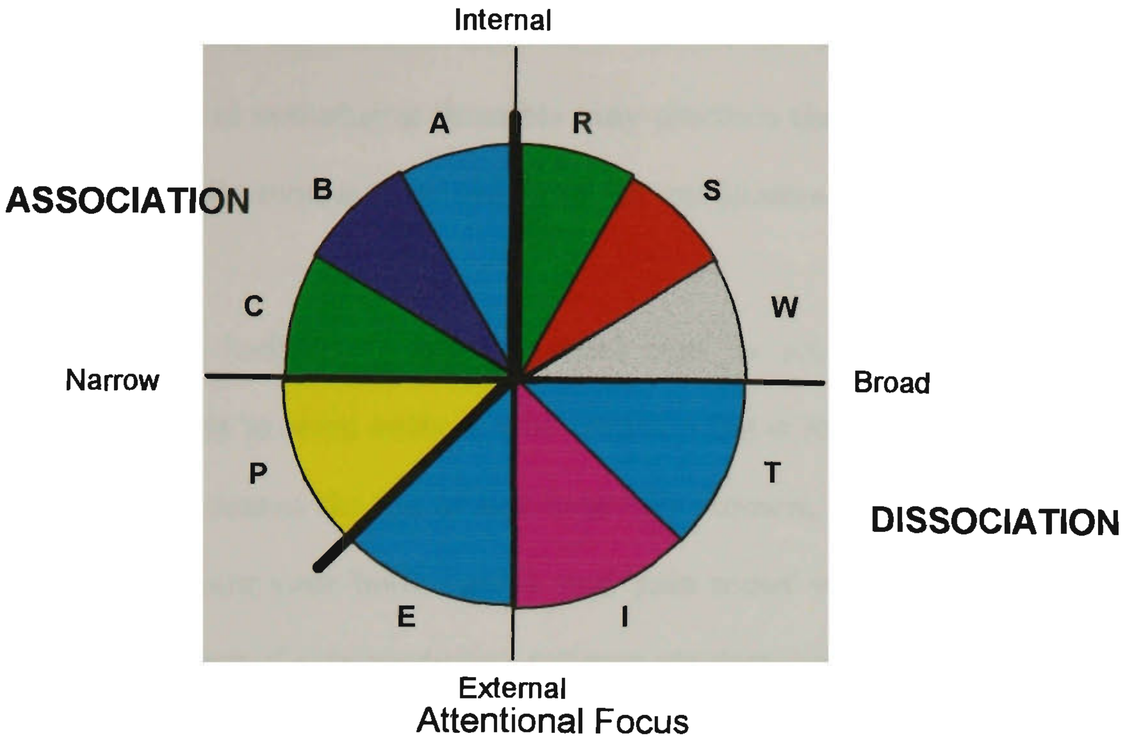
(T) TALK AND CONVERSATIONAL CHATTER
direct speech when in communication with others, thoughts expressing follow up to verbal exchanges, unintelligible or inconsequential chit-chat
["How's it going (name)", "How are the new Nikes wearing?"] " (p.46/47)

There is a degree of commonality in the definitions of cognitive strategies given by Morgan and Pollock (1977) and Schomer (1986). Morgan and Pollock (1977) suggested that association involves monitoring of both body signals and external cues (other runners), and periods of self instruction and that as a result of these processes the athlete decides on his or her pace. Schomer (1986) included under the general heading 'association' the sub-categories; feelings and affects, body monitoring, command and instruction, and pace monitoring, again focusing on the monitoring of bodily cues as the basis for pace adjustment.

Although Schomer (1986) nominated a sub-category 'environmental feedback', he did not include this in the associative group. However, he described 'pace monitoring' as "feedback on current performance with respect to...any other available form or method of pacing" (p.47). During a marathon, common thoughts may be: "this head wind is getting stronger, check the pace, take smaller steps" or "it's getting hotter - must slow down and make sure I drink more water" or "hey that guy's pulling away - better pick up the pace". Each of these thoughts is initiated by monitoring external information, is run-related, involves pace monitoring and/or command and instruction, and results in an adjustment to performance. It can be argued that these statements are associative statements. Schomer's (1986) classification system may be better served by extending the 'pace monitoring' category to include all run-related environmental information that the athlete uses to make adjustments to his or her running performance. Where environmental observations are not run-related, they should be classified as "ambient information". This would effectively eliminate the necessity for the category "environmental feedback". Thus, when athletes direct their attention to the weather (external focus) and modify their perception of effort or pace as a consequence of their observations, then they are associating. On the other hand, if they ponder the day, the warmth, the blue sky, then they may be dissociating.

Schomer (1986) also amalgamated Nideffer's (1981) attentional style categorisation into the mental strategy classification. Nideffer's classification of attention is based on two orthogonal dimensions: width of attention (broad or narrow) and direction of attention (internal or external). The width of attention concerns the amount of information an individual has to process at any given time, whereas direction refers to whether the individual is directing attention to internal cues (feelings, thoughts) or to external cues (environment) (Schomer, 1986). The model below (Fig. 1) offers an overview of Schomer's mental classification system. The vertical and horizontal axes represent the attentional focus dimensions. The solid black line indicates the division between the broad classification of associative and dissociative cognitive strategies. It should be noted that Schomer's sub-classification of strategies encompasses the essential features of Morgan and Pollock's (1977) definition of association and dissociation.

Using this interpretation, Schomer argued that association would be primarily an internal/narrow focus whereas dissociation would be essentially internal/external broad. The concepts of internal focus and external focus are useful as general descriptors of the attentional direction or type of cognitions an athlete is experiencing. However, both association and dissociation consist of strategies that can be classified according to the possible combinations of internal, external and broad, narrow. Schomer's model of cognitive strategies does not allow for some reported forms of external/narrow focus. For example, the practices of fixing gaze on a moveable spot or focusing on a distant object, both external narrow focus techniques, have been noted by others (Gill & Strom, 1985; Morgan & Pollock, 1977; Morgan et al., 1983; Sachs, 1980).



KEY:

ASSOCIATION

A: Feelings and affects
B: Body Monitoring
C: Command and Instruction
P: Pace Monitoring

DISSOCIATION

E: Environmental Feedback
R: Reflective Activity Thoughts
S: Personal Problem Solving
W: Work, Career and Management
I : Course Information
T: Talk and Conversational Chatter

Fig. 1 Diagramatic Representation of Schomer's (1986) Strategy Classification System

Given Schomer's *in vivo* system of data collection, there are some thought processes that would go unreported. If subjects were at some stage engaged in 'fixing their gaze', they may have had some difficulty verbalising this process. A runner does not constantly think "look at the peak of that mountain" for example, she or he just does it. Further, although Schomer (1986) envisaged a "dissociation - daydreaming and drifting" category, he observed that "no altered states of consciousness...mental drifting...or other mystical Zen-like experiences were reported" (p.56). Again, it is the very nature of these experiences that they cannot be easily verbalised. Paying conscious attention to verbalising thoughts may preclude the process of daydreaming and would certainly inhibit any tendency to meditative or self-hypnotic states (Herrigal, 1960).

However, the inclusion of any external cues as relevant to the associative process is in contrast to some authors who truncate the definition of association even further. In order to assess the use of association by runners, Ungerleider et al. (1989) asked "Do you monitor your 'body signals' and 'pain zones' when competing?" (p.246). There was no mention of race conditions nor race strategies as part of the assessment. Further, Sachs (1984) stated, "... in the truest sense, association appears to be restricted to focusing on one's own bodily sensations." (p.290). Morgan and Pollock (1977), however, clearly indicated that body monitoring and *attention paid to others in the race* are both an integral part of the associative strategy.

The foregoing research indicates that endurance performers are able to monitor both their bodily signals and aspects of the external physical environment to determine if and what changes are necessary to their performance. There are two essential features of this process: first, the performer intentionally monitors task related cues and, second, adjustments to performance may be made as a result of information gained (Morgan, 1978; Morgan & Pollock, 1977; Schomer, 1986). On this basis, ***association is defined as occuring when an athlete purposefully monitors any task-related cue, internal or external, and as a consequence makes a decision to maintain or alter pace or performance.***

Dissociation is considered to be an 'attentional diversion' (Sachs, 1984) wherein the runner "purposefully cuts himself off from the sensory feedback he normally receives from his body" (Morgan, 1978, p.39). Summers et al. (1982), further suggested that dissociation may help the runner negotiate not only pain zones but also the boredom and monotony of endurance performance. Hence dissociation may be viewed as a strategy to help cope, not just with the pain, but with any noxious consequence of the activity. Again, however, the issue of purposefulness is stressed. Dissociation occurs when the athlete chooses to focus on cues, other than those arising from the body, for the purpose of distraction.

Pennebaker and Lightner (1980) have presented an argument to describe the perceptual processes involved when an external attentional focus is used to cope with pain. They have argued that:

> "Where both internal and external sources of information are potentially available, the processing of one will restrict the processing of the other. Further, the probability that attention will be directed externally is a function of the novelty or complexity of the external environment" (p. 165).

This conclusion is based on two principles derived from perception and cognition research. First, stimuli that are novel or complex will be processed in greater detail than redundant or simple presentations (Berlyne, 1960). Second, there is a limit to the quantity of information that can be processed by an individual at any given time (Navon & Gopher, 1979).

Rejeski, (1985) used Leventhal and Everhart's (1979) "parallel processing model" of pain to explain the action of dissociative strategies. Essential to this model is the distinction between perception as "all the processed material to which one can attend" and focal awareness as "that segment of potential stimuli to which one does attend" (Rejeski, 1985, p.373). The use of dissociative strategies reduces the experience of pain (effort) because the distracting cognitions prevent the noxious stimuli from entering focal awareness. "Dissociative strategies provide relief from fatigue by occupying limited channel capacity that is critical in bringing a percept into focal awareness" (Rejeski, 1985, p.374). This model is consistent with Pennebaker and Lightner's (1980) argument that when different stimuli are in competition, the more dominant (stronger, more complex or more novel) stimulus set will be the object of focal awareness.

Lorentzen and Sime (1979), as cited in Sachs (1984), proposed three categories of the dissociative state: diversions (which includes general fantasies of a non-run-related nature and meditation that involves some active technique), problem solving, and spontaneity. As opposed to meditation, spontaneity includes those situations where the athlete thinks of "nothing at all" or where there is a "free flow" of thoughts with no particular pattern. Sacks et al. (1981) found that competitors in a 100 mile race often reported meditative thinking, during which the "runners are focusing neither on themselves nor on some distracting thought, but rather they are not particularly focusing at all" (p.173). By contrast Schomer (1986) found no evidence of what he called meditative thinking, while recording the verbalisations of marathon runners during performance. Sachs (1984) has suggested that the themes present in dissociative categories are somewhat determined by the athletes' reasons for running. When the run provides an opportunity for the athlete to 'escape' from the pressures of everyday life, then the dissociative cognitions are more likely to be of fantasies, meditation or distractions. If, on the other hand, the run is considered a time for particularly clear thinking, then the runner is more likely to spend time on problem solving and organising thoughts and ideas.

