MENTAL STRATEGIES AND THE PERCEPTION OF EFFORT: IMPLICATIONS FOR THE PSYCHOLOGICAL TRAINING OF MARATHON RUNNERS

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Thesis submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in Psychology.

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Several attempts have recently been made by psychologists to uncover the mystique that surrounds the superior athletes and their superior performance. Researchers wonder whether continuous participation in a specific sport induces both peak performance and certain mental strategies or whether the perchance or purposeful adoption of a cognitive strategy enhances performance (Cratty, 1983). In their effort to find a causal relationship, psychologists have endeavoured to understand the mental processes of athletes, speculating on how the quality or quantity of their thoughts might contribute to their excellent performance. Yet results have been clouded over by anecdotal reports and rather unsystematic accounts of subjective experiences and views. Tentative explorations into the mind of the marathoner are beginning to set the stage for the unravelling of this highly complex and fascinating realm. This research project sets out to focus on the mental strategies of the marathoner and to discover their contribution to the marathoner's limit of performance.

SPORT PSYCHOLOGY - A HISTORICAL PERSPECTIVE

Although sport psychology is a relatively recent development, psychological issues pervaded the arena of sport and the training methods of athletes long before they were systematized in the past few decades. The mind-body interaction, which already fascinated the philosophers in ancient Greece, has continued to have an intuitive influence on athletic performance through the sporting eras.

Most scholars since the time of Plato propounded the so-called dualistic position, believing that the mind and the body were of different natures and that only the mind had an influence on the body. During the Middle Ages the mind was credited not only for thought processes and reason, but also for reproduction, perception and locomotion (Schultz, 1975). The radical idea on the mutual interaction of mind and body was brought forward by Descartes in the 17th century.

It is difficult to point to an exact origin of sport psychology. Although reference to a text on the psychology of soccer, appearing as early as 1801, is given in Vanek and Cratty (1970), the early development of sport psychology and general psychology cannot be perceived and studied as separate entities. General psychology was evolving from the established disciplines of philosophy, medicine and education, when Wundt set up the first laboratory, devoted exclusively to psychology, in Leipzig in 1879. According to Wundt, psychology was the science of experience and his areas of investigation included sensation, attention, feeling, reaction and association. He had the worldly insight to realize that the mind-body problem was not to dissappear that quickly, even with advances in scientific method and technology (Robinson, 1976).

While researchers in Wundt's laboratory were devoted to the analysis of conscious experience, psychologists in Central Europe were also beginning to focus on issues related to motor learning and motor responses. Galton in England produced some exemplary work on the problems of mental inheritance and individual differences in human capacity. His interests were very varied and included a study of anthropometric and psychometric measurements on more than 9000 people in London over a period of 6 years. These included data on height, weight, breathing power, strength of pull and squeeze, quickness of blow, sense of hearing, sight and colour (Schultz, 1975).

One of Wundt's students, Cattell, characterizing the American functionalistic spirit, focused much of his work on mental testing and the measurement of individual differences.

By 1920 a surge of interest in the field of physical education was noticeable and attempts were being made by physical educators to gain wider knowledge on sport and recreation than was supplied by medicine.

In the years immediately after World War I, a team of German psychologists did pioneering work in the domain of physical education. Their approach was known as "Psychotechnik" and encompassed philosophical, experimental and practical issues. In 1921, Schulte published a philosophical text entitled "Body and soul in sports: An introduction to the psychology of physical exercise". His research interests entailed, amongst others, studies on hand-steadiness while aiming, speed and rhythm control, and the force of the jump from a diving board (Rokusfalvy, 1980). He also compiled a battery of tests to assess the physical ability of young children. His book "Increasing performance in exercises, games and sport activity" may be seen as one of the earliest attempts to focus on superior athletes and their psychological preparation. Topics such as team interaction and pre-start tension were also dealt with.

Giese expanded this knowledge to "objektive Psychotechnik" by studying environmental aspects influencing sporting performance, such as lighting and temperature requirements of gymnastic halls. He also explored the size, shape and suitability of sporting equipment and sought solutions to the prevention of sports injuries (Rokusfalvy, 1980).

Sippel's experimental research concerned the beneficial effect physical activity has on the academic potential of children. His results were published in two books, "Physical education in schools and the mental work of school children" and "Physical exercises and mental activity".

Around this time, Griffith, considered by some as the "father of sport psychology" in the United States began to make informal observations on possible psychological factors related to basketball and football (Kroll & Lewis, 1978). His main areas of study were psychomotor skills, learning and personality testing. In 1925 he was the first to establish a sport psychology laboratory and offer courses to both students and athletes. Unfortunately, his extensive output of knowledge had no direct impact on coaches and physical educators during his time. Only much later, in the 1960s, with a renewed upsurge of interest in motor performance (Cratty, 1967; Lawther, 1968; Oxendine, 1968; Singer, 1968), were structured courses on motor learning, later to be re-labelled sports psychology, to appear in the United States (Cratty, 1983). The first half of the 20th century in the United States is indicative of a dearth of research involving the coach, the athlete and the psychologist.

Impressive work continued to come from Germany, particularly from the Deutsche Schule für Körperkultur (Institute of Physical Culture) in Leipzig after World War II. Work during the 1950s and 1960s focused on the elite athlete and the relationship between performance arousal and physical readiness for competition. German teams, preparing for the Mexico Olympics in 1968, were accompanied by psychologists during their high-altitude training and given tests on performance and concentration levels (Vanek & Cratty, 1970).

Ogilvie and Tutko, two pioneer United States sport psychologists in the 1960s began to employ personality testing to study personality traits of athletes in various sports, as did many other researchers using a variety of standard personality tests (Cooper, 1969; Kroll, 1967; Lakie, 1962; Peterson, Weber & Trousdale, 1967; Singer, 1969; Slusher, 1964). But the inconsistent findings bred many skeptics and other means of evaluating athletes began to be sought (Eysenck, Nias & Cox, 1982; Horsfall, Fisher & Morris, 1980; Martens, 1975). Involvement of psychologists in the United States national teams was minimal till the late 1970s (Klavora, 1980b; Morgan, 1980; Suinn, 1980a).

According to Vanek and Cratty (1970), the start of sport psychology in Russia may be traced back to 1901 when Lesgaft researched the psychological benefits of exercise. Today, Russia has created more physical education institutes, sport psychology laboratories, and has trained more sport psychologists than any other country. Soviet sport psychologists are paid by the state and are attached to national teams together with the coaching staff and the team physician. The psychologists function is to conduct personality tests and to prepare the athletes for competition. Athletes are "discovered" often at an early age and given state support and co-operation as sport and international contests take on important social, national and ideological connotations (Smieskol, 1972). The ever-increasing demand for superior performance, has led Soviet researchers to direct more effort towards the elite athlete and his need for psychological training. Another task of sport psychology in Russia today, is the establishment of models of the

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SUMMARY

The balanced preparation of an athlete depends on the integration of physiological, biomechanical and psychological factors that govern performance. To optimize the performance potential of any sport participant, knowledge about the three factors contributing to applied sport science has to be generated through rigorous analysis of theory and practice. Physiological and biomechanical principles of performance have till recently dominated the sport science arena. Psychological knowledge of sport is now gaining in scope and dimension. It was the objective of this thesis to contribute to the expanding field of sport psychology and, in particular, to the psychological knowledge on marathon running.

The thesis is laid out in two parts. The first part, consisting of five chapters, presents a review of relevant literature pertaining to psycholological facets of sports training. As an introduction, the development of the field of sport psychology is outlined, followed by an overview of the history of the marathon. Physiological limits and psychological complexities of sports performance conclude the first chapter.

The current interest in mental strategies employed during long-distance running is traced through research thrusts into the mental practice of skills and psychological pre-performance

preparation techniques. The beginnings and continuation of psychological research into the mental aspects of detailed and isolated motor skill execution and how this trend has impacted on mental imagery training is considered in Chapter 2. In physical skill research, mental rehearsal is primarily applied as the sole short-term intervention technique aiming to improve the behavioural output of the specific motor skill practised. Systematic scientific inquiry is lacking and a one-treatment approach is not uncommon. Clinical research provides the integration of mental imagery rehearsal into more comprehensive behaviour modification programmes in sports settings. Numerous muscle relaxation techniques, adopted from clinical practice, are now receiving extensive attention in the pre-performance and particularly pre-competition phase of athletes' training routines. These productive adaptations, together with the emergence of sports-specific intervention procedures, are reviewed in Chapter 3.

Current research trends are indicative of the progression away from auxiliary, isolated mental skill practice to augmented, complex mental strategy intervention processes. Chapter 4 reports on investigations undertaken in order to explain the athlete's mental activity during long-distance running. Research findings illustrate what kind of mental strategies athletes adopt to cope with the effort, stress and strains of competition and training. How a person comes to perceive the effort involved in physical activity is assessed in Chapter 5.

In the second part of the thesis, also consisting of five chapters, concepts and theories propounded by researchers reviewed in the preceeding chapters come under scientific scrutiny. It is argued in Chapter 6 that Morgan and Pollock's theory, which states that only elite marathoners can afford to use an associative mental strategy because of their superior physiological constitution, is misleading. As increases in physical conditioning are irrefutably linked with increases in training intensity, marathoners, regardless of running status, have to expose themselves to ever-increasing efforts to procure performance improvements. For optimum performance energy expenditure must be efficient, economical and safe. Dissociative thinking during long-distance running does not enable athletes to regulate actively the running process to match the supply of energy with the demand set by the specific course or situation, often exposing athletes to the additional risk of overuse injury. When adopting an associative mental strategy, athletes actively manipulate the running process to their advantage. To attain and maintain high training intensity associative thinking has to be practised by the marathoners regardless of their running status. The thesis is put forward that increases in associative mental strategy are directly related to increases in the perception of effort. Qualitative differences within associative thinking may be attributed to the prolonged shaping process to which experienced runners have been exposed. Based on the serial modal model of thinking, an information-processing system elucidating the above-mentioned thesis is displayed.

Chapter 7 concentrates on the task of recording the continuous verbalized thought flow of marathoners during their training runs. Previous mental strategy research has until now relied heavily on pre- and retrospective questionnaire data. The present data gathering technique utilizing light-weight microcassette tape recorders is seen as a major advance in the research methodology. The development of a precise, functional mental strategy classification system based on the broad association/dissociation classification and Nideffer's attentional style categorization is documented in Chapter 8. The content analysis of the transcribed thought verbalizations was based on this sytem. Results indicate that marathoners irrespective of running status engage in associative thinking to similar degrees.

Detailed analyses of the hypothesized relationship between specific thought components and training intensity are offered in Chapter 9. All subset regression analyses were executed. Extremely strong positive linear relationships were revealed to exist between specific task-related thought components and effort sense. Qualitative differences within the associative mental strategy are examined in the light of the shaping process to which experienced marathoners are exposed. The newly developed mental strategy classification system is utilized in Chapter 10 to advance an associative mental strategy training programme. Light-weight, hands-free, two-way radios made continuous communication between trainer and marathoner feasible. This contributed substantially to the effective shaping

and enhancement of a precise and directive associative mental strategy. Ten case studies are evaluated, lending considerable support for the training in associative mental strategy to enable marathoners to achieve and maintain an efficient and safe running household. Recommendations for the adaptation of this training method into general use are discussed.

PART 1

CHAPTER 1

INTRODUCTION

In their pursuit of excellence, human beings try to attain higher and ever-distant goals. In the field of sport, they are consistently striving to break the existing records and are indeed succeeding. And thus the question arises of where will it all end? Is there a limit to human performance? Will this limit be physiological or psychological, and will we experience the day when the last record will have been broken?

Although many athletes are endowed with the genetic ability to do well and although they undertake arduous training programmes, their performances still vary tremendously over time and place. It is this phenomenon that is of interest to psychologists and has attracted them into the world of sport. It is becoming more and more evident that "mental fitness" is a major complementing factor in the achievement of optimum athletic performance. The requirements of a champion go further than a rigorous training regimen. It is the psychologist who may offer the athletes psychological insight and training so that during competition they may elicit all their resources for the near superhuman effort of superior performance.

Besides talent, athletes need sound motivation so that they may endure the endless ordeal of training. They also need thorough preparation for the competitive event and need to excel at competing. This implies that competitors must master the stress of the contest and be able to monitor their arousal level prior to and during performance. Yet every competitor has his or her own requirements, be they cognitive or emotional, which need to be identified. A balanced preparation which takes into account that optimal performance is influenced by a myriad of factors is vital in the training and coaching of athletes. The integration of the scientific knowledge on the physiological and psychological factors is steadily being accepted in the sporting field. Sport psychologists, believing that superior athletic performance is a balanced psycho-physiological blend, are drawing on knowledge from physiologists, physical educationalists, clinical psychologists, research psychologists and biophysicists. Hickman (1980) suggested that an intricate mind-body synthesis will eventually contribute to an expanded dimension of human capabilities.

Today, peak form and peak performance over an extended period of time are necessary requirements of the sportsperson. It is only the athlete who can maintain this high standard consistently who will ultimately outperform competitors and receive the laurels. During peak performance the athlete makes use of superlative human potential. Privette (1981) has noted that world class athletes discover the techniques necessary to make their own supreme performance a recurring event.

"ideal" athlete in various sport disciplines constructed from psychological traits and characteristics (Shneidman, 1980).

In 1965, the First International Congress of Sport Psychology was held in Rome by invitation of the Italian Ferrucio Antonelli. This turned out to be a notable unifying meeting for researchers from many countries.

The Second International Congress of Sport Psychology was staged after the 1968 Mexican Olympics and showed that a rapid growth of sport psychology was beginning to take place.

THE HISTORY OF THE MARATHON

The marathon is a long-distance footrace which commemorates the legendary triumph of an Athenian named Pheidippides, who in 490 B.C. is supposed to have started from the battlefield of Marathon and headed for Athens, approximately 40 kilometres away, to bring news of the Greeks' victory over the Persians. The story goes that as he completed the strenuous journey and pronounced his joyous news to his countrymen in Athens, he collapsed dead to the ground.

Martin, Benario, and Gynn (1977) have concluded that the historical evidence for this heroic feat is very meagre, and that even the runner's name was probably not Pheidippides. Their prime source is taken from the history books of Herodutus who lived around this time, and wrote:

> And first, before they left the city, the generals sent off to Sparta a herald, one Philippides, who was by birth an Athenian, and by profession and practice a trained runner. This man, according to the account which he gave to the Athenians on his return, when he was near Mount Parthenium above Tegea, fell in with the god Pan, who called him by his name, and bade him ask the Athenians, "Why they neglected him so entirely, when he was kindly disposed towards them, and had often helped them in times past, and would do so again in time to come?" ... On the occasion of which we speak, when Philippides was sent by the Athenian generals, and, according to his own account, saw Pan on his journey, he reached Sparta on the very next day after quitting the city of Athens. (p.821)

It is significant to note that no mention is made of this man "Philippides" returning to Athens to join the battle at Marathon and his ensuing trip to Athens to carry his victorious news, nor of his resultant death.

Another reference comes from the Roman historian Cornelius Nepos of the 1st century B.C. who states:

> The Athenians, distressed by this war so near and so great, in their own land, sought aid nowhere other than from the Lacedaemonians (Spartans) and sent Phidippus, a runner of that class known as hemerodromoi, to report how urgent was the need of aid. (Martin et al., 1977, p.822)

The present interest in endurance races dates back to the inclusion of a marathon event in the first modern Olympic Games, which were instigated by the Frenchman Baron Pierre de Coubertin in 1896. The legendary run was re-enacted from the Marathon Bridge to the city of Athens and was appropriately won by a Greek, Spiros Louis. It was not until the Olympic games in 1924 that the marathon distance was standardized to 42.195 metres (Midgley, 1983) or 26 miles and 385 yards (26.219 miles), run only once previously at the 1908 Olympics in London. The extra 385 yards were added in 1908 so that the marathon could start at the royal residence at Windsor Castle and end directly in front of the royal box in the stadium (Encyclopaedia Britannica, 1979).

Since these early times many kinds of endurance races have been established both in metric and mile distances, but it is the standard marathon that has achieved greatest popularity in terms of the number of participants worldwide. The interest among all nations, all age groups and for both sexes to participate in this gruelling long-distance running event is today still growing markedly ("Laufen: Besser als", 1978). Both the quality and the quantity of new records continue to improve.

After the 1968 Olympic Games in Mexico there was a renewed upsurge of scientific research into marathon training, much previous physiological investigation having been undertaken before World War II (Maron & Horvath, 1978). But the coaches and runners, with their winning philosophy based solely on personal experience, "became uneasy companions" (Lucas, 1977, p.859) to the medical doctors, dieticians, physiologists and biophysicists who derived their knowledge from laboratory tests.

The International Amateur Athletic Federation (IAAF) does not give an official list of "world records" for the fastest finish times of the marathon event, as no two marathons can be run under exactly the same conditions (Encyclopaedia Britannica, 1979). Firstly, the climatic conditions such as temperature, humidity and wind direction all effect the performance of the participants and cannot be controlled. The second problem that needs to be taken into consideration is the course terrain, which will differ tremendously in surface, gradient and altitude from place to place. Another problem that relates to the course is the accurate measurement of the distance of 42.195 metres which, when not done by an actual line drawn on the full length of the course surface that the competitors must follow, can lead to an erroneous distance interval.

Figure 1 and 2 give an indication of the steady, nearly linear improvement of performance in the marathon race over the past years both for male and female runners. It should be mentioned that female runners were only officially admitted to marathon running in America as late as the 1970s, after a long and bitter struggle to prove their capabilities (Kusczik, 1977). The first Olympic marathon event for women was held in Los Angeles in September, 1984.

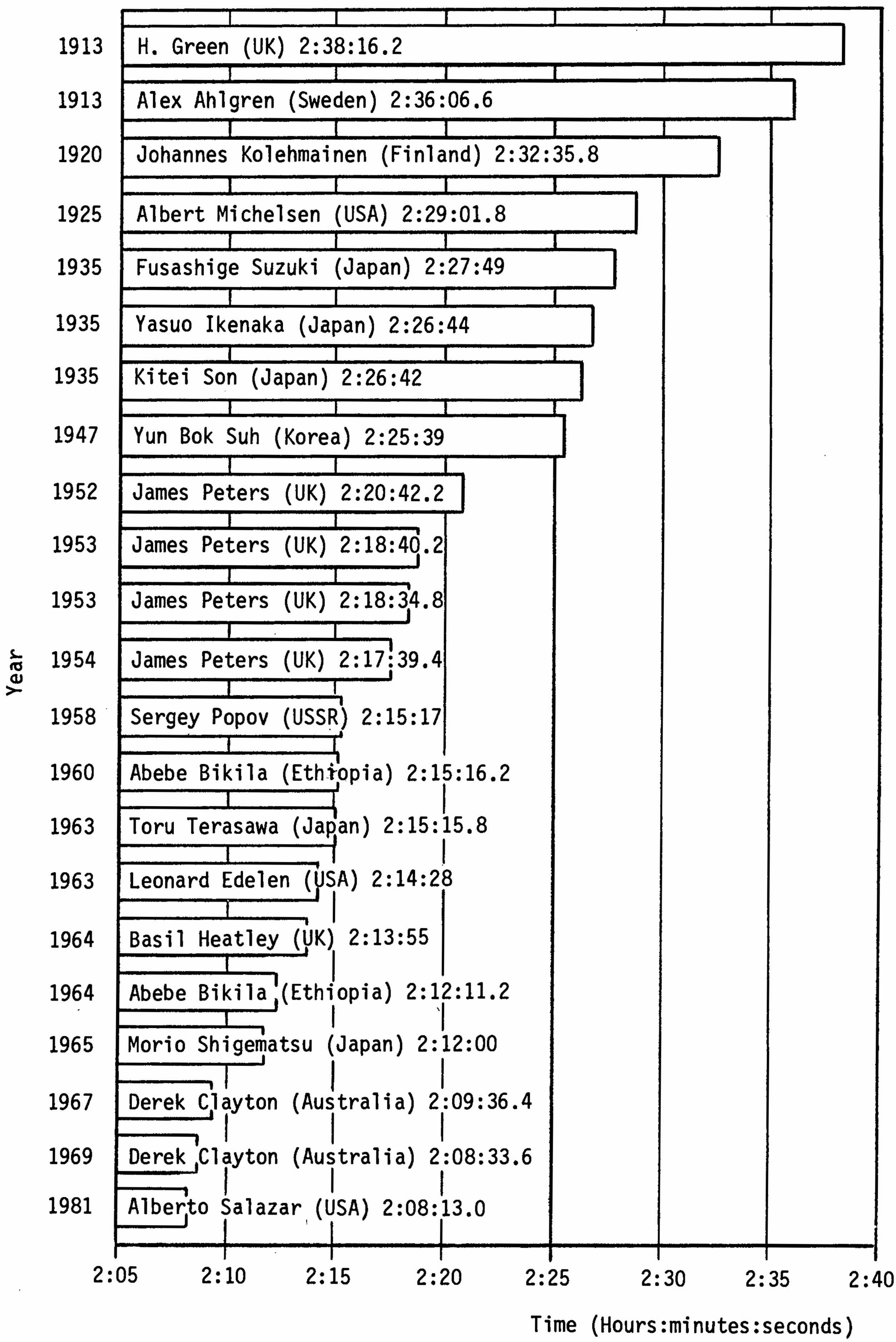


Figure 1. Marathon race times for men (adapted from Wilkerson, 1982, p.40).

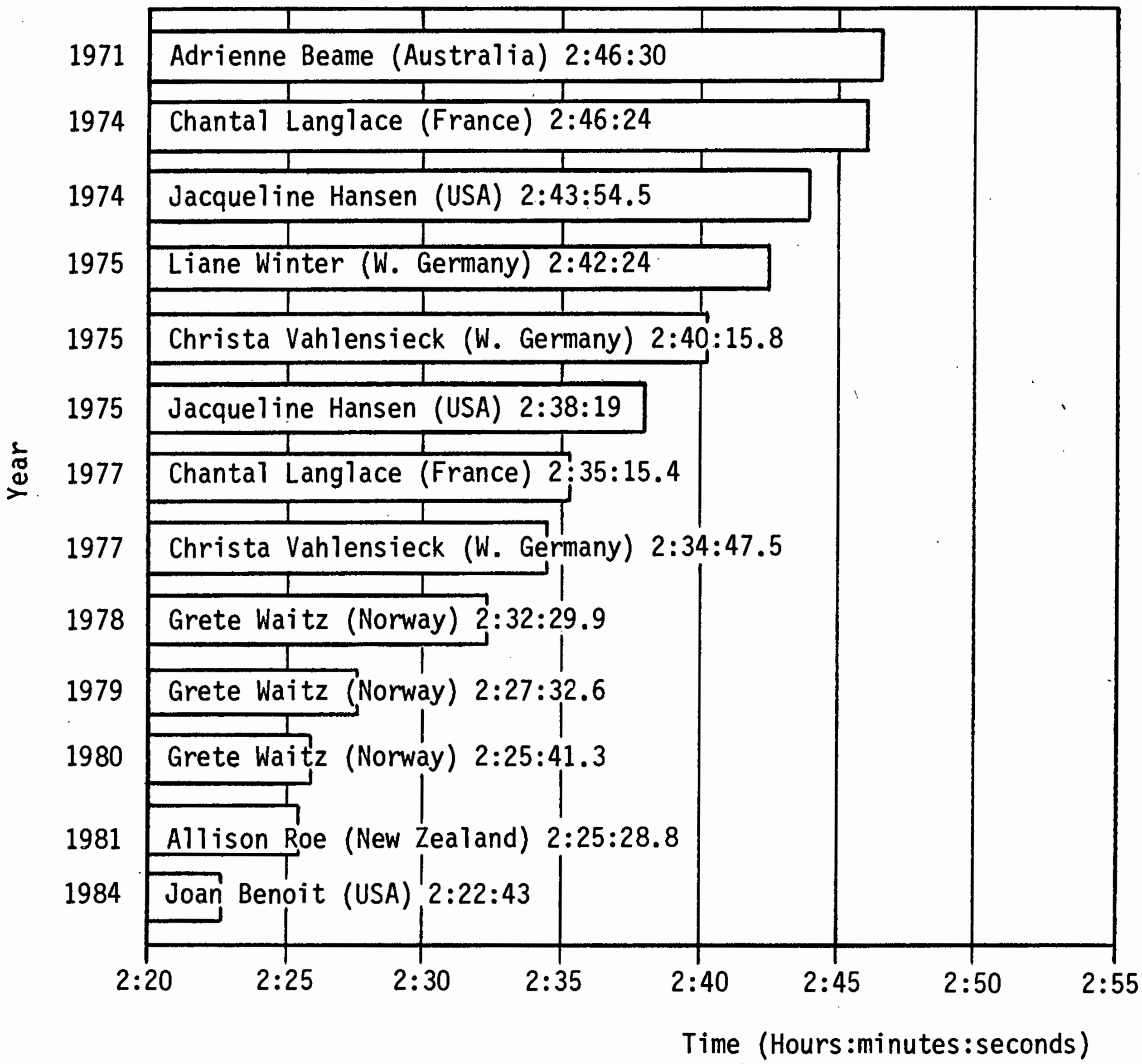


Figure 2. Marathon race times for women (adapted from Wilkerson, 1982, p.40; updated for 1984).

When plotting the average speed in metres per minute of the record breaking runs (from 100 metres to 42.195 metres) against the progression of time of the past 50 years, the rate of acceleration has averaged approximately 0.75 metres per minute per year (Ryder, Carr & Herget, 1976). This rate of acceleration for the short distance races is hardly detectable, so that one might be mislead to believe that the limit of performance has already been reached in this area of sport. Yet in a long-distance event such as the marathon, the increase in mean speed has been shown to be approximately 0.9 metres per minute, which implies that the athlete will gain 116 metres each year, or knock off about 21 seconds from the record each year. A projection based purely on improvements in mean speed is given by Ryder et al. (1976) for the marathon event since 1925 in Figure 3. The overall improvement from the record time in 1925 to the projected record in 2028 has been calculated to be 24.7%.

When trying to anticipate the records of the future by looking at the trends of the past one usually concentrates on dates rather than on the training effort that goes into producing a record performance. This, however, is vital because the limit to performance may lie in the training programme rather than in the athlete:

> The physiological, pathological and psychological reactions that limit proportionate increases in the intensity

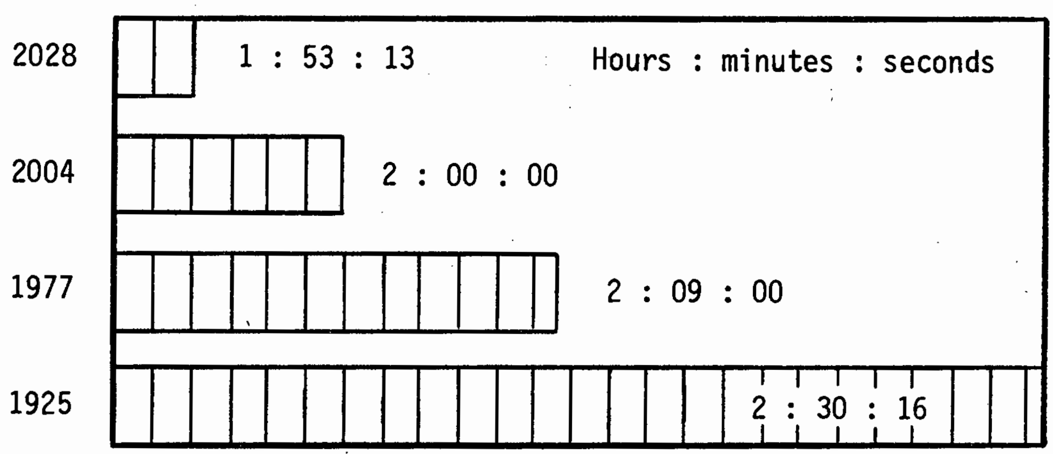


Figure 3. Projected marathon records for the years 2004 and 2028 (adapted from Ryder, Carr & Herget, 1976, p.118).

> of training are already distressingly familiar to coaches and sports physicians. At present the factor limiting record performances may be pathological or psychological, but it is not physiological. (Ryder et al., 1976, p.119)

One of the aims of the sport psychologists, therefore, is to seek ways of extending those psychological limits.

PHYSIOLOGICAL LIMITS TO PERFORMANCE

The marathon race represents a classical test of physical fitness and peak performance. The individual's successful completion of this arduous event is the result of a multitude of factors which need to blend harmoniously. There is no one formula that can predetermine success and thus serve as a prescription for the next marathon event or the next marathon competitor.

There are several external variables such as time and location of the event, the difficulty and familiarity of the course, the climatic condition, the availability of sufficient drinking stations, traffic control and pollution, and a large supportive spectator audience that will have an effect on the performance of the athlete. Most of the above variables may be accounted for in advance and should not influence the well-prepared and highly trained runner to a great extent. Internal factors like age, weight, percentage body fat, skeletal structure, state of health and diet, the capacity for oxygen intake, and muscle fibre composition contribute markedly to the determination of an individual's maximal running speed. However, as the human body operates on the basis of all systems interacting in synchrony, "the body is only as fast as its slowest part" (Wilkerson, 1982, p.36).

Individuals who manage to produce superior performance must first and foremost be endowed with the correct genetic factors. It has been shown that in order to be a world champion marathoner, one must have the innate capacity to consume oxygen at a very high rate. This physiological factor can readily be measured using a laboratory treadmill. The athlete's oxygen consumption increases nearly linearly as the work load continuously increases until a point is reached at which, although the athlete can run a little faster, his oxygen uptake reaches a plateau. This point is called his maximum oxygen consumption (VO_2 max) or maximal aerobic power. Research has indicated that elite male marathoners have VO_2 max values of up to 60% higher than the average population (Noakes, 1981). Even a demanding exercise regimen cannot improve the maximum oxygen intake of an athlete by more than 10% (Wyndham, Strydom, Van Rensburg & Benade, 1969). This phenomenon has led to the saying that "champions are born and not made". Anyone considering entering the world arena of middle- and long-distance running should have a maximum oxygen uptake close to or preferably above 80 $ml.kg^{-1}.min^{-1}$ in the case of men and above 70 $ml.kg^{-1}.min^{-1}$ for women (Astrand & Rodahl, 1977; Saltin & Astrand, 1967).

Among superior distance runners with elevated VO_2 max values relative to the general population, it is not the contestant with the highest value that necessarily runs fastest (Thomas, Zebas, Bahrke, Aranjo & Etheridge, 1983). VO_2 max, therefore, cannot fully explain the different results of elite marathoners. Rather, the single physiological factor that is now accepted as the true discriminater of performance capacity is the ability to maintain a speed requiring a large percentage of VO_2 max for an extended period of time (Noakes, 1981; Sen Gupta, Mathew, Gopinath & Jayashankar, 1983). As was mentioned, VO_2 max varies minimally with training, but it is this last named factor that can be influenced substantially through a demanding training schedule.

It is found that when marathoners go beyond this critical % VO_2 max and drive themselves to using an even higher percentage of their VO_2 max, their blood lactic acid levels begin to rise sharply. These "lactate-turnpoints" may be lowered with training and thus postpone the onset of fatique (Wyndham, Strydom, Van Rensburg & Benade, 1969). Research done by Nagle and Balke (cited in Morgan, 1984) on trained runners pointed to the following interesting relationships between work intensity, blood lactate levels and endurance times. When the runners increased their work intensity from 71% to 77% of VO_2 max they experienced a 100% increase in blood lactate and a 33% decrease in endurance time. When the work intensity was pushed to 86% of maximum, they experienced a 400% increase in blood lactate and a corresponding 50% decrease in endurance time. It is thus essential that the elite marathoner runs close to his optimum range of % VO_2 max.

Hence, the vital factor in the exercise programme of the serious marathon runner is endurance training; he needs to be able to withstand prolonged work at an optimally high energy consumption. Ryder et al. (1976) considered that maximal exposure to the severe conditions under which the marathoner needs to compete will possibly bring about this adaptation. They foresee a situation in which the marathoner, striving for the ultimate limit in performance, will devote his life to running at race pace.

A further factor that appears to determine how long an endurance athlete can maintain the physical exertion required during a marathon is the concentration of glycogen in the muscles at the start of the race and the rate at which these glycogen stores are utilized (Fitts, 1977). Training causes the initial muscle glycogen concentration to increase and reduces the rate of muscle glycogen metabolism by allowing a proportionately larger percentage of fat to be utilized during exercise (Hendriksson, 1977). These adaptations further enhance the performance of the elite athlete.

Running performance is also affected by the contestant's muscle fibre composition, which again is a genetically predetermined factor (Pyke, 1979; Saltin, Hendriksson, Nygaard, Anderson & Jansson, 1977). Slow-twitch muscle fibres characteristically exhibit a higher content of myoglobin and a greater capacity for oxidative processes, which implies that muscles containing a large percentage of these fibres are well adapted to cope with prolonged endurance events such as marathons in which the emphasis is on aerobic metabolism (Knuttgen, 1979). Fast-twitch fibres, on the other hand, have a greater anaerobic capacity and a high percentage of these fibres are found in sprinters. Appropriate training can improve the efficiency of the muscle fibres, but cannot change the person's muscle fibre composition (Costill, Daniels, Evans, Fink, Krahenbuhl & Saltin, 1976).

Another anatomical consideration that influences running performance is stride length which is determined by the factors of leg length, fixed by heredity, and hip flexibility. Only the latter is trainable and can result in a longer stride and therefore possibly in a faster running speed (Wilkerson, 1982).

At this point, mention should be made of certain ergogenic aids certain athletes either ingest or inject in order to enhance their performance capabilities. The misuse of drugs destroys fair play in sport, and doping is beginning to be heavily penalized in some countries. The use of steroids and other pharmaceutical products to change the athlete's physiology is potentially dangerous, and has in instances already been fatal (Beckett, 1984).

The continued record breaking performances during the past century have thus partly been due to factors like the increase in human size, advances in technology, insights from the field of medicine and work physiology, and the increased amount of leisure time available for training. Research done by exercise physiologists has removed many ill-founded notions and superstitions regarding training for endurance events and replaced these with programmes that may be specifically adapted to each athlete's unique, laboratory-tested physiological characteristics. The wider use of computers will play an ever-increasing role in determining the ultimate training regimen for individual athletes resulting in more athletes being optimally prepared for the possibility of breaking records and for reaching ever-distant limits in performance. Clein (1980) predicted that by the end of the century the process of natural selection, too, will play a role. With the advance in the fields of science, medicine and technology, and the sociological tendency of runners to marry runners, the physiological capacity of the human being has not yet been fully grasped, let alone tested. Further optimum performances and faster running times are therefore predicted.

Finally, it is interesting to note that approximately two-thirds of the men who break a world record never break another one. This phenomenon was reported by Ryder et al. (1976) who stated that only about 20% of runners improve on their own record and 25% establish a further record at a new distance. Ryder et al. offered their own reason for believing that man has not yet reached his physiological limit of performance:

> The champions stop not at a given speed but when they set a record. Succeeding champions do the same. They telescope in their relatively short racing lives all the achievements of the great runners of the past and then stop with a gold medal, just as their predecessors did. Since it is the medal and not the speed that stops them, the speeds they reach cannot be considered in any way the ultimate physiological limit. (p.114)

PSYCHOLOGICAL COMPLEXITY OF PERFORMANCE

Physiological variables such as maximum oxygen uptake (VO_2 max), percentage utilization of maximum aerobic power, body build and muscle fibre composition have all been used by researchers to identify marathoners with superior performance capabilities from runners with a wide range of physical abilities. Yet, when studying the near homogeneous group of elite marathoners the physiological predictors lose their value and become a mass of inconsequential data. It has therefore recently become the trend to look towards the field of psychology to supply answers to what differentiates the winner from the rest of the group of equally talented and trained individuals. As the marathon is one of the most physically demanding events among sporting contests and only the extremely well-prepared and fit athlete may hope to succeed, it lends itself ideally for study by psychologists, for it must also surely rank as one of the most arduous events in terms of its psychological demands. And it is in this area that much research still needs to be done. It is Hickman's (1980) belief that "learning to influence your physiology mentally is an important missing ingredient in most western training systems" (p.131). Thus, when considering the physical side of sports it appears that the athlete has become over-educated and that it is the psychological aspect of training and performance that has been neglected and therefore needs attention.

Should a marathoner only rely on his natural endowments and his fitness training his chances of success would be minimized and his peak performances would merely be random events. A serious marathon competitor must, therefore, be aware of the fundamental psychological determinants of optimum performance, which include appropriate emotional arousal, stress coping mechanisms, the ability to relax in anxiety evoking situations, consistently high motivation, excellent concentration, task-orientated attention, the capacity to adjust to varying circumstances, and personality traits of high self-confidence and self-esteem.

The highly proficient athlete needs insight into and control over such emotions as stress, anxiety and tension (Alderman, 1974; Singer, 1972). Although there are definite differences to each of these emotional responses, it is their similar effect on human performance that is of interest here. Their debilitating somatic states are familiar and include tightness of muscles, nervousness, awareness of heart beat, sweating, upset stomach, shortness of breath, blurred vision, disrupted co-ordination, and proneness to injury (Kroll, 1980; Tutko & Tosi, 1976). It is the goal therefore of the athlete to recognize the stressors of competition and to be versatile in anxiety management techniques, so that he/she may prevent the onset of any of the above physical disruptions. The resultant behaviours can be very distracting and can ruin carefully planned trials and tactical manoeuvres.