There is also some discussion in the literature as to whether certain cognitions are purely associative or dissociative. Morgan et al. (1983) reported a study in which subjects in the dissociation group are presented with relaxation techniques as their strategy. Yet Morgan and Pollock (1977) clearly indicated that it is when associating that athletes "constantly remind themselves to relax, stay loose and so forth" (p.390). Again, Morgan et al. (1983) reported a further study in which subjects in the dissociation group were to say the word *down* to themselves as each foot struck the ground. Schomer (1986) has argued that such strategies could become pacing strategies and as such cannot be considered task un-related. "In this context their dissociative meaning takes on associative properties for any marathoner interested in steady running rhythm" (Schomer, 1986, p.55). Summers et al. (1982) also found difficulty in categorising marathoners' strategies. Some 63% of their sample "reported strategies that could not be classified into either category, they were associative by relating directly to the run yet also dissociative in distracting the runner's mind from their bodily sensations" (p.968). An example offered involved setting sub-goals such as running from one drink station to the next. In the latter examples (foot strike and location of drink stations) it can be argued that the athlete is attending to external cues. The use of synchrony between pseudo mantra and foot strike becomes an "available form of pacing" and according to Schomer's (1986) classification a form of association. Summers et al. (1982) have suggested that setting a sub-goal may be dissociative "in distracting the runners' mind from their bodily sensations" (p.968). However, as a distraction from bodily sensations, the runner does not continue the run thinking only of the next drink station. 'Making it to the next drink station' in fact becomes a form of pacing, similar to such strategies as 'only a mile to go', 'there's the finish line', 'just make it to the next lamp post'. These are not meant to block out pain but rather are used by the runner to push the body further. They are external cues employed to modify or maintain pace.

The instances and examples of dissociative strategies reported in the literature above indicate that dissociative thoughts can be both internally and externally directed. Strategies such as 'building a house brick by brick', 'playing a stack of Beethoven recordings' in one's head are of an internal focus, whereas, strategies such as 'focusing on a distant object', 'looking at the scenary' and 'talking to other competitors' direct the runner's attention externally.

Thus, by way of definition, ***dissociation occurs when an athlete attempts to cope with the effort, boredom and/or monotony of an endurance run by purposefully using internally or externally directed, non-run-related thoughts to block negative stimuli.*** The success of dissociative techniques is dependent on the novelty, variety or complexity of the distractions and their potential to compete with any noxious stimuli in dominating focal awareness.

Although Schomer's (1986) cognitive strategy classification system goes a long way in removing the confusion when categorising athletes' cognitions, the technique used to develop the system has limitations when addressing the entire possible range of cognitive strategies. Notwithstanding these limitations, Schomer's sub-classifications present a useful working model. This model has been used as the basis for strategy measures in more recent research (Masters & Lambert, 1989, Newsham et al., 1991). However, the attempt to find correspondence between cognitive strategies and attentional focus is of limited value, save that of attentional focus being used as a descriptor of the various components of cognitive strategies.

2.6.2 Cognitive Strategy Measures

Most of the data regarding the use of cognitive strategies or attentional focus has been collected using a variety of techniques relying on subjects' memories or interpretations of past mental activity. Methods have included post event interview (McDonald & Kirkby, 1989; Morgan & Pollock, 1977; Morgan et al. 1987), post event questionnaires (Durtschi & Weiss, 1986; Masters & Lambert, 1989; McDonald & Kirkby, 1989; Newsham et al., 1991; Silva & Appelbaum, 1989; Weinberg et al., 1984; Wrisberg & Pein, 1990), and post experimental questionnaire or interview (Clingman & Hilliard, 1990; Gill & Strom, 1985; Okwumabua et al., 1983; Spink & Longhurst, 1986; Wrisberg et al., 1988). Assessment of cognitive strategy use after the event has ranged from a single question: "What percentage of the time did you use the cognitive strategy that the experimenter presented to you?" (Weinberg et al., 1984, p.28), "Do you monitor your body signals and pain zones when competing?" (Ungerleider, 1989, p.246), through questionnaires in which subjects are presented with a number of cognitive strategy check items and a cognitive strategy score is calculated (McDonald & Kirkby, 1989; Okwumabua et al., 1983; Silva & Appelbaum, 1989; Wrisberg et al. 1989,), to open ended interviews (Gill & Strom, 1985; Morgan et al., 1987).

Schomer (1986) has mounted strong criticism of these techniques of data collection and argued that a runner's thoughts must be recorded *in vivo*.

> "To advance current knowledge on cognitive coping strategies and to avoid retrospective falsification, as well as to demythologise findings based on anecdotal reports, research into the mental strategies employed by long-distance runners has to happen on the spot during the activity of running to enable an unobscured, articulate analysis." (p.43)

Drawing on Gilhooly's (1982) serial modal model of thinking, Schomer argued that the contents of working memory during the processing of task related cognitive activities are very transitory. Therefore, when considering cognitions used over the period of performance, "retrospective verbal reports cannot yield as accurate information as current verbalisation" (Schomer, 1986, p.55).

Sacks et al. (1981) earlier attempted a method of collecting information by asking questions of runners while they were competing in a 100-mile race. Schomer (1986) advanced this procedure by having marathoners carry a tape recorder during a training run and instructing them as follows:

> "I am interested to know what runners think of during their run. So I would like you to say aloud whatever comes to your mind during this run...Speak your mind. There are no taboo issues or limits here. You can speak in whatever fashion you like. You don't necessarily have to say complete sentences, phrases or words..." (p. 45).

Schomer suggested that the runners in this study did not experience any difficulty in matching the speed at which thoughts occur and their subsequent verbalisation. The method of taping cognitive processes *in vivo* has been criticised by Masters and Lambert (1989), as "this rather intrusive form of data collection is likely to have influenced his findings in favour of greater association" (p.162). Unfortunately, Masters and Lambert did not develop this criticism any further. Perhaps Schomer's method creates an expectation in the subject's mind that she or he should make verbal reports most of the time. Complying with this expectation would preclude a proportion of those cognitions that are not associative in nature, such as daydreaming, meditative states and self-hypnosis techniques. A further possibility for greater association reported by subjects is that the instructions to subjects promotes in them an increased self awareness or self consciousness and hence they are more aware of subjective (bodily) experiences.

Taken together, the criticism of Masters and Lambert (1989) and the problem of the measurement methodologies precluding certain types of strategy (e.g. daydreaming, meditation, self-hypnosis) call into question the validity of Schomer's technique. However, notwithstanding these uncertainties, more recent research has utilised Schomer's classification system of cognitive strategies as the basis for questionnaire instruments. Masters and Lambert (1989), despite their criticism, analysed runners' reported cognitive activity according to Schomer's classification. Runners' reported statements were classified as either associative or dissociative, then each class was expressed as a proportion of the total number of statements reported. Both Newsham et al. (1991) and Wrisberg and Pein (1990) used questionnaires incorporating items based on Schomer's classification. Using a Likert scale type questionnaire, cognitive strategy scores were assessed by summing the ratings on each group of items. Wrisberg and Pein (1990) assessed the runners' use of dissociative strategies only, whereas Newsham et al. (1991) measured the use of both association and dissociation.

There appears to be no solution to the dilemma of data collection. In most cases the pragmatics of the situation will determine the method of collection used. In view of the fact that both post-performance measures and *in vivo* measures have their strengths and weaknesses, the researcher needs to choose the technique that minimises the possibility of aberrant results. The use of Schomer's (1986) classification system is dependent neither on his division of the categories according to attentional style, nor on the method of data collection he employed. Rather, the use of this schema as the basis for an 'activity specific' questionnaire, using Likert type response categories, appears to provide the most refined and practical measuring instrument to date.

2.6.3. Strategy Manipulation

In a number of experiments where researchers have tried to manipulate subjects' cognitive strategy use or attentional focus, the researchers have been content with simple verbal instructions. In some cases the instructions consisted of a one off explanation of how the subjects were to structure their thinking, depending on the type of strategy that was required (Clingman & Hilliard, 1990; Gill & Strom, 1985; Morgan et al., 1983; Sachs, 1984; Weinberg et al., 1984). In other cases the subjects were given more information and time to practice the appropriate technique. Spink and Longhurst (1986) and Okwumabua et al. (1983) used verbal instructions wherein subjects were provided with a rationale for the strategy and guided instruction in the use of the strategy. Okwumabua et al. (1983) continued instruction in strategy manipulation at regular intervals throughout the experimental period. Both research teams reported that some subjects did not adopt the given strategy and suggested that the period of strategy familiarisation was perhaps inadequate. Spink and Longhurst (1986) recommended that cognitive strategies should be practised over time just like physical skills. Okwumabua et al. (1983) also suggested intensified subject involvement during instruction in the manipulation.

Sachs (1984) also reported that subjects did not adhere to experimenter manipulated strategies. After questioning subjects in his study, Sachs proffered several possibilities for this lack of adherence. As with Spink and Longhurst (1986) and Okwumabua et al. (1983), Sachs (1984) suggested that "if manipulating the quality of the run...through changes in cognitive strategies is to be effective...more specific training in these strategies will be needed" (p.294), and that such training would include the provision of information about the benefits and techniques of particular strategies. Sachs also found that some of the runners had, over their years of involvement in running, developed a particular cognitive strategy style. Sachs suggested that most of these runners were content with their own style and found difficulty in adopting a strategy different from the one they habitually used.

In addressing these issues regarding the difficulty of training subjects in strategy use and further overcoming some runners' resistance to the adoption of a 'new' strategy, Wrisberg et al. (1988) offered an alternative approach. They suggested that subjects' internal or external focus of attention be experimentally manipulated. In their study, self focus was manipulated by having subjects watch themselves in a mirror as they performed and at the same time listen to an amplification of their breathing. External focus was established when subjects watched a film and listened to the sound track while performing. A subsequent assessment of induced attentional focus indicated that the desired focus was achieved. Gill and Strom (1985) manipulated subjects' external focus by having them direct their attention to a collage that was located at eye level and three feet in front of the subject. In the internal focus condition subjects were asked to concentrate specifically on their legs. Gill and Strom reported an effective manipulation of attentional focus.

There appear to be two potent ways of manipulating a subject's cognitive strategy use or direction of attentional focus. Cognitive strategy manipulation requires an extensive training program in which the subjects are given a rationale for the procedures, actively partake in deciding the content of the strategies and spend time developing and rehearsing the various strategies. Wrisberg et al. (1988) and Gill and Strom (1985) offered an alternative method of manipulating components of cognitive strategies in controlled experimental situations. However these manipulated cues must be sufficiently novel and/or complex to ensure their pre-eminence in focal awareness (Pennebaker & Lightner, 1980).

2.7 SUMMARY

An athlete's performance in an endurance activity is determined by his or her physiological capacity and the ability to tolerate the physical discomfort, pain and perhaps boredom associated with the activity. However, as Morgan et al. (1983) suggested "In the final analysis, the decision to stop, maintain pace, or accelerate pace while performing an endurance event, such as the marathon, is governed by cognition" (p.252). At the cognitive level, it is the athlete's perceived exertion that provides the basis for decisions regarding performance

Perceived exertion is the cognitive integration of a variety of physiological and psychological inputs (Borg, 1982, 1985). At the physiological level, perceived exertion is influenced by central signals emanating from the cardiorespiratory system and by inputs from the peripheral system, such as the exercising muscle, joints, and metabolite concentration. These sensory inputs are weighted according to their relative strengths and integrated into an overall perceived exertion by the individual

(Mihevic, 1981). The final evaluation of perceived exertion, however, is the result of psychological modifications to the influence of these physiological inputs (Morgan, 1973; Rejeski, 1981). A variety of psychological factors have been found to influence the level of perceived exertion. These have included personality variables, motivation, social influences, expectations, past experiences and cognitive strategies (Hardy et al., 1986; Morgan, 1973; Rejeski, 1981).

Cognitive strategies are particular mental activities that a person can use to modify perceived exertion. Morgan and Pollock (1977), reported that athletes use two types of strategies, which they termed 'association' and 'dissociation'. Essentially association involved the athlete in monitoring body signals and making adjustments to pace accordingly. Dissociation occurred when the athlete purposefully blocked out body signals. Morgan and Pollock indicated that elite athletes (i.e. the better performers) used an associative strategy, whereas novice athletes tended to use dissociative strategies. In later work, Schomer (1986) refined the definition of these cognitive strategies, but did not alter their essential meaning.

Similarly, researchers in the area of attentional focus have suggested that certain attentional foci are able to affect an athlete's performance. Wrisberg and Pein (1990) stated that "attentional processes may diminish the perceived discomfort of physical exertion" (p.427). However, attentional focus research has established that athletes who adopt an external focus while exercising perform better than those who adopt an internal focus. The results of this research have been explained in terms of perceptual processes. In a situation where both internal and external sources of information are available, the processing of one will restrict the processing of the other. The probability that attention will be directed to one source as opposed to the other is a consequence of the novelty, complexity, or dynamics of the selected source (Pennebaker & Lightner, 1980).

Thus, when considering how cognitive processes influence physical performance, it appears there are two opposing views. A situation that has not gone unnoticed in the more recent literature (Horne, 1993). Morgan and Pollock (1977), on the one hand, suggested that performance is enhanced by associating, that is by closely monitoring body signals and the task. Research has shown that most athletes report using some degree of association during their performance. Morgan and Pollock (1977) argued, however, that where association is not an option then dissociation, or distracting strategies, is a way of coping with the noxious stimuli arising from the exercising body. Morgan (1978) has even suggested that athletes need to develop association skills if they are to improve competitive performance.

On the other hand, Pennebaker and Lightner (1980) and subsequent attentional focus research has placed the emphasis on external (distracting) strategies as the optimal means of coping with the noxious stimuli resulting from performance. Under this model, an internal focus is considered to be debilitateing to performance. Attentional focus research suggests that athletes must shift their focus externally, thereby blocking internal signals from focal awareness and consequently reducing perception of effort. The athlete will then be able to perform longer or harder until a critical effort sense is reached. An internal focus, such as monitoring the body, will only exacerbate noxious physiological signals thereby increasing the perception of effort and performance will deteriorate accordingly.

The present study aims to investigate the effect of manipulating subjects' cognitive activity in terms of attentional focus and the consequent change in perceived effort and performance. Subjects' cognitive strategy use will be manipulated such that they are predominantly associative (i.e., focused on internal cues and external task-related cues) or dissociative (i.e., focused on external cues or internal task-unrelated cues). Subsequent effect of these strategies on rated perceived exertion and performance at a running task will be assessed.

Subjects will be required to run to exhaustion on a treadmill. As the speed of the treadmill is not under the subjects' control, they will be forced to either maintain pace or terminate their performance. The treadmill speed for each subject will be adjusted so that for the major section of the run all subjects will perform at the same relative workload (Morgan, 1981). The experimental constant-speed run protocol is such that all subjects, then, should experience increasing levels of those noxious physiological signals perceived as pain.

The outcome of these manipulations is predicted to be consistent with the research of Pennebaker and Lightner (1980). During the experimental phase the attention of subjects in the association group will be manipulated so that they continually focus on task related internal and external cues. Under this condition, subjects monitor the noxious stimuli arising from the activity. Since these pain signals are negatively valenced, "the more an individual focuses attention on a given symptom, the more painful or disliked the symptom should become" (Pennebaker et al., 1978, p.1). Thus, any painful physiological signals will be enhanced and become the more dominant signals in terms of focal awareness. Hence, perception of effort will be raised and performance will deteriorate accordingly.

Subjects in the dissociation group will run under similar conditions except that their attentional focus will be directed to a program of non-task-related internal and external foci. Under these circumstances, the novel or complex stimuli will successfully compete with the noxious physiological stimuli. Hence, any unpleasant signals resulting from the constant speed run will be blocked from focal awareness. As a consequence, subjects' perception of effort will be reduced and performance will be extended until a later critical level of perceived exertion is reached.

More specifically it is hypothesised that:

1. ***The association group will report a significantly higher rated perceived exertion than the control group.***
2. ***The association group will report a significantly higher rated perceived exertion than the dissociation group.***
3. ***The dissociation group will report a significantly lower rated perceived exertion than the control group.***
4. ***Performance time for the association group will be significantly less than that of control group.***
5. ***Performance time for the association group will be significantly less than that of dissociation group.***
6. ***Performance time for the dissociation group will be significantly greater than that of the control group.***

CHAPTER 3. METHODOLOGY

3.1 RESEARCH DESIGN

The following experiment was based on the paradigm used by Morgan et al. (1983). Subjects were required to exercise on a treadmill at 80% of their maximal aerobic power (MAP) while their cognitive strategy use was manipulated. A modification of the techniques used by Wrisberg et al. (1988) for the manipulation of cognitive strategies was employed.

Subjects were ranked on the basis of MAP scores. Matched groups of three subjects were randomly allocated to one of three conditions: association, dissociation or control. A repeated measures design was used within each group to assess baseline and experimental values of the dependent variables. Difference scores between experimental and baseline values were used for later statistical analysis.

3.2 DESCRIPTION OF SUBJECTS

The subjects in this study were 33 male volunteers. The age range was 17 to 34 years with a mean of 23 years (SD = 4.39). All subjects were actively involved in some form of regular running activity, from social jogging to marathon and triathlon training and competition. The subjects were fully briefed prior to the study and each signed a consent form which is presented in Appendix 2.

3.3 DESCRIPTION OF MEASURES

A number of descriptive measures were recorded for each subject. Because of the aerobic nature of the experimental activity and in order to determine appropriate treadmill speeds, maximal aerobic power was used as an indicator of the aerobic fitness of each subject. As running ability is dependent on aerobic fitness, it was necessary to ensure that each group was matched in terms of level of fitness. A number of researchers (McDonald & Kirkby, 1989; Sachs, 1984; Schomer, 1986) have suggested that running experience can influence both the degree and level of sophistication of cognitive strategy use. Hence, a *Running Experience Survey* was used to broadly assess whether a subject was highly trained, a regular runner or an occasional jogger. Each of the experimental and control groups had to reflect an equivalent mix of running experience.

Dependent measures included heart rate, rated perceived exertion and performance time. Heart rate was recorded as a check that subjects were running at or near the prescribed 80% of maximal aerobic power. During maximal aerobic power assessment and each experimental run, the heart rate recorded at termination of activity (exhaustion) was taken as a measure of maximal heart rate. Rated perceived exertion was measured for each subject under each condition using the Borg scale (Borg, 1978). A cognitive strategy score was calculated at baseline run to determine each subject's preferred strategy. A second strategy score was determined after each experimental run as a means to check the effectiveness of the strategy manipulation. Finally, performance was determined by measuring the time to exhaustion for each subject.

3.3.1 Maximal Aerobic Power:

Maximal aerobic power (MAP) was determined using a run to exhaustion on a treadmill. After a period of warm up and stretching the subject was prepared for on-line data collection. The subject walked/jogged/ran on the treadmill for two minute continuous work periods at 4 km/hr, 6 km/hr, 8 km/hr, 10 km/hr and 12 km/hr. Where necessary, the test was extended from this point by increasing the grade of the treadmill by 2% every two minutes until volitional exhaustion.

The MAP tests were conducted using an on-line open-circuit spirometry system. Expired air was collected via a Hans Rudolph 2-way valve connected to a pneumatic digital spirometer. Expired air was analysed for O_2 and CO_2 content by Applied Electrochemistry Analysers. Calibration of the analysers was carried out before each test using Analytical Grade Gas (C.I.G. Melbourne). Data from the analysis were fed to an on-line IBM PC linked via an A to D converter.

3.3.2 Running Experience:

Each subject's running experience was assessed using a *Running Experience Survey* which is shown in Appendix 3. The survey assessed 'running frequency' as the average number of times per week that the subject ran, 'running distance' as the average distance in kilometres per run, and 'run period' as the number of weeks in the past year that the subject had run at the frequency and distance recorded. The final experience score was determined by calculating a frequency/distance product and dividing by 52 (the number of weeks per year). It is suggested that a runner who has run 5km three days per week for a year has a qualitatively different experience than a runner who has run 3km on each of five days for only the last week. The **Running Experience Score** was determined for each subject using the data from the survey and the following equation:

$$RES = \frac{RF \times RD \times RP}{52}$$

where:

RES	=	Running Experience Score
RF	=	Run frequency: average number of times per week the subject runs .
RD	=	Run distance: average distance per run (km).
RP	=	Run period: period (weeks) over which RF/RD combination has been maintained in last year.

3.3.3 Heart Rate : (HR)

During running sessions in the laboratory the subject's heart rate was monitored using a Sportstester PE3000 Heart Rate Monitor. The subject wore an elasticised strap around the chest. Attached to this strap was a miniaturised electrode and transmitter system. Heart rate (beats/min) was averaged over a ten second period and displayed on a digital watch. The heart rate for each subject was read manually and recorded at rest, then every two minutes during the run, with a final reading taken immediately after the subject terminated the run.

3.3.4 Rated Perceived Exertion (RPE)

Ratings of perceived exertion were obtained by means of the Borg Scale (Borg, 1978) shown in Appendix 1. The Borg scale is a fifteen point category scale, with values ranging from 6 to 20 which match the variation in heart rate from 60 to 200 beats/min. Borg (1982), however, cautioned against taking this relationship too literally. At equidistant intervals along the scale verbal descriptions, such as, "Very, very, light"; "Very, very, hard" facilitate subjects' anchoring of their perceptions against a specific scale value. The scale was printed on a poster and hung in the laboratory near the treadmill.

3.3.5 Cognitive Strategies:

Although *post hoc* cognitive strategy evaluation has been criticised (Masters & Lambert, 1989; Sacks et al., 1981; Schomer, 1986), other more intrusive measures have also been criticised (Masters & Lambert, 1989). The propensity for *in vivo* methods of cognitive strategy measurement to miss or preclude significant types of strategy use can result in biased measures. Using the survey approach, that incorporated strategy statements based on the definitions of association and dissociation developed in this research, was considered to be the most pragmatic solution to the problems of cognitive strategy measurement (Masters & Lambert, 1989; Newsham et al., 1991).

Using a **Post Run Questionnaire** developed by the author and displayed in Appendix 4, each subject's cognitive strategy profile was measured. The survey consisted of sixteen statements that are potential responses to the question: "During the run you have just completed how much of the time did you attend to or think about...?". Based on Schomer's (1986) classification of cognitive strategies, eight of the statements were associative in nature and eight were dissociative. Associative statements included both internal and external task-related cues. Dissociative statements reflected a mix of both internal and external non-task-related content.