Much debate has gone into the enquiry of the ideal level of arousal of athletes prior to and during performance (Bunker & Rotella, 1978; Klavora, 1980a). The "drive theory" model suggests a simple linear relationship between performance and activation, whereas the "inverted U hypothesis" points to an optimum level of activation. However, absolute levels of arousal might not be as important as the individual's pattern of arousal change (Epstein & Fenz, 1962; Fenz & Epstein, 1969; Gissen & Sapow, 1980; Landers, 1978). Task complexity may also play a role in determining arousal requirements. High arousal has been associated with a narrowing of attention resulting in a decreased ability to respond to vital cues (Easterbrook, 1959; Nideffer, 1980b).

Kauss (1980b) suggested emotional "readying" prior to competition: before trying to adjust the overall arousal level of athletes, the diverse emotions of confidence, excitement, fear, guilt, anger, aggression, etc. should receive individual attention. The old adage of having to "psych-up" every athlete before competition is no longer found to be appropriate (Fisher, 1976b).

The motivational level of an athlete can mean the difference between winning and loosing. It is an elusive quality that first causes the athlete to select a certain sport in preference for another and then makes the person continue the activity with vigour and enthusiasm, even under adverse conditions (Singer, 1980). Terms such as motivation, drive, commitment, and mental toughness are used to describe the psychological involvement of an athlete making advantageous use of mental skills and strategies. The incentives of achievement, power, and affiliation are prime motivators in a sport situation (Watson, 1979).

There is a close connection between thought patterns and behaviour. A negative mental attitude leads to self-depreciatory feelings and loss of confidence which limit the person's performance. Such an attitude interferes with the positive motivation and healthy self-image needed for optimal performance. Only positive and assertive thought processes, together with realistic goal-setting will benefit the athlete and help him attain superior performance.

It must be emphasized that psychological training can only be seen to complement the marathoner's present physical capabilities. Training can never supply what does not exist but can only build upon prevailing qualities. Psychological conditioning may be seen to "fine-tune" physical aptitude by allowing physical skills to be exhibited and extended optimally. Rushall (1981) discussed the principle of balanced preparation as it relates to athletes:

> No longer can one seek simple, single ingredients for coaching and teaching which are believed to vastly affect performance. The implication of this principle is that training and teaching must integrate, with the appropriate emphasis, the physiological, biomechanical, and psychological factors that govern performance. To emphasize one area over another is an uninformed decision. The content of training must emphasize the three areas of applied sport science. If this is done, the content of most training and teaching programs will be vastly different to those which are witnessed today. (p.31)

The endurance aspect of long-distance running allows the psychologist to study the complex interaction between the mind and the body - the marathoner being a willing subject to suffer through 42.2 kilometres of stress, pain, fatique, and boredom. The question on the kind of thought processes that marathoners employ in order to cope with this exhausting event has only been touched upon. In this study a model was established that links the athlete's mental strategies to his/her perception of effort during the run. This model then formed the basis for the further enhancement of performance by steering the thought patterns and thought flow of the marathoner during training.

CHAPTER 2

MENTAL PRACTICE OF SKILL

Running is a skill that human beings learn very early in life. Although running represents a highly complex skill, once learned, it hardly needs any attention at all. The skill of running, therefore, is not expected to be enhanced much through mental practice. The task of running becomes automated and little information processing is required for its use in everyday activities (Jones, 1979; Perry & Sacks, 1981). The emphasis during a long-distance race, however, is on the maintenance of the activity of running rather than the single execution of the movement skill.

As the mental practice of skill knowledge represents the beginnings of the research into the mental facets of sporting activities, it will be briefly reviewed in this chapter to place subsequent research thrusts on the mental processes taking place during the execution of a sport into perspective.

One is quite familiar with the sight of an athlete concentrating before commencing a physical routine. During his mental rehearsal he thinks about individual steps of his ensuing movements, makes adjustments or alterations in his mind. Only then is he ready to execute his performance "live".

There is no doubt that physical practice leads to the attainment of skills. Yet to what extent mental practice can influence the learning of motor skills has been the focus of attention of many researchers over the past decades.

Not all motor tasks are characterized by the same degree of "motorness" (Martens, 1971). It is not easy to find a motor skill which may be designated as "purely motor", having no cognitive component at all. On close examination it will be noted that nearly all motor skills are in fact "perceptual motor skills" and thus will entail cognitive features. Hence, it may be assumed that the acquisition of a practical skill may be hastened by mental practice.

Mental practice has been defined by Richardson (1967a) as "the symbolic rehearsal of a physical activity in the absence of any gross muscular movements" (p.95). In the literature the technique of mental practice has also been studied under the headings of "symbolic rehearsal" (Sackett, 1935), "imaginary practice" (Perry, 1939), "implicit practice" (Morrisett, cited in Corbin, 1972), "covert rehearsal" (Corbin, 1967a), "conceptualizing techniques" (Egstrom, 1964), "mental rehearsal" (Singer & Witkin, 1970), and "psychomotor rehearsal" (Sterner & Carpp, 1977).

In order to obtain information on this issue of mental practice on the learning of motor skills, a multitude of experiments has been undertaken on a wide range of skills, on diverse subjects of differing abilities, and with a large amount of between-study variation. This has often led to incongruous and often contradictory results being reported in the literature. The general design of studies exploring the efficacy of mental practice on motor performance usually included four groups. The first group, the control, did not practise the skill at all, the second group practised the skill physically only, the third group practised the skill mentally only, while the fourth group practised the skill both physically and mentally.

The early beginnings of mental practice

One of the earliest and most important study on the effects of mental practice was undertaken by Vandell, Davis, and Clugston (1943). Thirty-six male subjects, made up of college freshmen, junior and senior high school boys, were divided into three separate experimental groups, using the skill of dart-throwing in two and basketball throwing in the third. The groups were matched on motor ability, age and physique. Each experimental group was further subdivided into a control, physical practice, and mental practice group. The control group practised the motor skill only on the first and the 20th day, the physical practice group exercised the skill overtly for 20 days, and the last group was introduced to the skill on the first day, but then continued to mentally practise the skill for 15 to 30 minutes each day until the final test of skill acquisition on the 20th day. Substantial improvements were accounted for in both the physical practice and mental practice groups. The dart-throwing junior high school boys decreased their performance in the control group by 2%, but increased their performance by 7% in the physical practice group, and by 4% in the mental practice group. The dart-throwing college freshmen showed no improvement in the control condition, but increased their performance by 23% in the physical practice condition, and by 22% in the mental practice condition. The basketball-shooting highschool boys increased their performance by 2% in the control, as well as by 41% in the physical practice group, and by 43% in the mental practice group. The lack of statistical analyses and the very small sample sizes in each group can be criticized, but the study stimulated further research.

The study by Twining (1949), using the ring toss as skill to be learned, incorporated statistical analysis. He found that the physical practice group had improved by 137.3%, whereas the mental practice group had improved by 36.2%, and the control group, with no practice over the 21-day period, by 4.3%.

The early research findings were reviewed by Richardson (1967a). Despite shortcomings in design, the majority of studies showed a definite improvement with mental practice of skill. Statistically significant results due to mental practice techniques were found in 11 studies, and a further seven indicated a positive trend.

Negative findings were reported by three researchers and one study was equivocal.

White, Ashton, and Lewis (1979), however, argued that later results do not seem to be as conclusive. They stated that although Oxendine (1969) found the combination of mental and physical practice to be more time-saving and effective than physical practice, mental practice only sessions have been shown to accelerate learning of a motor skill by Corbin (1967b) and Rawlings, Rawlings, Chen, and Yilk (1972), but to have been only of minimal use in the studies by Corbin (1967a), Shick (1970), Singer and Witkin (1970), and Stebbins (1968), and hardly effective in the study by Smyth (1975).

Theoretical propositions

Much research has concerned itself with the question whether mastery of a motor skill is due to a central or a peripheral process (Jones, 1965). Two main hypotheses have been proposed to explain the learning effects of mental practice on the aquisition of motor skills. Following Jacobson's (1932) electromyographical research, a psychoneuromuscular theory was proposed (Arnold, 1946) which suggests that thinking about a movement causes actual, though minimal innervations in the muscles associated with the movement of the motor skill. It is believed that this minute muscle activity provides sufficient kinaesthetic feedback to facilitate learning transfer to the physical practice situation.

The second hypothesis, the symbolic learning explanation, was first offered by Sackett (1934) who assumed that a task could be classified in terms of separate dimensions such as motor and symbolic. According to this explanation, mental practice can only enhance motor performance if cognitive factors are present in the activity. This concept received experimental support from Morrisett (cited in Richardson, 1967b) who stated that the relative amounts of motor and symbolic learning required to perform a skill will determine what conditions of mental or physical practice will be most advantages. Wrisberg and Ragsdale (1979) further supported the notion that mental practice enhances motor activity as an increasing function of the cognitive demand of the skill and that mental rehearsal has more effect during the initial stages of practice when cognitive or verbal activity is prevalent.

Fitts and Posner (1967) saw skill learning to entail three phases, starting with the cognitive phase, leading to the associative and then to the autonomous phase. This implies that as the subject improves on the skill being learned, his conscious involvement decreases.

Many present theories of skill aquisition maintain that skill learning is cybernetically controlled (Zecker, 1982), the most important one being the closed-loop theory propounded by Adams (1971). In order to make adjustments to movement, knowledge of results of the past movement acts as feedback, guiding and altering the continuous movement of the motor performance. The closed-loop system allows for error detection and error correction while the movement is in progress.

Methodological considerations

When studying the results of experiments on mental practice of motor skills, several methodological problems need to be considered, some of which have been discussed in the reviews by Richardson (1967a, 1967b), and Corbin (1972).

Most studies have not given sufficient importance to the instructions delivered to the mental practice group. Subjects have often been left to their own devices with minimal instructions on how to mentally practice the skill. Seldom was a set of instructions given as detailed as that of Whitely (cited in Richardson, 1967b) for mentally practicing the skill of ball-throwing:

> Try to see and feel yourself picking up the ball in your hand, taking the ball behind you as you transfer your body weight backwards onto your rear foot in preparation for the throw. Try then to imagine the second part of the action, in which having selected your point of aim on the target, you complete the throw with a forward twisting movement of the body and a forward movement of the arm and hand. Watch the ball during its flight; remember the target has been dusted with chalk and the place where the ball strikes will remain clearly marked after the ball has rebounded from the target. Give this

> mark careful attention and in your next throw try to make adjustments in your action and the selection of your point of aim, which you feel will result in a more accurate throw. I shall stop you in 15 minutes time. Now quietly concentrate. (p.268)

Besides verbal instructions being given to the mental practice group by the experimenter before the practice sessions, studies have also made use of films, film strips, direct observation of the skill being performed by someone else, continuous oral instructions or written instructions.

As it is often easier to mentally rehearse a skill more often in a given practice time than to physically execute the motion, a further variable is introduced. In order to control for possible variation, Start and Richardson (1964) issued an instruction sheet containing a logical analysis of the gymnastic movement which was used in conjuction with oral instructions.

Due to the immense variation in practice time per session used in the experiments, the question of an optimal length for practice sessions arises. Investigators should be aware of the phenomenon of reactive inhibition and try to minimize the effect of distraction due to loss of concentration in a lengthy mental practice trial session. From the study by Twining (1949) it seems that sessions should not last beyond 5 minutes. A loss of motivation may also be experienced by subjects if the trial sessions follow each other too closely without adequate breaks (Gilmore & Stolurow, 1951).

Linked with the problem of the optimum length of practice trials is the amount of days, weeks or months that the practice should extend over. Results from 1-day studies have often been compared with several week-long studies without consideration for possible paradoxial distance effects whereby decreases in performance level may result (Corbin, 1972).

Skills may be described as ideational (including mirror-drawing, maze-tracing etc.), perceptual motor, or solely motor, and it is perhaps the skill specificity that may determine the way in which mental practice can facilitate performance. Ryan and Simons (1981) found that on a motor-cognitive continuum, the skills close to the cognitive end of the continuum could be enhanced through mental practice, whereas the skills lying near the motor end of the continuum showed little or no resultant improvement after mental practice.

When drawing conclusions on the effectiveness of physical and/or mental practice on the learning of a motor skill, due consideration should be given to the individual differences of the subjects partaking in the experiment. The amount of previous experience of the skill under study was shown to have a direct influence on the effectiveness of mental practice (Corbin, 1967a, 1967b). This influence was shown to be significant only with complex motor skills (Phipps, cited in Corbin, 1972). Intelligence scores, within the range used, were not found to be indicative of ability to enhance performance through mental practice (Oxendine, 1969). Studies trying to elicit the relationship between performers' high motor ability and their capacity to utilize mental practice more advantageously have not brought forward conclusive results. The study by Wichman and Lizotte (1983) demonstrated that improvement on dart-throwing after mental practice was greater for subjects with an internal than with an external locus of control.

Imagery and mental practice

The role of imagery in mental practice studies has not been that widely studied yet. Several books have been written on how to improve certain sporting skills through imagery, based on personal experience. Publications like "Better golf without practice" by Morrison (1940), "Golf my way" by Nicklaus and Bowden (1974), "Fosbury on flopping" by Fosbury (1974), "The inner game of tennis" by Gallwey (1974), and "Inner skiing" by Gallwey and Kriegel (1977) brought the idea of mental practice into public focus.

In a controlled study by Start and Richardson (1964) it was found that neither vividness nor controllability of imagery could predict performance of a mentally rehearsed gymnastic skill. Interestingly, though, when the two variables were coupled, subjects with vivid, controlled imagery benefitted significantly from mental practice. Contrary to these findings, Rawlings and Rawlings (1974) suggested that visual imagery control was an important factor in the effective mental practice of a motor skill. Inhibitions developed during the mental practice session were believed to cause the improvement in performance in the rotary pursuit tracking task.

Marks (1977) performed a laboratory study on the efficacy of mental practice, also using a rotary pursuit tracking task and reported that subjects with vivid visualizing ability, as measured by a questionnaire (Marks, 1973), experienced significant benefits in the mental practice of this physically demanding psychomotor skill. This finding was substantiated by Ryan and Simons (1982) using a novel balancing task.

White et al. (1979) suggested that their significant correlation between kinaesthetic imagery and improvement of an action-reaction swimming start may be explained in terms of Schmidt's (1975) schema theory:

> One may speculate that the more clearly or more accurately, the person can imagine the particular series of actions involved, the more efficiently may he/she mentally practice them and smooth out the minor, or major, flaws in the action plan or schema. A poor image of the actions would be a degraded blueprint with the essential parts missing or so out of focus that the plan cannot be read off quickly and efficiently. (p.76)

In summary, there seems to be overall agreement that mental practice can enhance skilled motor performance, but for this to occur, practice conditions need to be optimal. Knowledge of this mitigating factor will ultimately determine the potential value of mental rehearsal in skill aquisition.

The reason for the diverse nature of skill research, which today is as multi-faceted as the definition of skills, is given by Adams (1971):

> Instead of starting with ideas about the laws and theory of movements and then finding the best situations in which to test them, investigators of skills have often started with tasks that looked skillful and, by studying them, hope to arrive at laws and theory. This approach is backwards for scientific productivity because it results in disconnected pockets of data that lack the unifying ideas that are general scientific principles. (p.112-113)

CHAPTER 3

PSYCHOLOGICAL TRAINING TECHNIQUES

While research into physical training techniques has been a long-standing and on-going process and has contributed to the rapid development of superior performance in many sports, research into the mental preparation of athletes for competition has been remarkably slow. But the situation is changing rapidly and sport psychologists are focusing their attention on the transference of traditional relaxation techniques and cognitive strategies from the clinical setting to the sporting realm.

The term "psychological preparation" was first used in the Russian sport literature in the 1960s by Roudik and Puni (Vanek & Cratty, 1970). This term denotes the psychological training for a specific sports event, whereas the general psychological preparation of the athlete was given the term "volitional-moral preparation".

Since then, the sport psychological literature reveals a multitude of references on the importance of including a psychological training programme into the physical regimen of the athlete (Singer & Kane, 1979).

"Mobilization readiness" (Genov, 1976), "psycho-emotional readying procedures" (Kauss, 1980a), "psycho-regulative procedures" (Schilling, 1980), "mental fitness" (Taylor, 1981), "psychical fitness" (Geron, 1976), "psyching-up strategies" (Weinberg, Gould & Jackson, 1980), "psychological momentum" (Hoffman, 1983; Iso-Ahola & Mobily, 1980), "fine-tuning" (Wenz & Strong, 1980) is some of the phraseology used when dealing with aspects of the athlete's psychological preparation for competition.

Suinn (1980c), in an analysis of principles and applications related to sports performance, described certain "correct responses" that are required of the athlete if he is to perform well. Correct responses are listed to be dependent on the following: isolated motor responses, preparatory or arousal responses, adapting responses, linking responses and cognitive or thought responses. Current psychological approaches to enhance these responses include progressive relaxation, systematic desensitization, autogenic training, meditation, hypnosis, biofeedback, mental imagery, and self-talk which will be discussed under separate headings in this chapter.

From the results of a questionnaire drawn up to tap information regarding the use of clinical psychology in the sport setting, Ogilvie (1979) disclosed that the problems sport psychologists have been most frequently called upon to treat related to, amongst others, pre-start tension, lack of concentration, stagnation in performance, achievement motivation, fear of success, mental blocks and loss of self-confidence. When sportsmen receive psychological "treatments", Weingarten (1982) reported that they reject extreme clinical procedures and prefer those connected with their body. This is seen to be natural as it is their physique that is held in highest esteem.

The following relaxation and psychological training techniques represent a general division of procedures employed to manage anxiety and enhance the athlete's performance. There is much overlap amongst the techniques described, and their efficiency in sport psychology need further verification. The current research undertaken with these methods has relied on small samples, often individual case studies have been cited, and control and placebo groups have, too often, been conspicuously absent. However, testing certain psychological training methods is made difficult by the fact that it is problematic to control for variables such as fluctuations in physical fitness, changing competitive environments, and the strict application of only one training technique.

Different athletes have different requirements, some being more affected by cognitive strategies, others more by emotional factors (Lanning, 1980). Therefore, the athlete needs to be acutely aware of his individualistic needs when applying any one of the multitude of psychological training methods or recently produced "training packages" offered to him.

PROGRESSIVE RELAXATION

The history of relaxation training goes back to the pioneering work of Jacobson (1929) who developed a relaxation method to relieve anxiety and tension, originally for hospital patients. In the preface of his classical book "Progressive relaxation" he wrote:

> There has been a long-felt need on the part of the medical and surgical profession for a method of study and management of the nervous element that appears in a large variety of diseases. Less clearly realized has been the want of an approach to problems of fatique, debility and lowered resistance occurring in patients who are not properly called neurotic but whose energy output in muscular terms might properly be economized in the interests of their general state of health.... In what direction is it more natural to look in order to meet the foregoing problems than that of rest? Rest has been found useful in treatment throughout the practice of medicine. Nature often enforces it where the physician does not order it. (p.iv)

Jacobson evolved a method whereby the neuromuscular system, as well as the mind, could be brought to rest through an extreme degree of relaxation. Relaxation of a muscle group was found to be physiologically incompatible with contraction of that same group, and therefore relaxation training was seen to combat the anxiety response by eliminating tension in the muscles.

Jacobson observed that a tense patient, apparently in a state of rest, will continue to show signs of mental activity, anxiety or other emotional arousal by breathing irregularly, fidgeting or uttering unneccessary speech. Such a person will retain symptoms of nervousness and fatique even after several hours of quiet. The person who is unpracticed in the technique of relaxation will show external bodily signs of "residual tension" brought about by fine tonic contractions of the muscles. Reflex activities such as wrinkling the forehead, frowning, rapid eye movements, frequent winking, and restless shifting of a part of the body may be noticed.

It is often not sufficient to tell an athlete who is suffering from anxiety to just relax because usually the individual does not know how, nor may he/she be able to detect which muscles in the body are tense. "Cultivated" relaxation, as opposed to "ordinary" relaxation aims first to teach the person to relax the voluntary system of the body which later leads to the quiescence of the vegetative system, resulting in the subsiding of the emotions. Under such conditions of rest, the pulse rate returns to normal, the breathing becomes more regular, the knee-jerk diminishes, the oesophagus relaxes, and mental and emotional activity become minimal. This pleasant and restful state may lead to natural sleep.

Jacobson taught his patients to recognize the presence of muscular contractions, no matter how minimal they were. In order to help the subject locate certain tensions in the body, Jacobson suggested that a "muscle sense" be cultivated whereby only one muscle group be contracted at a time, and then be allowed to relax before moving i.e. progressing to the next muscle group. Once proficiency was attained, the contraction phase was eliminated and attention was given only to the relaxation phase. Contraction in the early phases of the method was used to indicate that "progressive relaxation is not subjectively a positive something, different from contraction, but simply a negative" (Jacobson, 1929, p.49) and that the act of relaxation did not involve the application of effort.

Patients who managed to attain a high skill in progressive relaxation reported that with complete ocular relaxation, they experienced the disappearance of mental activity, thought processes, and emotional imagery.

Jacobson's training schedule was extremely time-consuming and detailed: it entailed 15 different muscle groups undergoing progressive relaxation over 50 - 200 sessions. Wolpe (1958, 1969), who incorporated Jacobson's relaxation technique in the context of behaviour therapy, shortened the technique substantially. This shortened version forms the basis of most of today's relaxation procedures which have been adapted to suit specific circumstances and individuals (Franke, 1982).

It is recommended that subjects at first lie comfortably on their back with their arms at their sides and with legs uncrossed, but a sitting position or any alternative comfortable position may be adopted at a later stage with no decrease in results (Wolpe & Lazarus, 1966).

Although the exercises in the relaxation training appear very simple, the essence lies in their regular practice over weeks or months. With dedicated practice, progressive relaxation can be a powerful dominant response in a stressful sporting situation.

A sample set of instructions, developed by Steinmetz (cited in Greenberg, 1983), is given below:

> Now, as you relax, clench your right fist.
> Clench it tighter and tighter, and study the tension as you do so.
> Keep it clenched and feel the tension in your right fist, hand and forearm.
> Now relax.
> Let the fingers of your right hand become loose.
> Observe the contrast in your feelings.
> Now, let yourself go and try to become more relaxed all over.
> Once more, clench your right fist really tight.
> Hold it, and notice the tension again.
> Now, let go, relax, let your fingers straighten out.
> Notice the difference once more.
> Now repeat that with your left fist. (p.160)

Progressive relaxation has been found to be very beneficial in the sporting environment where athletes are exposed to extreme stress before and during competition. The method is experiencing a new growth period in the field of sport psychology (Fisher, 1976b).

The great advantage of the method of progressive relaxation is that the athlete is in full control over his own relaxation. In endurance events such as long-distance running it has been found that high levels of tension prior to and during the race can have a detrimental effect on the athlete's performance (Oxendine, 1976). By utilizing this technique the athlete is in a position to check and adjust the tension in the body or in a specific group of muscles and, thereby, assume an active role in the control of his level of arousal. Many athletes also use progressive relaxation to get to sleep the evening before a competition.

Jacobson's technique has been employed in studies on individual athletes as well as on sports teams with beneficial performance changes (Franke, 1982; Nideffer & Deckner, 1976). Progressive relaxation is often not used in isolation, but combined with other mental rehearsal and imagery techniques to facilitate optimum performance (De Witt, 1980; Gravel, Lemieux & Ladouceur, 1980; Suinn, 1980c; Wenz & Strong, 1980).

SYSTEMATIC DESENSITIZATION

Systematic desensitization is a behaviour modification procedure derived from classical conditioning. Developed by Wolpe (1958), it is primarily used by clinical psychologists and psychiatrists to treat fears or phobias.

The object of the procedure is to diminish a maladaptive response by concentrating on an antagonistic response. The relaxation response is seen to be incompatible with the anxiety response, i.e. a person cannot be relaxed and tense at the same time. Therefore, during the process of desensitization, the patient is first introduced to relaxation training eg. Jacobson's (1929) relaxation technique, and learns to alternatively tense and relax various muscles. The next step in systematic desensitization is the establishment of an "anxiety hierarchy" consisting of a list of stimuli that produce the anxiety, which are ranked in order from the least fearful to the most anxiety eliciting item.

During the desensitization procedure, the patient sits comfortably in a chair, with eyes closed, while being asked to visualize the first scene of the hierarchy list. Should no noticeable anxiety be experienced, the therapist describes the next item on the list. No move to the next stimulus of the hierarchy is made before the patient can cope with the given anxiety cue. Gradually, the patient is able to pair relaxation with strong anxiety-eliciting cues without feeling aroused (Kazdin, 1977). Finally, once the patient has managed to eliminate the anxiety response in the laboratory setting, transfer to the real life environment of the feared stimuli needs to be undertaken.

Systematic desensitization may also be successfully used in a sport setting (Bauer, 1977; De Witt, 1980; Spinelli & Barrios, 1980; Ziegler, 1978). Some athletes need to lessen their anxiety with a method other than basic relaxation, which might not sufficiently reduce the extreme anxiety experienced. The trauma of a past injury received during the sporting activity or the phobia of performing in front of a large spectator crowd can adversely affect an athlete's performance. The deconditioning process of systematic desensitization may be an effective remedy of helping the athlete perform to his/her optimal capacity.

A sample of an individualized anxiety hierarchy for a marathon runner, who experiences serious, debilitating anxiety symptoms at the start of every important race, could look as follows:

1. Driving to the stadium
2. Observing the crowds of people from a distance
3. Seeing other racers warm up
4. Recognizing opponents
5. Warming up
6. Hearing the first call-up through the loudspeakers
7. Moving towards the starting line
8. Tremor in hands and legs
9. Shortness of breath
10. Palpitations of heart

11. Standing in the midst of the noisy competitor crowd
12. Hearing the shot of the start of the race.

Panic before or during a competition uses up valuable energy, which cannot be afforded. Through gradual exposure to the anxiety stimuli the athlete is taught to relax and conserve enery for the run.

AUTOGENIC TRAINING

Autogenic training may be considered a relaxation procedure with a unique theory and procedure. Around the turn of the 19th century, the brain physiologist, Oskar Vogt, noted that patients were able to put themselves into a state similar to the hypnotic state and report decisive recuperating effects. The condition of "autohypnosis" brought about a decrease in fatigue, tension and psychosomatic disorders.

In the 1950s the German neurologist and psychiatrist, Johannes Schultz, noted that his hypnotized patients experienced two types of sensation: a feeling of heaviness in the limbs and torso, and a feeling of agreeable body warmth. This correlation suggested that a state similar to that of hypnosis might be induced by concentrating on heaviness and warmth in the extremeties. Based on the observations of Vogt, Schultz (1953) developed "autogenic training" using six standard exercises orientated towards the body and further meditative exercises orientated towards the mind.

The feeling of warmth was ascribed to the dilation of the blood vessels with a resultant increase in blood flow, while the sensation of heaviness is due to the relaxation of muscle groups. As both these phenomena are elements of the relaxation response, autogenic training has become a very useful relaxation technique for people having to cope with stress. Originally, the technique was employed on neurotic patients, but through the descriptions of Schultz's student, Luthe (1962, 1969), it soon became popular among healthy individuals who sought to regulate their physiological and psychological processes.

Extensive experimental tests have been undertaken to verify the physiological processes taking place during autogenic training (Cratty, 1983). Physiological changes that accompany the technique include alterations in body temperature, blood sugar, blood pressure, white blood cell count, respiratory and heart rate, generation of alpha waves, and skin resistance (Hendricks & Carlson, 1982; Luthe, 1969).

The six "standard exercises" of autogenic training that precede the second phase of autogenic meditation should be practiced in a quiet surrounding, either in the reclining or seated position, with eyes closed. The first exercise focuses on the sensation of heaviness in the arms and legs, the second exercise focuses on the sensation of warmth in the arms and legs, the third exercise focuses on the sensation of heaviness and warmth in the area of the heart, the fourth exercise concentrates on the process of breathing, the fifth exercise focuses on the sensation of warmth in the abdomen, and the sixth exercise focuses on the sensation of coolness of the forehead.

Successful use of Schultz's technique of autogenic training initially depends on the effective instructions of an experienced clinician, and on the high motivation and co-operation of the subject, who should be reasonably intelligent, be able to concentrate intensely, and be reasonably suggestible.

Sample instructions for each of the six exercise stages are given below:

Stage 1: Heaviness
My right arm is heavy
My left arm is heavy
Both of my arms are very heavy
My right leg is heavy
My left leg is heavy
Both of my legs are very heavy
My arms and legs are very heavy

Stage 2: Warmth
My right arm is warm
My left arm is warm
Both my arms are very warm
My right leg is warm
My left leg is warm
Both of my legs are very warm
My arms and legs are very warm

Stage 3: Heart
My heartbeat is calm and regular (repeat four or five times)

Stage 4: Respiration
My breathing is calm and relaxed
It breathes me (repeat four or five times)

Stage 5: Solar plexus
My solar plexus is warm (repeat four or five times)

Stage 6: Forehead
My forehead is cool (repeat four or five times)
(Greenberg, 1983, p.148-149)

The second phase includes instructions for the self-regulation of the mental state, in which the individual visualizes colours and people and himself in various situations with different feelings.

Although it usually takes several months to become proficient in the use of autogenic training, once mastered, it is especially useful for fast relaxation in a competitive environment. For this reason it has found new and effective application in the realm of sport (Mühlen, 1974; Reschetnikow, 1980; Schilling, 1980). With continued practice, even short autogenic phrases, such as "I feel strong, relaxed and in control" before or during competition can bring about the desired relaxed state of mind and body (Wenz & Strong, 1980).

As autogenic training is a relaxation technique, several modified versions have arisen to allow it to be integrated with various other readying techniques (Cernikova & Daskevic, 1972; Frester, 1972;

Machak, cited in Vanek & Cratty, 1970; Schmidt, 1971). Also related is the Russian adaptation called "psychical self-regulation" (PSR), a method designed to allow the athlete to mentally regulate certain physiological functions (Hickman, 1980).

MEDITATION

The roots of meditation are to be found in the Eastern religions of India and Tibet some 4000 years ago; but the practice of meditation in the West has been popularized since 1959 mainly due to the efforts of the Indian Guru, Maharishi Mahesh Yogi, who developed a simple form of meditation that anybody can easily learn, called "transcendental meditation" (TM). The technique was designed for the individual living in a stressful, competitive city environment. The different meditative systems, including Yoga and Zen, involve various techniques for attaining their goal. These include breathing exercises, focusing attention on an object, or repeating a mantra, the secret Sanscrit syllable assigned by a teacher.

Layman (1978) pointed to various common features among the Oriental approaches to meditation:

> As far as technique is concerned, all stress the importance of an erect posture permitting

> deep and easy breathing, and all state that the meditative position should be a relaxed one. All stress that meditation is in terms of contemplation of concrete sensory images rather than engaging in reflective thinking or logical reasoning. All seek to develop awareness of the present, with lack of concern for the past and future, and all provide training in concentration of attention. All are based on a theory of the unity of all aspects of the universe, and see meditation as a means of increasing awareness, eliminating illusory thinking, stilling the mind, stabilizing the emotions, and making more energy available for the activities of life. (p.267)

Although most of the meditational systems form part of a religious dogma, the techniques may nevertheless be practised independently for the benefit of relaxation and optimizing performance.

Early research into the physiological effects of meditation was undertaken on the Indian yogis and Zen masters (Anand, Chhina & Singh, 1961; Katsamatsu & Hirai, 1966). Recent scientifically controlled studies have reported the following physiological changes due to meditation: decreased oxygen consumption, lowered heart rate, respiration and blood pressure, decreased galvanic skin response, lowered metabolic rate, increased blood flow in peripheral muscles, and the appearance of Alpha waves (Allison, 1970; Goleman & Schwartz, 1976; Kanellakos, 1976; Layman, 1978; Orme-Johnson, 1973; Wallace, 1970; Wallace & Benson, 1972). The changes noted are opposite to those induced by a stressful event (Bloomfield, Cain, Jaffe & Kory, 1975).

According to Layman (1978) neurological research on meditation points to the activation of the non-dominant hemisphere of the cerebral cortex which is involved in intuitive thought, perception, kinethesis and spatial motor behaviour, which could indicate a relationship between meditation and sporting performance.

Besides reducing anxiety, meditation has been shown to be related to an internal locus of control, greater self-actualization, more positive feelings after a stressful event and improvement in sleeping patterns (Greenberg, 1983). It is, therefore, not surprising that meditation has been applied extensively in a sport setting (Herrigel, 1953; Reddy, Bai & Rao, cited in Layman, 1978; Rohe, 1974; Spino & Warren, 1979).

Meditation may be particularly useful to athletes who need to maintain control over fine motor co-ordination and timing (Nideffer, 1981). During meditation the individual learns to avoid distractions by concentrating on some sensory image or on the repetitive mantra. The ability to attend passively to distractions may be utilized by the runner in a competitive situation to focus his/her attention back to counting, pacing and relaxed breathing.

HYPNOSIS

The development of modern hypnosis as a field of study about

200 years ago is generally attributed to Franz Anton Mesmer, who claimed that an animal fluid, a life force akin to magnetism, flowed between patient and magnetist and could help bring about cures. Only later was it recognized that the hypnotic effect was a result of suggestions given to the patient.

Although hypnosis has been associated with the mystical, the strange and the sensational, it has in recent times found widespread application in the medical and psychological field (Coe, 1975). By accepting suggestions during hypnosis patients have been treated for chronic anxiety, tension, insomnia, addictions, obesity, and cigarette smoking. Hypnosis has also been found helpful in relaxing patients before an operation, and as a method to relieve pain. Other hypnotic experiences include phenomena such as distortion of perception and memory, hallucinations, amnesia, and age regression.

Despite extensive research, there is no singly accepted theory on the altered state of awareness experienced during hypnosis (Barber, Spanos & Chaves, 1974; Coe & Sarbin, 1977; Hilgard, 1977; Orne, 1977).

The essential characteristics of most induction procedures are the continuous, repetitive verbal suggestion of the hypnotist leading to relaxation, focusing on the hypnotist's voice, feeling of drowsiness and heaviness of the eyes. The lethargy of the initial stages gives way to a hypnotic state in which the subject is responsive to the hypnotist's requests. While under the "control" of the hypnotist, the person can adjust such involuntary responses as respiration and heart rate (Barber, cited in Fisher, 1976a).

Pulos (1980) believed that when psychological factors play an inhibitory role, hypnosis can be helpful in relieving anxiety, building confidence, and increasing motivation:

> In the hypnotic mode, the conscious, critical mind interferes less and the powerful forces of the subconscious can be mobilized much more easily so that a more natural flow of the desired physical skill can take place. Thus overcoming the limitations of the conscious mind is a recurring theme of this approach in introducing the hypnotic mode to the athlete. (p.148)

During hypnosis people respond to suggestions in such a way that allows them to experience events as if they were actually happening. This phenomenon has found useful application in the sporting field (Morgan, 1972). Johnson (1976) pointed to the fact that experiments with hypnosis are not limited to those trying to elicit greater achievement from athletes, but have also concerned themselves with neuromuscular and psychological problems the athlete might be experiencing which hinder the athlete from performing optimally.

Sport psychologists have used hypnotic time regression successfully by focusing either on past optimal performances of the athlete or by rehearsing the athletic skill and noting incorrect responses which, too, are reproduced during visualization, and, therefore, become amenable to change (Johnson, 1961, 1976; Nideffer, 1981; Pressman, 1980; Pulos, 1980).

Some athletes reject the process of hypnosis as a training technique because they see it as a performance manipulation by an outsider and prefer to attribute their success solely to their own endeavours (Butt, 1976; Vanek & Cratty, 1970).

BIOFEEDBACK

Biofeedback is indicative of a stimulus-response approach to research and may be seen to have evolved from the scientific fields of psycho-physiology, learning theory and behaviour therapy.

Katkin and Goldband (1975) defined biofeedback as follows:

> Biofeedback refers to any technique that uses instrumentation to provide a person with immediate and continuing signals concerning bodily functions of which that person is not normally conscious. Usually, biofeedback connotes external feedback from visceral organs such as the heart or blood vessels, but it also refers to feedback from any physiological function, including central nervous system activity (brain waves) and peripheral striate muscular activity. (p.537)

By observing biofeedback instrument readings, the subject can detect the effect of different feelings, thought processes, and sensations on the physiological functions of the body.

The application of feedback in the past has been mostly directed towards the treatment of specific disorders, such as headaches, hypertension, asthma, and psychological complaints of anxiety and tension.

Although this technique of biofeedback has only recently found relevance in the field of sport in the West, much work has been done in Eastern Europe and the Soviet Union in the past decades using biological monitoring devices to objectively assess emotional arousal states of athletes (Cratty, 1983). Biofeedback offers a means of adjusting anxiety levels to allow for a desired, optimal performance.

Early research in biofeedback was directed towards the demonstration that body processes previously acknowledged to be involuntary could, in certain circumstances, be brought under voluntary control. It was established that subjects could influence, amongst others, heart rate, blood pressure, brain waves, galvanic skin response, blood flow, gastro-intestinal functions, breathing, and muscle tension (Green & Green, 1977; Kamiya, 1968; Kimmell & Hill, 1960; Shearn, 1962).

An accepted explanation of the biofeedback process is detailed by

Ziegler (1978). The subject's attention is diverted from the source of stress to the internal body feedback. This new focus helps to reduce the arousal output to the internal organs and decreases tension in the muscles, with a concomitant stimulation decrease to the central nervous system. The repeated cycle of events conditions the central nervous system to cope with more stress and enhances the memory function to elicit the relaxation response.

Instruments involved in biofeedback training include the thermister for skin temperature feedback, electromyography (EMG) to measure muscle activity, electrocardiography (EKG) to measure heart rate, electroencephalography (EEG) to indicate brain wave frequencies, and the Galvanic skin response (GSR) apparatus which measures palmar sweat gland activity. The ultimate goal, though, of biofeedback training is the voluntary self-regulation of physiological processes without the help of instruments. The equipment is to be used as a training device and is not designed to be utilized on a routine basis during stressful situations in the sporting arena.

Biofeedback may teach the athlete selective control over physiological processes and be considered a useful supplement to relaxation training, systematic desensitization, or cognitive training (Bauer, 1977; Benson, 1975; Blanchard & Epstein, 1978; De Witt, 1980; Wenz & Strong, 1980).

MENTAL IMAGERY

Mental imagery may be viewed as the visual copy of a memory, or objects, or processes which is experienced without the equivalent sensory stimuli being present again. The concept of mental imagery and its related terminology such as mental practice, mental vision, inner seeing, visualization, the mind's eye, covert imagery, and the Russian term ideomotor training, has received much attention in the past in philosophy, medicine and psychology. Sheehan (1978), in his study on mental imagery, finds it disappointing that, although the existence of imagery is undebatable, we are still unable to define its nature.

Clinical use of predetermined imagery has found considerable application in the field of cognitive behaviour modification (Cautela, 1970; Lazarus & Abramovitch, 1962; Paul, 1966; Wolpe, 1958). The early research by Jacobson (1930) contributed extensively to the understanding of mental imagery, by revealing that visualization and muscular activity occurred concurrently. The mental imagery of running, for example, causes minute, though measurable tension in the muscles of the leg. Later studies have confirmed the simultaneous autonomic activity with covert imagery (Barber & Hahn, 1964; Craig, 1968).

Although visualization techniques have been practised for a long time, they have only recently been introduced on a formal and controlled basis to the environment of sport. The initial studies on mental imagery concerned the mental practice of motor skills; the detailed review by Corbin (1972) indicating that mental rehearsal could, in cases, positively influence motor skill performance (see Chapter 2). Yet Silva (1982) has pointed to the difference between these studies and the use of mental imagery techniques in clinical psychology:

> In most physical skill research mental rehearsal is often utilized exclusively as the intervention strategy to improve behavioral output or performance. What was actually rehearsed or covertly conditioned has often been poorly defined and seldom systematically controlled by the experimenter.... Cognitive intervention in clinical settings often occurs over a period of weeks or months. Most physical skill studies provide very short-term intervention sessions, and a one-treatment approach is not uncommon. (p.445)

As it is highly unlikely that any athlete does not make use of some form of mental imagery in training for his performance, "imagination is probably the most widely applied mental tool in modern sports" (Hickman, 1980, p.119). Yet this does not imply that the athletes are using the correct or most beneficial mental imagery in their preparation for the sporting event. For mental imagery to make a contribution towards optimal performance, it needs to be controlled, modified and elaborated, and be practised like a skill (Syer & Connolly, 1984). Only then can the use of mental rehearsal hope to enhance performance.

Some basic principles of mental imagery rehearsal in regards to sport training have been given by Liebetrau (1982):

1. The athlete should have some previous experience in the sport. Mental practice, therefore, should not be used to teach an athletic skill.
2. Mental imagery rehearsal should not be used in isolation, but rather as a vital adjunct to physical practice.
3. The continuous mental imagery rehearsal of a certain action can lead to automatic, intuitive performance that often results in superior achievement. During the visualization process the athlete can practise a variety of movements, and condition himself to novel competitive situations without actually previously encountering them.
4. Another use of mental imagery rehearsal is the detection and analysis of certain weaknesses in style or strategy, without having to make mistakes in an important competitive event.
5. Tense-scene mental imagery should only be used during practice sessions in order to highten arousal or aggression, if needed, but would act as a distraction if used during competition.
6. During mental imagery rehearsal the athlete can imagine himself going beyond his physical practice results and thereby not limit his expectations for future performances.

Mental imagery of various kinds and in various forms have been utilized to help the athlete become a better performer. Hickman (1980) described a typical training method which should help the athlete create appropriate task-related visual imagery:

1. Choose a time and place in which you will be undisturbed for 15 minutes and assume a comfortable posture.
2. Close your eyes, breathe deeply into the chest and abdomen, and relax completely for two or three minutes.
3. Create a blank white screen in your mind, focusing on it very clearly.
4. Imagine a circle which fills the screen and slowly make the circle blue.
5. Develop as rich and deep a blue as possible, then slowly change to another color, repeating this procedure through four or five colors.
6. Allow the images to disappear, relax, and observe the spontaneous imagery which arises.
7. On your blank screen, create the image of a glass (a simple object), develop it clearly in three dimensions, fill it with a colorful liquid (like coffee or kool-aid), add some ice cubes, insert a straw, and write a descriptive caption underneath.
8. Allow the image to fade and repeat the process with other objects (choose items associated with your sport).
9. Relax and observe the spontaneous imagery which arises.
10. Select a variety of scenes and develop richly detailed images of them (practise with sport related environments such as a swimming pool, a track, etc.).
11. Relax and observe.
12. Practise visualizing people, including strangers, close friends, and yourself.
13. To end each session, breathe deeply three times, slowly open your eyes, and adjust to the external environment. (p.120-121)

The afore-mentioned visualization technique is seen to be directed outwards, in contrast to the inner directed visual imagery experience described by Murphy and White (1978). Athletes have claimed that they sometimes focus on their own organs, muscles and blood vessels, and that this "inner seeing" allows them to have some control over their physiological processes.

When reviewing the sport literature, it may be evidenced that many mental imagery-rehearsal techniques have lately sprung to the fore and are being offered to the athlete for improving performance. Many use various cognitive adjustment procedures in combination with relaxation techniques (Gordon, Pfost & Stevens, 1982; Long, 1979; Smith, 1979).

The cognitive intervention procedure for the enhancement of sport performance by Silva (1982) entails three phases. During the initial phase the researcher tries to identify a cognitive set that is believed to be the cause of inappropriate responses or dissatisfactory performance. In the second phase, called the restructuring phase, the athlete needs to accept that certain images or thought processes can have negative performance consequences and, therefore, must be replaced by more productive, cognitive ideas. Only once the athlete demonstrates a belief in the necessity of such a modification, Silva insisted, may the ensuing covert conditioning prove to be effective. During the last phase, self-instructional imagery is paired with concentrative cues.

Visuo-motor behaviour rehearsal

A technique known as visuo-motor behaviour rehearsal (VMBR), which was developed by Suinn (1972b) and first applied in a sport setting to help skiers manage their pre-competition anxiety, has received much attention (Gravel et al., 1980; Hall & Erffmeyer, 1983; Lane, 1980; Noel, 1980; Spinelli & Barrios, 1980; Weinberg, Seabourne & Jackson, 1981). The first step in the comprehensive training programme involves the teaching of an abbreviated version of Jacobson's (1929) progressive relaxation technique. The athlete needs to be aware of tensions in his muscles and have a method at his disposal to physically and mentally monitor his arousal response just before or during the stress of competition. Once the athlete has mastered the relaxation exercises, he should use mental imagery to rehearse his athletic skill. Suinn (1980b) believed that the imagery experienced during relaxation is more than just a visual phenomenon, but is also a "tactile, auditory, emotional and muscular" (p.308) experience.

To show that the imagery during VMBR lies on the reality end of a continuum of imagery, with dream imagery on the far end, EMG measurements were recorded of an alpine skier while he visualized completing his ski course. Jumps and turns, which require extra muscle activity, showed up with increased EMG recording activity measurements (Suinn, 1980c). Suinn (1980b) elaborated:

> The imagery of visuo-motor behavior rehearsal apparantly is more than sheer imagination. It is a well-controlled copy of experience, a sort of body-thinking similar to the powerful illusion of certain dreams at night. Perhaps the major difference between such dreams and VMBR is that the imagery rehearsal is subject to conscious control. (p.308)

Errors in the performance of a skill may be corrected by visually rehearsing the athletic skill in slow motion (Suinn, 1972a).

The third and final step involves the transfer of the learned skill to the competitive situation. Cratty (1980) pointed to the importance of matching the practice demands as closely as possible to the real competition or race, as both physical and psychological factors can have a novel, usually negative, influence on the athlete. Thus VMBR can help an athlete become completely familiar with racing tactics and the conditions of the course.

As the athlete's level of arousal prior to and during competition can lead to muscle tenseness, reduced efficiency and incorrect attentional focus, the athlete needs to prepare himself psychologically for the stress of competition. In this regard, Suinn (1980b) suggested that on race day the athlete either visualize a previously successful performance to build up confidence, or, should he be anxious about certain executions during competition, practise these mentally until they become automatic. Preparation for the impending competition should continue once on the site of the race or tournament. Bodily stress signals should be noted and countered through further use of VMBR.

After having attended to the US ski and US biathlon teams during the Winter Olympics in 1975, Suinn (1977) described his psychological training programme as an action- or behavioural-oriented technique aimed at enhancing performance.

SELF-TALK

People's emotional reactions and verbalizations are directly related to their belief-system, their thoughts, their prejudices, their attitudes and their self-confidence. Language, it was found, can play an important role in determining our emotional state (Dollard & Miller, 1950). Therefore, self-verbalizations, be they expressed aloud or as thoughts, exert a powerful influence on a person's behaviour and reactions. As self-talk may be either positive or negative, the effect can have either advantageous or disadvantageous consequences on an individual's performance. Liebetrau (1982) believed that self-talk can be viewed as the single most important determinant of success in the field of sport, besides the athletes physiological potential and physical fitness.

According to Ellis (1962), who developed the rational emotive therapy (RET), certain irrational beliefs, assumptions or expectations can lead to maladaptive behaviour. He concluded:

> If ... people essentially become emotionally disturbed because they unthinkingly accept certain illogical premises or irrational ideas, then there is a good reason to believe that they can be somehow persuaded or taught to think more logically and rationally and thereby to undermine their own disturbances. (p.191)

Later findings validated the observation that the type of self-statements an individual makes bears a relationship on his emotional reactions (Goldfried & Goldfried, 1980).

Zastrow's (1979) self-talk therapy, based on Ellis's theory of human functioning, sought to help individuals remove undesirable emotions, gain in self-confidence and achieve a healthier self-image through rational, positive verbalizations. Zastrow propounded the following theme: "You can be whatever you choose to be. Your self-talk makes you what you are, and you can change your self-talk to become what you want to be" (p.2).

Only knowledge of the relationship between the quality of one's thoughts and the resultant actions can result in an individual performing to the optimum of his ability. Athletes, who consistently belabour themselves with any of the following kinds of statements, are not creating an internal environment that is conducive to peak performance:

1. Fear
"I'm afraid we are going to lose."
"I'm afraid I'm never going to get any better."
"I'm afraid I'm not playing well."
"I'm afraid I'll make stupid mistakes."
"If I goof up they (teammates, coaches, fans) won't like me."
"What if I choke at a crucial time?"

2. Lack of self-confidence
"I don't believe I can improve."
"I never win the big ones."
"My opponent is better than I."
"I'm too old, too slow, too short, too tall, (etc.)."

3. Self-condemnation
"I always screw up things."
"That was a dumb shot."
"I should have known better."

4. Poor concentration
"I can't keep my mind on what I'm doing."
"It's hard to get really absorbed."
"I get in a groove and then 'bang' I lose it."

5. Trying too hard
"The harder I try, the worse I get."
"I can't seem to relax out there."

6. Lack of willingness to win in competitive sports
"I can't get pumped up for the game or match."
"I lack the killer instinct."
"I feel better when I am losing."

7. Perfectionism
"I am never content with my performance."
"I'll never be as good as I want to be."

8. Self-consciousness
"I am always self-conscious about how I'm doing."

9. Frustration
"I can't shake off a mistake."
"I feel like quitting when I miss a shot."

10. Anger and blame
"I'm so mad at myself I can't think."
"The referee is calling them wrong. He can't see straight."
"How can he (opponent) do that to me?"
"The coach is always picking on me."

11. Boredom
    "It's hard to get excited about this anymore."
    "It isn't much fun anymore."

12. Expectations
    "I never can reach the coach's expectations of me."
    "I guess I just don't expect enough of myself."

13. A busy mind
    "I am too busy thinking about what to do to actually do it."
    "I try to remember everything I've learned but I can't." (Weinhold, 1982, p.125-127)

Several psychologists have studied the mental techniques used by individual athletes just prior to performance and have found that several types of self-talk strategies are employed. Allmer, Sonnenschein, and Tradt (1979) explored the effectiveness and frequency of various "naive Techniken", i.e. self-taught psychoregulative methods including self-talk used by athletes in diverse sports. They suggested that these individualized mobilization/relaxation techniques should not be underrated by the coach or the athlete, but should be tested for their continued effectiveness at regular intervals.

Shelton and Mahoney (1978) reported the following findings on the content of psyching-up strategies amongst weight-lifters before a strength test:

> Self-efficacy strategies were ... exemplified by statements such as "I told myself that I could do it". Attentional focus is illustrated in one subject's focus on "concentrating on having those muscles react better". Preparatory

> arousal strategies were intended to "get yourself excited, get your blood moving, squeeze down with all your might, and get mad and give it one big surge with all your might". Finally, the use of imagery was exemplified by the subject who said: "I pictured myself, first of all, doing it. I pictured myself squeezing it and pulling every ounce of strength that I had in my body into that one wrist. I just concentrated as hard as I could on that one ... just on my hand and making it close no matter what. I just tried to close my hand." (p.282)

Similar thought categories were found by Weinberg, Gould, and Jackson (1980), and Caudill, Weinberg, and Jackson (1983), the latter researchers adding a statement category designated "religious beliefs".

While studying the effectiveness of a cognitive behavioural treatment package for cross-country ski-racers, Gravel et al. (1980) classified the athletes' thoughts prior to competition into five themes: (1) ruminations of self-depreciation (2) failure ruminations (3) pain ruminations (4) climatic and topographical ruminations and (5) other ruminations including family and work problems. The researchers used a technique called "thought-stopping" to reduce the occurrence of the maladaptive, performance inhibiting thoughts. Whenever the athlete indicated that the ruminations were beginning to appear vividly during imagery sessions, the therapist would shout the word "stop" and simultaneously produce a loud noise.

In an effort to explore the nature of attentional processes determining the performance of athletes, Etzel (1979) studied the attentional capacity of 71 international rifle-shooters. He postulated that attention was a psychological phenomenon, reflecting five relatively independent dimensions which could be revealed by analyzing typical task-related utterances: (1) Thoughts about capacity eg. "When I experience 'match pressure', it seems that I must exert more mental effort to perform well." (2) Thoughts about duration eg. "I cannot regularly focus my attention solely on my performance for more than 10 seconds at a time." (3) Thoughts about flexibility eg. "I can rapidly change the focus of my attention from external to internal portions of my shooting performance." (4) Thoughts on intensity eg. "I feel better prepared to deal with the task of shooting when I am well rested and alert." (5) Thoughts about selectivity eg. "When I'm shooting, it's not difficult for me to shut out everything but thoughts concerned with my performance." (adapted from p.286)

Gallwey and Kriegel (1977) pointed to the potential consequences of self-verbalizations by distinguishing between an "outer game" and an "inner game" in competitive sports. The outer game deals with technique and skills necessary for executing the sport, whereas the inner game refers to the thought processes taking place in the athlete's mind before or during the game. It is often during this inner game that a battle rages between "self 1", the voice that criticizes, judges, worries and pontificates, thereby distorting the perceptions and the natural potential of the body, called "self 2". The assumptions relating to the inner game, though not laboratory tested, and the recommendation of avoiding too much critical self-talk has helped many performers. Cobb, Kahn, and Cath (1977), too, warn of the dangers of listening to inner dialogues which often reflect unfulfilled expectations and a conflict between the real self and the ideal self.

Increased attention has recently been given to the important role a cognitive variable, like positive self-image, can play in the enhancement of performance (Fisher, 1976a; Mahoney, 1974; Meichenbaum, 1977). Bandura's (1977) theory of self-efficacy which aroused much interest, analyzed the effect of perceived self-efficacy on performance:

> The strength of people's convictions in their own effectiveness is likely to affect whether they will even try to cope with given situations.... Given appropriate skills and adequate incentives, however, efficacy expectations are a major determinant of people's choice of activities, how much effort they will expend, and how long they will sustain effort in dealing with stressful situations. (p.193-194)

Investigations into the relationship between the athlete's expectations and performance output have been extensively reported in the sport psychological literature (Feltz, Landers & Raeder, 1979; Highlen & Bennett, 1979; Mahoney & Avener, 1977; Nelson & Furst, 1972; Rotella, Gansneder, Ojala & Billing, 1980;

Weinberg, Gould & Jackson, 1979).

An athlete's perception of his physical capabilities will influence his self-confidence and in turn, determine the nature and direction of the self-talk employed. Therefore, a person with high self-esteem will have faith in his capability and have an optimistic outlook on future performances and engage in positive self-talk. He expects to be successful and usually is. But the person with low esteem is caught up in a vicious circle, whereby his poor judgement of his abilities and his negativistic attitude to competition leads to unsatisfactory performance which leads to lower self-confidence and defeatist self-talk. The individual's self-serving biased reasons for performing well or poorly have been studied (Fitch, 1970; Heider, 1958). Most research reports that a successful individual attributes his achievement to internal factors such as ability and effort whereas an unsuccessful person attributes his failure to external factors such as environmental conditions and bad luck.

A method to improve self-confidence has been forwarded by Railo and Unestahl (1980), called "symbol and anti-symbol training". In order to train away a defeatist attitude, the athlete first has to engage in as many negative thought associations as possible and translate these into symbols meaning words, sentences or pictures. The proceeding step would then be to establish anti-symbols, thereby replacing the negative reactions with positive thoughts and verbalizations. This training helps to "program the unconscious with positive steering impulses" (p.258).

Various researchers have designed cognitive intervention programmes to study their effect on sports performance, including strategies such as preparatory arousal, imagery, attentional focus, self-efficacy statements and self-talk (Barling & Bresgi, 1982; Gould, Weinberg & Jackson, 1980; Meyers & Schleser, 1980; Meyers, Schleser, Cooke & Cuvillier, 1979; Weinberg, Gould, Jackson & Barnes, 1980). Comparing results is complicated by the fact that experiments have been performed on diverse conceptual-cognitive activities with varying levels of task complexity, such as motor performances involving speed, strength and endurance, sport skills such as gymnastic movements and tennis serves, and games such as basketball. The aims, too, have often not coincided, with some designs setting out only to improve on the skill while others aimed to reduce stress as well. Weinberg, Gould, Jackson, and Barnes (1980) raised two further issues in connection with the possible facilitatory effect of cognitive strategies on performance. Firstly, cognitive strategies may need to be practised before they are applied to improve performance, especially on complex tasks and secondly, individuals might possess different preferences for using specific cognitive techniques.

From the above discussion it becomes clear that the arbitrary imposition of cognitive strategies on athletes yield, until now, very unpredictable and unsatisfactory results. Much future research is needed to clarify the role of mental strategies to effect emotional and cognitive changes to optimize athletic performance.

CHAPTER 4

MENTAL STRATEGIES DURING PERFORMANCE

The role of cognitive strategies in the attainment of optimum performance has recently received a surge of interest. A cognitive movement is clearly noticeable in the field of sport psychology, with many attempts being made to modify the athlete's behaviour by changing the way he thinks. The anecdotal wisdom of training being more mental than physical is being carefully scrutinized in sport psychology laboratories and in the field. Due to the fact that athletes are unable to change their genetic make-up and, therefore, cannot change their physical endowments, sport psychologists have turned to the potential of cognitions as an important auxilliary means towards athletic excellence. Tutko and Tosi (1976) stated it simply:

> Obviously, you can't control the weather or field conditions. You can't change the laws of nature applying to the trajectory of the ball. You can't change luck and you can't change the other players (much). But you _can_ be in control of yourself and your emotions - and thereby play your own game. (p.7)

Whereas the previous chapter focused on various relaxation procedures and psychological training techniques available to the athlete before the actual execution of the activity, this chapter will focus on the thoughts the athlete, specifically the runner, experiences during training or competition. The endurance nature of marathon running lends itself ideally to the study of the thoughts of a runner, as he sets out to cover the distance of 42.2 km. Hardly any other event offers as much time to implement mental strategies as does marathon running. There are hours filled with thoughts, reflecting the athlete's involvement with effort, fatigue, pain and boredom.

Cratty (1983) is one of the few researchers who has attempted to formulate a typology of the multifarious mental states that athletes find themselves in before and during performance. The classification system contains aspects of the athlete's mental activity under five main sections. In the first subdivision the thoughts of an athlete are analyzed according to whether the self-talk and mental programming are initiated on his or her own, are being experienced intentionally or unintentionally, or whether the athlete is receiving various mental, task-related instructions, such as general or hypnotic suggestions by a coach or sport psychologist.

In the second subdivision an evaluation is made of the athlete's thoughts according to the following distinct intellectual processes: observational and verbal imagery, memory, classification and categorization, analysis and synthesis, divergent and convergent production, evaluation and problem solving.

The third category reflects the "state" in which the athlete's mental activity processes are taking place. Altered states may be induced by others through relaxation, mental suggestion, hypnosis, can be achieved with the use of drugs, or may be experienced as exhilarations or "highs" through prolonged and committed endurance activities such as running.

In the fourth major division the athlete's thoughts are organized into two main areas according to content. Certain thoughts dwell on general, non-task specific topics, such as fear of competition, self-efficiency, attribution in regards winning or losing, motivation, tactics, dissociation, and physiological process regulation. Yet other thoughts may focus on the fears, the tactics and rewards in regards to a specific task, skill or competition. Cratty suggested a further possible classification of these thoughts on content into those that are coloured or influenced by the athlete's emotional state and those that are rationally based and involved with improvement of technique.

The last category gives details of the time and place of the athlete's mental activities. The time division indicates a short-term time component covering the mental activity before, during or after a competition, and a long-term time component including thoughts during childhood, during competitive athletic years, or of the post-athletic career. The place division points to a geographical location where the thoughts are being processed which may be happening during the day or night between other non-task related activities, at the place of practice, or at the stadium, arena, hall or race meeting.

The problem of attempting to classify an athlete's thoughts rests with the fact that it is extremely difficult to document all the thoughts that are flashing through the athlete's mind at a very fast rate. Researchers have used mainly interview data and questionnaires to extract information regarding the mental activity of athletes during performance. This method is extremely unreliable, as Berger and Mackenzie (1978) pointed out:

> The authors recognize that any lived experience of a sports participant is different from the reported experience. At best, we have only the subject's recollection of that experience, part of which she is bound to forget, part of which she may not be willing or able to share because of fear, embarrassment, or lack of conscious awareness. (p.371)

Researchers have, nevertheless, proceeded to establish hypotheses on the mental processes of athletes based largely on retrospective, self-report data. In order to gain an overview of the present "state of the art" in the field of mental strategies employed by runners during the activity of an endurance event, studies will be reviewed in which researchers have tried to analyze and categorize the athlete's thoughts as well as those few studies in which they have embarked on the task of adjusting the athlete's thoughts and mental strategies in the hope of improving performance output.

The early research done by Morgan, Horstman, and Cymerman (cited in Morgan & Pollock, 1977) on the cognitive strategies employed by marathon runners, revealed that most of their thoughts were directed away from the activity of running with the tendency to "dissociate" from the painful sensory input of their body. During the arduous task of covering 42.2 km, marathon runners have reported building houses in their minds, writing letters, listening to Beethoven, computing mathematical problems, or reliving their entire school and university careers. One marathoner reported age regressing and turning into a steam locomotive before the approach of a steep hill. This kind of mental imagery is similar to that popularized by Spino & Warren (1979) who suggested visualizing large hands, tow ropes, spinnakers or magic carpets to help alleviate the pain and the boredom of the long-distance run.

An allied form of dissociation may have been used by the Tibetan monks practising the art of "lung-gom", which is the ability to travel swiftly across inhospitable terrain for long periods of time. Watson (1974) reported of one monk that is supposed to have travelled over 300 miles in only 30 hours which constitutes an average speed of about 10 miles per hour. In comparison, today's marathoners run at an average speed of about 12 miles per hour for times between 2 and 3 hours. It is possible that the Tibetan Mahetangs repeated a sacred mantra in a meditative-like trance in order to achieve this feat, but arriving at the true facts of the above anthropological tale is difficult.

Thus Morgan, Horstman, and Cymerman (cited in Morgan & Pollock, 1977) designed a controlled laboratory experiment to test the usefulness of using a "pseudo-mantra" like the word "down" with subjects at 80% of their maximal aerobic power to complete exhaustion on the treadmill. The researchers reported an average 30% increase in performance with subjects repeating the monosyllable "down" while exercising. As there were no concomitant cardiovascular, metabolic or endocrine changes with the performance increment, the researchers concluded that the improvement was due to the effectiveness of the cognitive dissociation strategy to help cope with endured pain and stress.

However, when Morgan and Pollock (1977) interviewed a group of 8 world class marathoners in a study to obtain a psychological characterization of the elite distance runner, they found that a completely different mental strategy to dissociation was being employed and labelled it "association". They ascertained that elite marathoners with running times below 2:20 focused intensely on their body, alert to any pain signals or sensation coming from their feet, muscles, heart or lungs. Their pace was carefully set according to how their body responded. Commands of "relax", "breathe deep", "stay loose" were continuously used to monitor their physical state. The phenomenon of the "runner's wall", an extremely painful phase claimed by many to hit them at the point when their muscle glycogen stores become depleted, was dismissed by these elite marathoners as a myth.

Berger and Mackenzie (1978) reported a 4-month case study of a 35-year old female jogger, who as part of the experiment was required to keep a diary of her thoughts, emotions and feelings experienced on the run. After experiencing difficulty recalling her thoughts in exact detail after returning from the run, she had her thoughts recorded after each 0.6 mile running interval, with a maximum of four intervals per running session. The researchers then set out to content analyze the 32 one-to-two page initial journal entries as well as the 100 typed pages of verbal recordings, not to investigate mental strategies but rather to categorize emotions expressed while running in an attempt to find a psychological meaning of the activity of running to the subject. For the athlete in this study self-understanding and the recognition of inner needs were reasons for engaging in the activity of running.

In a study to examine, amongst other topics, the changes in state of mind experienced by a runner during the various stages of a run, Carmack and Martens (1979) questioned 250 male and 65 female runners of different levels of fitness and experience. The results of the questionnaire revealed that during the first half and last quartile of the run the under-40-minute runners experienced dominant feelings of psychological uneasiness, such as boredom, depression and irritability, whereas the over-40-minute runners reported psychological feelings of well-being, such as happiness and optimism. This trend was reversed for both groups in the third quartile. Carmack and Martens noted that the mind-set a runner engages in when setting out on a run may be the determining factor in distinguishing the two groups' distinctly different state of mind experiences. The researchers reported that having found a "means to tap these fleeting states of mind is a significant development in itself" (p.39), and they wondered if conditions of the run could be manipulated to enhance the pleasant psychological states during a run.

In an article discussing the role of attention in optimal athletic performance, Nideffer (1980b) suggested that both the experienced and inexperienced runners are "dissociating" to the pain encountered during the run. The difference, he explained, is that:

> The experienced runners' confidence and past successes allow them to be open to the painful cues and to objectively read and react to them. In "associating" to the pain in an objective, rational way, they are "dissociating" from it emotionally. (p.111)

Inexperienced runners, on the other hand, are unable to attend to their aches and pains without being negatively affected by the worry of their weakening physical condition. In order to maintain their self-confidence, they tend to dissociate away from the painful, physical cues. Nideffer suggested that novice runners should be taught associative strategies in order to become more aware of sensory stimuli and be able to interpret these correctly, so as not to extend themselves beyond their physical capabilities.

Freischlag (1981), in an attempt to study selected psycho-social characteristics of marathoners, examined 55 subjects in regard to genetic and ethnic factors, family composition and source of influence, perceptions of training and competition, and methods of coping with stress. On analyzing the cognitions of marathoners with average best times of 3:23 in a pre-race test, he reported that 2 runners said they thought of nothing, 15 focused on personal affairs, 13 on finishing the race, 12 on their position in the race, 7 on their bodies, and 6 on the mechanics of running. Therefore Freischlag concluded that most marathoners use either associative or dissociative thoughts while running, but he did not resolve the question of whether the athletes' cognitions changed from one focus to another during the course of a race. In regard to coping with pain during the arduous race, 13 competitors reported running through it, 13 said they decreased their pace, 18 tried to mentally displace the pain stimuli, while 6 relied on self/situational assessment. Freischlag noted that here was an increased reliance on associative type thinking to monitor their body in periods of stress.

In an experiment to investigate mental states and psychological coping of ultra-distance runners in a 100-mile race, and to avoid retrospective falsification of data, Sacks, Milvy, Perry, and Sherman (1981) set out to question runners during the process of the competition. Ten male runners were asked the same list of nine questions every 3 hours by an investigator cycling beside the runner. After analyzing the runners' responses recorded on a light-weight, portable tape recorder, it appeared that, on the surface, the runners' thoughts confirmed associative thinking. No dissociative thinking as defined by Morgan and Pollock (1977) was in evidence, nor was there any support that the runners experienced a "high" during the race. On examining the runners' comments more closely, the investigators inferred that other, less bodily-related thoughts were occurring as well, but that these were not readily volunteered by the runners as seen by the following interview:

> Runner: "Well, I daydream, if that's what you mean."
> Investigator: "What do you daydream about?"
> Runner: "Anything. Nothing in particular." (p.172)

The researchers hypothesized that the runners stressed their associative thoughts more than those "other thoughts" because of a vested, emotional attachment to them. They concluded, however, that the "other thoughts" were not to be classified as dissociative thinking as defined by Morgan and Pollock (1977). The runners' free thoughts were similar to those emanating in a meditative trance in which ideas, feelings or images simply flash through the mind with little significance to the runner, and were, as the researchers believed, irretrievable. They, therefore, suggested that a third kind of thinking, besides association and dissociation, called "meditative thinking" occurred during long-distance running events.

Summers, Sargent, Levey, and Murray (1982) surveyed 363 middle-aged runners, attempting their first marathon, to gain information on their reasons for entering the race, their perceived outcome after the race, and their experiences while running. From the pre-race questionnaires supplied to the subjects, the researchers reported that during training runs 69% of the runners adopted a dissociative mental strategy, mostly thinking about family, work and the environment. The information gleaned from the post-race questionnaires indicated that during the marathon only 6% of the runners used dissociative thoughts, with 30.7% using associative thoughts. The majority of runners (63.3%), however, utilized a mixture of the two types of strategies, talking to other runners, setting subgoals, thinking about the run and using distractions to cope with bodily pain.

Sachs and Pargman (cited in Cratty, 1983) postulated three divisions of dissociative thoughts among runners. There are those that fit the creative diversion e.g. house-building, letter-writing thoughts reported by Morgan and Pollock (1977), those that may be categorized as problem-solving thoughts and finally a more general subdivision including spontaneous thoughts. Using a questionnaire to obtain their information, the researchers reported that athletes used mostly dissociative thinking during training runs, although some athletes tended to shift their attention between associative and dissociative mental activity.

Although there have been several attempts to document the cognitive strategies runners employ during training and racing, very few studies have concerned themselves with the effectiveness of the use of an associative versus a dissociative strategy. In order to determine which cognitive strategy would lead to enhanced performance, Okwumabua, Meyers, Schleser, and Cooke (1983) selected 31 undergraduate students with little or no running experience and randomly assigned them to three experimental groups: (1) the dissociative group (2) the associative group and (3) the relaxation group. The dissociative group was instructed to mentally remove themselves from the act of running and to focus their attention on an object not related to the run and repeat a phrase or word as in meditation. The associative group was encouraged to closely concentrate on their breathing and on any pain sensations eminating from the muscles and to closely monitor signals from their body. The relaxation control group practised relaxation exercises but were not given any training in a cognitive strategy. Each group met for 3 hours per week, engaging in aerobic training for 2 days and in anaerobic training for 1 day a week. A performance measure over a $1\frac{1}{2}$-mile run was taken before and after the 5-week experimental period. Self-report measures of cognitive strategies used during runs revealed that subjects had not adhered to their experimenter's instructions regarding the use of a specific cognitive strategy. What did emerge, though, was that the runners became more associative over the trial period, irrespective of which group they were in. An additional analysis, disregarding the initial group assignments was undertaken to study the effect of the actual cognitive strategy employed by the runner. The results indicated that the runners who initially reported using a larger proportion of dissociative than associative thinking, showed a greater enhancement in running performance. The researchers believed that these findings lent partial support to Morgan and Pollock's (1977) conclusions that beginner runners cannot afford to associate as they do not as yet have the physical capabilities of experienced runners. Okwumabua et al. proposed the existence of a possible bi-directional relationship between cognitive strategies and the level of physical conditioning.

In an effort to gain information on the effectiveness of a dissociative, an associative or a positive self-talk strategy intervention on running performance, Weinberg, Smith, Jackson, and Gould (1984) designed an experiment in which 60 male subjects were required to run for 30 consecutive minutes around a 440 yard track, and try to cover as much distance in this time as possible. The subjects, matched on running ability, were divided into the three strategy groups and into one control group, receiving no strategy instructions. Analysis of the laps covered by the subjects showed no significant between group or within group differences. The researchers pointed out the difficulty of imposing a different coping strategy onto experienced runners who usually have developed their own, fairly set cognitive strategy, and therefore resist a change in their habitual thought processes. Further, the researchers determined that the runners might not have been sufficiently stressed during the experiment to have made effective use of their particularly assigned cognitive strategy.

PAIN AND PAIN CONTROL

No champion athlete will have achieved excellence without having experienced extremes of pain, be it from injury or from muscle fatigue. Today's athlete, in order to make it to the top or stay at the top will often spend between 1 and 6 hours in a daily training schedule with a high risk of "overuse" injuries.

> The elite sportsmen and women of today form a gladitorial minority who are stressed to the extremes of physical as well as mental tolerance.... The major limiting factor in many athletes' performances thus becomes the injury threshold. (Sperryn, 1984, p.27)

No runner will be able to reach for the limits of endurance performance without having an effective strategy to cope with the inevitable onset of pain sensations. The old saying of "if it doesn't hurt, you cannot be trying hard enough" has dangerous consequences for the runner's health. During a run the foot hits the ground an average of 1000 times a mile every 7 to 10 minutes ("Woes", 1978):

> The force of impact is about three times his weight. The shock wave travels from heel through ankle to lower leg, knee, upper leg, hip and lower back. Ill effects are legion. Every runner sooner or later is likely to suffer from a sprained or twisted ankle, knee inflammation, stress fracture of the leg bone, shin splints, hamstring pulls, low-back pain, heel pain or blood blister of the toes. (p.55)

Says Cooper (1981): "Scratch marathoners once, and they tell you how wonderful they feel. Scratch them twice and they tell you about their latest injuries" (p.267).

Sternbach (1968) who analyzed the physiological, behavioural and psychiatric descriptions of pain responses, defined pain as follows:

> 1. A personal, private sensation of hurt
> 2. A harmful stimulus which signals current or impending tissue damage
> 3. A pattern of responses which operate to protect the organism from harm. (p.12)

Weisenberg (1977) comprehensively reviewed the major theories of pain perception, the role of psychological variables, the problems related to pain measurement, and the correlates of pain perception. Of interest to this study are the behavioural attempts to manipulate the pain sensation with strategies such as imagery, rationalization, attention, distraction, reinterpretation, self-verbalization, etc. (Beers & Karoly, 1979; Chaves & Barber, 1974; Jaremko, 1978; Spanos, Horton & Chaves, 1975; Worthington, 1978).

Some marathoners speak of "hitting the wall", a very painful zone that they experience towards the end of the marathon, which signals that the body's glycogen stores have become depleted. Although the topic is much debated, most elite marathoners dismiss "the wall" as a myth. They believe that by focusing on the body and adjusting pace accordingly, they avoid over-extending themselves. As one runner in Morgan (1978) stated: "The wall exists for runners who monitor their watches instead of their bodies" (p.43).

Sacks et al. (1981), who obtained information on the mental states of runners participating in a 100-mile road race, also commented on how the athletes managed to cope with the problem of pain:

> When pain occurred, they responded to it by noting its presence, altering their stride, taking aspirin, or wondering what the pain might mean or forecast - but pain was considered

> more of a signal, a sign, than something distressing in itself. By some mental trick or conditioning, pain for these ultramarathoners was seen as a sensation rather than an unpleasant experience in itself. (p.173)

In their study on middle-aged, non-elite runners, Summers, Sargent, Levey, and Murray (1982) reported that 56% of the subjects declared having hit the wall, with the majority (73.3%) experiencing this pain phenomenon after 19 miles of the course. However, no significant relationship was found by the researchers between subjects experiencing the wall and the type of mental strategy used. In a more recent study, Summers, Machin, and Sargent (1983) found similar results. However, a significantly higher proportion of the male marathoners experienced the wall than did female marathoners. The researchers pointed out that this finding was in agreement with Fixx's (1977) proposition that women have a naturally greater endurance capacity due to their larger supply of fat reserves.