Item 5(f) in the survey asked if the subject used "focusing" or "switching off" as a technique. This item was designed to cover those situations where the subject may use an external/narrow type of strategy, for example, picking a spot on the wall and focusing on that spot during the run, or having no particular cognitive focus. This type of strategy does not figure in Schomer's (1986) classification as it is not easily measured by verbalisation methods. Item 5(n) related to the use of internal or external cues as a means of pacing. These two types of cue were specifically included as Schomer's (1986) classification does not make provision for these types of strategy. They are considered to be important variants of the cognitive strategies being examined here. Both items were explained to the subjects and examples given, when subjects were given the questionnaire.

Subjects responded to each statement of the survey by marking their choice on a line representing the range "Not at All" (0) to "Most of the Time" (5). Each of the associative items was given a positive valence whereas each of the dissociative items was negative. A subject's *Cognitive Strategy Score* was equal to the algebraic sum of associative scores and dissociative scores.

$$CSS = \Sigma AS + \Sigma DS$$

where:

CSS = Cognitive Strategy Score
AS = Associative strategy responses
DS = Dissociative strategy responses

Hence, a positive cognitive strategy score indicated that the subject used predominantly associative strategies during the run. Conversely, a negative cognitive strategy score indicated a preference for dissociative strategies. The formula used to calculate cognitive strategy score in this study is similar to that of Okwumabua et al. (1983), except that, in this study, the proportion of time spent using each strategy is taken into consideration. In the present research, the inclusion of a Likert type scale for each response addresses this requirement. The system of measurement used in the present study has been successfully used by Newsham et al. (1991).

3.3.6 Performance - Timed Run:

On each of the three occasions in the study, subjects participated in a run to exhaustion. The run started with three, two minute incremental warm up speeds: 4 km/hr, 6 km/hr and 8 km/hr. The subject then settled into a fifteen minute steady state run at a speed required to work the subject at 80% MAP. After this period, the angle of the treadmill was increased by 2% every two minutes. Timing of the run started when the subject had two feet on the treadmill. The clock was stopped on termination of performance, indicated by the subject grabbing the support bars.

A number of safety precautions were available during treadmill runs. A light cord was strung between the back end of the support bars. If the subject's pace was slowing he would drift backwards. The cord would come into contact with the subject's buttocks, alerting the subject of the need to make a change in pace. An emergency button was also available on the support bars. If this button was pushed, the treadmill shut down and the belt came to a stop. Finally, an investigator was always stationed beside and slightly to the rear of the subject. In the event that the subject lost footing, he was quickly supported.

3.3.7 Experimental Controls:

A number of experimental controls were utilised to minimise the effects of potential contaminating extraneous variables.

In the laboratory, climatic conditions were held constant over trials. The mean temperature of the laboratory was 19.3°C (SD = 1.3°C). No cooling equipment (i.e. fans) was provided during the runs. Water was available in a plastic drink bottle at easy arms reach from the subject. Subjects were instructed to avoid any extremes in dietary intake (e.g. high alcohol consumption, carbohydrate loading) and activity (e.g., heavy training session) during the 48 hour pretest period. Subjects ran at the same time of day on each occasion. Baseline and experimental runs were conducted within a week of each other. This ensured that any differences observed would not be the result of individual training programs. The same treadmill was used for each occasion. The treadmill was calibrated prior to each run. No feedback of performance was made available to the subject. All clocks were covered and the subject was asked to remove his wrist watch. Individual performance was not discussed until the final debrief.

3.4 PROCEDURE

3.4.1 Phase One - Determination of Maximal Aerobic Power

On the first day the subject was briefed regarding the study and signed the consent form. At this point the subject completed a *Pre-Run Questionnaire* as shown in Appendix 5. The questionnaire inquired of the subject's attitude to the task, dietary intake and physical activity during the previous 48 hours. More particularly it sought to identify any factors which may unduly influence the subject's running performance, (e.g. ill health, lack of motivation, fatigue, carbohydrate intake).

The subject was then allowed time to become familiar with the laboratory environment. Subjects were given practice at mounting, dismounting, walking and running on the treadmill. At the end of this practice all subjects reported being comfortable using the treadmill. After a short break the subject underwent the testing protocol to determine his maximal aerobic power (MAP). During this run, heart rate was monitored and recorded every two minutes. At exhaustion a final heart rate was recorded. On completion of the test the subject rested and when he was fully recovered the subject was allowed to leave.

Using the data from the maximal test, a treadmill speed corresponding to 80% of the subjects MAP was computed for use in the experimental runs. All subjects involved in the study completed MAP testing before any further testing was carried out. This enabled the subject pool to be rank ordered in terms of MAP.

3.4.2 Phase Two - Pre-test (Baseline Run)

On arrival at the laboratory the subject completed the Pre-Run Questionnaire. The subject changed into running attire and the heart rate monitor was fitted. Resting heart rate measures were taken. The subject was then given three minutes to re-establish confidence in walking/running on a treadmill. After resting heart rate was re-established the subject returned to the treadmill and completed the timed run protocol. The subject was given the simple instructions:

> "As with the assessment run last time, we want you to again run to exhaustion. This time you won't have to wear the headgear. When you feel you can't run any longer, just grab the hand rails and step off the treadmill"

During this baseline run the laboratory was decked with sporting posters and travel posters in order to provide visual stimuli. Any conversation with the experimenter was acknowledged but a conversation was not initiated by the experimenter. These procedures were incorporated into the design to cater as much as possible in a laboratory setting for those subjects whose usual strategies involved looking at scenery and/or talking with running partners.

At the completion of the timed run the subject remounted the treadmill at a much reduced speed for a cool down period. When the subject's heart rate had reached baseline levels plus 10-15 b.p.m., the treadmill was stopped and the subject advised to dismount and walk slowly about the laboratory to regain balance. At the end of the cool down period the subject was shown the Borg scale and asked to give an estimate of the effort involved in the run. The measure of perception of effort was assessed at this point so that a more global view of the run would be considered by the subject. If the measure was taken at the point of exhaustion, the possibility exists that most recent experiences would bias the subjects' estimates (Schomer, 1986). Next the subject was given the Post-Run Questionnaire to assess the cognitive strategies utilised during the laboratory run.

3.4.3 Phase Three - Post Test (Experimental Run)

On the third and final occasion in the laboratory, the subject followed a pattern similar to Phase Two. On arrival the Pre-Run Questionnaire was completed. After fitting the heart rate monitor the subject was ready to begin the timed run. For this run the same protocol was adopted as for the baseline run. However, depending on the subject's allocated group (Associative, Dissociative, Control), the subject performed under different instructions and conditions.

Associative:

Prior to commencing the run the subject was handed a sheet on which the following instructions were printed:

> "Today we are again asking you to run for as long as you can. On this occasion we are interested in observing your awareness of your body's signals. We are particularly interested in observing any changes that occur as exercise intensity increases, especially at high intensity levels. At regular intervals during this run you will be asked questions about your body signals (pain, effort, breathing, etc.) and about the run (pace, technique, time, etc.). When you are required to make a verbal response it need only be short and in time with your breathing. Do not go into lengthy explanations. Where you consider it appropriate you may use a number from the scale on the wall in front of you".

The subject was then fitted with ear-muff headphones that were connected to a National Video Cassette Recorder. A pre-recorded tape was started as the subject began his run. During the run at random intervals (10sec - 60sec) the subject was asked to monitor and report on various physiological sensations or aspects of the run. The subject was asked to comment on general feelings of fatigue and discomfort, specific feelings in the legs, arms, and chest, body temperature, breathing, perceived exertion, treadmill speed, the elapsed period of the run and the quality of run.

The laboratory environment was made as bland as possible. The treadmill faced a plain grey brick wall. All posters were removed. Experimenters were well out of sight and did not respond to any conversation. This was done to minimise potential environmental distractions, which would be inappropriate to this associative strategy.

Dissociative:

Prior to commencing the run subjects in this group were handed a sheet on which were printed the following instructions:

> "Today we are again asking you to run as long as you can. On this occasion we are interested in observing your cognitive functioning (thinking/reasoning). We are particularly interested in observing any changes that occur as exercise intensity increases, especially at high intensity levels. At regular intervals during the run you will be asked to carry out different types of mental tasks. These will include: recalling details about yourself, memory tasks, simple calculations general knowledge type questions (Trivial Pursuit!) and details regarding the video that will be screening in front of you. When you respond to the questions your answer need only be short and in time with your breathing. Do not go into lengthy explanations".

The subject was fitted with ear-muff headphones that were connected to a National Video Cassette Recorder. A pre-recorded tape was started as the subject began his run. A 53cm National TV. monitor was set up six feet in front of the treadmill. During the run excerpts from the films "Ghandi", "Life of Brian" and "The Killing Fields" were shown on screen. These movies were chosen for their potential distraction value, without the possibility of their being inspirational/motivational. As well as listening to the sound track from these movies, at random intervals (10sec - 60sec) the subject was asked questions about the video, about his life history, education, employment and was given memory tests, general knowledge quizzes and minor arithmetical calculations to complete. The laboratory environment was the same as the baseline run condition, except that researchers were not available to interact with the subject.

Control:

The control group was asked to run as for the baseline run in Phase Two. All conditions were the same. Subjects were asked to run to exhaustion as they had done on the previous occasion.

On completion of each run, subjects in all conditions walked on the treadmill for a cool down period. After cool down, subjects were shown the Borg Scale and asked to give an estimate of their perceived effort. Subjects then completed the Post Run Questionnaire to assess cognitive strategy use. Subjects were fully debriefed on the nature of the research and given their personal results for all measures. After general conversation the subjects were thanked and escorted from the laboratory

CHAPTER 4. RESULTS AND ANALYSIS

4.1 NATURE OF STATISTICAL ANALYSIS

Raw scores for subject descriptive information, cognitive strategies and run performance are presented in Appendices 6-8. These data have been analysed for four purposes. First, descriptive data were analysed to establish the homogeneity of the treatment groups. Second, cognitive strategy scores were analysed to determine the effectiveness of the strategy manipulations conducted as part of the experiment. Third, rated perceived exertion scores were analysed to determine the effect of cognitive strategies on the subjects' assessment of the effort required in each run. Fourth, the duration for the run to exhaustion was analysed to assess the impact of cognitive strategies on performance.

In the case of the strategy manipulation check and the analysis of the dependent variable data, difference-scores were used. Each subject in the study performed on two occasions, baseline and treatment, except that the control group did not receive any treatment as such. In analysing these data the baseline value was subtracted from the subsequent treatment value. These difference-scores, therefore, reflect the **change** in the particular variable for each subject. The change scores were analysed as single variables. One-way analysis of variance (ANOVA) was used to compare differences in variables between groups. Hobson and Rejeski (1993) argued for the analysis of difference scores rather than covariance analysis of task responses "because...reactivity represents elevation over baseline" (p.87). In this study the essential component of analysis is the change in perceived exertion and performance from baseline levels. Hence it was considered more appropriate to analyse difference scores.

Statistical analysis was carried out using the SPSS PC+ program. Where a significant effect was demonstrated in the ANOVA technique, relevant means were analysed to determine the source of the effect. Because this analysis was post hoc, the Scheffé method of determining statistical significance was used. For all analyses an alpha level of 0.05 was adopted.

4.2 DESCRIPTIVE DATA

The homogeneity of the groups in terms of age, aerobic capacity (MAP), running experience (RES) and baseline cognitive strategy use was checked using a One-way Analysis of Variance. An ANOVA summary for each analysis appears in Tables 1- 4 below. In each case, results show there was no significant difference between groups.

Table 1. ANOVA Summary Table for Age

Source	DF	SSQ	MSQ	F Ratio	F Prob.
Between Groups	2	2.9697	1.4848	.0725	.9302
Within Groups	30	614.5455	20.4848		
Total	32	617.5152			

Table 2. ANOVA Summary Table for Running Experience Scores

Source	DF	SSQ	MSQ	F Ratio	F Prob.
Between Groups	2	366.4697	183.2348	.2469	.7828
Within Groups	30	22266.2727	742.2091		
Total	32	22632.7424			

Table 3. ANOVA Summary Table for Maximal Aerobic Power Scores

Source	DF	SSQ	MSQ	F Ratio	F Prob.
Between Groups	2	8.7273	4.3636	.0862	.9177
Within Groups	30	1519.4545	50.6485		
Total	32	1528.1818			

Table 4. ANOVA Summary Table for Baseline Cognitive Strategy

Source	DF	SSQ	MSQ	F Ratio	F Prob.
Between Groups	2	1.1515	0.5758	.0217	.9782
Within Groups	30	797.4091	26.5803		
Total	32	798.5606			

These data indicate that the three groups were homogeneous in terms of these particular variables which have been shown to exert influence on cognitive strategy use (Masters & Lambert, 1989; McDonald & Kirkby, 1989; Okwumabua et al., 1983; Ungerleider et al., 1989) and in terms of their actual cognitive strategy use. Review of the Pre-run Questionnaires used before each testing showed consistent dietry intake, mood levels and pre-test behavior before baseline and experimental episodes.

4.3 MANIPULATION CHECK

Checks were required to verify that: 1) during the steady state run, subjects were exercising at a relative workload equivalent to 80% of maximal aerobic power and 2) that the manipulation of subjects' cognitive strategy use during Phase Three performance was achieved.

4.3.1 Steady State Run

During Phase One of the experiment, subjects' maximal aerobic power (MAP) was determined. From this a treadmill speed was calculated for each subject equivalent to a workload of 80% MAP. Using the subject's maximal heart rate from Phase One, steady state runs of 80% MAP were verified using the mean heart rate from the steady state run segment. Appendix 9 shows the maximal heart rate and mean heart rate for each subject during Phase Two and Phase Three steady state runs. The percentage of maximal heart rate for each subject's steady state performance verifies that each subject was exercising at the appropriate relative workload.

4.3.2. Cognitive Strategy Manipulation

Successful manipulation of cognitive strategy use was manifested in significant directional changes in cognitive strategy scores. For each subject a cognitive strategy change score (ΔCS) was calculated by subtracting the Phase Two (baseline) cognitive strategy score from the Phase Three (experimental) cognitive strategy score. A positive change score indicates that the subject was using predominantly associative strategies during the Phase Three run compared to the Phase Two run. A negative change score reflects a shift to greater use of dissociative strategies during the latter run. A zero change score indicates there was no significant change in overall cognitive strategy use. Table 5 shows the mean cognitive strategy scores for each group and their respective change scores.

Differences between groups were investigated using one-way ANOVA on change scores. ANOVA results shown in Appendix 10 indicate a significant between groups effect ($F_{(2,32)} = 60.09$, $p < 0.05$). A post hoc analysis of means using the Scheffé method indicated that all means are significantly different. Examination of the means in Table 5 shows that mean change scores for the associative and dissociative groups are significantly different from the control group and are in the direction consistent with the experimental manipulation.

Table 5. Mean Cognitive Strategy Scores for Groups

	Baseline Score	Experimental Score	Δ Score
Association Group	4.05	11.91	7.86
Dissociation Group	4.32	-5.36	-9.68
Control Group	3.86	5.95	2.09

Ideally the change score for the control group would be zero. To verify that the control group mean cognitive strategy score had not changed significantly between Phase Two and Phase Three conditions, a paired t-test was conducted. Results of this analysis shown in Appendix 11, indicate that there was no significant difference between conditions ($t_{(1,10)} = -1.40$, $p < 0.01$)

Data from Table 5 show that the intended manipulation of cognitive strategy use was effective. Subjects in the association condition shifted in the direction of greater use of associative cognitive strategies. The subjects in the dissociation condition showed more use of dissociative cognitive strategies. The cognitive strategy profile of the subjects in the control condition did not show any significant change. It should be noted at this point that although the shifts in strategy use for the association and dissociation conditions were significant, subjects still did ***not*** use one strategy to the total exclusion of the other.

4.4 Experimental Effects

To determine if the experimentally manipulated cognitive strategy regimen caused a change in perceived exertion and performance, change scores for each subject on both these variables were calculated. The resulting mean change scores were then analysed.

4.4.1 Perceived Exertion

To determine the effect of cognitive strategy manipulation on subjects' perception of effort, the change in perceived exertion was calculated for each subject. The perceived exertion reported after the Phase Two run (baseline) was subtracted from that reported after the Phase Three run (experimental). The resulting change score (ΔRPE) was positive if the subject reported higher perceived exertion in the experimental run, and negative if the experimental run was perceived as less effortful. Table 6 shows the mean baseline and mean experimental perceived exertion scores and the mean change score for each condition.

Table 6. Mean Rated Perceived Exertion Scores for Groups

	Baseline Score	Experimental Score	Δ Score
Association Group	16.09	18.18	2.09
Dissociation Group	15.18	14.73	-0.45
Control Group	16.27	16.82	0.55

Differences between the experimental conditions were determined by performing a one-way ANOVA on the mean perceived exertion change scores (see Appendix 12). A significant main effect for groups was observed ($F_{(2,32)}$ = 9.629, p = 0.0006). Post hoc analysis of the means using the Scheffé technique showed that change in rated perceived exertion for the association condition was significantly different to that of the dissociation or control condition. There was no significant change in perceived exertion between the dissociation condition and the control condition. Inspection of the means in Table 6 shows that there was a significant increase in perceived exertion in the association condition compared to the dissociation and control conditions.

On the basis of the results obtained, the following decisions are made in terms of the hypotheses regarding cognitive strategy use and perceived exertion. Hypotheses 1 and 2 are supported. The data above indicate that there was a significantly greater increase in rated perceived exertion for subjects in the association condition than for subjects in either the dissociation or control condition. Hypothesis 3, however, is rejected. Although there was a trend in the direction of a decrease in perceived exertion for subjects in the dissociation condition compared to those of the control condition, this difference was not significant.

4.4.2 Performance

Change in performance (ΔT) for each subject was calculated by subtracting the run time for Phase Two (baseline) from the run time for Phase Three (experimental). A negative change score represents a decline in performance, whereas a positive change score shows a performance improvement. Table 7 shows the mean baseline run time, mean experimental run time and mean change time for each condition.

Table 7. Mean Performance Scores (secs.) for Groups

	Baseline Run	Experimental Run	ΔT
Association Group	1405	1364	-41
Dissociation Group	1376	1430	54
Control Group	1479	1507	28

A one-way ANOVA on mean change scores as shown in Appendix 13 indicated a significant between groups effect ($F_{(2,32)} = 10.12$, $p = 0.0004$). Post hoc analysis of means using the Scheffé method indicated that the mean change for the associative group differed significantly from the means for the dissociative group and the control group. Inspection of the group means in Table 7 suggests that the performance of the associative group declined significantly when compared to the control group. The observed improvement in performance for the dissociative group when compared to the control group was not significant

These results lead to the following decisions in terms of the hypotheses regarding cognitive strategy use and performance on the run to exhaustion. Hypotheses 4 and 5 are both supported. Results indicate that subjects in the association condition showed a significantly greater decrease in duration for the run to exhaustion than subjects in either the dissociation or control condition. However, hypothesis 6 is rejected. A trend towards an increase in duration of run to exhaustion for subjects in the dissociation condition compared to those of the control condition was observed, however, the difference was not significant.

CHAPTER 5. DISCUSSION

5.1 General Discussion

The aim of this study was to assess the efficacy of associative and dissociative strategies as ways of dealing with the discomfort associated with prolonged physical activity. More particularly the influence of these strategies on perception of effort and performance at a physical task was investigated. It was predicted that associative strategies, by exacerbating any noxious physiological signals, would cause an increase in perceived exertion and a subsequent deterioration in performance. On the other hand, it was predicted that dissociative strategies would act to block any physiological signals, resulting in lower perceived exertion and enhanced performance.

Results from this study only partially support the predictions above. The use of predominantly associative strategies, monitoring task related cues, was found to lead to a significant increase in rated perceived exertion and a significant deterioration in performance. The change in perceived exertion was significantly higher for the association group than for the dissociation and control group, and the subsequent performance time for the association group was significantly less than the other two groups. These results are consistent with Pennebaker and Lightner's (1980) argument that an internal attentional focus will result in a deterioration in performance On the other hand, the use of predominantly dissociative, or distracting strategies, was not found to have a significant effect on rated perceived exertion nor on performance. The dissociative group's change in perceived exertion and performance was not significantly different from those of the control group. These results are not in accord with the findings of previous research (Gill & Strom, 1985; Morgan et al., 1983; Pennebaker & Lightner, 1980), that indicate distraction strategies will enhance performance.

There are two possible explanations for the failure of the dissociation group to demonstrate significant changes. These explanations relate to the nature of the distracting stimuli and/or the run protocol. In order that distracting strategies have pre-emminence in focal awareness, it is critical that they be sufficiently novel or complex to compete with the noxious stimuli arising from the active body. Although subjects reported that they attended to the presented distractions, they indicated that at higher levels of physical distress these distractions were not of sufficient interest to maintain primary position in focal awareness. There are a number of potential criticisms of the distraction strategies used given these results. First, the items selected may not have been sufficiently motivating (e.g., recalling numbers, answering one off questions about family, work, school), second, some of the arithmetic problems presented may have been beyond the ability of some subjects to handle without pencil and paper, and third, the choice of videos presented may not have been of sufficient interest to compete with pain signals. The timing of the presentation of the distractions may also detract from the overall effectiveness of the strategy. Each distraction presented to the subject was of short (5 - 10 secs.) duration, except for the continuous display of the video. The constant shift in content of the distractions may have prevented the subjects settling on an external cue that for them was appropriate. In general discussion with subjects during the debriefing, a number mentioned they would rather have been involved in a conversation or watched a more appropriate (to them) video (suggestions included action movies or erotic movies). Weinberg et al. (1984) have suggested that many athletes find it difficult to adopt strategy profiles that are not consistent with their own. Thus, despite the dissociation group subjects attending to the presented distractions, it may be these external cues did not provide any more potential for blocking pain signals than did the subjects' own methods.