Orlick (1980) discussed several techniques that runners use to cope with the discomfort of pain, knowing that the pain is not of the severity to signal the start of potentially harmful tissue damage. Most superior marathon runners focus their attention on the task at hand; they concentrate on their running pace, their rhythm, their relaxation:

> "Are you going too fast, too soon? Take it easy, slow down a bit, relax."

> "Think about lifting your knees, lengthening your stride, relaxing and running through it."
> "If it is a specific muscle group that is hurting, then adjust stride and rhythm so it's easier on that group."
> "Think tactics, concentrate on how you will overtake the runner in front of you."
> "Set a goal of what you want to do before going into a race, and dwell on these thoughts."
> "Concentrate on keeping pace, try to relax."
> "Don't panic, relax, don't fight it, maintain pace, flow."
> "Loosen up, stretch your strides, talk to yourself." (Orlick, 1980, p.208)

Others try to talk themselves through their pain zones:

> "I have come this far, I can go a few more miles."
> "Must not stop! Must not fail! Pain is not too bad, it could be worse."
> "If others can do it, so can I."
> "Another few minutes and it will be over."
> "I started it and I'm going to finish it."
> "One mile out of time."
> "Everyone hurts as much as I do."
> "Think of all the training you've done, don't blow it now."
> "If I'm hurting they must be in real trouble."
> "You've got to finish - hold on to your pace."
> "Think of how good you'll feel when it's over."
> "You've got to get past it, once you get past it, it doesn't hurt as much."
> "You will be o.k. in a little while, pain will go away."
> "At the end you won't care about now."
> (Orlick, 1980, p.209)

Most marathon runners are aware of the fact that they cannot remove the pain experience completely and, therefore, only set out to reduce it to a bearable level:

> "I try to lessen it."
> "I try to live with it by keeping it at a certain level."
> "I try to keep it at a comfortable level."
> "Go with it, it's natural, you get used to it."
> (Orlick, 1980, p.209)

A technique for coping with pain used mainly by novice and average runners is to divert their attention completely away from the pain stimulus and only think about something pleasant, like a trip, a scene at the beach, future plans, etc.

Another coping strategy that has been reported to help in managing pain is the reinterpretation of the stimulus:

> "It's just the feeling you get when your muscles are working, it's not really pain."
> "It's not my biggest competitor to beat."
> "You're in good condition, you can relax and run with it."
> "A certain amount of pain clears your head, makes you more aware."
> "It's a good thing, a barometer of effort and energy expended."
> "Without it you cannot explore your limits."
> "In order to reach my goals I have to be able to suffer."
> "Each painful contraction brings you closer to the finish line, like in the marathon of childbirth."
> (Orlick, 1980, p.210-211)

Others, again, try to get absorbed in the pain, distinguishing its size, intensity, locality, characteristic shape and colour.

It has been shown that control over pain has an important influence on pain reduction, pain tolerance increasing as subjects attribute these changes to their own efforts (Weisenberg, 1977). This finding links up with Bandura's (1977) self-efficacy theory whereby it is found that people's perceived control over their behaviour will determine "whether coping behavior will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences" (p.191).

THE RUNNER'S HIGH

The exhuberant, free-flowing phase often experienced by runners and referred to in the popular literature as the "runner's high", has recently received attention in both the psychological and physiological research (Markoff, Ryan & Young, 1982; Moore, 1982). This "altered state of consciousness", as Kostrubala (1977) labelled the euphoric occurrence, will be discussed in the light of dissociative thinking, as the author believes that it is only possible to achieve this mental state, should it exist, by allowing the thoughts to wander from the painful, laborious task of running to more pleasant imagery scenes. Spino and Warren (1979) designated the sensation as "a balanced integration of mind and body that is in effect the kind of mental state sought by meditators" (p.26). Similarly, Shainberg (1977) sees long-distance running as a form of meditation: "The run is present and thought is a smoke screen that avoids what is happening here with the run" (p.1005).

Glasser (1976) suggested that this psychologically beneficial, detached state of mind is the reason for runners becoming positively addicted to running. He described the positive addiction (PA) state as a pleasant, translike, euphoric mental state that exercisers reach indirectly and which meditators try to reach directly. The following comment from a runner, who responded to Glasser's survey in a popular running magazine, points to the "dissociative" nature of the PA state:

> If I am tired the first mile of any run is difficult because my mind is driving my body to run. After the first mile my subconscious takes over and my body functions automatically. My mind is then free to wander and does. Only when I run hard for a short distance, run hard uphill, or run very long distances is my mind functioning with respect to running and actually driving my body. I cannot categorize my thoughts while running and I have attempted to do so over the past two or three years. All I can say is that my mind is not on my body, or on my immediate surroundings. It is as though my mind is resting in a vacuum. Please note I use the word resting not functioning. (p.115)

The phenomenon of running addiction, interpreted either as negative or positive, has received much attention in the sport psychology literatúre (Baekeland, 1970; Hailey & Bailey, 1982; Morgan, 1979; Restak, 1984; Sachs, 1981; Sachs & Pargman, 1979; Thaxton, 1982).

In order to collect more reliable research data on runners' mental states, Carmack and Martens (1979) developed a questionnaire to measure "commitment to running" (CR), the term they preferred to "positive addiction". A factor labelled "spin-out" which included items that related to the meditative, detached, dreamy state of mind of positively addicted runners was found to be most identifiable with the over 40-minute runners.

Pargman (1980) proposed that all regular runners, depending on their motivation, are to be found somewhere on a continuum, labelled addiction or dependence (A-D) on the one end and commitment or dedication (C-D) on the other. The identification of the runner as an A-D or a C-D type runner points to the kind of mind experience the runner will encounter. Pargman speculated that:

> Individuals in the addicted-dependent (A-D) part of the continuum tend to participate with comparatively less psychological awareness and intellectual understanding about their running than do committed-dedicated (C-D) runners. When A-D runners attempt to explain their immoderate enthusiasm, they tend to emphasize perceived exhilaration and joy. Their focus is usually not upon motivational or causal factors. The A-D runner describes his/her need to participate purely in terms of affect or emotions generated by the run as well as feelings experienced before and during it. Rarely is inquiry made about reasons for the run beyond descriptions of a strong inner force crying out to be satisfied. Furthermore, A-D types make reference to withdrawal symptoms when the need to run is unsatisfied. Their only relevant realization is that if they don't run they feel unwell. (p.91)

On the other end of the continuum, the C-D type runner bases his reasons for running on intellectual and rational principles. Pargman elaborated:

> C-D types make no claim for euphoric, mind-bending, esoteric, Zen-like experiences. They do not report mental spinouts or long periods of dissociation from the run in order to focus their thinking upon problems or topics of their own selection. Real-life reinforcers support their conception of the run as a positive, supportive experience. (p.92)

In one of the few studies which probed the mental states of runners at 3-hourly intervals with the help of a standard questionnaire during an actual race, a 100-miler, Sacks et al. (1981) reported that none of their interview data pointed to the runners having experienced a high at any stage during the race.

On analyzing questionnaire data of 363 novice runners attempting their first marathon, Summers, Sargent, Levey, and Murray (1982) disclosed that 48% of the subjects reported having experienced a runner's high during training runs. Most of their descriptions of this phenomenon could be classified into three main groups: (1) psychological well-being (2) physical well-being (3) "spin-out", the dreamy, detached state of mind. However, the data of the post-race questionnaire indicated that only 24% of the runners experienced a high, which, the researchers pointed out, is in agreement with Glasser's (1976) suggestion that this state is rarely felt if the run is goal-directed. In follow-up research, Summers, Machin, and Sargent (1983) reported that the marathoners who experienced the runner's high thought it occurred between 9 to 16 miles into the race.

Plamondon, Cloutier, and Pinard (1983) questioned 896 runners among the 10,300 participants of the 1981 Montreal International marathon and reported that 46% of the subjects disclosed experiencing mental dissociation, while 67% disclosed experiencing pleasurable states during training runs. The researchers believed that these findings indirectly confirmed the often-mentioned runner's high.

Interestingly, Wagemaker and Goldstein (1980) did not limit their discussion of the phenomenon of the runner's high to the mental state experienced during the run. Wagemaker reported feeling well rested after a run, along with the euphoric effect he sometimes experienced. EEG changes showed a reversal of right-left confusion after running, similar to the effect of sleep on the process of thinking, which purportedly allows the subjects to think clearer and concentrate harder.

Finally, the concepts of "peak experience" (Maslow, 1968; Ravizza, 1977), "peak performance" (Privette, 1981, 1982), and "flow" (Csikszentmihalyi, 1975) exhibit characteristics similar to the mental state of runners during dissociation, and the phenomenon of the runner's high. Csikszentmihalyi described the experiential state of flow as follows:

> Flow denotes the wholistic sensation present when we act with total involvement.... It is the state in which action follows upon action according to an internal logic which seems to need no conscious intervention on our part. We experience it as a unified flowing from one moment to the next, in which we feel in control of our actions, and in which there is little distinction between self and environment; between stimulus and response; or between past, present, and future. (p.43)

CHAPTER 5

PERCEPTION OF EFFORT

When human beings are involved in hard work, it is not sufficient merely to study physiological parameters of their performance, but due attention needs to be given to the individual's subjective evaluation behind the performance. The physical exertion of runners during training or competition also constitutes hard physical labour. Of interest to this study are the questions of how hard are the athletes trying, how much effort are they expending, and how do they perceive the pain and the stress of long-distance running.

The fact that an individual is able to rate the "cost" of every run in terms of a subjective psychological parameter points to a sensory ability in the human being of assessing work load - the effort sense. Although exercise physiologists have been aware of the existence of a psychological adjunct to physiological effort, the attempt to find a measure for perceived exertion has only recently been embarked upon. Borg (1973) stated convincingly that:

> Problems of perceived exertion are a part of larger problems concerning the need for quantitative measurement of subjective symptoms of various kinds: exertion, fatique, discomfort, pain, etc. Quantitative measurements of such factors are desirable for clinical

> diagnosis, for therapy and exercise prescription, for evaluations of performance capacity, and for many other applications. (p.90)

The importance of the effort sense began to be recognized with the scientific work undertaken into exercise prescription. To determine the frequency and the duration of exercise is simple, but to determine the intensity at which the exercise should be carried out is not so easy.

One method to assess physical work load is to measure the person's oxygen uptake during the activity. Portable equipment exists to analyze the expired air for information on the energy cost of various physical activities, but is too cumbersome and impractical a method for exercise prescription. Another method is based on the generally accepted linear relationship between oxygen uptake and heart rate (Astrand & Rodahl, 1977). Therefore, it is feasible to determine a target heart rate which corresponds to a required work load. However, this method has its drawbacks as the self-monitoring of pulse-rate can lead to erroneous results. A further, more practical method is based on the individual's experience of coping with strain: the talk test. Exercise at an intensity that still allows you to talk to a fellow exerciser. The method is a good guide for novice runners, but a little vague for the experienced runner who needs to exercise at a specific intensity to maintain the training effort.

In order to devise a more scientific measure of perceptual intensity, Stevens (1957, 1966) developed ratio scaling methods, the scale having an absolute zero and values spaced at equal intervals. A drawback to this method is the difficulty of making inter-individual comparisons as subjects rate intensities by making only relative judgements (Borg, 1982). An object that is judged to be twice as heavy as another does not give any information on its actual weight.

In the 1950s the Swedish exercise physiologist, Gunnar Borg, researched long-term changes in physical work capacity among lumberjacks. He noted that individuals have the ability to identify their own physiological responses and to merge these through the central nervous system into a unitary rating of perceived exercise intensity (Hage, 1981). Borg (1962) introduced a 21-graded scale with a verbal description attached to every second number from 3 = "very, very light" to 19 = "very, very laborious" and 11 = "neither light nor laborious". The individual's estimation of perceived work correlated significantly (0.80 to 0.90) with objective measurements of heart rate obtained while exercising on a bicycle ergometer.

A new category scale for ratings of perceived exertion, to become known as the RPE scale or Borg scale, was later introduced and consisted of a 15-graded scale with values from 6 to 20 to link it with the variation in heart rate from 60 to 200 beats per minute. This new scale is depicted in Figure 4. It should be noted that

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

Figure 4. The 15-graded scale for ratings of perceived exertion (Borg, 1978, p.44).

the new scale is asymetrical, some verbal expressions have been changed and the midpoint has been lowered to allow the subjective values to grow linearly with the physiological response. The new scale has found widespread application in many countries (Borg & Noble, 1974).

The concept of the Borg scale has been described by Sheehan (cited in Hage, 1981) as the most liberating idea that has eminated from exercise physiologists:

> Too many people are hung up on figures to evaluate exercise. They get caught up on how many miles they run each week when we know that the full fitness equation has nothing to do with mileage. (p.138)

Even though many investigators have lauded the introduction of the RPE system for its reliable use and ease of application in exercise schedules, some discrepancies have been pointed out. People who are extroverted, neurotic, anxious or depressed do not show the high correlations between RPE and heart rate, and a decreased correlation has been found in elderly subjects (Hage, 1981).

Borg's findings have aroused much debate as to the primary physiological cue for the determination of the subjective rating of perceived exercise intensity. Borg's vision of an integrated, multiple sensory input system resulting in a subjective, yet functional rating of perceived effort, has not been accepted by all researchers.

> Perceived exertion is the best indicator of the degree of physical strain. The perception and integration of many bits of information, many signals from the body - from the muscles, from the periphery, from the cardiorespiratory center. If we could integrate all the physiological cues in a perfect way and give weight to the different variables, then we would have a perfect measurement of physical strain. To me this perception is a kind of gestalt - the integration of many phenomena, many signals. And that is why it functions so well. (Borg, cited in Hage, 1981, p.143)

Other researchers have been adamant at finding a primary sensory cue for the subjective rating of work load, by indicating a multitude of physiological and neuromuscular parameters to be the key input for the perceived exertion. Recent investigators have followed up the suggestion of Ekblom and Goldbarg (1971) that two factors appeared to influence the individual's perceived exertion during physical work: a local factor influenced by the feeling of strain in the exercising muscles and limbs, and a central factor determined by the heart rate, respiratory rate and oxygen uptake.

Mihevic (1981) extensively reviewed the studies that have been involved with the identification of physiological cues for the perception of effort, but described the search for a primary perceptual cue as "a rather simplistic attempt to probe the complex psychobiological dynamics of the exercise response" (p.150). A summary of some of the findings follows.

Central factors as cues for perceived exertion

Central factors that have been investigated in regards to their relevance to perceptual ratings are heart rate, ventilation and respiratory rate, and oxygen consumption.

There has been strong evidence of the existence of a linear relationship between heart rate and perceived exertion across various work loads. However, experimental manipulations such as the use of pharmacological agents or changes in environmental conditions have indicated that heart rate is not the primary physiological cue for perceptual response (Davies & Sargeant, 1979; Ekblom & Goldbarg, 1971; Kamon, Pandolf & Cafarelli, 1974; Noble, Metz, Pandolf & Cafarelli, 1973; Pandolf, Cafarelli, Noble & Metz, 1972). It should be pointed out that the RPE scale was originally intended for increasing intensities of work under normal conditions (Mihevic, 1981).

Although several researchers have proposed that oxygen consumption is a critical determinant of perceived exertion (Sargeant & Davies, 1973; Skinner, Borg & Buskirk, 1969; Skinner, Hutsler, Bergsteinova

& Buskirk, 1973), no proof exists that the individual is able to monitor oxygen consumption at will. Moreover, as several physiological measures are closely linked with metabolic demand during exercise, it is highly probable that a more accessible physiological response than oxygen consumption would act as a more potent stimulus for perceived exertion (Mihevic, 1981).

Most investigations into the role of respiratory rate on RPE have found it to be an important source of perceptual input, especially as subjects are able to consciously monitor their ventilatory response (Horstman, Morgan, Cymerman & Stokes, 1979; Kamon et al., 1974; Morgan & Pollock, 1977; Noble et al., 1973; Pandolf, Cafarelli, Noble & Metz, 1972). In order to test the validity of central factors as perceptual cues of exertion, researchers have focused on the effect that training might have on RPE. It is to be expected that fit individuals perceive a heavy work load to be of less effort than untrained individuals due to their superior physical conditioning resulting in various physiological and biochemical adaptations. The studies by Ekblom and Goldbarg (1971), and Docktor and Sharkey (1971) confirmed a reduction in both heart rate and RPE after endurance training. However, the methodologically superior studies by Patton, Morgan, and Vogel (1977), Nagle, Morgan, Hellickson, Serfass, and Alexander (1975), and Morgan and Pollock (1977) found evidence contradicting the above proposition. The researchers noted a similarity of perceived effort at absolute exercise intensities between the groups differing in fitness.

In summary, although central factors play an influential role in determining effort sense, the research undertaken in this field does not warrant either heart rate, oxygen consumption or respiratory rate to be the primary source of perceptual input during exercise.

Local factors as cues for perceived exertion

Local factors that have been considered to provide sensory stimuli for the perception of effort are lactate concentration, Golgi tendon activity and general muscle sensations.

Much research evidence points to a good correlation between blood lactate concentration and perception of exertion (Edwards, Melcher, Hesser, Wigertz & Ekelund, 1972; Ekblom & Goldbarg, 1971; Gamberale, 1972). However, the mechanism by which lactate accumulation acts as a perceptual stimulus is not yet clear. Although blood lactate only starts to rise significantly with exercise intensities of 50% to 65% of maximum oxygen consumption, studies have shown that lactate concentration may even provide perceptual cues at relatively low exercise intensities (Allen & Pandolf, 1977; Horstman, 1979; Pederson & Welch, 1977). The muscular pain associated with lactate concentration may act as a potent sensory source for monitoring effort rating.

Many researchers have implicated several kinesthetic cues, such as mechanoreceptor and proprioceptor feedback, Golgi tendon activity and sensory input from the working muscles as a major influence of effort sense (Cafarelli, 1977; Ekblom & Goldbarg, 1971; Lollgen, Graham & Sjogaard, 1980; Robertson, Gillespie, McCarthy & Rose, 1979a, 1979b). Further evidence for the dominant role of these local factors comes from the observation that significant perceptual differences were recorded despite comparable metabolic and cariopulmonary responses at different cycling rates (Pandolf, Kamon & Noble, 1978; Stamford & Noble, 1974). However, the role of proprioceptive responses and general leg muscle sensations as relevant sensory cues remains speculative as detection of these inputs cannot be quantified (Mihevic, 1981).

Other factors as cues for perceived exertion

Some physiological measures cannot readily be classified as local or central cues for perception of effort. Frankenhaeuser, Post, Nordheden, and Sjoeberg (1969) have pointed to raised blood catecholamine levels as indicators for perception of exercise intensity, but their mechanism as a perceptual agent is not yet clear.

Further potential perceptual stimuli might arise via the individual's skin temperature and sweat response, yet studies engaged in establishing their importance as perceptual cues have found no direct relationship (Kamon et al., 1974; Noble et al., 1973; Pandolf, Cafarelli, Noble & Metz, 1972).

Mihevic (1981) concluded that the endeavour of researchers to try and center their attention on a fundamental perceptual cue has been rather artificial:

> The focus on a primary sensory input for the perceptual system during exercise fails to consider the mediating influence of factors such as exercise intensity, work duration, lag time of neurogenically vs biochemically governed responses. There is a wealth of physiological, neurological, and biochemical data to support the importance of a variety of biological responses, differentially weighted according to these considerations, which the individual may consciously monitor, but most certainly evaluates at a conscious or unconscious level. (p.160)

Psychological considerations

In the search for specific physiological control systems contributing to the judgement of pain and exhaustion, certain psychological influences have received only lesser attention, although their role might not be of lesser importance.

Kinsman, Weiser, and Stamper (1973) have pointed to subjective responses that may play a vital role in perceived exertion ratings, namely fatigue, task aversion and motivation. Lynch (1983), too, stated that fatigue may be triggered by the mind without a physiological basis.

Pandolf (1982) produced an explanatory model that describes a hierarchical system showing the complexity of arriving at a rating of perceived exertion. Certain discrete sensations experienced during exercise such as being bored with the task at hand, or alternatively, being highly aroused and determined, may feed directly into the individual's "superordinate" level of subjective reporting.

As has been mentioned previously, variance in RPE has been found for individuals who may be described as extroverted, neurotic, anxious or for those who consistently underestimate their levels of perceived exertion (Hage, 1981).

Morgan, Raven, Drinkwater, and Horvath (1973) evaluated certain hypnotic suggestions on perceptual and metabolic responses to a standard bicycle ergometer task. They found appreciable variance in the subjects' judgement on work load during hypnosis. The researchers suggested that "complex somato-psychic phenomena govern both perceptual and physiological responsivity to muscular exertion" (p.99).

Stones (1980) set out to investigate the role the visual system played in the judgement of pace and fatigue of runners. His results showed that perceived fatigue was not solely determined by physical exertion. The researcher hypothesized that attenuated visual input leads to a reduction in the processing of fatigue relevant information which consequently results in the lowering of perceived exertion.

Pennebaker and Lightner (1980) examined the importance of external versus internal information during exercise and its effect on the individual's perception of fatigue. In the first experiment, subjects who listened to a recording of street sounds while exercising reported less fatigue than subjects who had to listen to an amplified version of their own breathing. In a second experiment it was found that runners clocked a significantly faster time on a cross-country course than on the lap course, but reported no difference in perceptions of fatigue. The researchers believed that external cues during the cross-country race blocked the role of internal cues resulting in a lowering of the effort sense. This, in turn, seemed to let the runners increase their pace. However, the implications of foresaking vital internal cues are discussed elsewhere (Chapters 6, 9 & 10).

PART 2

CHAPTER 6

ASSOCIATIVE/DISSOCIATIVE THINKING AND EFFORT SENSE

Morgan and Pollock's (1977) associative/dissociative mental strategy classification has dominated research into the cognitive activities of marathoners during long-distance racing and training. On the basis of interview data they postulated two divergent coping strategies: association, by which the runner pays close attention to bodily signals, and dissociation, by which a marathoner shuns sensory inputs because of the discomfort they might create. According to Morgan and Pollock elite marathoners associate, effectively reading their body and modulating pace accordingly, whereas non-elite runners dissociate from any potentially painful, sensory cues. The researchers offered a schematic representation (see Figure 5) of their findings in terms of the perception of effort and proposed the following conceptualization. Situated in the centre of the runner's sensory system is the "perceptostat", which integrates all other sensory systems along with information stores built from past environmental experiences. This perceptostat is switched "on" when a runner engages in associative thinking, and switched "off" when he/she adopts a dissociative mode of thinking. Morgan and Pollock used the analogy of a household furnace to illustrate the actions of their model. As the furnace is being driven by a thermostat, the runner is driven by his/her perceptostat. A system

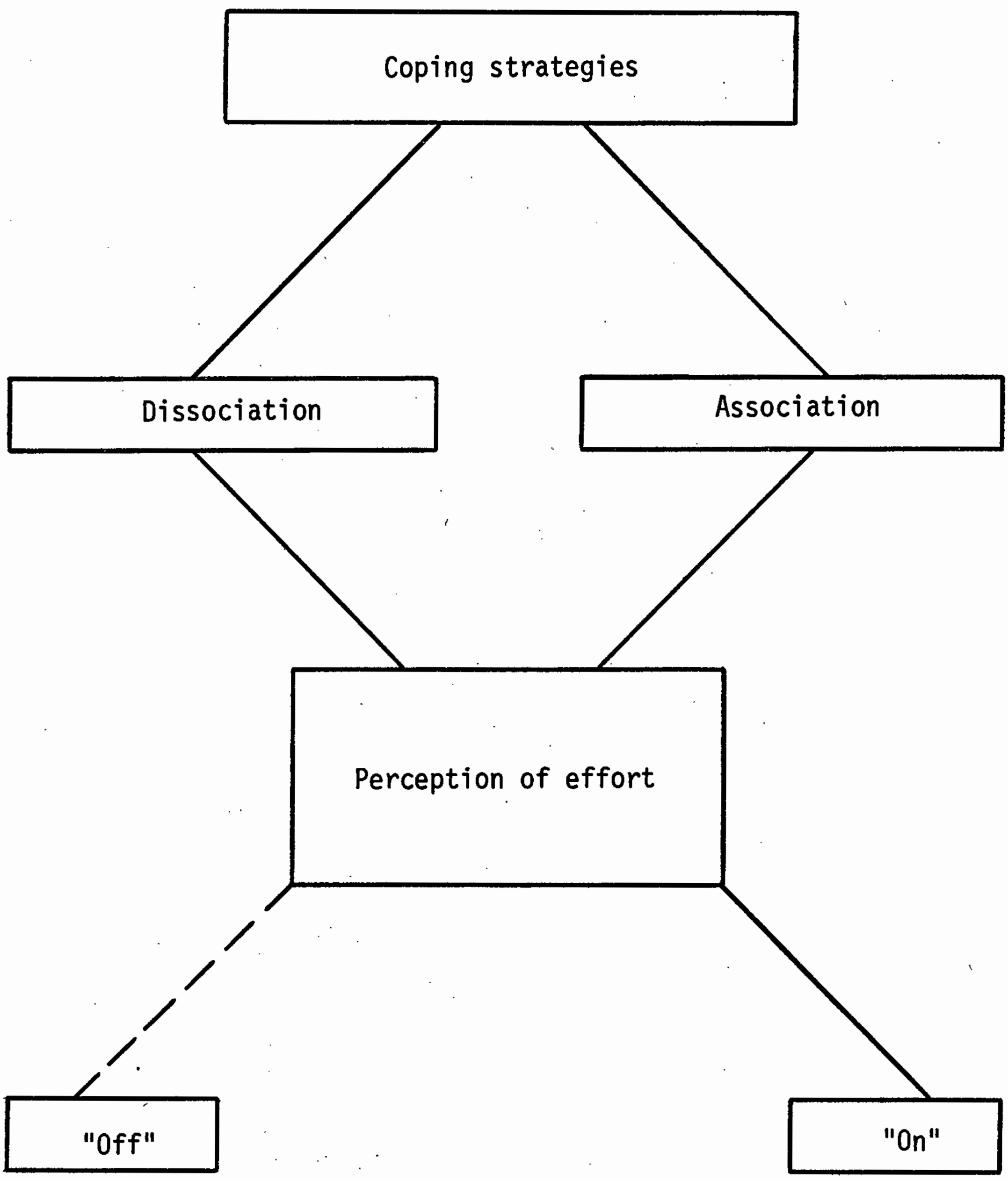


Figure 5. The Perceptostat Model (as adapted from Morgan & Pollock, 1977, p.400).

failure would be brought about in a household where the thermostat is turned on or off without regard to the prevailing temperature demand. A similar, but less drastic, effect would be manifested if the thermostat were faulty and its malfunctioning were to create an environment that is either too cold or too hot. The actual mean temperature always overshoots or undershoots the desired optimum displayed by the thermostat setting. The household furnace with a faulty thermostat is running extremely inefficiently, wasting fuel in its erratic attempts to regulate the room temperature. Morgan and Pollock proposed that this operation characterizes the non-elite runner engaged in dissociative thinking. The marathoner switches his/her perceptostat off by ignoring sensory cues from the body. The perceptostat stays off until alerted by a severe signal to resume functioning. By that stage the runner might already have incurred serious tissue or organ damage in the form of parathesia or dyspnea. Extremely severe signals such as the incipience of heat exhaustion or bone fracture would result in complete system trauma. Dissociative thinking is seen to involve deficits in the non-elite runner's energy household throughout the race, as only severe alerting signals bring about adjustments in pace, repaying the deficit momentarily and then returning to the signal shunning mode of thinking again. Literally being out of touch with the body, the marathoner may overtax him/herself too early and have no energy left for the finish of the race. Morgan and Pollock saw the net result of such an inefficient energy handling approach as the eventual coming up against the "wall". In contrast, the elite runner incurs a deficit only at the start of a run and soon accomplishes a relative steady state by associating to the sensory cues, effectively regulating pace. Association is believed to generate such a conscious focus of relaxation that it could be partly responsible for the lower oxygen consumption recorded in elite runners:

> While these differences are small when viewed in terms of ml/kg.min., extension of such a difference across 42 kilometres takes on a significant meaning. At any rate, whether one's chief concern is with performance or avoidance of trauma, an associative strategy would appear to be more efficacious than a dissociative one. (Morgan & Pollock, 1977, p.401)

A graphical representation of the association/dissociation function in regard to the runner's energy household is presented in Figure 6 and Figure 7 respectively. Whereas association performs a regulatory operation and can be seen to act as a valve to the runner's energy reservoir, dissociation does not render such a modifying service; it just keeps the energy flow open.

Morgan and Pollock attributed the elites' capacity to associate to their physiological superiority, which permits them to run at a greater percentage of their maximum aerobic power without encountering discomfort. For example, in laboratory tests, elite runners' lactate levels at treadmill running speeds of 12 mph were

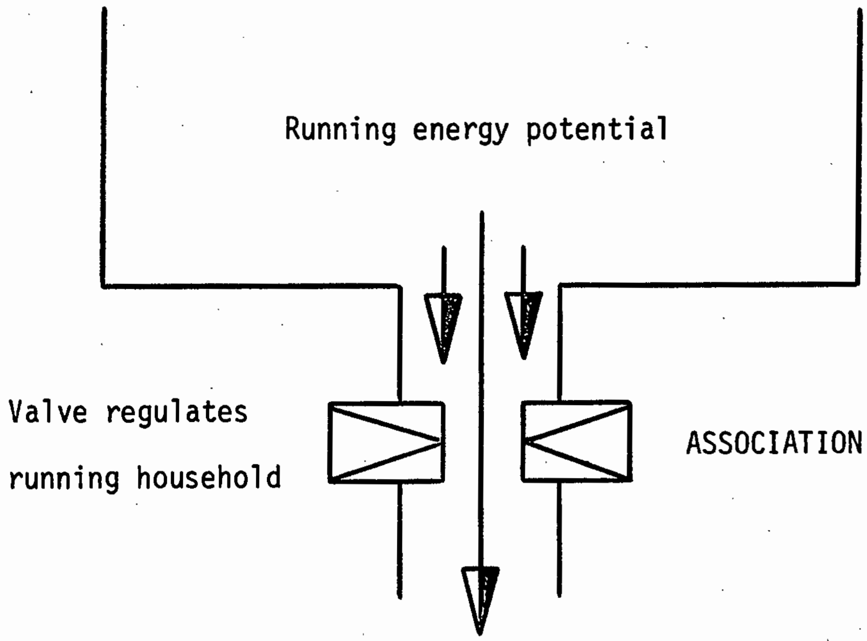


Figure 6. Running energy during association is spent at a rate at which the energy supply matches the demand set by course/situation.

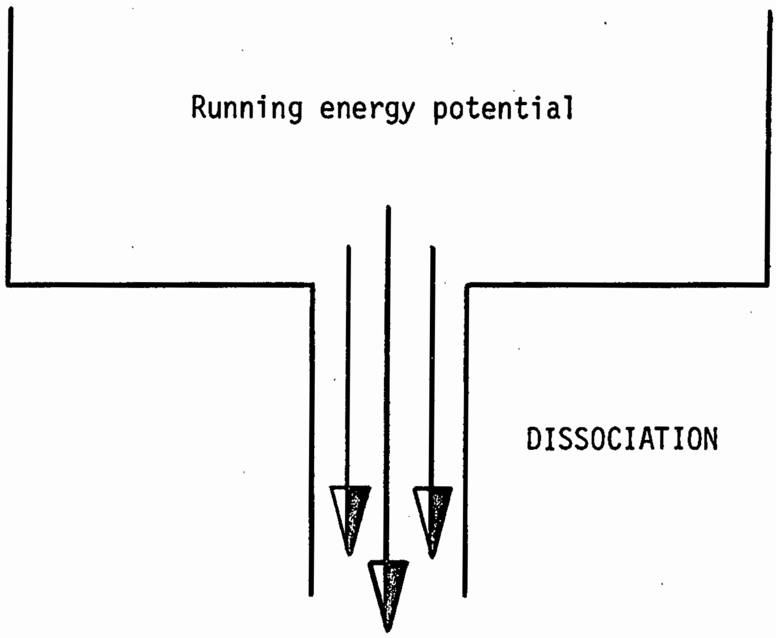


Figure 7. Running energy during dissociation is drained without the supply of energy matching the demand set by the course/situation.

recorded as 31 mg%; this was less than half as much as for the non-elite runner at the same speed. Regardless of which physiological parameter used, the physiological cost was always significantly less for the elite runner. According to Morgan (1978) the elite can afford to associate because their lungs, heart and muscle power is so substantial that they suffer less during a race.

Even though non-elite runners exercise at significantly higher metabolic loads, they only start to perceive the exercise intensity to be more severe than the elite at treadmill speeds of 12 mph. Morgan and Pollock (1977) ascribed this finding to the onset of anaerobisis in the non-elite runners, who arrived at 95% of their maximal aerobic power at that speed. They speculated that higher perceived exercise intensities would most probably have been reported by non-elite runners even at treadmill speeds below 12 mph if running would have continued for longer durations, because in contrast to the elite, the non-elite runners had not achieved a perceptual and physiological steady state at 10 mph.

When exercise demand is evaluated in terms of heart rate, ventilatory volume or percentage of maximal aerobic power in comparison to a non-elite runner, a thoroughly trained athlete encounters significantly less exercise stress. It is with the successive maximal exposure to the conditions under which he/she will run a race that the athlete specifically adapts by making the respiratory, circulatory, enzymatic, musculoskeletal, endocrinal and psychological adjustments necessary to perform most efficiently under that stress (Ryder et al., 1976). An athlete has to work hard to attain the spectacular improvement in specific endurance (the ability to perform sustained work at a high input of energy) that will eventually let him/her encounter less exercise stress when compared to less trained individuals under similar conditions. According to Ryder et al. the aspiring runner has little more than a gross estimate to gauge his/her training effort by. Performances and training methods of current record holders are evaluated by aspiring athletes in order to judge how much greater a training effort in terms of speed and endurance is required to approach or better their record. To achieve the ability to perform prolonged work at a high input of energy, Ryder at al. listed two essential adaptive needs for the runner:

> √(1) to induce changes that will enable him to better meet the demands of his external environment and (2) to maintain homeostasis, the essential consistency of his internal environment. (p.118)

Whatever the mechanisms of this adaptation process may be, the runner has to repeatedly expose him/herself to ever greater training stress.

Ryder et al. recognized Le Chatelier's principle at work in the athlete's adaptation process. When the equilibrium in a closed system (athlete's physiological condition) is disturbed by changing the conditions (increased training effort) surrounding the equilibrium, the equilibrium will shift in such a direction (superior physiological condition) as to cancel the effect of the change (Toon, Ellis & Brodkin, 1968). It is well known that endurance training, concentrating on cellular metabolism in muscle alone, effects adaptive changes in tissue respiration, in aerobic and anaerobic enzyme systems and in systems that store energy. Such adaptations capacitate hard training, aspiring runners to run aerobically at speeds that forced their predecessors to run anaerobically. In line with Le Chatelier's principle it is the proportional increase in the intensity of training that shifts the athlete's metabolic equilibrium so that he/she can run aerobically at an intense rate of work (Ryder et al., 1976). While sustaining homeostasis, the runner effects this adaptation guaranteeing that the body makes use of its most efficient mechanisms for the conversion of stored reserves into energy. Thus the runner fulfills both adaptive needs as stipulated by Ryder et al. previously. To set a new record, personal or competitive, it is the daily training effort that is the challenge to be mastered. Considerations that limit the athlete's training, not his racing, are what the runner has to transcend to set new records. Ryder et al. considered these inhibiting factors to be psychological and not physiological.

Workouts from 30 minutes to 2 hours, three times per week, with exercise intensities at a high percentage of aerobic power are minimally required for aerobic capacity conditioning, challenging both the oxygen transport system and the oxidative processes of the muscle cells (Knuttgen, 1979). Minimal improvements derive from training at 60% of aerobic power capacity. Greater improvements result from higher training intensities employed, if the amount of time per workout is kept constant. This applies to every person endeavouring to improve his/her aerobic power essential for the activity of running. In the 7-month gradual marathon training schedule by Dr. Tim Noakes (see Appendix 1) and used in this study, the above stipulated training intensity and frequency represent the half-way mark for people previously totally out of breath and shape, with the second half of the training schedule rapidly picking up in demand. Put in another way, training effort is required from the novice runner through to the elite marathoner. Increases in physical conditioning, and ultimately improvements in race performance, go hand in hand with increases in training intensity.

According to the physiological argument total energy expenditure is at an optimum when the rate at which energy is used is constant (Ryder et al., 1976). For a maximum effort during training or race the rate of energy expenditure must be such that all available energy is exhausted just as the training session or race ends. Economy and energy efficiency are imperative in long-distance running (Astrand & Rodahl, 1977).