A further explanation for the lack of significance for dissociative strategies in this study may be linked to the run protocol. The steady state run component lasted for a period of fifteen minutes before the grade of the treadmill was progressively increased. It is possible that control subjects and dissociative group subjects entered the final phase of the run with different estimates of perceived exertion. However, the intensity of the graded treadmill run may have been sufficiently severe to mask these differences when subjects retrospectively reported their level of perceived exertion. Although the perceived exertion and performance differences between the control group and the dissociation group were not significant, they did show a trend in the direction of lower perceived exertion and improved performance for the dissociation group. This suggests that perhaps some of the subjects were entering the graded phase of the run with a lower perceived exertion than those in the control group. If the steady state run was over a longer time frame (and thereby more consistent with real life situations), the suggested differences between dissociation and control group may become more pronounced. In a modified experimental design, ratings of perceived exertion could be taken at the end of the steady state run and immediately prior to each subsequent increase in treadmill grade. This would provide an accurate measure of between group differences and provide a more refined indication of the mechanism of dissociative strategies.

Although the results obtained for the association group in this study are consistent with research results reported in the attentional focus literature, they do not fit comfortably with the fact that elite athletes do report using associative strategies. Previous research, and this study, has shown that a focus on body signals and external task related cues can result in reduced performance. Under what circumstances then can such monitoring lead to performance enhancement? Morgan & Pollock (1977) and Schomer (1986), in their respective explanations of association, have shown that the associative strategy must have some functional consequence if it is to lead to performance enhancement. Morgan and Pollock (1977) suggested that "the elite runner associates **and** attempts to process this information, or 'read his body' **and** modulate pace accordingly"[p.399. Emphasis added]. Schomer (1986) in his classification of cognitive strategies included the subcategories 'Command and Instruction' and 'Pace Monitoring' under the heading 'Associative Strategies'. Schomer (1986) reported that runners dealt with pain by determining the origin of the pain and then making adjustments to performance. Sachs (1984) also suggested that association is used to identify the source of pain and determine appropriate courses of action. Clearly then association as used in cognitive strategy research requires that body monitoring be accompanied by an appropriate performance adjustment response. Merely attending to noxious physical stimuli only exacerbates their negative effect. The athlete needs to be able to deal with the source of the stimuli if association is to lead to enhanced performance. Hence, it can be argued that the monitoring of task related cues is a necessary but not sufficient component of effective association.

In the present study subjects were required to run to exhaustion on a treadmill over which they had no control in terms of speed or grade. Thus, apart from some minor potential to relax the upper body and perhaps control their respiration rate, subjects had little to no control over the running process. In terms of pace they could only keep up to the speed of the treadmill or stop. Hence, if the run became painful or distressing, there was little, if anything, the subject could do to physically alleviate any noxious physiological sensations. In the experimental association condition subjects' cognitions were manipulated to focus on body and task related cues. This meant that subjects focused primarily on the noxious stimuli generated by their performance. As there was no potential for substantial pace adjustment, subjects running under these conditions reported higher rated perceived exertion and, assessing the run as more effortful, they terminated their performance earlier than in the baseline condition.

A further possibility for the reduced performance of those in the associative group relates to strategy mix. Research evidence suggests that all runners use a mix of dissociative and associative strategies (Masters & Lambert, 1989; Newsham et al., 1991; Sachs, 1984; Schomer, 1986). Indeed, the subjects in this study developed a mix of strategies to cope with the baseline run. No matter what amount of associative strategy use was reported, all subjects reported varying quantities of dissociative strategy use. Schomer (1986), recognising the role of dissociation, commented that, "dissociative thinking permits the runner to negotiate temporary pain zones and distract from the monotony of the running process" (p.42). However, Pennebaker and Lightner (1980) have suggested that improved performance may result more from the decreased use of an internal focus rather than the increased use of an external focus. Although subjects in the association group reported using some dissociative strategies, the possibility exists that they were not able to use a sufficient selection of these to guarantee the appropriate strategy mix to support enhanced performance.

Essentially it appears that endurance performers are able to monitor both their bodily signals and aspects of the external physical environment in order to determine if and what changes to their performance are required. There are two necessary components to this process. First, the performer intentionally monitors task related cues and, second, adjustments to performance may be made as a result of information gained (Morgan, 1978, Morgan & Pollock, 1977; Schomer, 1986). In this study, the observed increase in reported perceived exertion and decreased performance of subjects in the association group may, therefore, have resulted from the fact that these subjects were unable to make any adjustment to pace subsequent to monitoring physiological and run-related inputs.

In light of the above comments, it is argued that the results of Pennebaker and Lightner's (1980) study are not inconsistent with the observations of Morgan and Pollock (1977). Rather, an alternative interpretation of the results of the Pennebaker and Lightner study is presented.

Pennebaker and Lightner, (1980) had subjects run a cross country and lap course and measured the time to complete the comparable length courses. Results showed that subjects performed better (i.e., ran faster) on the cross country course than on the lap course, even though both groups reported the same level of fatigue symptoms. Pennebaker and Lightner suggested that the external focus required on the cross country run, presumably to keep to the route and avoid obstacles, blocked out the pain signals and hence resulted in a faster performance.

It is possible that both groups reporting the same fatigue levels is a fortuitous result. Essentially the study conducted by Pennebaker and Lightner (1980) represents only part of a valid paradigm. Running a cross country course and a lap course require different performance strategies that are not simply differences in focal awareness. On the cross country run it would be necessary for subjects to monitor terrain and the circumstances of the run. As a result they would adjust their pace and technique: turning, weaving, making sure of footing and modifying pace to ensure a safe and comfortable run. Under these conditions, subjects' focus of awareness would be externally task related and form the basis of associative cognitions. In fact it would be difficult to run a cross country course with a non-responsive external focus. On the lap course in the Pennebaker and Lightner (1980) study, subjects were required to run a flat, uninteresting course. Such an activity would become monotonous and boring. In the absence of strong, novel, external stimuli, subjects would as

Pennebaker and Lightner suggested become internally focused on the increasingly distressing physiological cues thus causing a heightened perception of effort and a consequent reduction in performance. A more appropriate investigation requires a second experimental condition wherein subjects run the same lap course with considerable external distracting stimuli available. It is not just by accident that athletes, the military and many social runners train as a group. The group run provides external stimuli (talk, singing, chants, visual distractions) that compete successfully with noxious internal stimuli for predominance in focal awareness. Under this added condition subjects should report less fatigue and/or improved performance.

This study and previous research suggests that association and dissociation are both viable cognitive strategies for dealing with the sense of effort experienced during physical activity. The utility of each strategy is dependent on the circumstances and the purpose for which it is used. In a situation where noxious stimuli arise as a result of the performance of an activity, the athlete can utilise both association and dissociation. When the athlete associates she or he chooses to monitor task relevant cues. As a consequence of this monitoring, the athlete should, to varying degrees, modify aspects of the activity to reduce the source of these noxious stimuli. In those situations where such adjustment is not possible, or is limited, then constant body monitoring is counter productive because the nett effect is the enhancement of perception of effort and a consequent deterioration in overall performance. The alternative strategy is to focus on non-task-related stimuli, that is, to dissociate. Given distracting stimuli of sufficient strength or novelty, the limited channel capacity to focal awareness is blocked to pain signals. Here then, there is a resultant decrease in the perception of effort with the concomitant effect on performance.

5.2 LIMITATIONS OF THE STUDY

A number of factors that may have improved the precision of the results of this study need to be considered. A subject's motivation for running, their pattern of strategy use, the instrument used to measure their cognitive strategies and the run protocol used are areas where this present study may be in need of modification.

Masters and Lambert (1989) have argued that an athlete's choice of cognitive strategy may relate to their reasons for running. They proposed that the more competitive athlete prefers to associate during competition to ensure proper running mechanics and performance. However, in training or social runs the emphasis is more on dissociative strategies. In this study, no assessment of subjects' attitude to the run was carried out. Given Masters and Lambert's arguments, perhaps the more competitive subjects in this study were inclined to use association. This may account for the finding that several subjects performed better under the association condition than in the baseline condition. Three of the eleven subjects showed no decrement in performance. Interestingly these same subjects recorded the highest three baseline run times. Post experimental interview with these subjects revealed that they saw the experimental run "as a chance to do better", "not let the treadmill beat me". Despite the fact that the emphasis of the study was not on performance achievement and that the subjects had no idea of their run time, these subjects appeared to adopt a competitive attitude.

Sachs (1984) has argued that athletes generally establish their own pattern of cognitive strategy use. Although instructions to subjects in this study de-emphasised the nature of the investigation, the truth of the matter is that subjects were directed to use specific cognitive strategies. As the run progressed, subjects asked to engage in cognitive activities contrary to their usual protocol, would more than likely become distressed. Given that subjects use a balance of strategies, as would appear to be the case from the recorded baseline cognitive strategy scores, forced emphasis on one strategy type or the other may have been disturbing to the subject. This appears to be an inherent problem of research requiring cognitive strategy manipulation. Even though the cognitive strategy manipulation in the present study was effective, each subject, although recording a shift in predominant strategy use, still utilised both strategies. Further, there is some suggestion (Sachs, 1984; Weinberg et al., 1984) that the timing of strategy use (i.e., using the right strategy at the right time) may be the critical determinant of performance outcome. This present study looked only at global cognitive strategy use and the subsequent effect on perceived exertion and performance. The effect of variations in pattern of strategy use (content and timing) was not investigated.

The cognitive strategy instrument devised for this study is potentially biased in favour of measuring association strategies. There is only a limited number of body and task related cues to which the subject could attend. These, therefore, are easier to specify and measure, resulting in association scores which are a more accurate reflection of the subjects' actual use of association. On the other hand, the range of internal and external factors which could be involved in dissociation is limitless. Hence, it is difficult to include all possibilities in a short questionnaire. Further, when subjects are dissociating they may spend only a short period focusing on each of a large number of potential distractions as opposed to lengthy periods on a few. The strategy measuring instrument under these circumstances, where a proportion of the varied dissociation strategies is not covered by items in the instrument, would record an artificially low dissociation score. Hence, the measuring instrument is more responsive to association strategy use than dissociative strategy use.

The run times recorded under the regimen used in this study were in the order of 20 - 30 minutes. This is not generally considered an endurance period in sports such as distance running, cycling, or triathlon. Typically the marathon can take between two and eight hours to complete. The Ironman Triathlon (2.4 mile swim, 112 mile bike ride, 26 mile run) is completed between 8 hours and 16 hours depending on the level of athlete. Further, the nature of the study required that subjects had minimum potential to make adjustments to performance. The pace of the run and conditions of the run were fixed. A forced run at 80% MAP and finishing on inclines of 2 - 6 % does not reflect conditions in the real world. Clearly, results of a study conducted over a longer period and under more naturalistic conditions may have been different.

The absence of an experimental condition wherein subjects could voluntarily alter the speed of the treadmill does not allow for conclusive statements about the effect of changes to technique as a result of monitoring run-related cues. The addition of such a group would allow comparisons between groups with and without control, thus indicating the value of monitoring internal cues **and** making changes to performance, suggested by Morgan & Pollock (1977) and Schomer (1986) as being an important aspect of association.

The above limitations indicate a number of areas in which this study could be improved, however, they are not considered of sufficient importance to negate the results obtained.

5.3 Future Research.

Considering the limitations raised in the previous section and several issues raised by other researchers in the area of cognitive strategy use, a number of directions for future research are indicated. Future research needs to consider three main aspects of cognitive strategy use: intention, pattern or timing, and strategy use and injury.