Only through circumspect surveillance of the body's functions can an athlete hope to optimize his/her running household and, therefore, expedite and consolidate his/her training effort. Associative thinking is the means of attaining and maintaining high training intensity without running the risk of tissue, organ or system trauma. As any runner has to expose him/herself to successive approximations of his/her relative physiological tolerance in order to procure aerobic conditioning, associative mental strategies are not perceived to be exclusively practised by elite long-distance runners. It is hypothesized that an increase in associative thinking is directly related to an increase in training intensity regardless of the running status of the athlete. As the superior runner's training schedule is far more rigorous than that of a novice or average athlete, the superior runner is expected to be exposed to associative thinking far more often and for longer durations. This reiterative exposure will manifest itself in a practice effect with the net result of associative thinking of a more explicit and exact nature. As such precise associative thinking would mediate the runner's performance even more efficiently, associative thinking assumes qualities of a pervasive reinforcing agent. It is well known that the effectiveness of performance feedback, particularly with competent, experienced athletes, is directly related to its preciseness (Carron, 1978). The preciseness of associative thinking in the superior runner is thought to be shaped by reinforcing successive approximations towards the terminal response: efficient, precise monitoring of specific body parts' functioning. The experienced runner has learned that the philosophy "if it doesn't hurt, you can't be training hard enough" is precariously false. Sperryn (1984) put it in a nutshell when he said that "Nature's reply to this is 'now that it hurts, you know that you have injured yourself and will have to stop training anyway'" (p.27). Among others, Morgan and Pollock (1977) cited the example of a runner immersed in dissociative thinking trying to "run through the pain", ending up with clean fractures of both the left and right fibula. Even the repeated wear and tear of minor joint injury may introduce or hasten the degenerative condition of osteoarthrites and curtail sport or inflict lasting pain on movement (Sperryn, 1984). Although dissociative thinking permits the runner to negotiate temporary pain zones and distract from the monotony of the running process, therefore initially negatively reinforcing the activity of running, or high training intensity, the attendant risk of tissue, organ and system trauma is a severe price to pay. Task-unrelated thinking does not demand the extreme state of concentration as associative thinking, and indeed, is far more pleasant, but when a high training effort is demanded it might result in bitter punishment. According to Morgan (1978, 1984) this is the "buy-now-pay-later" or "automatic" style of running. The tendency to ignore warning signals and shun even severe pain is proportionally higher in a meaningful, highly-valued race, in which a lot of time and sweat has been invested during training (Sanderson, 1981).

Apart from injury avoidance, associative thinking puts the athlete into control of his/her running process. According to Morgan (1978,

1984) this is the "pay-as-you-go" or "manual pilot" style of running. The perpetual feedback check establishes the runner's control over potential pain situations. This diligent state of control, in turn, reduces the subject's stress and pain reactions (Weisenberg, 1977). Pain tolerance has been shown to increase when subjects are in a position to attribute pain tolerance changes to their own efforts (Davison & Valins, 1969).

Relaxation has also been reported to be an effective procedure for increasing pain tolerance (Weisenberg, 1977). Task-related thinking is directed at establishing a steady state and preserving energy, in which the attainment of a relaxed approach to the maintenance of the running process are essential objectives. Although the initial practice of associative thinking demands concentration and tolerance of discomforting sensory cues, the pay-off is consequential. High training effort can be maintained at optimal levels of energy consumption, and the risk of injury is minimalized. These factors respectively positively and negatively reinforce the practice of associative thinking, shaping the thoughts of the runner with experience in successive approximations to more and more efficient, precise instruments of control.

It is, therefore, hypothesized that there will be a quantitative and qualitative difference within the associative mental strategy displayed by marathon runners of differing running status. The postulated difference within the associative thinking mode will manifest itself in a predominance of thoughts on specific body parts and their functioning for superior athletes.

The tendency towards more precise body monitoring for superior athletes is recognized to come about through a successive approximation method whereby initially any kind of task-related thought reinforces the maintenance of an associative mental strategy, as the task-related thought lets the athlete establish control over his/her running process. Feedback from the resultant more safe and efficient running process acts to gradually reduce the range of task-related thoughts until only exact body monitoring produces the desired optimal running state. This successive shaping process is time-dependent and will, therefore, indirectly express itself in increased training frequencies and training durations for superior runners.

In order to elucidate the interrelationship and functioning of the above-mentioned hypotheses and processes the following fundamental model of an information-processing system is presented and graphically depicted in Figure 8. The model focuses on the processing of the sensory information generated through the running process and on the way the marathoner can manipulate this information in terms of associative/dissociative thinking. The operations within the system, that will be referred to below, adhere to those applicable to a serial modal model of thinking, which is consistent with many broader frameworks for the whole human information processing system

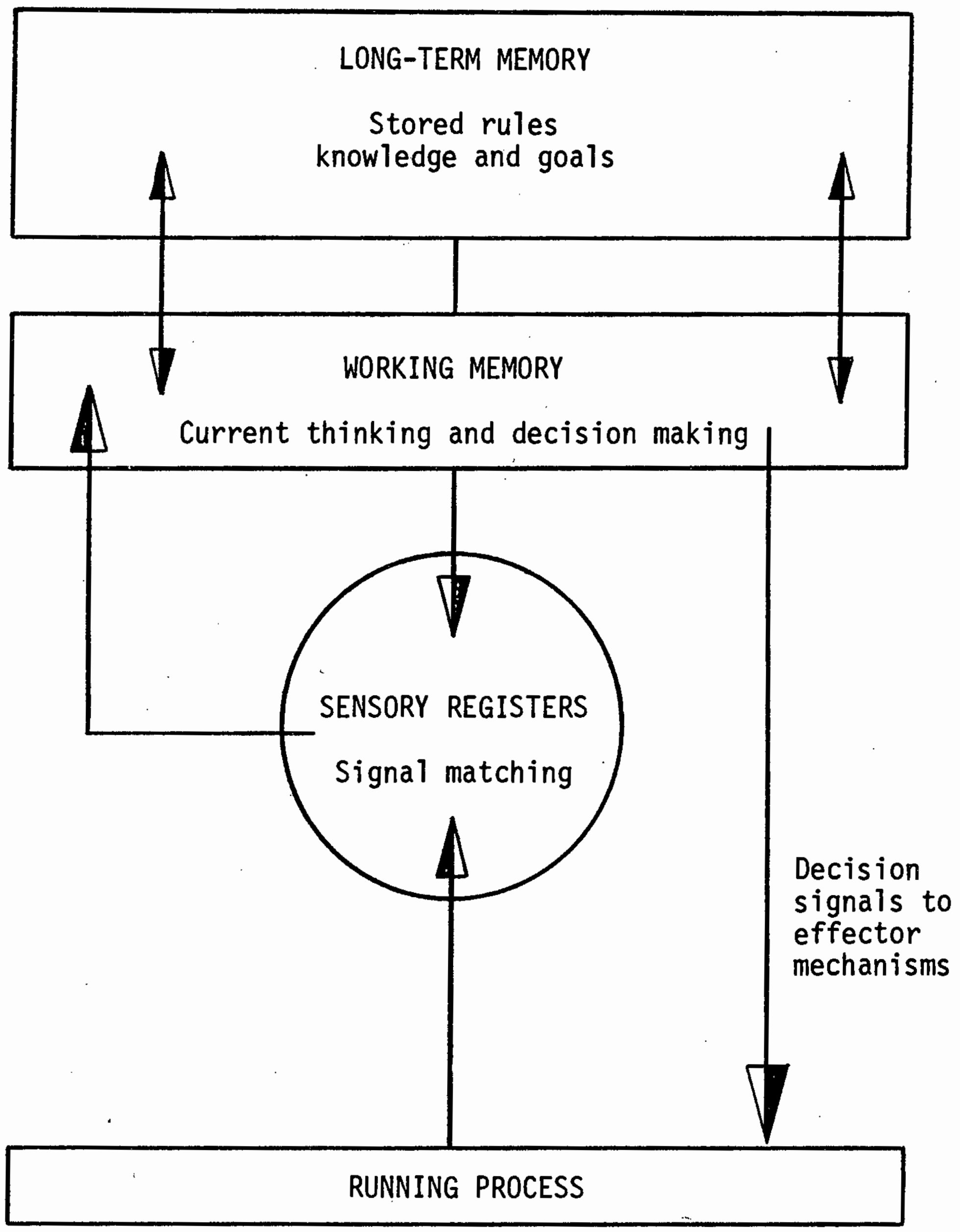


Figure 8. Model of information processing system.

(Gilhooly, 1982; Klatzky, 1980). According to the serial modal model individuals have a vast long-term memory (LTM) and a small capacity working memory (WM, also known as short-term memory), supplemented by high-capacity but short-lived sensory registers (SR, also known as sensory memories). There is a sensory register for each sense. It is important to recognize that a substantial amount of stimulation entering the sensory registers originates from internal kinaesthetic sensors in muscles, tendons and joints (Welford, 1976), in addition to stimuli entering through eyes, ears, nose and skin from external sources. For the clarity of presentation and line of reasoning all sensory registers are depicted in one structure in Figure 8. Thinking is regarded as the manipulation of symbols both within the working memory and between long-term and working memory. These manipulations are understood to be in agreement with rules stored in long-term memory. At any specific moment current goals and the contents of the working memory determine which rule is adopted from long-term memory storage. The seriality assumption underlying the model states that only one thinking step occurs at a time. Processing of sensory cues from the running process commences with the stimuli entering sensory registers. This bit of information can stay in the sense appropriate register only for a brief period of time as information in the SR decays rather rapidly. The longer information stays there, the weaker it gets, till it vanishes completely. This erasing feature of the sensory registers guarantees that only current, prevalent stimuli are attended to. This process creates discrete information, rather than incoherent, overlapping material. While information about the stimulus is in a sensory register, a significant component of the system comes into play before it is passed onto the WM: pattern recognition, a complex process that results in contact between the raw information in the SR and the previously acquired knowledge of the marathoner. This complex process is signified by a closed pattern recognition loop. According to Klatzky (1980) a pattern is recognized when its sensory aspects are in some way matched with stored, meaningful concepts. In a general sense, pattern recognition is the process of assigning meaning to a raw stimulus in code form. Now the encoded, identified information can be passed on the WM. Here information can be held indefinitely by recycling material over and over again. This process, called rehearsal, keeps renewing the information so that decay is never complete. Without rehearsal information perishes. Apart from the limited holding time, there is a limit to the amount of information that can be held in WM. The memory span of the WM can accomodate only about seven items. Loss of information occurs if items are not rehearsed or by overloading the memory span. Once information has been committed to LTM by sustained rehearsal information is permanently stored in this highly organized structure and there is no more loss of information when on cannot recall something one once knew. The information is there, but one cannot get at it. Forgetting is a retrieval problem (Klatzky, 1980). Repeated rehearsal of a specific item in the WM enhances the representation of the item in LTM, so that later it is more amenable to recall. Knowledge stored in LTM is crucial to the process of recognizing arriving stimuli in the sensory registers. Completed information manipulations result in decision stimuli being acted upon by effector mechanisms altering the running process.

The information processing system has a delineated capacity to process information. This overall limitation can intrude into many aspects of processing and is not linked to a particular stage. The limited capacity is known as attention. Although sensory responses to stimulation are automatic, there is a point at which the system reaches its maximum capacity and is unable to process all inputs. At this point attention is anticipated to occur. Klatzky (1980) suggested use of the term "attention-demanding-process" instead of "attention" in order to avoid implying a fixed location at which attention happens.

Figure 9 displays the model according to how a marathoner processes sensory cues from the running process. The runner's long-term goal stored in LTM is to improve his/her marathon race time significantly. Also stored in LTM is the runner's knowledge about past training and race experiences, counsel from other runners and running literature. The accomplished marathoner will have committed numerous successful, as well as unfortunate running events, to LTM storage. Together with the productive, advantageous and invigorating running episodes, LTM will be stocked with momentos of discomfortable, painful and even traumatic incidents. The runner will have tried to

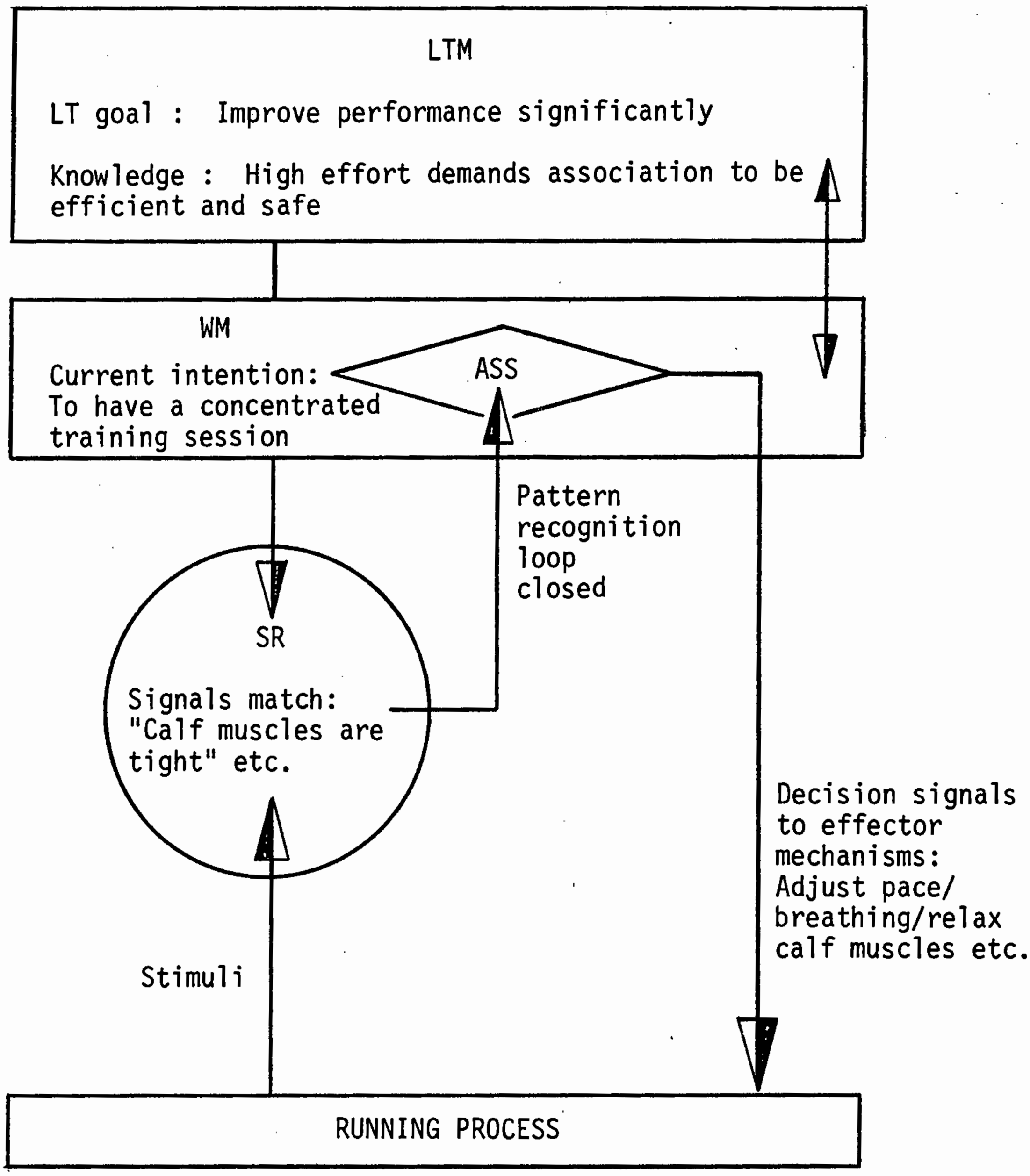


Figure 9. Information processing in an efficient running household.

make sense out of the multitude of experiences, analyzing every bit of available information according to which set of circumstances lead to what kind of outcome. And, in combination with successive exposure to high training efforts, he/she should be in the position to formulate the axiom that an intensive training session is best accomplished with a high degree of body monitoring to evade potential suffering and injury. Thus, with the current intention to produce a concentrated training session the marathoner adopts an associative mode of thinking in the WM. Sensory stimuli from the working body are entered into the sensory registers and equated to meaningful concepts stored in LTM. Raw sensory stimuli received from proprioceptive receptor cells situated in the calf muscles might equate to "calf muscles are tight". The meaningful information derived from this process is acted upon in the WM when decisions are made to adjust the pace and allow the calf muscles to perform at a lower intensity. The runner can reinforce this process by assertive instructions directed at the optimization of the running process by rehearsing the command "relax calf muscles" in the WM. The associative mental strategy adopted incisively upholds a closed pattern recognition loop, the essential feedback system for an efficient running household. Pattern recognition, the process of matching incoming sensory information with previously learned information stored in LTM, accelerates and becomes more exact with practice. This critical discriminatory retrieval process is shaped and calibrated to extremes in superior experienced marathoners through years and years of running experience. Sensory signals emitted from the adjusted running process will considerably reinforce associative thinking when the athlete realizes how much he/she can be in control.

With the general goal in mind to upkeep physical fitness and the current intention to have an enjoyable run, a runner can indulge in dissociative thinking during the training session. Most runners will have come to the notion that low to moderate training intensity allows for all kinds of mental thinking endeavours without running the risk of undue discomfort and injury by their very own actions. Others might not realize the potential danger and have not experienced the eventual painful pay-off of trying to shun warning signals from their body. At low training intensities this does not seem to present a hazard. It is when marathoners forcefully try to push through pain barriers and thereby inflict severe punishment on their bodies that they expose themselves to overuse injuries and system trauma. The example of a runner's thought processes when engaged in a low to moderately intense training effort is shown in Figure 10. Sensory signals emitted from the working body are not interpreted, as the dissociative thinking process effectively blocks the pattern recognition loop. This open-loop system maintains the activity of running without making adjustments to the running process. This means that the supplied running movement does not yield to changing course and system demands, and thereby incurs unnecessary energy expenditure. Dissociation produces an inefficient running household. Only extremely intense sensory stimuli

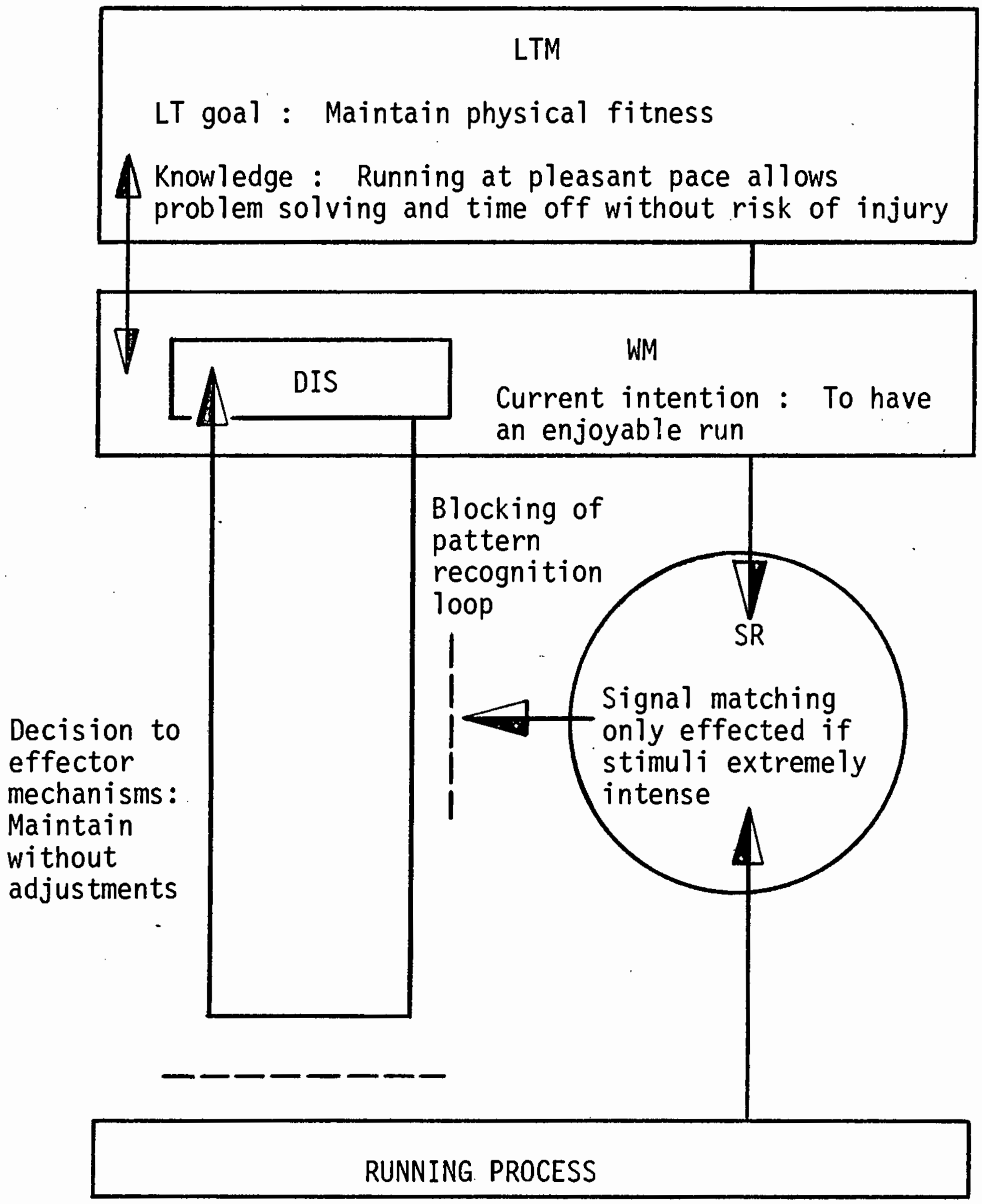


Figure 10. Information processing in an inefficient running household.

occasionally break through the autonomous dissociative thinking cycle, effecting momentary pattern recognition and hopefully directive task-related intervention.

Neither of the two mental strategies is conceived to be practised at the complete exclusion of the other. The hypothesized relationship regards the proportion of associative thinking the runner engages into to increase with advances in the training effort intensity. The marathoner who is prepared to endure repetitive, prolonged periods of high physical strain, necessary for significant improvements in physical conditioning, is seen to have formulated clear achievement goals, and will reiterate his/her intentions and express them in sustained effort during training. The resultant perception of effort after such a training session is constructed through the evaluation and integration of many bits of information processed during the activity of running. This "perception is a kind of gestalt" (Borg, cited in Hage, 1981, p.143) and deemed the most appropriate indicator of training effort intensity. Without the runner's intention, achievement of high training effort is impossible. Of course, superior runners also allow themselves to run at low to moderate levels of effort. On the other hand, novice and average marathoners can also attempt to maintain high training efforts. The pivotal ingredient is the learning process. More and more frequent successive approximations to the terminal response bring about a qualitatively calibrated mental strategy, letting the athlete cope with the physical strain of a demanding training scheme. Transitions from a predominantly dissociative to a predominantly associative mental strategy have been documented (Okwumabua et al., 1983) and are unquestionably part and parcel of the characteristic human learning experience to progress from the unqualified and approximate to the proficient and exact execution of skills. According to the principle of specificity (Rushall, 1981), the more a task is practised, the better the performance becomes. The performance, mental or physical, therefore, becomes less variable or improves in quality. Even for the best marathoner 2 hours (and some minutes) of racing or training present diverse opportunities to let the mind wander temporarily. Orlick (1980) propounded that effective concentration during events like marathons tends to be cyclical. The marathoner may engage in a careful body scan, talk to his/her body, reinforce his/her performance, remind him/herself to relax, then let his/her mind drift to his/her family life and restore his/her focused concentration to initiate a further body check sequence. Evidently, during concentration cycles the dissociative thinking episodes are expected to diminish, as associative thinking spans lengthen with increased training effort intensities. The amalgamation of the two mental strategies within the information processing model is graphically represented in Figure 11. Associative and dissociative mental strategies are depicted in relation to training intensity in the WM structure. As training intensity must increase proportionately to effect greater gains in aerobic conditioning fundamental to the ability to perform sustained work at a high, efficient input of energy, the theory is advanced

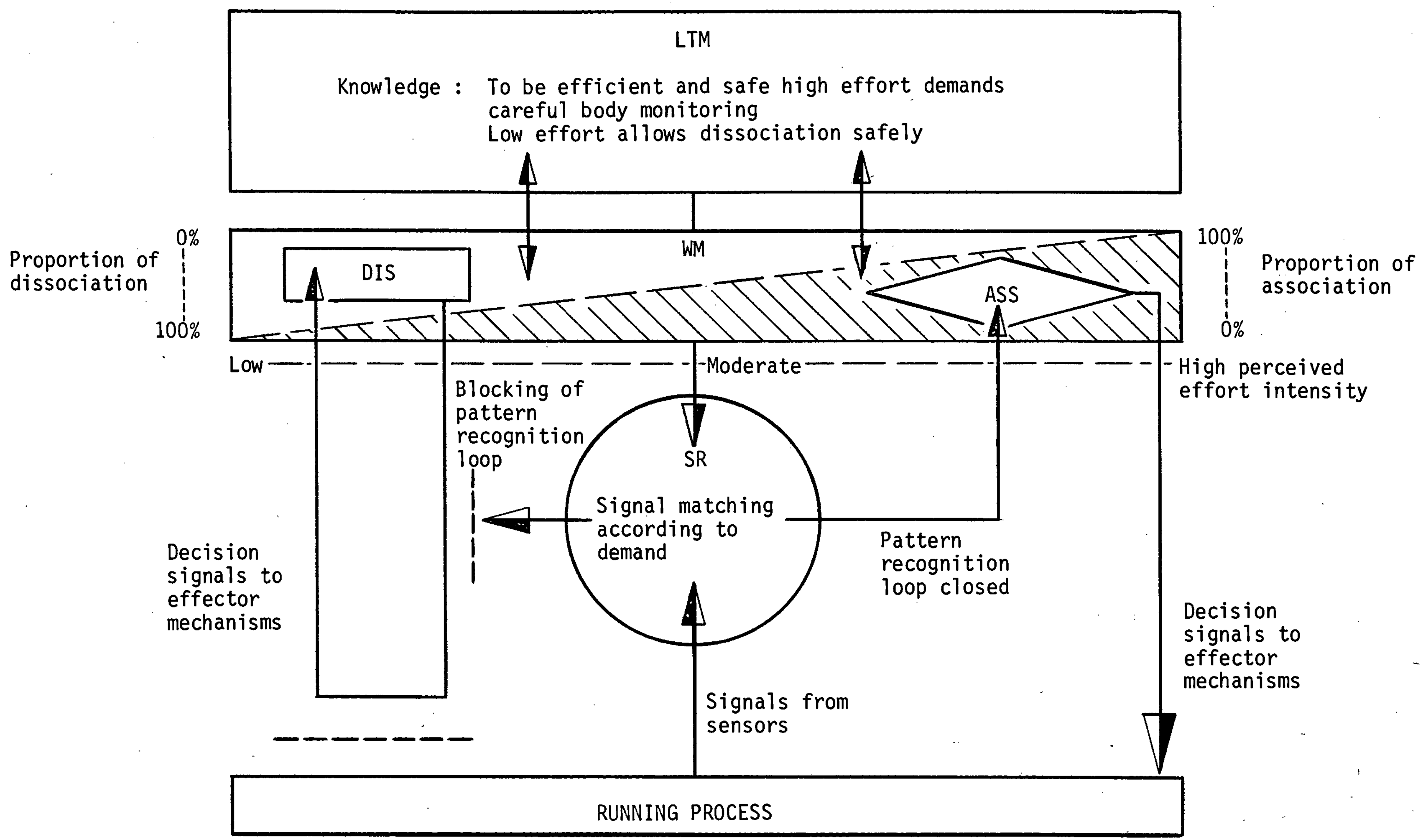


Figure 11. Information processing system combining associative and dissociative mental strategy approaches to running.

that the percentage of dissociative thinking declines as the percentage of associative thinking rises with increments in the perceived training effort intensity. Within the WM structure, the shaded area, representing the associative mental strategy, grows from left to right, as the light area, representing the dissociative mental strategy, diminishes from left to right. The area proportions are expressed in percentages and the perceived training effort is depicted from left to right as expanding from low, across moderate, to high. The pattern recognition process is contemplated to become more discriminating and congruous with increases in associative thinking. Only extremely intensive warning signals break through and are translated when the marathoner thinks about task-unrelated material. As the runner engages in more associative thinking and effectively demands constant acute feedback, task-related thinking is seen to sensitize and calibrate the sensory register.

The progression from an exclusively dissociative to an exclusively associative mental strategy approach to running can be compared to the way authorities have learned how to deal with mushrooming amounts of traffic. Initially, as traffic density increases and accident quotas take on alarming proportions, stop signs replace yield signs. Then traffic lights are introduced. With further traffic density increased traffic lights are synchronized to alleviate the congestion on the road. Finally, sensors are introduced to the road surface, feeding information about the whole traffic situation into a computer that has been programmed to optimize traffic flow in low and peak hours.

The following chapters recount the experimental endeavours involved in the "live" recording of marathoners' thoughts during training sessions of diverse intensities, the development of a functional subclassification system within the broad association/dissociation framework, the content analysis of the recorded thought texts, the evaluation of the hypothesized relationship between mental strategies and training effort, and the implementation of an exploratory mental strategy programme. Implications for the optimal psychological preparation in regard to mental strategies of marathon runners are discussed in the concluding chapter.

CHAPTER 7

MENTAL STRATEGY RECORDING

Research into the mental strategies adopted by long-distance runners to cope with the immense effort involved in completing a marathon has till recently relied entirely on post-event interview data (Morgan & Pollock, 1977), anecdotal reports (Lumian, 1965, 1974), pre-race questionnaires (Freischlag, 1981), pre- and post-race questionnaires (Summers, Sargent, Levey & Murray, 1982), self-report questionnaires during laboratory-type manipulation of cognitive strategies (Okwumabua et al., 1983) and post-experimental questionnaire data following cognitive strategy instruction (Weinberg, Smith, Jackson & Gould, 1984). Sacks et al. (1981) managed to interview ultra long-distance runners during a 100-mile road race by tape-recording answers to a structured questionnaire read out periodically to the runners by investigators bicycling alongside.

Nowhere before has the continuous thought flow of runners been documented. Sacks et al. have pointed the way in the right direction. To advance current knowledge on cognitive coping strategies and to avoid retrospective falsification, as well as to demythologize 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.

It was the aim of this investigation to record and document instantaneous thought processes of marathon runners during the full duration of their training runs.

SUBJECTS

The runners who served as subjects of this investigation consisted of three distinct groups: (1) novice runners of both sexes who had never run a marathon before and were in training for their first attempt, (2) male and female average marathon runners who had experienced at least two marathon races beforehand, and (3) superior marathoners of both sexes who had experienced a history of highly competitive runs.

Novice marathoners

Individuals in this group were drawn from a larger group of volunteers that were in training for their first marathon race. The training programme was developed by Dr. Tim Noakes, the convenor of the Metropolitan Sports Science Centre, University of Cape Town (UCT) Medical School (see Appendix 1). Advertisements in the local dominant daily newspaper asked for 10 men and women of all ages, who were healthy but physically unfit and had the ambition to run a marathon, to come forward and act as subjects in an interdisciplinary research project on marathon running.

Prospective subjects were informed about the 7-month gradual training programme leading up to the 1983 Peninsula marathon, the physiological and psychological measurements the researchers were interested in, and the changes in life-style they were expected to make in regard to their eating and drinking patterns and smoking behaviour. It was stressed that individuals from all walks of life, irrespective of race or religion, or current unfitness level were welcome.

Mr. Rob Cowling, a B.Sc.(Med)(Hons) Sport Science graduate of the UCT Metropolitan Sport Science Centre was in charge of the physiological aspects of the project and intended to utilize the data for a Masters degree (a thesis abstract is filed in Appendix 2).

The response to the advertisement of the Cape Town population was overwhelming: over 400 people volunteered. All volunteers were invited to a preliminary mass meeting where they registered and were introduced to running clubs so that they would have the means to realize their ambition of running a marathon even if not selected for this specific study. The researchers were able to accommodate a maximum of 34 people, who were selected from the group of volunteers on the following criteria:

1. Subjects had to be medically fit to undergo both testing procedures and training.
2. Subjects had to give written consent to undergo the testing procedures.

3. Subjects had not participated in any regular (three times a week or more) physical activity for at least 5 years previously.
4. Subjects had to be highly motivated to complete a standard marathon and be prepared to devote considerable time to the necessary training.

Motivational levels were indirectly assessed by screening the volunteers' stipulated reasons for wanting to participate in the research project. Distinct and intelligible reasons given counted in the volunteer's favour.

Once the training programme had progressed to a level where the majority of runners could sustain 30-minute training runs, 12 runners were randomly selected to participate in the mental strategy recording programme up to the start of their first marathon race (females: 6, mean age: 30.8 years; males: 6, mean age: 37.8 years).

Average marathoners

Locally known marathon runners with the minimum experience of two completed marathons and race times between 3 and 4 hours for males and 3½ and 4½ hours for females were contacted by telephone. The investigation was outlined to them and they were asked if they would be willing to take part. Of the 23 runners approached, 10 volunteered to be subjects and have their thoughts recorded on their regular training runs (females: 4, mean age: 29.8 years; males: 6, mean age: 27 years).

Superior marathoners

Highly competitive marathon runners with race times below 3 hours for males and below 3½ hours for females were included in the superior runner group. Of the 15 runners approached in the same manner as the average runners, 9 volunteered to partake (females: 3, mean age: 25 years; males: 6, mean age: 29.3 years). Six of the 9 superior runners were rated as elite South African marathon runners with race times of 2:17, 2:17 and 2:23 for males, and 2:42, 2:52 and 2:56 for females.

APPARATUS

One of the objectives of this investigation was to procure on-the-spot data recording for the full duration of the runner's training session. The equipment, therefore, had to be light-weight, small, unobtrusive, comfortable to wear and easy to operate. Seven microcassette recorder models were considered. After extensive test runs and consultations with experienced marathon runners it was decided to use the Pearlcorder S901 microcassette recorder by Olympus Optical Co-operation. Inclusive of two alkali batteries, this microcassette recorder weighed 240 g. It had a tape speed of 1,2 cm/s, allowing for 2 hours recording time (60 minutes per side with a MC-60 cassette). The dimensions of the recorder were 129 x 60 x 22 mm. A padded, adjustable belt was designed to allow runners to carry the microcassette recorder on the small of their back. The belt was made of soft cotton cloth with velcro strips at the front for belt size adjustment. The microcassette recorder was enclosed in a foam-padded pouch at the back of the belt in a horizontal position. A Pearlcorder ME4 electret condenser microphone, enclosed in a cotton pouch, was pinned at chest height to the front of the runner's vest with the help of two small safety pins, the connecting cord running down and under either arm to the small of the back. Figure 12 illustrates how a runner carried the ergonomically designed recording apparatus. Two sets of recording apparatuses were available to the researcher.

To facilitate the runners' rating of their level of perceived exertion after completion of a training run, flashcards were used. The Borg scale (Borg, 1978, p.44) was printed on cardboard. Two flashcards were available to the author. A card was shown to runners each time they had finished a mental strategy recording. The flashcard is depicted in Figure 13.

PROCEDURE

The novice runners' training programme was designed by Dr. Tim Noakes,

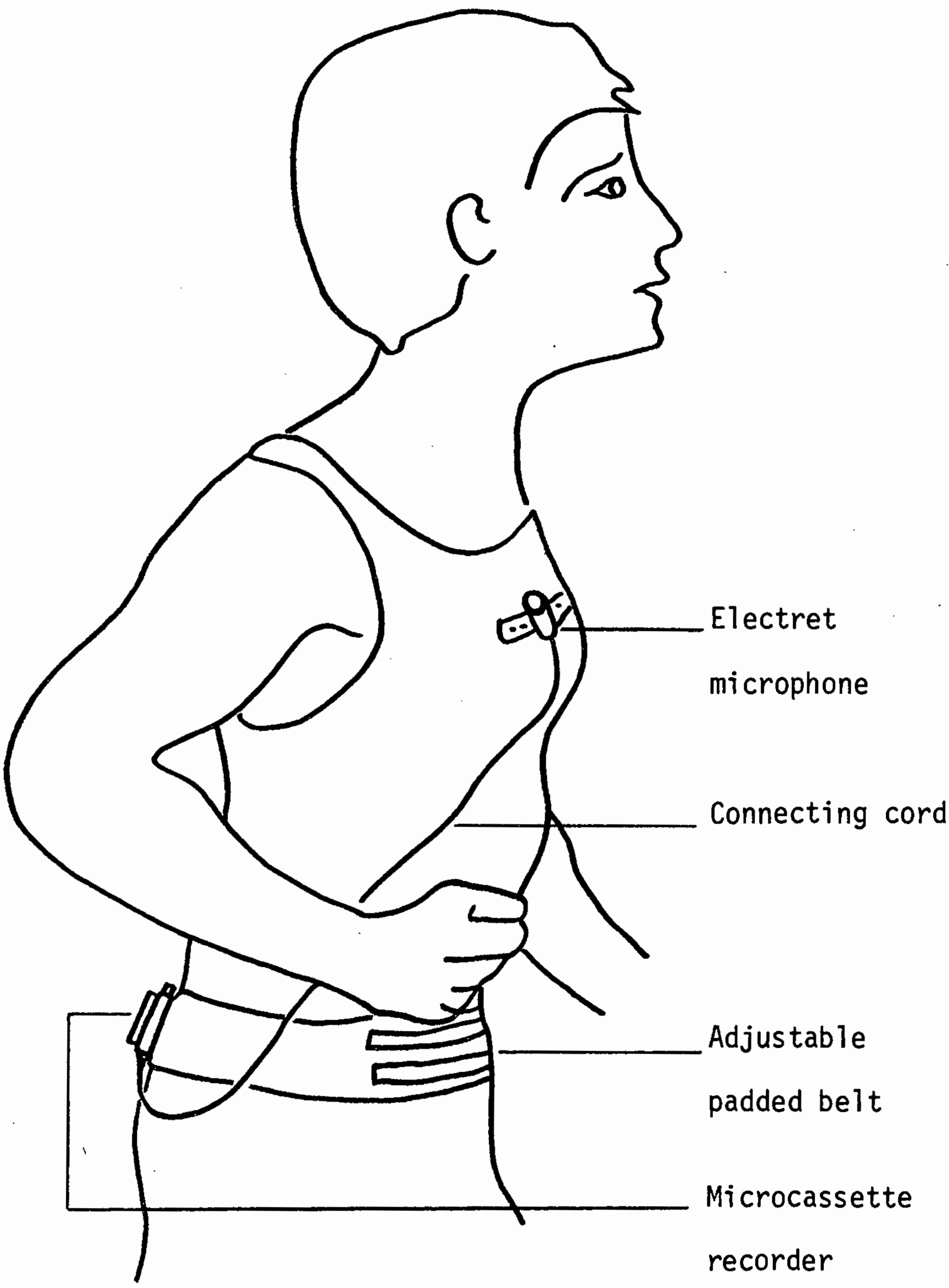


Figure 12. Long-distance runner carrying recording apparatus.