An essential aspect of cognitive strategy use concerns the intention of the athlete in using a strategy. McDonald and Kirkby (1989) conducted a survey of athletes wherein subjects were asked what strategies they used when certain situations arose. Subjects were asked to nominate "the strategies most used when it was very difficult to continue" (p. 4). The word "strategy" implies a purpose in the use of cognitions. Hence, it may be necessary to show that some cognitions are used with a sense of purpose whereas others arise spontaneously. Reports of "day dreaming" (Sachs, 1984) and "problem solving" during long runs (Masters & Lambert, 1989) would suggest that non-purposeful cognitions may arise during such activity. Perhaps during a period of "satisfactory adjusted running process" (Schomer, 1986, p.55), the mind can afford the luxury of wandering off.

The question of purpose of cognitions also raises the issue of other possible classifications of strategies besides association and dissociation. Summers et al. (1982) mentioned strategies used by marathoners that were difficult to classify as either association or dissociation. Weinberg et al. (1984) included positive self-talk as a potential cognitive strategy. The sports literature abounds with techniques for goal setting in sports achievement. Setting short term performance goals is a strategy often used by athletes when performing under stressful conditions (e.g., "Just to the next drink station", "next corner" or "just catch this guy in front of me"). Finally, it would be difficult to classify the mental processes that accompany dogged determination, when an athlete bulldozes through pain with just strength of motivation or sheer will power to complete a performance or reach a specific goal (Freischlag, 1981). The role of motivation in determining the outcome of endurance activities is rarely considered.

With respect to the pattern or timing of strategy use the appropriate questions to ask are not concerned with which particular strategy should be used, but rather which strategy is more appropriate under various performance conditions. As Weinberg et al. (1984) have suggested, the question may not be which strategy is better but rather what combination of strategies is more effective. Newsham et al. (1990) also argue this point. They have shown that strategy use is not exclusively association or dissociation. Rather, athletes use a different balance of strategies depending on the concentration required, level of fatigue and the duration of the event. Several authors, have suggested that the pattern of strategy use is different depending on whether the athlete is involved in competition or training (Masters & Lambert, 1989; Morgan & Pollock, 1977; Schomer, 1986; Summers et al., 1982). These researchers have reported a predominant use of associative strategies during competition and a higher proportion of dissociative strategies during training.

In terms of association, Schomer (1986) distinguished between elite and novice runners, not on the *quantity* of associative thoughts but rather on the *quality* of associative thoughts. Elite athletes exhibit an ability to read specific task relevant cues and make fine tuned adjustments to performance. Novice athletes, however, are only able to read global signals of discomfort and make gross adjustments to performance. This lack of ability on the part of the novice athlete to recognise specific sources of discomfort and make finely tuned adjustments to performance renders continued association inappropriate, hence the observation that many novice athletes predominantly dissociate. This argument is again consistent with the findings of Morgan and Pollock (1977), that elite athletes associate whereas novice athletes tend predominantly to dissociate.

The purpose of high training intensities is to give athletes the opportunity to push their bodies to new physiological limits. In doing this, athletes experience new sources of pain and discomfort and, through repeated sessions, learn how to recognise the cause of the pain and make the adjustments necessary to deal with it. Schomer

(1986) has shown that with increasing training intensities, athletes of all skill levels show a change in the quality of their associative thought in the direction of more specific body monitoring. Hence, as an athlete becomes more physically elite, she or he is able to utilise more associative type cognitive strategies. Schomer (1987) took this view even further when he argued that "to bring out the long distance runner's optimal physical skill in marathon running, association has to be taught" (p. 136).

The most effective response to pain is to determine its source and act to relieve or reduce it. Both elite and novice athletes are able to do this but to differing degrees. Elite athletes have the skill to recognise pain sources and make fine adjustments to technique, hence, they behave optimally by associating. Novices on the other hand, are not so skilled at recognition and do not know how to make fine adjustments to performance, so their optimal choice is to dissociate from the pain. Further study is required to determine the importance of the quality of associative thoughts and the consequent level of skill in making appropriate adjustments to technique. The above comments suggest that, rather than investigating the merits of one type of cognitive strategy over the other, research should be directed at determining the most appropriate temporal or contextual patterns of strategy use that would facilitate performance.

Morgan and Pollock (1977) and Masters and Lambert (1989) raised several issues when considering the relationship between strategy use and injury. Morgan and Pollock (1977) argue that athletes who use dissociation run the risk of blocking out essential pain signals and hence exacerbating any injury. Morgan (1978) gave graphic examples of athletes sustaining severe injuries as a result of dissociating and (according to Morgan) not perceiving early warning signs of impending injury. Masters and Lambert (1989) and Schomer (1986), on the other hand, argued that pain should be a sign to associate. Masters and Lambert (1989) suggested that the injuries cited by Morgan (1978) are examples of athletes persisting in spite of the pain. They suggested that it is only after the athlete has satisfactorily dealt with the pain that association stops. They proposed that dissociation only occurs after pain has been reduced. Schomer (1986) has argued that a "satisfactory adjusted running process" (p. 55) occurs only after bouts of association. Schomer (1986) reported that runners dealt with pain by determining the origin of the pain and then making adjustments to performance. Sachs (1984) also suggested that association occurs when pain is perceived. "At the first awareness of pain, association was used to identify the source and nature of the discomfort and assess possible courses of action (i.e., stop, slow down, speed up)." (p. 293).

Cognitive strategies are used by athletes to deal with the pain and discomfort as well as the boredom of physical activity. If there is a potential for injury as a consequence of the use of particular strategies, then the issue of strategy training by sport psychologists needs to be resolved quickly. Athletes need to be educated to listen to their bodies and trained to make any performance adjustments that will reduce the potential for injury and as a consequence enhance overall performance. In the event that athletes do use dissociative strategies, they should be cognizant of the limitations of these types of strategy and advised not to persist with the strategy when they are aware of pain signals of ever increasing intensity.

The role of specific cognitive strategy use, the timing and pattern of use, the notion of preferred styles of strategy use and the possible link between strategy use and injury again raise the measurement of cognitive strategies as an issue. Attempts have been made to investigate patterns of strategy use using retrospective techniques. Masters and Lambert (1989) asked runners to complete a race diary soon after finishing a marathon. The race diary asked questions about strategy use during various segments of the race. Newsham et al. (1991) have used a similar method to determine cognitive strategy use during various stages of an Ironman triathlon. These surveys, however, are subject to the limitations of retrospective reports: recency effects, selective recall, fabrication. Equally difficult, however, are *in vivo* reports. As stated earlier, *in vivo* assessment of cognitive strategy use may bias results towards associative cognitions by drawing attention to physiological signals and other run-related factors. Also, the dialogue between researchers and athletes during performance can itself become a distraction. Finally, there are those cognitions: daydreaming, focusing, synchronising, that do not lend themselves to *in vivo* discussion, and any attempt on the part of the researcher to introduce such discussion or self-reporting by athletes during performance would break the athlete's flow. This problem of cognitive strategy measurement requires careful consideration and consultation with athletes followed by research in order to determine those methods that are the most appropriate and legitimate.

5.4 APPLIED ASPECTS OF STUDY

Endurance athletes need to be trained to use both association and dissociation strategies effectively in terms of timing and application. For association to be effective, the athlete must learn to read bodily and environmental signals sensitively and must know how to respond to various levels in these signals. The purpose of high training intensities is to give athletes the opportunity to push their body to new physiological limits. In doing this, athletes experience new sources of pain and discomfort and, through repeated sessions, learn how to recognise the cause of the pain and make the adjustments necessary to deal with it. Schomer (1986) has shown that with increasing training intensities, athletes of all skill levels show a change in the quality of their associative thought in the direction of more specific body monitoring. Hence, as an athlete becomes more physically elite, she or he is able to utilise more associative type cognitive strategies. Schomer (1987) took this view even further when he argued that "to bring out the long distance runner's optimal physical skill in marathon running, association has to be taught" (p. 136). For dissociation, training can be directed at strengthening specific dissociation techniques so they work effectively, but always permitting strong bodily signals to enter awareness. Much more research is needed on the specifics of reading bodily signals and the most effective physical and mental responses, and on the selection of personally suitable dissociation strategies that are both effective and sensitive. Only then will sport psychologists be in a position to reliably train athletes to use the optimal blend of cognitive strategies.

Both association and dissociation have been defined as purposefully executed cognitive strategies. An athlete is said to associate when she or he purposefully monitors any task related cue, internal or external, and as a consequence makes a decision to maintain or alter some aspect of performance. On the other hand, an athlete dissociates when she or he attempts to cope with the pain, boredom or monotony of an activity by purposefully using internally or externally directed non run-related thoughts to block noxious stimuli.

Based on the findings of this study and the work of other researchers, the following general comments are made with a view to improving the athletes' ability to cope with and enhance performance at endurance activities:-

1. Athletes should be trained to recognise specific signals arising from the working body and understand the source of these signals. In training, athletes should develop the skills necessary to make broad and fine adjustments to performance in order to alleviate or reduce the sources of noxious stimulation.

2. When a satisfactorily adjusted running process is established athletes may comfortably shift to other cognitive alternatives: dissociation, focusing, synchronising, 'meditative states', to deal with low level discomfort, boredom or monotony.

3. When dissociating or using other cognitive techniques, athletes need to be alert to the possibility of pain signals penetrating focal awareness. Such signals should be dealt with in the appropriate manner through association.

4. Athletes should be encouraged to withdraw from an activity if they have reached the limit of their ability to make adjustments to performance in the light of ever increasing pain signals.

5. Each athlete may need to experiment to determine his or her most effective strategy use in situations of differing performance demands.

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APPENDICES

PERCEIVED EXERTION SCALE

6	
7	VERY, VERY LIGHT
8	
9	VERY LIGHT
10	
11	FAIRLY LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD
16	
17	VERY HARD
18	
19	VERY, VERY HARD
20	

SUBJECT CONSENT FORM:

I ....of................................

....hereby give my consent to be a subject in the Exercise Physiology Study entitled: Cognitive Strategies and Endurance Performance. I have had all the various aspects of the testing procedure outlined to me in detail and fully understand the potential risks associated with a study of this type.

....

Subject Signature Date

....

Witness Signature Date

APPENDIX 3. RUNNING EXPERIENCE SURVEY

1. NAME:

2. AGE:

3. DO YOU RUN COMPETITIVELY? |YES| |NO|

4. SPORT: |MARATHON| |TRIATHLON|

   |OTHER|...