6

7 VERY VERY LIGHT

8

9 VERY LIGHT

10

11 FAIRLY HARD

12

13 SOMEWHAT HARD

14

15 HARD

16

17 VERY HARD

18

19 VERY VERY HARD

20

KINDLY RATE YOUR TRAINING INTENSITY
(PERCEIVED EXERTION) ON THIS SCALE

Figure 13. Borg scale flashcard.

an experienced sport physician and marathoner. The complete running schedule, emphasizing careful progression from walking to running and then a steady increase in the duration of training runs, is filed in Appendix 1. All novice runners were issued with (1) the detailed daily training programme, (2) a list of running tips outlining what kind of shoes and dress to wear, what to eat and how to approach the training tasks, (3) a list of official running clubs to enable the novice runner to join one of them and become a licensed athlete to compete in the 1983 Peninsula Marathon, and (4) log books, asking the novice runner to carefully document his/her running times throughout the training programme. As part of the physiological study undertaken by Mr. Rob Cowling, all novice runners were requested to detail their smoking history, and, in the case of female novice runners, their menstrual cycle history. After having been informed about the possible minimal risks associated with the physiological test procedures, all volunteers gave written consent for the researchers to draw approximately 60 ml of blood three times in the 7-month period, to undergo maximal treadmill tests three times during the same period, and to perform two muscle biopsies.

In addition, all novice runners consented to fill out a battery of psychological tests at the start, the middle and the end of the marathon training programme. The psychological test battery was composed of (1) the Profile of Mood States (McNair, Lorr & Drooleman, 1971), (2) the Adjective Check List (Gough & Heilbrun, 1980) and

(3) the California Personality Inventory (Gough, 1975). These tests were administered to monitor possible changes in personality disposition, self-concept and affective profile during the training period. Data obtained from the above-mentioned tests are to form the basis of future research papers on psychological changes experienced due to physical exercise training programmes (Schomer, 1983).

Novice runners met with the researchers on Wednesday late afternoons and Sunday mornings for their training runs. During the other days of the week runners were expected to individually organize their running venues and possible partners. This pattern was maintained for the entire 7-month period with a 2-week recess over the Christmas season.

Mental strategy recordings commenced once the programme had progressed to a level at which the majority of trainees could sustain a minimum of 30 minutes running. This occurred approximately 3 months into the programme. Twelve individuals were randomly selected to have their thought patterns recorded at regular monthly intervals till the end of the study. On average, every individual in the group of 12 carried the recording apparatus four times. The first two recordings were generally regarded as trial sessions to enable the runners to familiarize themselves with the apparatus and to get used to the task of verbalizing their thoughts during their training runs out loud.

Once the apparatus was comfortably fitted to a runner, the author instructed the runner in the following manner: "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. Please remember that these tapes are treated in the strictest confidence. No third party will know what you have said. Speak your mind. There are no taboo issues or limits here. You can speak in whatever fashion you like. You do not necessarily have to say complete sentences if that is not the way you think. You can say whatever comes to your mind in sentences, phrases or words. Do you have any questions before you commence running?" Any queries or clarifications in regard to the recordings were answered by the author before the runners started on their training session.

During the initial two recordings for each individual the author or an assistant accompanied the runner on a bicycle. The bicycle rider trailed approximately 30 metres behind the runner so as not to disturb the runner's natural flow of thoughts or running pace. Periodically the cyclist would approach the runner and encourage him/her to speak freely of whatever came to mind. The cyclist also assisted in the changing of the tapes in case the training run went on longer than an hour and the runner requested such help. It was found that few runners needed any encouragement to speak freely or assistance with the tape change beyond the first recording session. Once the runner had completed the training run, the author requested the runner to rate his/her perceived training intensity (level of perceived exertion). The flash-card depicting the Borg scale was shown and the runner was asked: "Please rate your training intensity for this training run. I would like to know how much you think you have exerted yourself during this training session. Make use of the interval ratings shown on this card." Ratings of perceived exertion (RPE) values were recorded on the tape. Only then was the apparatus switched off and removed.

It was emphasized to average and superior runners that the author wished to fit in with their individual training programmes. Average and superior runners suggested times and venues where they felt a representative recording session could take place. The researcher arranged on average four recording sessions with every subject in these two groups. The sessions took place in regular monthly intervals approximately 4 months before they entered a marathon race. Although provision was made to regard the first two sessions as familiarization trials the majority of runners reported that one trial session was sufficient for familiarizing them with the apparatus. They did not experience any difficulty verbalizing their thoughts and did not think it necessary to be accompanied by the author or an assistant on a bicycle for the trial session. Instructions in regard to the recording prior to the run were identical to those given to the novice runners. Average and superior runners rated their RPE with the aid of the Borg scale in the same way as the novice runners at the end of a mental strategy recording sessions.

OUTCOME

Across the groups the recording apparatus was carried 109 times. Forty-one recordings were treated as familiarization trials and were, therefore, not made available for transcription. Of the 68 remaining recordings, 64 were judged as undisturbed and representative by the runners. Due to malfunctioning of the electret microphone and recording button a further two recordings had to be eliminated.

Of the 62 recordings qualifying for transcription, the novice runner group contributed 24, the average runner group 20, and the superior runner group 18. Each of the 31 subjects had 2 qualifying tape recordings. All of the 62 qualifying recordings fell within the stipulated 45 minutes minimum and 120 minutes maximum training run times. The 45/120 minute time interval restriction was imposed to let novices' training run durations correspond to those typically reported for the average and superior runners in this study. Recording time ranges and averages for all groups are shown in Table 1. To determine whether there were significant differences in the training run times for the three groups of runners, in spite of the stipulated training run interval, a one-way ANOVA (Keppel & Saufley, 1980; Lindner, 1979; McCall, 1980; Snodgrass, 1977) was conducted. No significant between group differences were found. The results are summarized in Table 2. Recording times for each group are listed in Appendix 3.

Table 1

Recording time ranges and averages for all groups

	Beginner runner	Average runner	Superior runner
Minimum/maximum recording time (in minutes)	50 - 110	58 - 117	60 - 120
Average recording time (in minutes)	79.58	84.50	88.50

Note. Overall range: 50 - 120 minutes.

Overall average: 84.19 minutes.

Total recording time: 86 hours 33 minutes (5193 minutes).

Table 2

ANOVA summary table for training run durations across all groups

Source of variance	df	SS	MS	F
Between groups	2	833.434	416.717	1.206
Within groups	59	20387.607	345.553	
Total	61			

Not significant, $p > 0.25$ (Pearson & Hartley, 1954, p.156).

DISCUSSION

"This is as close as you will ever get to a runner's mind" was the impromptu exclamation of one of the superior marathoners after his first recording session. Similar sentiments were expressed by the majority of subjects. Initial skeptical concern about the possible intrusive effect of thought verbalization on the natural flow of thoughts was laid aside by the average and superior runners surprisingly quickly and spontaneously. "Speaking your mind" was seen as a concentration and consolidation of the natural flow of thoughts. Average and superior runners generally required only one trial recording session to get accustomed to the process of saying aloud whatever they were thinking of during their training runs. Similar viewpoints were expressed by the majority of the novice runners, even though most of them utilized the two trial sessions to get used to the verbalization of their thoughts.

A concern of a different nature was expressed by 3 of the novice runners during their trial recording sessions. The runners were worried that they seemed unable to match the speed at which their thoughts occurred with the speed of their talking about them. After examining their tapes it was discovered that these runners were trying to speak in complete sentences only, as if they were writing a story about their thoughts during their training run. Discussing this finding with them, they acknowledged their persistant, frustrating attempt to explain their thoughts after having experienced and expressed them. These runners voiced a deep concern of having their recorded thoughts misunderstood and misinterpreted. It was explained to these runners that the author was interested in the verbalization of an as natural as possible flow of their thoughts and that they did not have to worry about the meaning of their thoughts. The researcher reassured them that whatever was on the tape would be treated strictly confidentially and that there was no set way of thinking for anybody at anytime. This was demonstrated to the 3 runners by letting them listen to a variety of unidentified recordings of runners unknown to them, effectively dispelling their worries.

It has been estimated that thoughts flash through the minds of humans at the rate of approximately 8 per second (Cratty, 1983). This rate cannot be replicated in the spoken word, nor has there been (and will there be for quite some time to come) any technique for translating the labyrinthine mental activity associated with the activity of thinking into decodeable language. The spoken word is the most authentic representation of this highly complex operation.

The runners in this investigation did not perceive the apparent discrepancy between the speed thoughts occur and the verbalization of these thoughts as an obstacle in the documentation of their thought processes. They reported that dominant central thoughts were the ones they were verbalizing and, therefore, an as accurate as feasible reflection of what a runner thinks during the activity of running. On the basis of the serial modal model of thinking Ericsson and Simon (1980) outlined the conditions under which verbalization can be expected to be an accurate account of mental activity. Most importantly, the verbal report has to be made concurrently with the task-related cognitive activity. For maximum validity the subject's report must be made in a free manner, that means in the subject's own words, not governed by any "experimenter-set categories which may not match the subject's own representational schemes" (Gilhooly, 1982, p.156). According to Ericsson and Simon (1980) only information in focal attention is "verbalizable". This implies that only information in the working memory is verbalizable. Information concerning inputs and outputs of current processes will, therefore, receive priority in free concurrent verbal reports. The serial modal model of thinking cautions that retrospective verbal reports cannot yield as accurate information as current verbalization about task-related cognitive activity because the contents of working memory during processing are very transitory. Subjects asked to furnish retrospective reports have to rely on inferences based on their implicit causal theories of behaviour.

After familiarization with the apparatus and the verbalization task normal mental processes were reported to be verbalized. Runners did not think that the process of recording itself was altering their natural mental processes in any significant way. At the onset of this investigation provision was made for quite extensive familiarization periods. Only novice runners made use of more than one trial recording session. For them both the task of long-distance running and the recording were novel experiences. Accordingly, more time was essential before feeling at ease with the recording task during their runs. For the average and superior runners the activity of running is extremely well integrated in their normal repertoire of behaviours. According to Jones (1979), the physical movement of running at this level of experience is extensively automated and attention can be paid to other aspects of the total performance.

A major factor contributing to the successful mental strategy recording was the ergonomically designed equipment. Extreme care was taken to bring the recording apparatus in line with the recommendations and requests of the advising body of experienced runners within the technological constraints imposed by the current variety of microcassette recorders available on the market. The final product was extremely well received as it was light-weight, unobtrusive, comfortable to wear, and it guaranteed ease of operation.

The research project concentrated exclusively on the recording of mental strategies during training runs as it is in the training phase that an athlete has to approximate and constantly test his/her potential for the real event (Ryder et al., 1976). Experienced marathoners expressed their strong support for this argument. They pointed out that there is very little room for innovation and implementation of untried ideas during a race. It is of interest to note that according to the serial modal model of thinking (Gilhooly, 1982), thinking is seen as the manipulation of symbols both within working memory and between long-term and working memory. The manipulations are understood to conform to rules stored in long-term memory. Rules selected from long-term memory depend on which goals are current and on the contents of the working memory. This implies that the mental side of the runner is as accessible to training as the physiological side. It is during training that goals are carefully conceptualized, different strategies for achieving them put to the test and successful ventures committed to long-term memory. Reiterated mental activities ease retrieval. The marathoner calibrates and ameliorates his/her mental and physiological potential in training. The marathon race outcome is a product of that concomitant training process.

Apart from this, exceptionally few marathoners were willing to carry a recording apparatus during a race when questioned about the possibility. During a race all possible precautions seem to be taken to avoid even the smallest distraction from the event.

Training run durations scheduled for the novice marathoners in Dr. Tim Noakes' training plan as from 3 months before the race event, approached those typically reported by average and superior runners. The difference did not lie in the duration, but in the frequency of training sessions per week. Some superior runners even reported putting in a morning and an evening training session. Nevertheless, the recorded perceived training intensities for each individual training run were based on equivalent effort durations. Though the thought verbalization rate and style for each athlete was expected to vary substantially, evaluations of content analyzed material were to be translated into proportions of occurrence founded on equivalent effort durations.

CHAPTER 8

MENTAL STRATEGY CLASSIFICATION

The associative/dissociative typology of mental strategy classification has been well-documented (Cratty, 1983; Morgan, 1978; Morgan & Pollock, 1977; Okwumabua et al., 1983; Summers, Sargent, Levey & Murray, 1982; Weinberg, Smith, Jackson & Gould, 1984). Associative thinking focuses the athlete's mental capabilities on the task at hand: the activity and maintenance of running. In this mental mode close observance is paid to feelings and sensations generated by the working muscles, joints, lung and heart with constant conscious reminders to stay relaxed and in control of the pace. Dissociative thinking distracts from the task at hand: the sensory signals from the working body are shunned. Athletes engaged in a dissociative mode think about everything but the activity and maintenance of running: they think about their childhood, their work opportunities, solve mathematical problems or relive whatever else might be pleasantly distracting. Morgan (1978) saw this mental strategy to be a form of self-hypnosis. Sachs and Pargman (cited in Cratty, 1983) undertook to explicate this primary division further, though they concentrated on the dissociation category. They postulated three subdivisions for the dissociative thought category: (1) thoughts reflecting diversion, (2) thoughts representing problem solving, and (3) those showing spontaneity on the part of the athlete. Within dissociative thinking diversion and

and problem solving were reported to be prevalent. The researchers cautioned, however, that their findings might well be biased, as the introduction of their questionnaire might have distracted and altered the runner's thought pattern.

An earlier study by Carmack and Martens (1979) surveyed the runner's state of mind at differing phases of the run. Though the researchers did not consider the association/dissociation mental strategy categorization, they generated three related states of mind factors from their post-event questionnaire data: (1) psychological well-being, (2) psychological uneasiness, and (3) a state of mentally "spinning free". The third factor included largely dissociative characteristics: dreamy and detached meditative states which were reported to occur after 40 minutes of running.

Another attempt at associative/dissociative itemization was made by Freischlag (1981). Again, post-event questionnaire data and anecdotal reports were used to evolve five cognitive foci: personal affairs, finishing race, position in race, body, and mechanics in running. No clear pattern emerged from the study and Freischlag concluded that few marathoners fail to either associate with body signals or dissociate by substituting thoughts of personal or race-related concerns, but that they fluctuate between the two modes.

Sacks et al. (1981) postulated an additional kind of thinking to the association/dissociation distinction. During "meditative" thinking runners are said to focus neither on themselves nor on distracting thoughts, rather they are not particularly focusing at all. This meditative mode of thinking is speculated to offer the runner a period of inconsequential reprieve, a kind of mental vacuum.

All of the above-mentioned studies were pointing in the right direction. Mental strategies were seen to significantly determine runners' ways of coping with the physiological and psychological strain of completing a long-distance race, how they could apply their potential, and what benefits they would derive from the running process. Mental strategies were seen as factors that lend themselves to change and, therefore, hold important ramifications for the improvement of a runner's performance.

A detailed, but functional breakdown of the basic associative/ dissociative mental strategy patterns was indispensable before any meaningful manipulation of the marathoner's thought processes could be envisaged. All of the above-mentioned studies were based on questionnaire-type data and were, therefore, limited in their specificity and operationality.

The purposes of this investigation were (1) to develop a functional mental strategy classification system that would optimize future manipulation of the runner's thought processes during training, and (2) to establish whether there exists a prevalence of associative mental strategy among superior marathon runners, compared to novice and average marathon runners.

Once the above objectives had been realized the principal hypothesis that associative mental strategy is directly related to the perceived expended effort was explored in the ensuing Chapter 9.

DEVELOPMENT OF MENTAL STRATEGY CLASSIFICATION SYSTEM

The well-established association/dissociation categorization provided the basis for more specific subdivisions within the two mental strategy modes. Association was seen to refer to task-related thinking, whereas dissociation was seen to refer to task-unrelated thoughts. It was the aim to elucidate functionally succinct subdivisions that would allow for future instructional feedback to the runners without the burden of complex abstract operational definitions. Apart from having to concur with the associative/ dissociative mental strategy classification framework the themes had to be effective instructional tools.

The author was also interested in amalgamating Nideffer's (1981) attentional style categorization into the mental strategy classification. Nideffer postulated two attentional dimensions that were related to effective performance: width of attention (broad or narrow) and direction of attention (internal or external). The width of attention was thought of in terms of how much information an individual had to process at any given time, whereas the direction referred to whether the individual was listening to his/her internal cues (feelings, thoughts) or external cues (things going on around him/her).

Association during the activity of running, in this context, was interpreted as primarily internal narrowing, whereas dissociation seemed to involve substantial internal/external broadening of the attentional focus. This implies that pertinent performance cues seemed to take centre stage when an associative mental strategy was adopted. On the other hand, broadening vision appeared to occupy the runner's mind when a dissociative mental strategy was maintained.

Nideffer (1978, 1980a, 1980b, 1981) has repeatedly emphasized the critical role of the appropriate attentional style for optimal athletic performance. In discussion with superior runners and from the analysis of a random sample of transcribed recordings it became apparent that the activity of marathon running created specific attentional demands on the athlete. Nideffer (1981) cited the example of a marathon runner with the potential to be a contender for an Olympic gold medal in the event. This runner's greatest strength was his ability to narrow his attentional focus, to discipline himself and to concentrate with a single-minded sense of purpose. This attentional narrowing process was seen as almost a prerequisite to achieving an optimal level of performance in marathon running. In addition, Nideffer's attentional style categorization offered further instructional insights and mechanisms for future optimal manipulation of mental strategies.

APPARATUS

The 62 undisturbed and representative recordings were transcribed by experienced secretarial staff on an Olympus Optical Microcassette Transcriber Model T600. On all typed hard paper copies of transcribed recordings the name of the runner and his/her resultant perceived effort rating were omitted. The mental strategy texts were coded numerically from 1 to 62. A separate list with corresponding codes was prepared for future name identification and perceived effort rating analysis. The list was stored in a sealed envelope. Twenty texts were randomly chosen for the development of the specific subclassifications within the associative/dissociative mental strategy classification framework and the attentional style categorization.

SUBDIVISION OF CLASSIFICATION SYSTEM

The texts were surveyed for recurrent thoughts on task-related and task-unrelated material. Within the task-related category the following issues dominated the runner's thoughts: breathing rhythm, pulse rate, muscle tenseness, sensations of vitality/fatique, general tiredness, feelings of stiffness, pain sensations, pace in relation to time, distance covered, running speed in comparison to others running, commands to relax, instructions of how to adjust the breathing, and commands to put in more effort. The main task-unrelated issues were: family problems, intimate relationship problems, career opportunities, work problems, planning of future deals, past marathon racing experiences or training sessions, past running strategies, preparation for future races, weather, temperature and light conditions, scenery descriptions, general whereabouts, conversational chatter with other runners, and unintelligible talk.

The multitude of issues listed above was then collapsed into leading theme categories. In order to derive at a functionally manageable classification, leading theme categories that could not accomodate a minimum of two main issues without loss of definitional explicitness were redelineated. Proposed theme categories were further rigorously rationalized if they violated the feasibility of exhaustive, mutually exclusive and independent classification. As a final criterion, theme categories had to manifest a pronounced attentional focus.

The following 10 categories emerged as valid and reliable mental strategy subclassifications:

1. Feelings and affects (A)

Thoughts concentrating on general sensations of the whole body, like feelings of vitality or fatigue, overall tiredness and stiffness without mention of specific body parts (for example: "I feel bushed", "still feeling fine", "I could embrace the world now, no aches and pains", etc.).

2. Body monitoring (B)

Thoughts of a here and now nature containing specific mention of anatomy, body parts, or body physiology like breathing rhythm, heart beat, or painful calf muscles (for example: "That thigh does seem a bit tired", "shoulders are stiff", "hands are cold", etc.).

3. Command and instruction (C)

Thoughts reflecting emphatic self-regulatory instructions to specific body parts or instructions to whole body functioning distinctly related to the activity and maintenance of running (for example: "Relax your shoulders", "slow, slow, go easy", "breathe deeply now", etc.).

4. Pace monitoring (P)

Verbalized feedback on current performance with respect to time, distance, speed or any other available form or method of pacing (for example: "running a bit fast for this section", "about a minute to go", "three kilometres to go", etc.).

5. Environmental feedback (E)

Thoughts of a here and now nature on the weather condition, temperature, light conditions, smell, and noise level (for example: "bit of a cloud over there, not too hot", "once you're on this stretch, it's so calm", "these car fumes - terrific, jic!", etc.).

6. Reflective activity thoughts (R)

Thoughts on past and future issues related to running, like past racing experiences or training sessions, and future race preparation and planning (for example: "the times I have run this race I have always made it", "I will enter the Peninsula marathon next year - give it a try", "I remember the way I struggled up this hill", etc.).

7. Personal problem solving (S)

Thoughts revolving around issues of an intrapersonal and interpersonal nature including reflective introspection, belief system evaluation and modification (for example: "Shame, I wonder how my girl is?", "feeling very self-conscious about that revolting photograph in the paper", "you know, as a kid I couln't get myself to look into peoples' eyes", etc.).

8. Work, career and management (W)

Thoughts spent on job, work and career opportunities including thoughts centering around the execution, planning and construction of work (for example: "Must get the kids to school on time tomorrow", "I'm supposed to cut the lawns - rats!", "I wonder if the patient I treated at work today is going to have another operation", etc.).

9. Course information (I)

Thoughts of a descriptive nature about scenery and general whereabouts that are of no consequence to pace (for example: "Those mountains look absolutely great at sunset - absolutely beautiful", "I'm going to run around this shopping complex", "flowers all around me, what a scene", etc.).

10. Talk and conversational chatter (T)

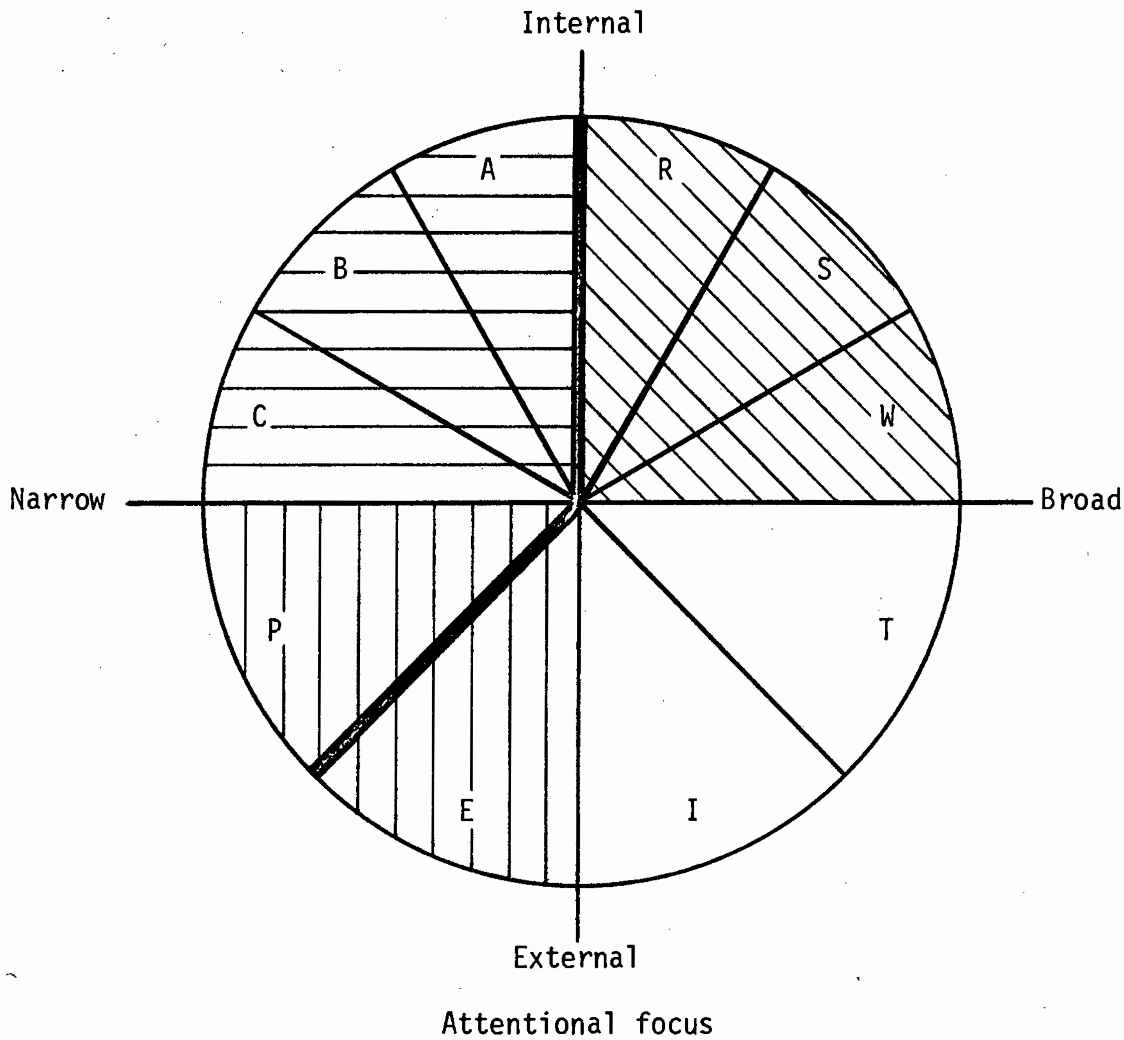
Direct speech when in communication with other runners and thoughts expressing follow-up chatter to initial exchanges, as well as unintelligible or inconsequential extraneous chit-chat (for example: "Hi (name), good to see you out here again - ya, I'm well", "How are your new Nikes? Comfortable?", "That was Graham, hell of a fellow, you know", etc.).

Feelings and affects (A), body monitoring (B), command and instruction (C), and pace monitoring (P) made up the task-related (associative) mental strategy spectrum. The task-unrelated (dissociative) mental strategy embraced reflective activity thoughts (R), personal problem solving (S), work, career and management (W), environmental feedback (E), course information (I), and talk and conversational chatter (T).

An athlete engaged in thoughts that could be classified as feelings and affects, body monitoring, and command and instruction, was seen to manifest internal narrow attentional style. The extremely focused and concentrated attentional style enabled such a runner to pursue the single-minded sense of purpose: the optimal monitoring and maintenance of the activity of running. Pace monitoring required a shift of the attentional style to an external narrow focus, so that the athlete was in the position to judge and calibrate his/her progress according to a narrow field of significant external cues.

A similar attentional focus was required to take in task-unrelated environmental feedback. A broadening of the attentional style was seen to occur for the rest of the dissociative mental strategy subdivisions. Reflective activity thoughts, personal problem solving, and work, career and management all manifested an internal broad attentional style. External broad attentional styles were characterized by course information, and talk and conversational chatter.

The complete mental strategy classification system is exhibited in Figure 14, with relevant abbreviations shown. The mental strategy subdivisions are placed within the attentional style axes. The position of a subdivision within an attentional style quadrant is indicative of its attentional centrality in relation to other subdivisions within the same quadrant. The associative mental strategy is clearly delineated from the dissociative field by a pronounced line. The size of the subdivisions does not symbolize their relative prominence in this general format; the design layout signifies their position in relation to the associative/dissociative and attentional style classification only. This mental strategy classification disc formed the basis for future graphical representations of mental strategy analyses, where percentage occurrence determined the relative size of the individual subdivision within the classification system.



A Feelings and affects
B Body monitoring
C Command and instruction
P Pace monitoring
E Environmental feedback
R Reflective activity thoughts
S Personal problem solving
W Work, career and management
I Course information
T Talk and conversational chatter

Associative mental strategy : A + B + C + P

Dissociative mental strategy : E + R + S + W + I + T

Figure 14. Mental strategy classification system.

CONTENT ANALYSIS

Having accomplished the development of a functional mental strategy classification, the 62 transcribed texts were readied for examination. Content analysis has been advanced specifically for investigating any problem in which the content of communication serves as the basis of inference (Berelson, 1977; Gottschalk & Gleser, 1969; Holsti, 1969). This well-established research method was used by the author to transform the communication content of the 62 transcribed texts, through objective, rigorous and systematic application of categorization rules, into data that could be condensed and statistically compared.

PROCEDURE

Two research assistants were trained in the content analysis technique to enable a double blind research design approach. After having been informed about the theoretical framework in which the author was operating, the research assistants were supplied with the 10 category definitions as stipulated above and the classification disc. These were discussed in detail. The author explained that the content analysis technique was being used for making inferences by objectively and systematically identifying the specified characteristics (designated in the category definitions supplied) of the runners' communications. The recording unit and the system of enumeration were explained with the help of some practice texts. Practice texts were drawn from a random sample of transcribed trial session mental strategy recordings. The most concise intelligible cognitive expression (sentence or phrase) that could be understood when isolated was defined as the recording unit. As the author was interested in proportionality of occurrence, enumeration of the defined recording unit was by a single mental strategy subcategory abbreviation (letters A, B, C, P, E, R, S, W, I, or T). A frequency count of the subcategory abbreviations in a completely content analyzed text was then transformed into percentages of occurrence. Three examples of portions of analyzed practice texts with encoded recording units are given below:

Practice text no. 1

"... The wind is right behind me now. Quite pleasant running.
|———— E ————| |———— A ————|
Lots of problems being involved in the administrative side of
|———————— W ————————
running. My time is taken up too much by it. There is a power
————| |———— W ————| |———— W ——
struggle at work, too. One of the guys on a big ego trip. Tries to
————————| |———— W ————| |— W —
manipulate. Doesn't have the finesse to do it successfully - the shit.
————| |———————— W ————————|
Wow, the seas are rough today. Quite a big swell running. The
|———— I ————| |———— I ————| |——

South-easter pushing it. Nice colour sky. Too many heavy trucks
I — I — E

around, shit. Appreciate one shouldn't run on the road. Hi (name of
S — T

other runner)! Sure I will join you on Saturday. Man, you are going
T — T

fast. Okay, see you. That was (name), hell of a guy at 52. Must
T — T

be making the best progress of all of us. My wife goes to a psychiatrist
T — S

madman for some while. I think she should run. Would do her a lot of
S — S

good. Thinking quite a lot of my daughters. The eldest very ambitious,
S — S

dominant. Okay, let's tackle this hill. Slow, now. Nice and easy
C — C — C

rhythm. Calves feel a bit tight. That's right, feels good. She must
B — A

be under quite some strain now. Standard 9 exams and being short-
S — S

listed for prefects..."

<u>Practice text no. 2</u>

"... The pain is entirely bearable, but it's still in the back of
A — B

your head. It all started up on that Camps Bay run. I kept running
—— R ——|| |——

in spite of a stiff leg. Carrying along fast now. At the zoo. Imagine
—— R ——|| |—— P ——|| |— I —|| |——

being in a cage. She makes me feel that way - sometimes. Oh, bloody
—— T ——|| |—— S ——|| |——

hell, that leg again. Right then, relax. Slow down a bit. Let me work
—— B ——|| |—— C ——|| |—— C ——|| |—— C ——

at it. Use your heels. That's better, good. All the other aches and
——|| |—— C ——|| |—— A ——|| |—— A ——

pains are gone. It's just this mother down at the bottom. It's nice
——|| |—— B ——|| |——

to be sweating again. My present leg pains are out of step with the
—— A ——|| |—— B ——|| |——

way I think I was. Concentrate on being smooth, smooth. Ah, what a
—— R ——|| |—— C ——|| |——

pity, I'm slowing down. Breathing is hard. Just doesn't feel as
—— P ——|| |—— B ——|| |—— A ——

comfortable as before. Concentrate on smoothness. Relax this leg -
——|| |—— C ——|| |—— C ——

damn it. Relax, relax, relax. I feel hotter than before. Go, go, go.
——|| |—— C ——|| |—— A ——|| |—— C ——|

Zoo parking lot coming up. Look at those trees. What a picture.
|—— I ——|| |—— I ——|| |—— I ——|

Sunlight through leaves and all..."
|—— I ——|

Practice text no. 3

```
"... Relax arms. Straight road. Lift legs. Eleven kilometres. Too
   C         I          C          P
fast. Slow down. Slight downhill. Thirty-six minutes. Should loosen
 P     C         I                P              A
soon. Running easy. Considerably slower now. Comfortable. I can keep
       A               P                     A         C
this pace. Hey, (name of other runner) - does your mother know you
                       T
are running? (laughter) Lift legs. Glide, glide, glide. Keep the
                         C          C                  C
pace. One, two, three. Drop arms. Just thinking about the end. I'll
        P              C           R
go all out the last 4 ks. One, two, three. Keep it up. Stride out.
        R                    P           C          C
Keep thrusting. Loosen shoulders. Look at those legs - what a doll.
  C               C                    T
No time to make friends. One, two, three. It's great seeing more
        S                  P                 T
people take this up. Keep moving. Uphill to the gates. Lift legs.
                       C               I               C
Relax shoulders. Keep pushing..."
  C                C
```

Both coders separately scored 12 identical practice texts and then came together with the author to compare results and clarify possible queries. Wherever a category allocation recording unit mismatch had occurred, exhaustive debate was entered into till the problem area was resolved.

The 62 qualifying texts were photocopied and full sets of photocopies were handed to each assistant for encoding. Encoding happened in a double blind fashion. Only entirely encoded texts were brought together and compared. Apparent encoding mismatches were discussed and resolved with the help of the author's guidance. Only once complete concordance had been reached, were category frequency counts conducted and percentage occurrences calculated. The data were entered into a standard data record sheet (depicted in Figure 15) for each text. Figure 16 shows a filled-in classification disc based on the first completed content analysis practice text.

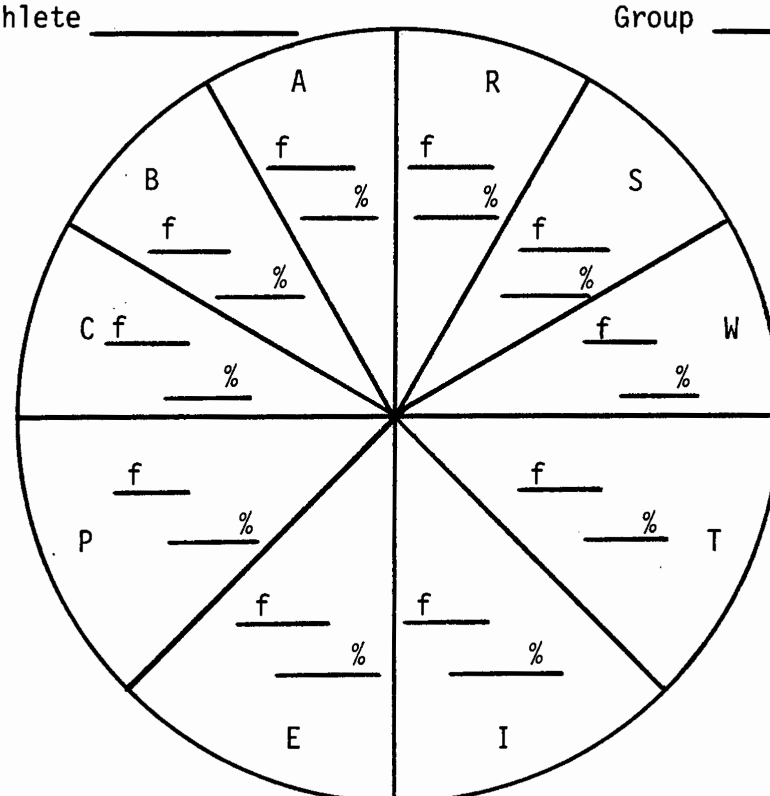
At the top of the record sheets the athletes' names and RPE values were filled in by the author from the identification list, till then stored in a sealed envelope. The record sheets were then sorted according to the novice, average and superior marathon runner grouping. Raw data tables were compiled from these sorted record sheets.

OUTCOME

In the 62 texts, 30 878 recording units were identified. That means

TEXT CODE ☐ RPE ______

Athlete ______ Group ______

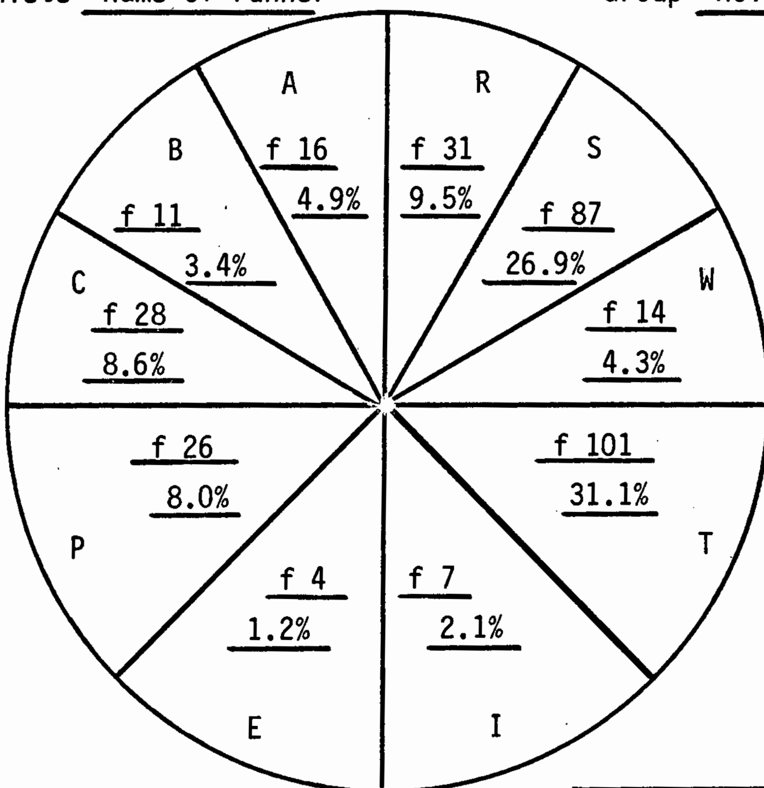


	f	%
Association (A + B + C + P)		
Dissociation (E + R + S + W + I + T)		
Internal narrow (A + B + C)		
External narrow (P + E)		
Internal broad (R + S + W)		
External broad (I + T)		
Total		100
Encoding mismatches		
Mismatches resolved		

Figure 15. Data record sheet.

TEXT CODE 24 RPE 12

Athlete Name of runner Group Novice



	f	%
Association (A + B + C + P)	81	24.9
Dissociation (E + R + S + W + I + T)	244	75.1
Internal narrow (A + B + C)	55	16.9
External narrow (P + E)	30	9.2
Internal broad (R + S + W)	132	40.7
External broad (I + T)	108	33.2
Total	325	100
Encoding mismatches	9	2.8
Mismatches resolved	9	2.8

Figure 16. Completed data record sheet based on practice text.

a text was composed of an average of 498.016 recording units, with a mean of 5.946 units verbalized per minute recording time. As can be expected, this verbalization rate varied quite extensively from one text to the next because runners expressed their thoughts in their unique, personalized fashion. The tempo of thought expression was as diverse as the length of the verbalized deliberations. In order to translate this apparent divergence within the text into coherent data, the absolute frequencies of occurrence were converted into percentages of occurrence. Knowledge about the proportionality of occurrence of mental strategies was of cardinal interest to the author. Sophisticated statistical analyses on the entire data set are documented in the following chapter where the interrelationships between mental strategies and effort sense come under close scrutiny.

The results of the content analysis were accepted as highly reliable as the double blind research outlay made independent verification of the encoding process credible. The two coders achieved 97.338% concordance when encoding the same texts entirely separately and blind. Of the total of 30 877 recording units processed, 30 055 reflected unanimous agreement. Of the 822 (2.662% of total) encoding mismatches, 468 (1.516%) concerned encoding unit queries and 354 (1.146%) category queries. All encoding mismatches were resolved after extensive discussion between the coders and the author, and the mental strategy classification content analysis was considered valid.

To test whether the superior runners in this research project manifested a prevalence for the associative mental strategy approach to running when compared to novice and average marathon runners, a Kruskal-Wallis One-Way Analysis of Variance (Bartz, 1976; Cohen & Holliday, 1979; Hinkle, Wiersma & Jurs, 1982; Welkowitz, Ewen & Cohen, 1982) was executed on the associative thought category data. An insignificant statistical difference was recorded ($H = 4.581$; $df = 2$; $p > 0.05$). Since the value of H was smaller than the tabled chi square value for $df = 2$ of 13.820, it was concluded that the samples came from the same population, with $0.05 < p < 0.10$ (Pearson & Hartley, 1954, p.131) that such a result would happen by sampling error alone. In terms of the data, the superior marathon runners did not manifest a prevalence for an associative mental strategy over the novice and average runners in this study. The range and distribution of associative thought proportions for the three distinct marathoner groups is depicted by the directional scattergram in Figure 17.

The overall average mental strategy disc is depicted in Figure 18 in comparison to the individual average discs for the novice, average and superior marathon runner groups in Figures 19, 20 and 21 respectively. The associative mental strategy section is highlighted in each disc. Analyses of the distinct subdivision differences within the associative and dissociative mental strategy modes are presented in the following Chapter 8.

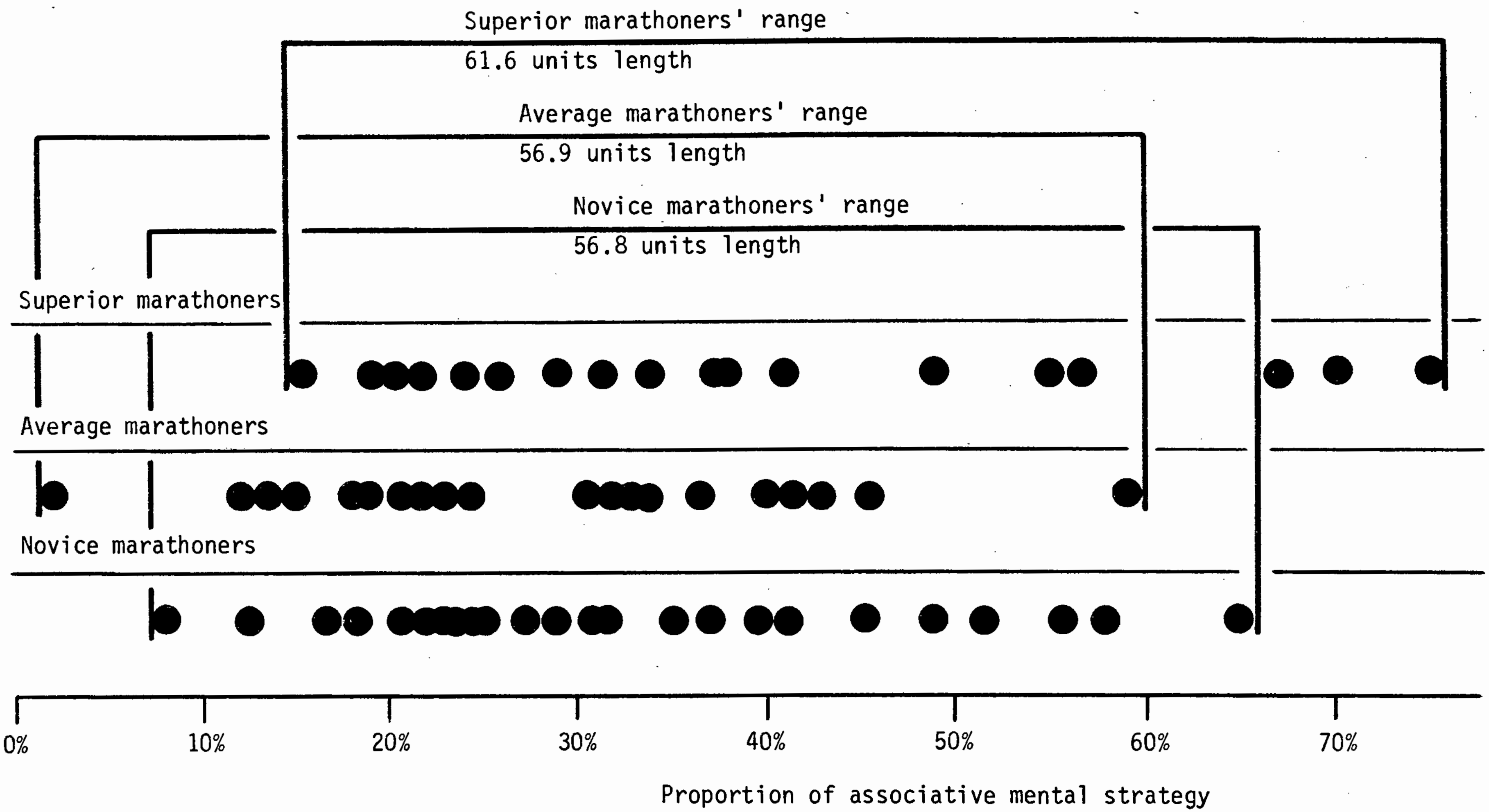
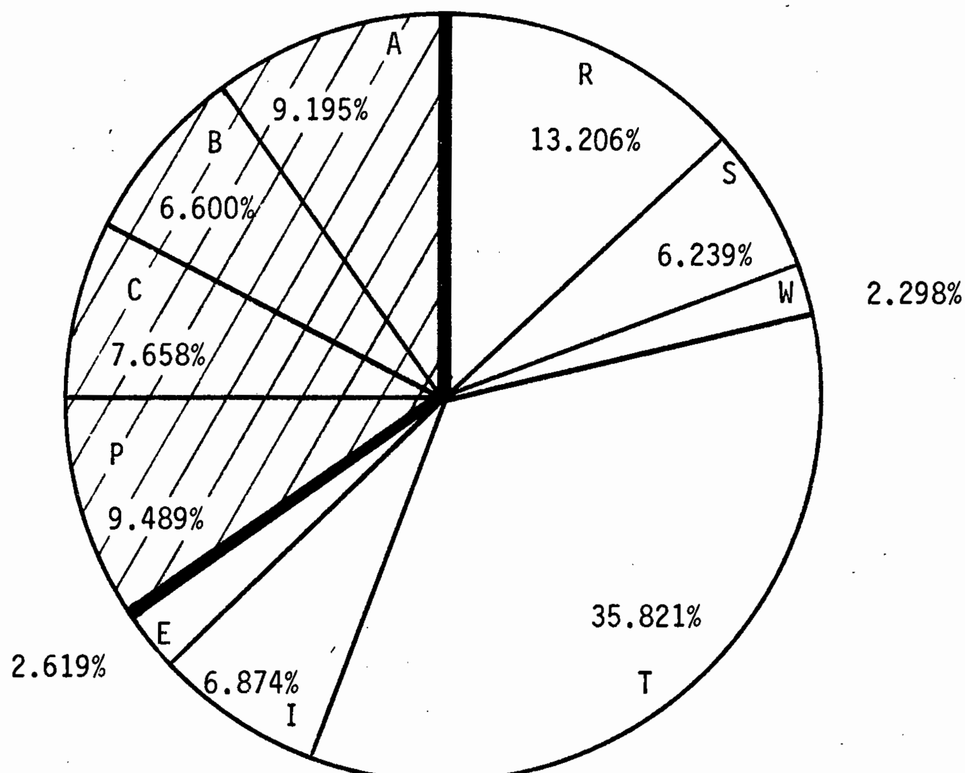


Figure 17. Directional scattergram of proportions of associative mental strategy for the experimental groups.



Association : 32.942%

Dissociation : 67.058%

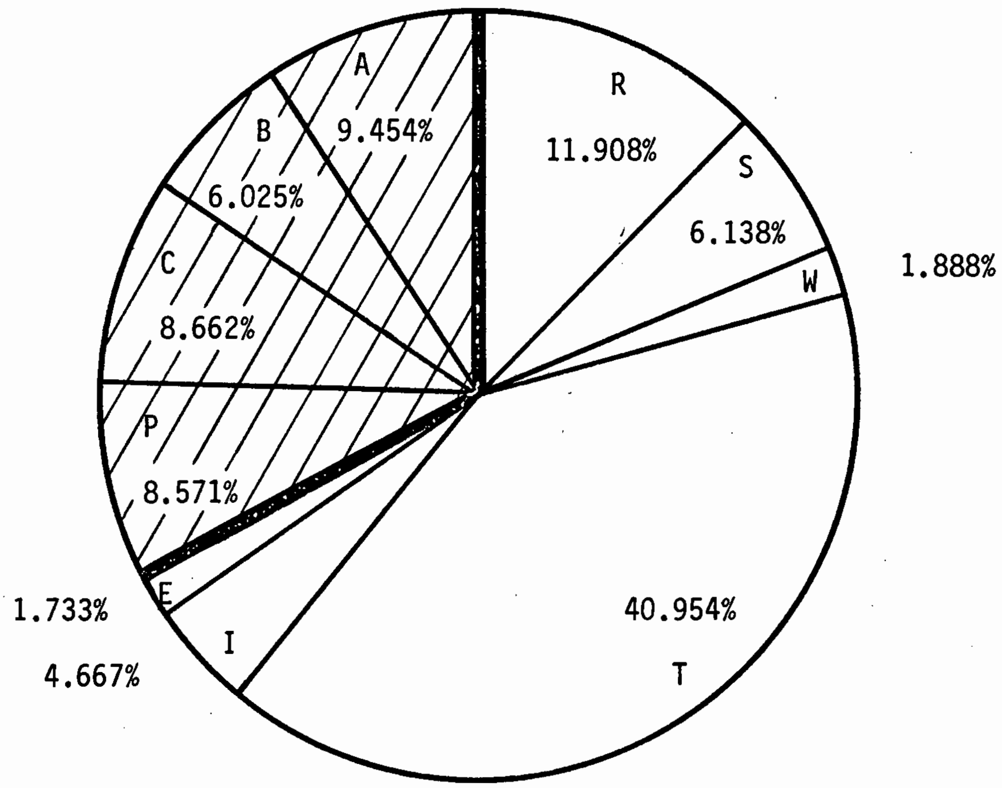
Internal narrow (A + B + C) : 23.453%

External narrow (P + E) : 12.108%

Internal broad (R + S + W) : 21.744%

External broad (I + T) : 42.695%

Figure 18. Overall average mental strategy disc.



Association : 32.712% ▨

Dissociation : 67.288% □

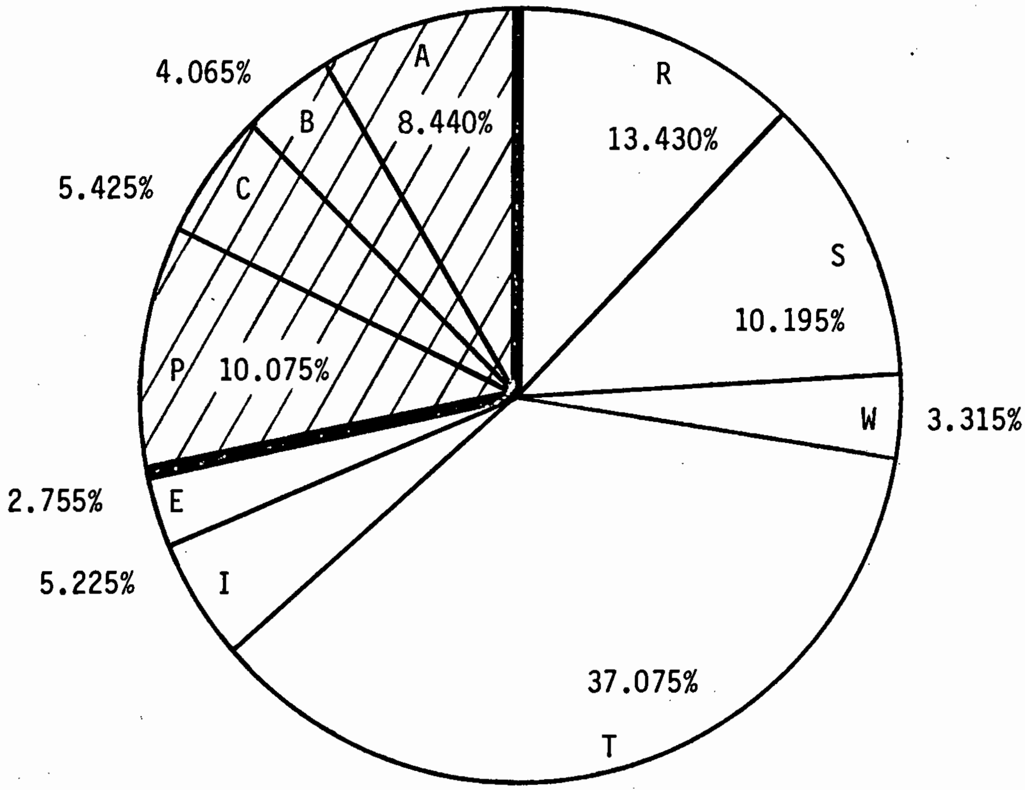
Internal narrow (A + B + C) : 24.142%

External narrow (P + E) : 10.304%

Internal broad (R + S + W) : 19.933%

External broad (I + T) : 45.621%

Figure 19. Average mental strategy disc for all novice marathoners.



Association : 28.005%

Dissociation : 71.995%

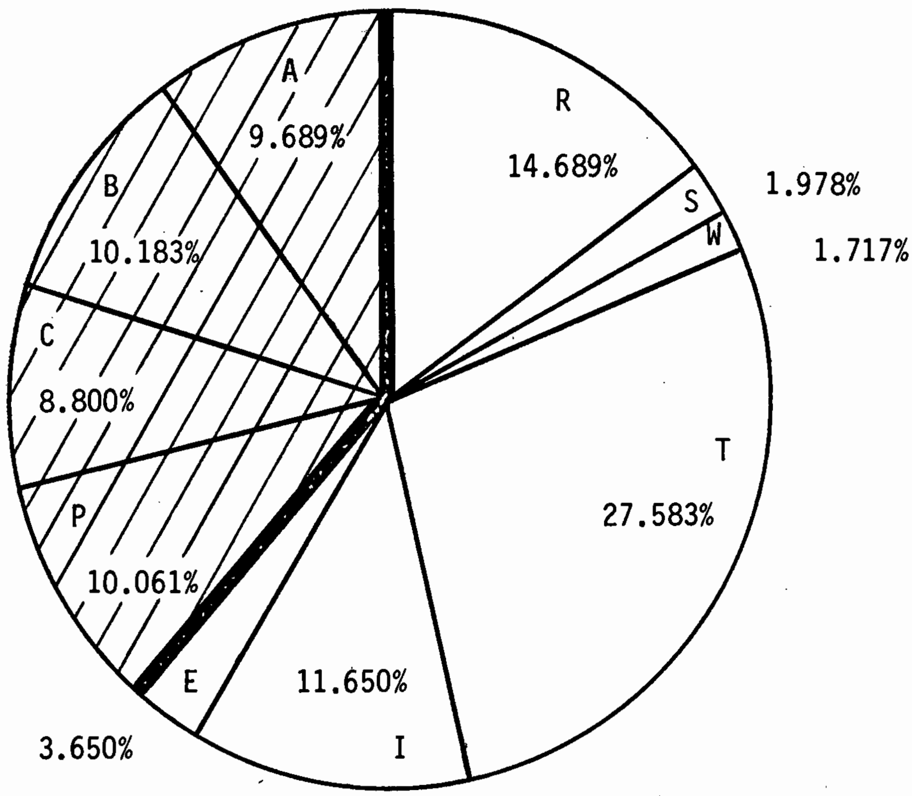
Internal narrow (A + B + C) : 17.930%

External narrow (P + E) : 12.830%

Internal broad (R + S + W) : 26.940%

External broad (I + T) : 42.300%

Figure 20. Average mental strategy disc for all average marathoners.



Association : 38.733%

Dissociation : 61.267%

Internal narrow (A + B + C) : 28.672%

External narrow (P + E) : 13.711%

Internal broad (R + S + W) : 18.383%

External broad (I + T) : 39.233%

Figure 21. Average mental strategy disc for all superior marathoners.

DISCUSSION

When the 62 qualifying tape recordings were being transcribed the initial reaction of the author to the growing body of texts was sheer exuberance. This feeling was dampened somewhat proportionally with the realization of what magnitude the ensuing content analysis work would be. The task at hand: make sense of 500 plus pages of runners' thoughts.

The mental strategy classification system that evolved through the careful scrutiny of sample texts for leading thought themes, and the amalgamation of these themes and Nideffer's (1981) attentional style categorization within the association/dissociation framework, made this task practicable. This did not imply, however, that the task of encoding the extensive texts would be less time-consuming. It meant that at the end the immense undertaking the mass of information available would be condensed into manageable, meaningful data.

The new system offered several points of cross-reference to the content analyst. Once a text had been dissected into articulate recording units, the analyst could allocate the leading theme categories and refer to the attentional focus manifested in the expressed thought, for confirmation and clarification in case any matter was in dispute. This cross-reference process added substantially to the definitional clarity of the relevant categories and thereby consolidated the high validity of the classification instrument further.

Another potential avenue of approach was to home in on the theme categories from the wide angle task-related/task-unrelated classification. Both coders emphasized the pivotal role the cross-referencing capacity within the system had played. This capacity would again be highlighted in the subsequent training situation.

Holsti (1969) cautioned about the delicate balance between content analysis complexity and resultant reliability. As categories and units of analysis become more complex, they are likely to become more useful and less reliable. Judging by the high degree of intercoder concordance achieved in the double blind method and the instructional potential the multi-dimensional classification system offered, this balance seemed to have been struck. It has to be mentioned here that both the unit of encoding (shortest meaningful cognitive expression) and the category descriptions were assimilated with confidence and ease by both coders. This must have contributed substantially to the reliability of the content analysis.

Of course, the envisaged mental strategy training programme would have to substantiate whether the instructional potential could be realized. In discussion with experienced runners the system was assessed as specific and logistically operable. A point that was stressed again and again is that a training programme had to be detailed and coherent, as well as responsive. The requirement of specificity was seen to be represented in the 10 precise theme categories. As the system amalgamated attentional foci and thought themes within the primary associative/dissociative framework, coherence was affirmed. The responsiveness of the system in regard to its applicability within a training scheme was judged to lie in its multi-dimensionality, a definite recommendation as far as the subjects' desired involvement (Schleser, Meyers & Cohen, 1981) in the active participation of the envisaged mental strategy manipulation was concerned. Should an athlete have difficulties in responding to the specific suggestion to concentrate on his/her breathing rhythm, for instance, the trainer would be in a position to approach the athlete from the attentional focus dimension instead, with a less specific suggestion that he/she should try and narrow the field of attention. Once that was achieved the narrow attentional focus could be directed to internal cues. This round-about alternative suggestion sequence would be responsive to the athlete's egocentric processing of thought manipulations and eventually serve the same purpose as the direct, specific intervention: to let an athlete experience and practise concentrated associative thinking.

No "altered states of consciousness", "runner's highs", "mental drifting", or other mystical Zen-like experiences were reported. The clear majority of subjects fell into what Pargman (1980) termed the committed-dedicated runner class and based their involvement in and reasons for running on intellectual, rational ideas. Euphoric, mind-bending running episodes did not feature in their mental strategy repertoire. Although a "daydreaming and drifting" ("D"; dissociative, internal broad attentional focus) mental strategy category was envisaged by the author, as such experiences have been widely proclaimed on the basis of retrospective information (refer to Chapter 4), runners' dissociative thinking appeared goal-directed and intentional. When asked whether the verbalization process prevented them from engaging in such mental activity, marathoners stated that this was not the case and that at the very rare occasions in their running histories they might have experienced anything similar, such states were most probably rather subconsciously perceived, inconsequential and fleeting.

The goal of the mental strategy training programme envisaged was to be able to train marathoners to control their thoughts and, therefore, their attention, so that they could match the specific attentional demands which are created by the maintenance of a high output training schedule aimed at the optimization of the runner's output during a marathon race. As Nideffer (1981) has stated, the ability to control attention and to shift attention from one focus to another is related to emotional arousal. In sport emotional arousal is heightened the greater the competitive stress of the situation. This reaction is part of the well-documented flight-fight response (Everly & Girdano, 1980; Girdano & Everly, 1979; Greenberg, 1983; Reilly, 1981b). Generally speaking, the closer the contest and the more is at stake, the greater the emotional arousal is likely to be with the concomitant disturbing physiological changes of heart and breathing rate increases, and galvanic skin response and muscle tension increments, to mention a few. In such a stressful situation, Nideffer (1981) asserted, the athlete tends to rely on his/her particular attentional strength. That means an athlete will focus on what he/she is most accustomed to focus on. If an athlete has developed and nourished a strong external broad attentional style throughout his/her experiences in dealing with the sporting environment, this attentional mode has become dominant for this particular athlete, and this is the focus he/she will initially rely on when under pressure. In case the pressure on the athlete is maintained or even intensified, this will lead him/her to involuntarily narrow his/her attentional focus. Now less information is processed, but more intensely. If the sporting situation is complex, therefore demanding attention to many different things at the same time, the athlete will experience coping problems. Finally, Nideffer stated, attention becomes internal on top of being narrow. This is where the danger lies for the marathon runner. Just as the internal narrow attentional focus can be positively centered on his/her attainment of a smooth running rhythm, avoiding possible exhaustion by overreacting to another runner's challenge, so too can it become fixed on the athlete's overwhelming negative affective feedback, expressing worry, doubt and concern about his/her abilities. This negative downward spiral is what has been referred to as "choking" (Nideffer, 1981). The automated activity of running is not complex and, therefore, a narrow attentional style can be a decided asset in monitoring relevant task-related information from the body and making logistic adjustments to the running process. What the marathoner cannot allow to happen is to let the narrow focus lock in on exclusively negative internal affective feedback. The optimization of the constant monitoring and adjusting process calls for internal narrow focusing of another kind: careful assessment of the body's functions and subsequent positive command and instruction to control the running process and not let the running process control the runner. If the athlete, for instance, receives painful cues, positive command and instruction create the expectancy or belief that he/she can cope with and make the necessary adjustments to overcome the pain. Statements of a positive assertive nature give an individual a sense of effective personal control over the stressful cues, which in turn reinforces the belief that one can in fact cope with the stressor (Girodo & Wood, cited in Weinberg, Smith, Jackson & Gould, 1984).

The command and instruction theme is seen as a vital integral mental strategy component within the new classification system and mental strategy processing model. Assertive guidance and dynamic encouragement during the run is absolutely essential in the maintenance of an efficient running household. Weinberg, Smith, Jackson & Gould (1984) have treated this mental strategy component as separate from association and dissociation. However, separating "positive self-talk-coping", as they called it, from associative thinking is artificial. Association does not mean passively listening to the body cues. Task-related thinking involves active intervention in the process of running. This active involvement completes the efficient feedback process that allows the marathoner to produce and maintain an efficient running household. Associative mental strategy occurs in a closed-loop system where feedback, error detection and error correction are key elements. There is a reference (experiences of successful runs stored in long-term memory) that sets the desired value of the system (optimal running energy utilization). The output (current running performance) is fed back and compared to that set value for confirmation, error detection and subsequent error correction. Without assertive guidance and dynamic encouragement vital mechanisms for error regulation are lacking. Feedback deteriorates into passive information accumulation. The compensatory capabilities are weakened and the output (current running performance) does not match the set reference value, thereby impairing the till then efficient running household.

As Nideffer (1981) has demonstrated, an athlete can learn how to achieve, maintain and shift his/her attentional focus. If a marathon runner does not have the attentional ability to direct his thoughts to task-related processes and maintain them in the constructive domain (affective feedback, body monitoring and command and instruction), he/she runs the risk of being propelled into an internal narrow attentional style by rising pressures in a competitive situation. This forced narrowing and internalizing of the thought spectrum is likely to result in undesired states of anxiety and even panic. It is, therefore, essential for the runner who intends to optimize his/her output to practise associative thinking to maintain an efficient running energy household and to avoid the negative downward choking spiral.

In Morgan and Pollock's (1977) original investigation it was reported, on the basis of questionnaire-type data, that elite marathoners adopted the associative mental strategy, whereas non-world class runners preferred to dissociate from the sensory feedback received from their bodies during a race. Elite runners, it was argued, could afford to associate because their phenomenal physical condition allowed them to do so, thereby processing the pain and discomfort cues from their bodies and avoiding the risk of tissue, organ and system trauma. Morgan (1978) reasoned that the elite marathoners' lung, heart and muscle power are so overwhelming that they suffer less during a race than the average or novice runner and can, therefore, bear to process the task-related pain and discomfort cues. Although highest percentage occurrences and a relatively cluster free spread of associative thinking were recorded by superior marathoners in this study, both novice and average runners showed similar prevalences for associative thinking (refer to Figure 17), the differences observed being statistically insignificant. Across the three distinct groups marathoners engaged in associative thinking to a resembling degree. On the basis of self-report questionnaires Okwumabua et al. (1983) reported that novice runners used increasingly more associative mental strategies as they gained running experience and physical proficiency. Okwumabua et al. saw this trend to support Morgan and Pollock's (1977) findings that only with increases in endurance and strength can the cost of adopting a task-related mental strategy be reduced and tolerated. The novice runners in the present study had progressed well into their training programme and average and superior marathoners reported well-established regular training schedules. This pool of running experience and advanced physical conditioning might partly be responsible for the trend documented here and will be discussed again in the subsequent chapter when quantitative and qualitative differences within the associative thinking have been examined in detail across the groups.

Sacks et al. (1981) hypothesized that runners emphasize thoughts that carry "emotional investment" at the cost of others that don't but have nevertheless been "thought". Associative thinking, imbued with emotional investment and important meaning, is remembered whereas task-unrelated material is passed over. If such a process is in operation during the activity of running, the accuracy of retrospective accounts on runners' thoughts are highly suspect. Post-event, verbal recalls would be reduced to a collection of highly biased, emotionally charged mental running momentos. This would imply that previously stated research findings and conclusions would be founded on rather shaky grounds. As the current study recorded concurrent continuous thought flows detailed accounts of whatever went through the runners' minds are available for inspection.

CHAPTER 9

MENTAL STRATEGIES AND THE PERCEPTION OF EFFORT

There is a momentous effort involved in the sustainment of a superior marathoner's training programme. Although specific training schedules show a great variety, runners may find themselves on the road for up to 200 km a week, week after week, one foot in front of the other. Whatever the specifics of a training schedule, as Ryder et al. (1976) pointed out, runners must obtain maximal exposure to the conditions under which they will run. To gauge how much greater a training effort they have to invest to beat a standing record, runners analyze the performances and training methods employed by the current record holders. Deductions made inevitably have to reflect a proportionate amplification of the training effort needed to run that fast that far. Ryder et al. predicted that future record holders will spend their lives running at a race pace.

What is asked of any marathoner who seeks to improve current performance is hard work - ever-increasing amounts of effort during daily training. It was the aim of this investigation to elucidate the relationship between the mental strategies employed by runners during training and the perceptions of effort. Based on the theoretical framework proposed in Chapter 7, it was hypothesized that high training intensity (reflected in high perceived ratings of exertion after a completed run) is directly related to high proportions of associative mental strategy. Low training intensity (as reflected by low ratings of perceived exertion) will be related to high proportions of dissociative thinking. The hypothesized positive direct relationship between increases in associative mental strategy and ratings of perceived exertion is said to hold regardless of the running status the athlete has achieved. This means the relationship will hold for novice, average and superior runners. In addition, the author was interested to explore the quantitative and qualitative differences within the associative mental strategy as reported by the three experimental groups. The previous two chapters have documented the methods and procedures developed to enable on-the-spot data collection, mental strategy systematization, and content analysis of the verbalized thought flow. The data analyses executed here are based on the data set generated in the preceeding chapters.

RESULTS

The data consisted of proportions (percentages) of activity time assigned to categories of activity as exogenous (independent) variables:

A: Thoughts on feelings and affects

B: Body monitoring thoughts

C: Thoughts reflecting command and instruction

P: Pace monitoring thoughts

E: Environmental feedback thoughts

R: Reflective activity thoughts

S: Thoughts manifesting personal problem solving

W: Thoughts on work, career and management

I: Course information thoughts

T: Talk and conversational chatter

100%

IN: Internal narrow attentional focus

EN: External narrow attentional focus

IB: Internal broad attentional focus

EB: External broad attentional focus

100%

and

ASS: Associative mental strategy

DIS: Dissociative mental strategy

100%

using the equations:

$$ASS = A + B + C + P$$

$$DIS = 100 - ASS = E + R + S + W + I + T$$

$$IN = A + B + C$$

$$EN = P + E$$

$$IB = R + S + W$$

$$EB = 100 - (IN + EN + IB) = I + T.$$

Two further systems of possible exogenous (independent) variables were constructed. The relationships between these sets of variables and endogenous (dependent) variable

Y: Ratings of perceived exertion

were studied across the entire set of 62 cases and within groups defined by a grouping variable (refer to Chapter 7)

G = 1: Novice marathoner

G = 2: Average marathoner

G = 3: Superior marathoner.

Although the dependent variable Y is not a continuous measure, it was decided that a multiple regression model would be used as an exploratory or explanatory tool. If that proved inadequate data transformations would be examined involving either or both the dependent variable and the independent variable set.

Since explanatory models are most advantageous when simple and efficient, a variable subset selection technique, based on Mallow's C_p criterion (Draper & Smith, 1981) was chosen (refer to Appendix 4). It is well-known that the criterion is conservative and may lead to the inclusion of more variables in the model than might strictly be necessary. Nonetheless, it serves as a basis to eliminate variables which seemingly exhibit no explanatory potential. It was, therefore, applied to the three subject groups' data and to the aggregated data for each of the variable sets

A, B, C, P, E, R, S, W, I, T

IN, EN, IB, EB

ASS, DIS.

Because each of these sets of variables is known to contain a linear dependency (the total is 100 for each subject), it was decided to eliminate one variable from each analysis. Here T, EB and DIS were dropped, but check analyses for simple linear regression on T and EB were conducted, in case of overlooked effects. No check run was necessary for DIS since in the last set using either variable in the model is equivalent to using the other.

The analyses based on C_p were produced from the BMDP9R programme (Dixon, 1981), with data summaries produced by BMDP1D. The runstreams used to generate the analyses are given in Appendix 5.

The overall pattern emerging across the analyses was that ASS gave remarkably strong correlations in all analyses within and across the groups of subjects. The exceedence or tail probabilities associated with the F-statistics were all smaller than the calculating power of the BMDP suite of programmes could handle and are reported as zero (technically at most 1 in 20 000). The findings of the above all subset multiple regression analyses are summarized in Table 3. Graphical representations of the above results are provided in the scattergrams with regression lines for all groups, the novice group, the average group and the superior group in Figures 22, 23, 24 and 25 respectively. Regression equations are listed in Appendix 6.