5. HOW OFTEN DO YOU TRAIN (RUNNING)?

   ....DAYS PER WEEK

6. HOW FAR DO YOU RUN ON AN AVERAGE TRAINING RUN?

   ....km

7. FOR HOW LONG HAVE YOU BEEN TRAINING AT THIS LEVEL DURING LAST TWELVE MONTHS?

   ....WEEKS

8. WHEN TRAINING, DO YOU USUALLY RUN,

   |ALONE| |WITH ONE OR TWO OTHERS| |WITH SMALL GROUP|

   |WITH A LARGE GROUP|

APPENDIX 4. POST RUN QUESTIONNAIRE

You have just completed a run to exhaustion! Would you now be kind enough to give us your feelings on the following:

1. Rate how hard you felt the run was. (Use number from scale on wall).
2. What most influenced your decision to stop.
3. If you experienced any discomfort or pain how did you cope with it?
4. If you experienced any boredom how did you cope with it?
5. During the run you have just completed <u>how much of the time</u> did you attend to, or think about:

	None	A Little	Often	Most of the Time
(a) Your breathing				
(b) Looking around the lab/watching the video				
(c) Pain in your legs.				
(d) Talking to others (other than answering questions)				
(e) Your work or school				
(f) "Focusing" and "switching off."				
(g) Your personal/family life				
(h) Distracting Tasks (not associated with running) (eg. singing, working out maths problems etc.)				
(i) The distance (time) to go (or how far (long) you had run)				
(j) General feelings of fatigue				
(k) Relaxing your legs (or arms or shoulders)				
(l) Other running or sporting commitments				
(m) Your body temperature/room tempearture				
(n) Getting your pace/breathing synchronized-getting into a rhythm.				
(o) The pace (ie. too slow or OK or too fast)				
(p) What you would do after the run (eg. rest, eat etc.)				

APPENDIX 5. PRE RUN QUESTIONNAIRE

Is there anything that will prevent you from performing your best today? If "YES" please explain.

What physical activities have you engaged in during the last 24 hours?
(eg. a run, game of football, sexual activity). Start from the most recent activity.

Activity	When	Intensity	Duration
Run	Last night	2k. - light	30 min.

What has been your food intake over last 24 hours. Start with your most recent meal.

Meal	Food	Approx. Quantity
(lunch today)	soup	1 bowl
	chops	3
	potato	about 1 cup
	peas	about 1 cup
	bread	4 slices
	coffee	1 cup
(snack)	mars bar	1
	milk	1/2 litre
(breakfast today)	muesli/milk	1 bowl
	toast/jam	2 slices
	coffee	1 cup

APPENDIX 6. RAW SCORE DATA - ASSOCIATIVE GROUP

#	Age	RES	MAP	CS1	CS2	ΔCS	RPE1	RPE2	ΔRPE	T1	T2	ΔT
1	26	10	56	-5	9.5	14.5	15	18	3	1463	1380	-83
2	34	15	48	4	12.5	8.5	15	17	2	1352	1332	-20
3	18	15	57	-1	6.5	7.5	14	16	2	1549	1597	48
4	18	3	63	10	16	6	15	18	3	1114	1074	-40
5	17	5	60	15	20	5	17	19	2	1464	1423	-41
6	22	60	71	3	12.5	9.5	18	20	2	1609	1617	8
7	29	25	61	12	15	3	16	18	2	1234	1191	-43
8	23	12	66	2	11	9	17	19	2	1550	1475	-75
9	21	2	54	2	11	9	16	20	4	1261	1140	-121
10	24	3	65	-3	6	9	17	18	1	1606	1607	1
11	26	2	61	5.5	11	5.5	17	17	0	1250	1171	-79

KEY:

Age: Age (Years)

RES: Running Experience Score

MAP: Maximal Aerobic Power (ml O_2 . Min^{-1} . $Kg.^{-1}$)

CS1: Phase 2 Cognitive Strategy Score

CS2: Phase 3 Cognitive Strategy Score

ΔCS: Cognitive Strategy Change Score

RPE1: Phase 2 Rated Perceived Exertion Score

RPE2: Phase 3 Rated Perceived Exertion Score

ΔRPE: Rated Perceived Exertion Change Score

T1: Phase 2 Run Time (secs.)

T2: Phase 3 Run Time (secs.)

ΔT: Run Time Change Score

APPENDIX 7. *RAW SCORE DATA - DISSOCIATIVE GROUP*

#	Age	RES	MAP	CS1	CS2	ΔCS	RPE1	RPE2	ΔRPE	T1	T2	ΔT
12	18	120	70	5	-6	-11	15	15	0	1777	1761	-16
13	30	15	61	7	-4	-11	15	13	-2	1599	1613	14
14	23	5	54	1	-7.5	-8.5	14	14	0	1419	1389	-30
15	18	2	61	13	-3	-16	17	15	-2	1290	1368	78
16	18	2	65	9	-5	-14	13	11	-2	1281	1428	147
17	24	10	62	-2	-9	-7	17	14	-3	1313	1366	53
18	24	5	48	3	-4.5	-7.5	16	17	1	1238	1288	50
19	19	2	55	5	-4.5	-9.5	16	15	-1	1198	1320	122
20	28	15	50	4.5	-5.5	-10	17	17	0	1233	1282	49
21	27	8	58	1	-5.5	-6.5	14	16	2	1245	1330	85
22	26	6	66	1	-4.5	-5.5	13	15	2	1538	1586	48

KEY:

Age: Age (Years)

RES: Running Experience Score

MAP: Maximal Aerobic Power (ml O_2 . Min^{-1} . $Kg.^{-1}$)

CS1: Phase 2 Cognitive Strategy Score

CS2: Phase 3 Cognitive Strategy Score

ΔCS: Cognitive Strategy Change Score

RPE1: Phase 2 Rated Perceived Exertion Score

RPE2: Phase 3 Rated Perceived Exertion Score

ΔRPE: Rated Perceived Exertion Change Score

T1: Phase 2 Run Time (secs.)

T2: Phase 3 Run Time (secs.)

ΔT: Run Time Change Score

APPENDIX 8. RAW SCORE DATA - CONTROL GROUP

#	Age	RES	MAP	CS1	CS2	ΔCS	RPE1	RPE2	ΔRPE	T1	T2	ΔT
23	18	15	67	3	-3.5	-6.5	13	15	2	1493	1595	102
24	19	9	63	-3	-4	-1	15	17	2	1417	1465	48
25	28	15	50	-1	1	2	16	17	1	1443	1453	10
26	19	100	73	3	5.5	2.5	15	15	0	1695	1759	64
27	18	4	59	12	15.5	3.5	18	17	-1	1492	1497	5
28	23	15	61	8.5	5	-3.5	19	19	0	1493	1542	49
29	26	15	59	8	8	0	17	16	-1	1237	1297	60
30	20	6	45	-3	9	12	16	16	0	1429	1385	-44
31	27	30	60	4	10	6	15	17	2	1554	1479	-75
32	26	2	50	6	11	5	17	16	-1	1478	1505	27
33	26	30	63	5	8	3	18	20	2	1542	1609	67

KEY:

Age: Age (Years)

RES: Running Experience Score

MAP: Maximal Aerobic Power (ml O_2 . Min^{-1} . $Kg.^{-1}$)

CS1: Phase 2 Cognitive Strategy Score

CS2: Phase 3 Cognitive Strategy Score

ΔCS: Cognitive Strategy Change Score

RPE1: Phase 2 Rated Perceived Exertion Score

RPE2: Phase 3 Rated Perceived Exertion Score

ΔRPE: Rated Perceived Exertion Change Score

T1: Phase 2 Run Time (secs.)

T2: Phase 3 Run Time (secs.)

ΔT: Run Time Change Score

APPENDIX 9. MAXIMUM, MEAN STEADY STATE AND PERCENT OF MAXIMUM HEART RATES

GROUP	S. No	HRMAX	SSHR1	%MAX	SSHR2	%MAX2
Association	1	197	160	81	162	82
	2	176	148	84	145	82
	3	204	167	81	168	82
	4	203	166	81	164	81
	5	214	174	81	171	80
	6	200	158	79	160	80
	7	195	156	80	158	81
	8	192	162	84	160	83
	9	200	166	83	173	86
	10	183	151	82	160	87
	11	199	160	80	175	88
Dissociation	12	186	157	84	148	80
	13	180	152	84	154	85
	14	192	154	79	158	82
	15	202	162	80	168	83
	16	205	170	83	170	83
	17	189	152	80	160	85
	18	204	172	84	166	81
	19	185	153	80	155	84
	20	194	162	83	166	86
	21	190	157	82	160	84
	22	192	158	82	162	84
Control	23	196	158	81	161	82
	24	203	165	81	166	82
	25	199	165	83	162	81
	26	190	155	81	157	83
	27	200	158	79	154	77
	28	207	168	81	166	80
	29	183	154	84	154	84
	30	193	157	81	159	82
	31	196	162	82	166	85
	32	188	153	81	158	84
	33	192	159	82	161	84

Appendix 10. ANOVA Summary Table for Cognitive Strategy Change Scores

Variable ΔCS
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	1759.13	879.568	60.095	.0000
Within Groups	30	439.09	14.636		
Total	32	2198.23			

Multiple Range Tests: Scheffé test with significance level .05

The difference between two means is significant if
MEAN(J)-MEAN(I) >= 2.7052 * RANGE * SQRT(1/N(I) + 1/N(J))
with the following value(s) for RANGE: 3.64

(*) Indicates significant differences which are shown in the lower triangle

Mean	GROUP	DISSOC	CONTR	ASSOC
-9.6818	DISSOC			
2.0909	CONTROL	*		
7.8636	ASSOC	*	*	

Subset 1

Group DISSOC

Mean -9.6818

- - - - - - - - - -

Subset 2

Group CONTROL

Mean 2.0909

- - - - - - - - - -

Subset 3

Group ASSOC

Mean 7.8636

Appendix 11. Paired T-test for Control Group Cognitive Strategy Scores

- - - t-tests for paired samples - - -

Variable	Number of pairs	Corr	2-tail Sig	Mean	SD	SE of Mean
CS1	11	.606	.048	3.8636	4.796	1.446
CS2				5.9545	6.039	1.821

t-value	df	2-tail Sig
-1.4	10	0.191

Appendix 12. ANOVA Summary Table for Rated Perceived Exertion Change Scores

Variable ΔRPE
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	36.1818	18.0909	9.6290	.0006
Within Groups	30	56.3636	1.8788		
Total	32	92.5455			

Multiple Range Tests: Scheffé test with significance level .05

The difference between two means is significant if
MEAN(J)-MEAN(I) >= 0.9692 * RANGE * SQRT(1/N(I) + 1/N(J))
with the following value(s) for RANGE: 3.64

(*) Indicates significant differences which are shown in the lower triangle

Mean	GROUP	DISSOC	CONTROL	ASSOC
-0.4545	DISSOC			
0.5455	CONTROL			
2.0909	ASSOC	*	*	

Subset 1

Group	DISSOC	CONTROL
Mean	-0.4545	0.5455

\- - - - - - - - - -

Subset 2

Group	ASSOC
Mean	2.0909

\- - - - - - - - - -

APPENDIX 13. ANOVA SUMMARY TABLE FOR PERFORMANCE TIME CHANGE SCORES

Variable ΔT
By Variable GROUP

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	52998.7	26499.4	10.122	.0004
Within Groups	30	78536.2	2617.9		
Total	32	131534.9			

Multiple Range Tests: Scheffé test with significance level .05

The difference between two means is significant if
MEAN(J)-MEAN(I) >= 36.1792 * RANGE * SQRT(1/N(I) + 1/N(J))
with the following value(s) for RANGE: 3.64

(*) Indicates significant differences which are shown in the lower triangle

Mean	GROUP	ASSOC	CONTR	DISSOC
-40.4545	ASSOC			
28.4545	CONTROL	*		
54.5455	DISSOC	*		

Subset 1

Group ASSOC

Mean -40.4545

- - - - - - - - - -

Subset 2

Group	CONTROL	DISSOC
Mean	28.4545	54.5455

- - - - - - - - - -