Table 3

All subset multiple regression summary table for subset ASS

	All (S = 62)		Novice (S = 24)		
C_p		0.118 ASS		0.113 ASS	
R^2	0.861	0.430 (C)	0.812	0.492 (C)	0.644 (IN)
				0.409 (B)	0.023 (EN)
				0.183 (A)	
R	0.928		0.901		
$\hat{R}^2$	0.858	0.421 (C)	0.804	0.469 (C)	0.628 (IN)
				0.382 (B)	-0.021 (EN)
				0.146 (A)	
F	370.99		95.16		
df	(1;60)		(1;22)		
Tail	0.000		0.000		

Table continued on next page

Table 3 (continued)

All subset multiple regression summary table for subset ASS

	Average (S = 20)			Superior (S = 18)		
C_p		0.130 ASS			0.118 ASS	
R^2	0.883	0.445 (S)	0.483 (IB)	0.887	0.587 (C)	0.780 (IN)
		0.348 (A)			0.503 (B)	0.426 (EN)
		0.305 (P)			0.396 (P)	
		0.290 (C)			0.001 (A)	
		0.068 (B)				
R	0.940			0.942		
$\hat{R}^2$	0.877	0.414 (S)	0.454 (IB)	0.880	0.561 (C)	0.766 (IN)
		0.311 (A)			0.472 (B)	0.391 (EN)
		0.266 (P)			0.358 (P)	
		0.251 (C)			-0.062 (A)	
		0.035 (B)				
F	136.04			125.50		
df	(1;18)			(1;16)		
Tail	0.000			0.000		

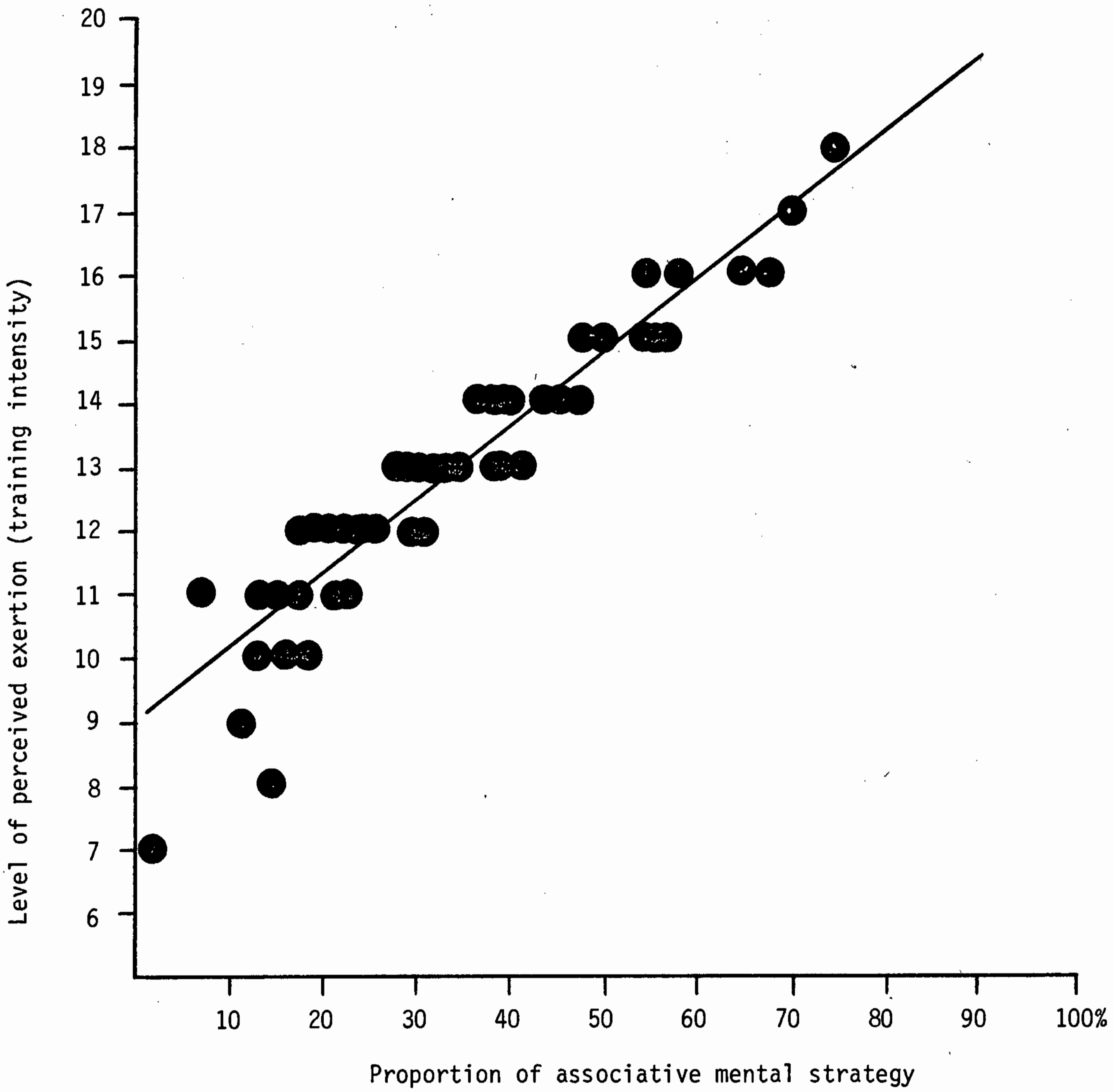


Figure 22. Scattergram of proportions of associative mental strategy and perceived exertion levels with regression line for all groups of marathon runners.

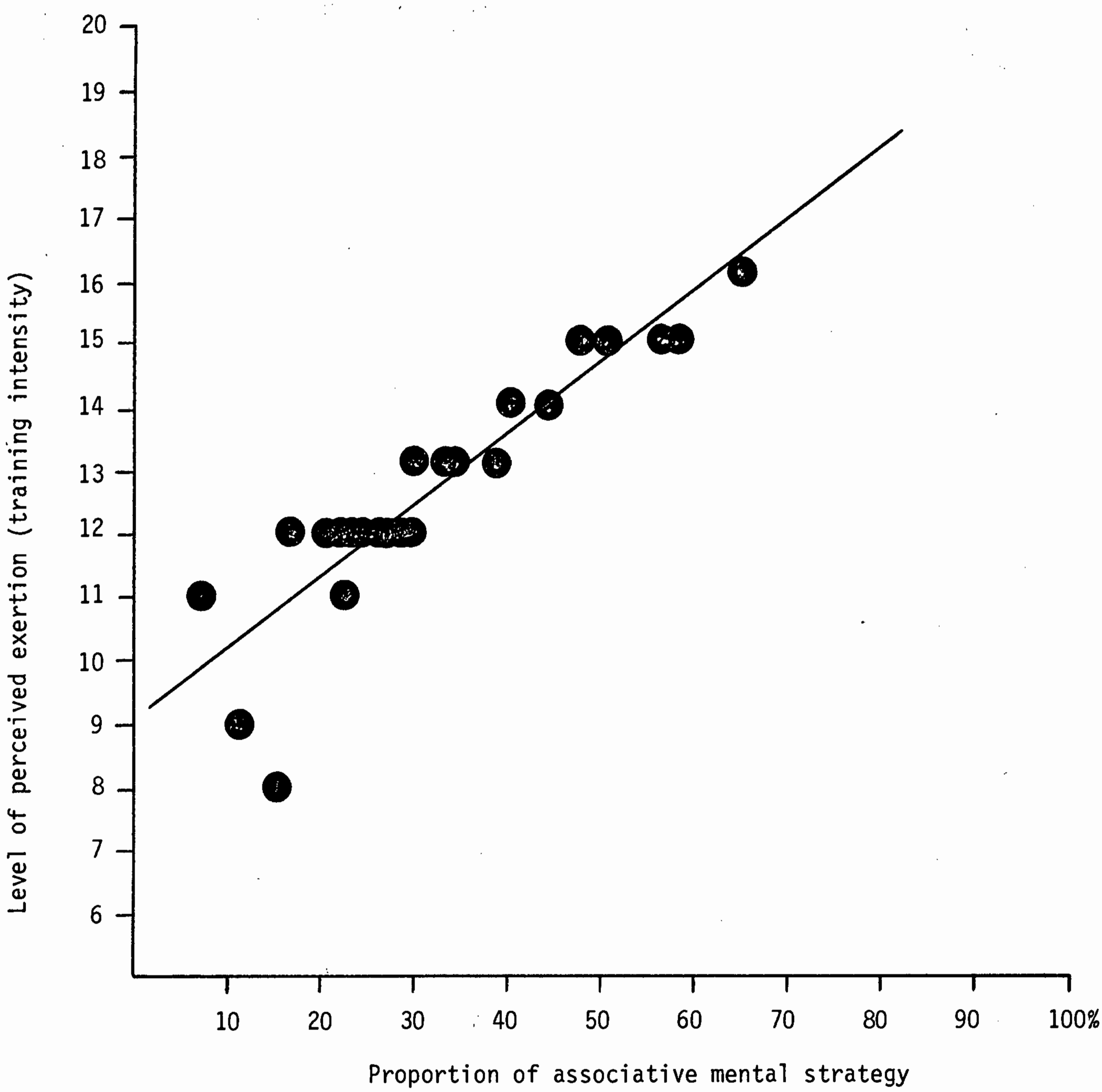


Figure 23. Scattergram of proportions of associative mental strategy and perceived exertion levels with regression line for novice marathoners only.

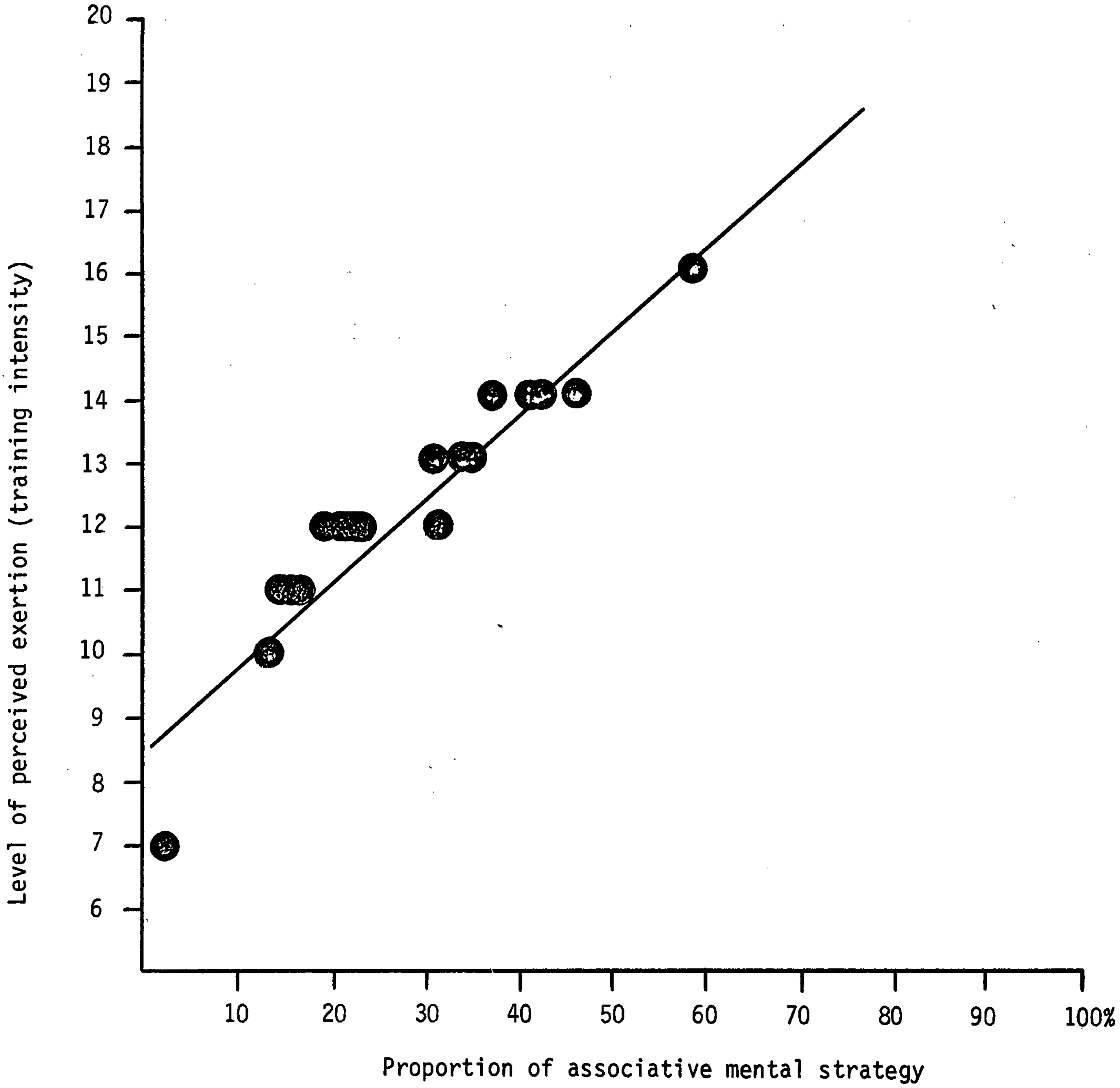


Figure 24. Scattergram of proportions of associative mental strategy and perceived exertion levels with regression line for average marathoners only.

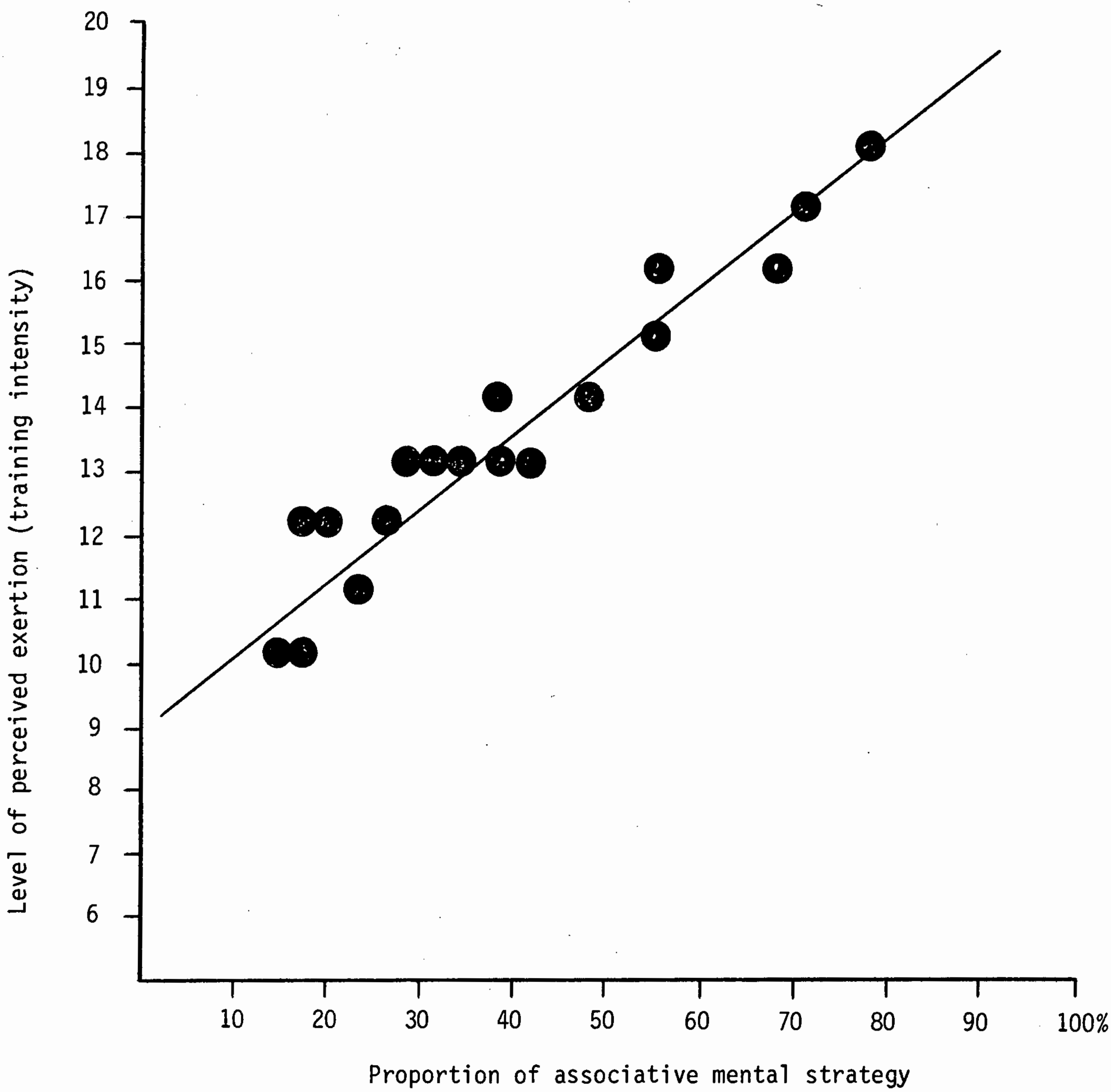


Figure 25. Scattergram of proportions of associative mental strategy and perceived exertion levels with regression line for superior marathon runners only.

Table 3 presents the squared multiple correlation coefficient R^2 and the squared correlation coefficients r^2 of the individual variables in the best subset. The so-called adjusted R^2 and adjusted r^2 values are included for completeness. In these tables the ratios of r^2 to R^2 values may be instructive but r^2 values may not be regarded as additive. Similar remarks apply to Tables 4 and 5.

Slightly better (multiple) correlation coefficients were obtained for the IN, EN, IB group, again with exceedence probabilities for the associated F-statistics being smaller than the programmes could accurately calculate, and reported as zero. Only in the superior group was a simpler model acceptable under the C_p criterion, which eliminated IB. Table 4 summarizes these multiple correlation coefficients.

The best multiple correlation coefficients resulted from subsets of the A, B, C, P, E, R, S, W, I variables; these subsets were

Novice	A C P R*
Average	A B* C P S
Superior	B C* P
Aggregated	A B C P R* S*

(The asterisk behind letters denotes that the variables in question are less important than others in the same group).

Since it was the author's concern that the subset A, B, C, P should be given particular attention, further BMDP9R analyses for this

Table 4

All subset multiple regression summary table for subsets IN, EN, IB

	All (S = 62)		Novice (S = 24)		Average (S = 20)		Superior (S = 18)	
C_p	4.00	10.88 IN,EN,IB	4.00	6.31 IN,EN,IB	4.00	6.11 IN,EN,IB	2.52	15.58 IN,EN
R^2	0.875	0.856 (IN,EN)	0.848	0.815 (IN,EN)	0.905	0.881 (IN,EN)	0.892	0.780 (IN)
R	0.935		0.921		0.952		0.945	
$\hat{R}^2$	0.868	0.851 (IN,EN)	0.825	0.797 (IN,EN)	0.888	0.867 (IN,EN)	0.878	0.766 (IN)
F	135		37.05		51.07		61.96	
df	(3;58)		(3;20)		(3;16)		(2;15)	
Tail	0.000		0.000		0.000		0.000	

subset indicated

Novice	A C P
Average	A B C P
Superior	B C P
Aggregated	A B C P

as optional under the C_p criterion. A summary of the above results is given in Table 5. In each case the multiple correlation was somewhat higher than that for ASS, as is to be expected. However, adjusted multiple correlation coefficients showed that only in the average group could A, B, C, P be assuredly replaced by ASS alone.

In the novice group the variable B showed no effect on the Y-values. While the Y-values indicate perceived exertion by the subject, largely determined by ASS, the associated performance may improve as relatively more time is transferred to activity B. Significantly more time is spent by the superior marathoner group in activity B than by the novice and average groups. No evidence was found of significantly different times spent in activity A (see Table 6). This study indicates that further research to examine that hypothesis may be useful and fruitful. (An apparent anomaly involves the average group's ASS mean score which is significantly less than the superior ASS mean ($p < 0.05$). This may indicate another possible effect of interest to be examined in a longitudinal study.)

The replacement of A, B, C, P by ASS within the average group results from the similarity of the coefficients of the four variables

Table 5

All subset multiple regression summary table for subsets A, B, C, P, E, R, S, W, I

	All (S = 62)		Novice (S = 24)		Average (S = 20)		Superior (S = 18)	
C_p	5.67	9.76 A,B,C,P,R,S	1.59	3.04 A,C,P,R	2.75	3.73 A,B,C,P,S	0.96	4.25 B,C,P
R^2	0.882	0.864 (A,B,C,P)	0.893	0.869 (A,C,P) 0.870 (A,B,C,P)	0.933	0.915 (A,C,P,S) 0.893 (A,B,C,P)	0.917	0.877 (B,C,P) 0.926 (A,B,C,P)
R	0.939		0.945		0.966		0.958	
$\hat{R}^2$	0.869	0.855 (A,B,C,P)	0.871	0.850 (A,C,P) 0.842 (A,B,C,P)	0.910	0.892 (A,C,P,S) 0.864 (A,B,C,P)	0.899	0.861 (B,C,P) 0.903 (A,B,C,P)
F	68.39		39.68		39.22		51.59	
df	(6;55)		(4;19)		(5;19)		(3;14)	
Tail	0.000		0.000		0.000		0.000	

Table 6

Statistical summary table for t tests with pooled variance

Activity A	Mean	Standard error	Subjects
	9.454	1.208	24
	8.440	1.392	20
	9.689	0.968	18

t test with pooled variance

	Average	Superior
Novice	0.550	-0.152
Average		-0.737

No significant differences

Activity B	Mean	Standard error	Subjects
	6.025	0.716	24
	4.065	0.551	20
	10.183	1.661	18

t test with pooled variance

	Average	Superior
Novice	2.170	-2.298*
Average		-3.495**

Superior group significantly higher than

novice : *$p < 0.025$

and average : **$p < 0.0025$

in the fitted regression model, and amounts to recognizing that within the average group perceived exertion is rated very much on all four of the variables equally participating in the subjective score.

Thus, although Y was not a continuous measure, the analysis, treating it as though it were, shows a clear tendency in Y to be related linearly to the specified activity component proportions. These relationships are graphically represented in Figure 26, and have strengths indicated (but not formally tested) by the magnitude of F-values and associated probabilities.

DISCUSSION

A strikingly strong relationship exists between the associative mental strategy and perceived training intensity. Proportional increases in the amount of task-related thinking go hand in hand with increases in resultant training run effort ratings. This relationship holds within and across all the groups of marathoners. The apparent strengths of the correlation coefficients lend strong support to the author's contention that regardless of the marathoner's running status a high training effort can only be achieved and maintained safely and efficiently by adopting a predominantly associative mental strategy that optimizes running economy and energy efficiency. Although novice, average and superior

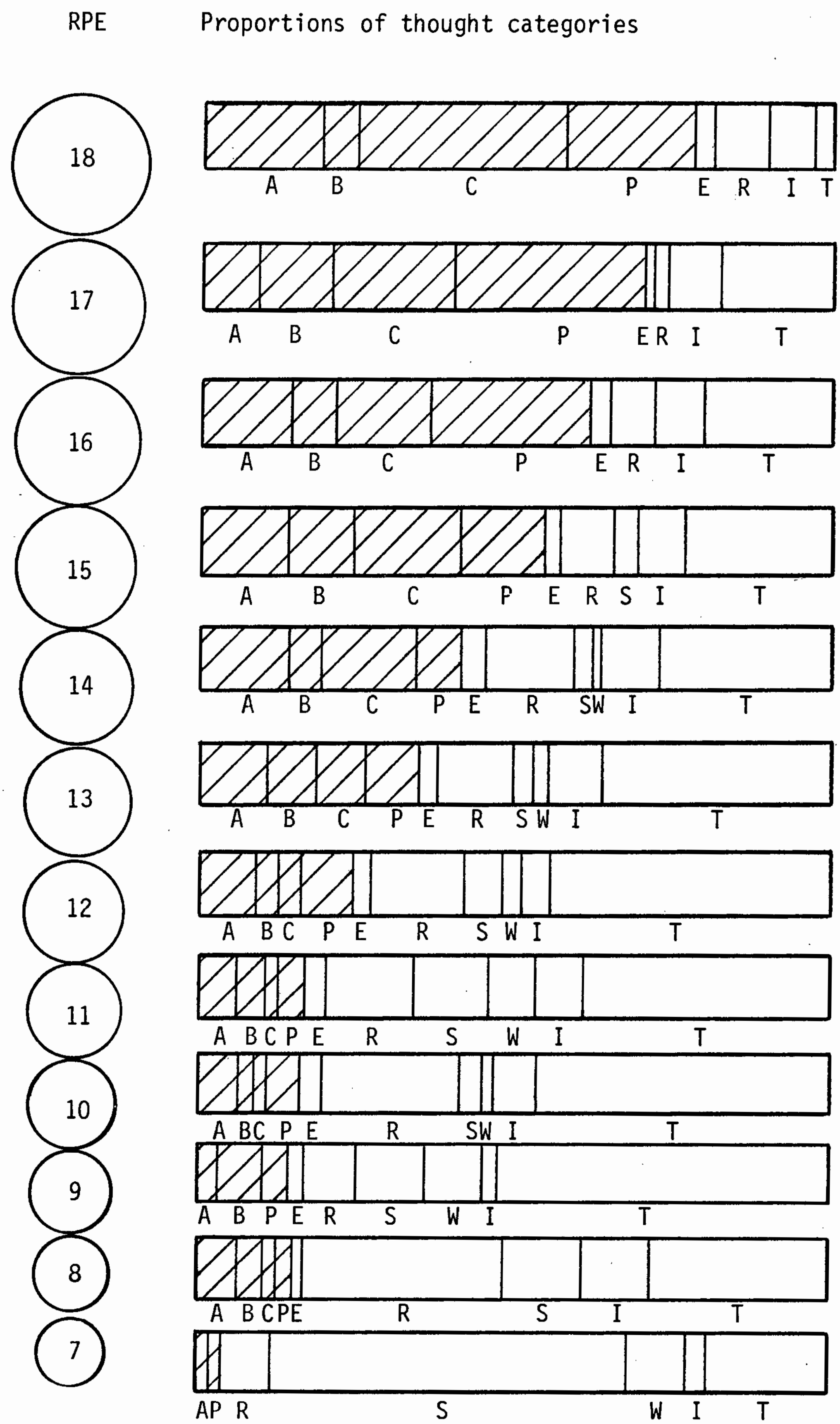


Figure 26. The relationship between RPE and proportions of thought categories with the associative mental strategy highlighted across all groups.

marathoners go into a training session or race with differing levels of aerobic conditioning, every marathoner has to invest increasing proportionate amounts of effort to promote and upgrade his/her relative current performance level.

The relationship between attentional styles and perception of effort shows a marginal gain in strength over the already convincing relationship between the general association classification and perceived training intensity. This finding underlines the author's assertion that the attentional focus classification provides a further particularization step within the broad mental strategy framework. It is only for the superior marathoners that the internal narrow and external narrow attentional foci alone yield a satisfactory predictive formula for perceived effort. The eliminated broad attentional foci do not play a significant role in determining the superior runners' effort sense. The superior runners' perception is governed by their concentration on narrow attention - to lock in on one thing at a time, to discipline themselves. This influential connection is seen to arise as a direct consequence of the laborious process these runners have subjected themselves to. The athletes' attention is shaped to mind information that is paramount to performance optimization.

Analyses of the detailed classification subsets substantiated this trend. The best multiple correlation coefficients were obtained here. The hypothesized quantitative and qualitative differences within associative thinking in relation to effort sense took on the following form: for the novice, feelings and affects, command and instruction, and pace monitoring made up the strong relation to perceived effort; the average runner widened the perception spectrum to include body monitoring; and for the superior marathoner, feedback on general feelings and affects did not influence the relation to perceived effort significantly. Effort sense of the superior runner arises out of the body monitoring, command and instruction, and pace monitoring components. The ACP, ABCP, BCP constellation typifies the impact of the effort sense specialization brought about by the ongoing learning process inherent in more and more exhaustive training schemes. Body monitoring shows a substantial effect on perceived exertion from an average marathoner status upwards, while the role of the general affective feedback diminishes in its relation to perceived exertion at a high running status. When it is the intention of average or superior marathoners to attain and sustain a high training effort, he/she does so with the help of exact and detailed body monitoring. This specialization effect can be explained by the shaping process the experienced athletes have been subjecting themselves to. Successive approximations to a finely tuned running household require an intimate knowledge of which body component behaves and contributes to the overall effort in which way. Overall, superior runners spend more time body monitoring than do novice and average runners when one disregards its unique contribution to effort sense. This statistically significant difference is the most distinctive characteristic of the superior runners' thought profile: specificity through thorough skill practice. Mental strategy training, guiding the runner to assimilate, or in the case of a superior runner foster, the exacting body monitoring technique is expected to yield a substantial improvement in the athlete's capacity to heighten his/her training effort without the risk of injury, and in the long term enhance his/her aerobic conditioning and race times. The above-mentioned trend generated exciting material for a longitudinal examination and will be discussed in Chapter 10.

A further qualitative difference became apparent on subsequent cross-reference to the text: exact and detailed body monitoring those very body components just checked. Whereas the novice runners instructed themselves to "relax, relax, relax", and "stay loose, man", the superior runners recurrently gave orders like "calf muscles relax", and "shoulders stay loose". Both verbalizations were correctly encoded as "command and instruction", yet the latter example typifies the superior runner's distinctive preciseness and power of control. Carron (1978) emphasized that feedback has to be precise in order to be effective for experienced athletes. Although this statement was directed at externally delivered feedback, the superior runner proves it to be valid for self-effected feedback too.

With increasing amounts of effort being exerted during training the verbalized thoughts across all groups took on more and more staccato characteristics. This is to be expected and natural. Extreme training intensities of a Borg scale value of 17 = very hard, and above were rare, with the majority of training runs being executed at moderate to high effort levels. At a low training intensity (RPE approximately = 10) a typical thought expressed about the weather condition (environmental feedback) would sound like this: "Gee, feel this fantastically fresh, cool morning." The same cognition under moderate training intensity (RPE approximately = 13) would be verbalized as: "What a fantastically cool morning." When expressed under high training effort (RPE approximately = 16) it would be cut down to its bare essentials: "Cool morning." This pattern is representative within and across the groups, as can be made out from the three text examples below. As effort ratings advance, sentence structures and narrations become rudimentary and unadorned. The excerpts originate from different runners and are listed in ascending effort order.

Average runner at low training intensity (RPE = 9)

"... Actually, better to run on the grass today. Look at those kiddies, as if nothing else mattered in the world. Playing in the mud pools. Feeling a bit tired running against the South-easter today. Hey, someone's doing tricks on their bicycle, like my son (name). Wonder if I should get him a new bicycle for Christmas? Would be nice, I think. Or, am I spoiling the brat? Or, should we just stick to a paddle-ski for Christmas? Both - no ways, that would really mean spoiling him. That would be detrimental to his future. I don't know, unpredictable that sort of thing. There are not as many people running as I thought there would be today. Wonder where that sqirrel is I usually see around here? Little squirrel - where are you? Quite funny, one day, running along here, there is this squirrel in the middle of the road, I mean pavement. I didn't want to get out of the way. Ended up having to jump into the road or I would have kicked it over. I'm not quite sure why it allowed me to get that close, perhaps it was taken unawares. Nice car that, probably an old Rover. Lots of old cars in Cape Town that still seem in peak condition. Ah - that building must be some kind of school. Legs are a bit heavy. Yesterday was a day - I felt so tired, really run down after my run with (name). I think VW made a mistake in discontinuing the Beetle, even though it chews more petrol than the modern little ones. It's so well-established. They must be losing out on lots of sales now. Must be lots of people wanting to buy a Beetle - it has character. I wouldn't mind one. Man, oh man, what a fantastic day for running. Someone in that car looking - nice dolly that one..."

<u>Novice runner at moderate training effort (RPE = 13)</u>

"... I'd damn well rather mark the essays. Am I glad not to be in the sciences. Okay - I feel much better than yesterday. I must try and relax a bit. I think I'm going to go on the dirt road here. Nearly took the wrong turn-off. Scared to run in the veld - those snakes you know. I just hate them. My shins really feel good. I suppose it's nice to recover that quickly from an injury. I wonder how far I've gone. One, two, about another 2½ ks to go. Means I'm running at 4½. Some runners say you must train at the speed you want to race, basically. (Name) says wait till the knee is better. Jogging casually now. You know, I think I should have stretched more. My shins getting that lame feeling again. Irritates me. Relax, baby - you'll get over it. Relax now. Such a beautiful day. I keep trying to turn my toes in, but seems difficult. Start looking after yourself. Would like to cycle again. But the cycle's flat and the road is too hot and too busy. I've overcome my fear of dogs. They seem to go for the guys. Must slow down now a bit. Cool off. Try and relax my shoulders. Yes, relax a bit, relax. That's better - much better. Hope I gonna feel like this tomorrow. I think I'm on the road to recovery. Gonna push harder again tomorrow. Shins are fine now. That's the feeling..."

Superior runner at high training effort (RPE = 18)

"... Feeling confident. Left hamstring a little bit tight. Legs a little bit heavy. Probably feel better once I'm warming up. Feels good to be out. Running a bit fast for warm-up. Slow down a bit. Warm in the sun. Tightness in left hamstring gone completely. Feeling strong. Just relax. Don't push too hard warming up. Easy. That thigh does seem a bit tired. Slow now. That's the way. Much better now. Been running for 20 minutes now. Got a slight sniff that is bugging me. Relax, just want to relax into this one. Very important to relax the neck and shoulders. Must relax the whole time. Picking up speed. Bit of a head wind here. Body feels good now. No aches, no pains. Legs feeling nice and loose. Getting really relaxed now. Kids playing around. Stride very comfortable. Good - just great to get out and exercise. Little twitch in my thigh muscle. Relax that muscle - relax. Ah, it's gone again. Haven't felt my knee problem for about a week now. It's fine right now. Push a bit harder now. Strong stride. Sometimes like to train with someone else. Just tuck in behind and relax. Feel completely warmed up now. Really a good place to train. Can give it all I got. That's it. Push, push, push. Good strong stride. Great. Just drive with your ankles. Gonna be a hard session. Getting stronger all the time. Keep relaxed. Relax neck and shoulders. Great stride..."

Runners that produced a high training effort were questioned about their ability to express thoughts while breathing heavily. They perceived the staccato manner of verbalization representative of their intense, concentrated way of thinking. There was no fixed thought sequence for novice and average runners. Body monitoring was not always followed by command and instruction, pace monitoring did not necessarily elicit affective feedback. Verbalization at lower training intensities showed similar trends. Of course, as training effort increased, associative thought sequences lengthened and dissociative thoughts were few and far between. This association/ dissociation pattern can be seen as a "concentration cycle", as suggested by Orlick (1980), though the detailed thought sequences within either of the two mental strategy modes were rather divergent. Concentration cycles are graphically depicted in Figures 27 and 28, symbolizing the predominantly associative and predominantly dissociative mental strategy modes respectively. Association is seen to resemble an effective feedback spiral with minimal dissociative thought interference. Each closed-looped feedback sequence enters the runner into a new feedback sequence based on the sensory cues from the altered running process. Dissociative thought flashes occur, but do not disrupt the sequence in any significant way. The running process is maintained at a safe and efficient energy consumption level resulting in a high overall effort output. The dissociative concentration cycle creates an open-looped feedback circle without the essentially beneficial processing of sensory cues. Momentary associative flashes do not affect the running process significantly. The result: a relatively inefficient low overall effort output.

Superior marathoners manifested a distinct qualitative difference at higher training efforts. Lengthy associative thought sequences seemed to be broken only once a satisfactory adjusted running process was assured. Very short dissociative thought flashes preceded the subsequent lengthy associative thought sequence that would only be interrupted once a new satisfactory running state was sensed. Novice and average runners, on the other hand, did not manifest such a clear concentration cycle. They engaged in short dissociative episodes even if no direct self-manipulation of the running process

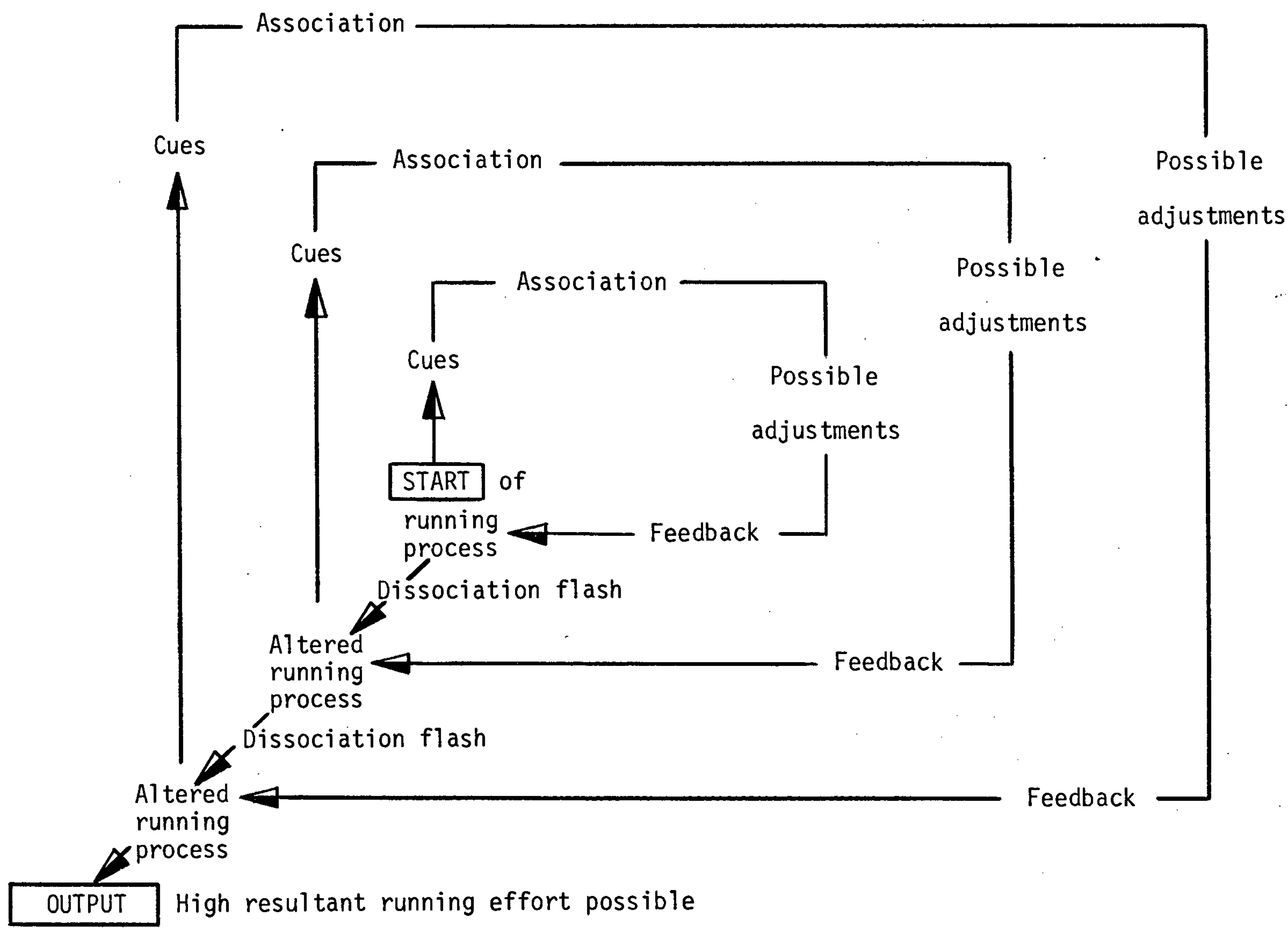


Figure 27. Association concentration cycle.

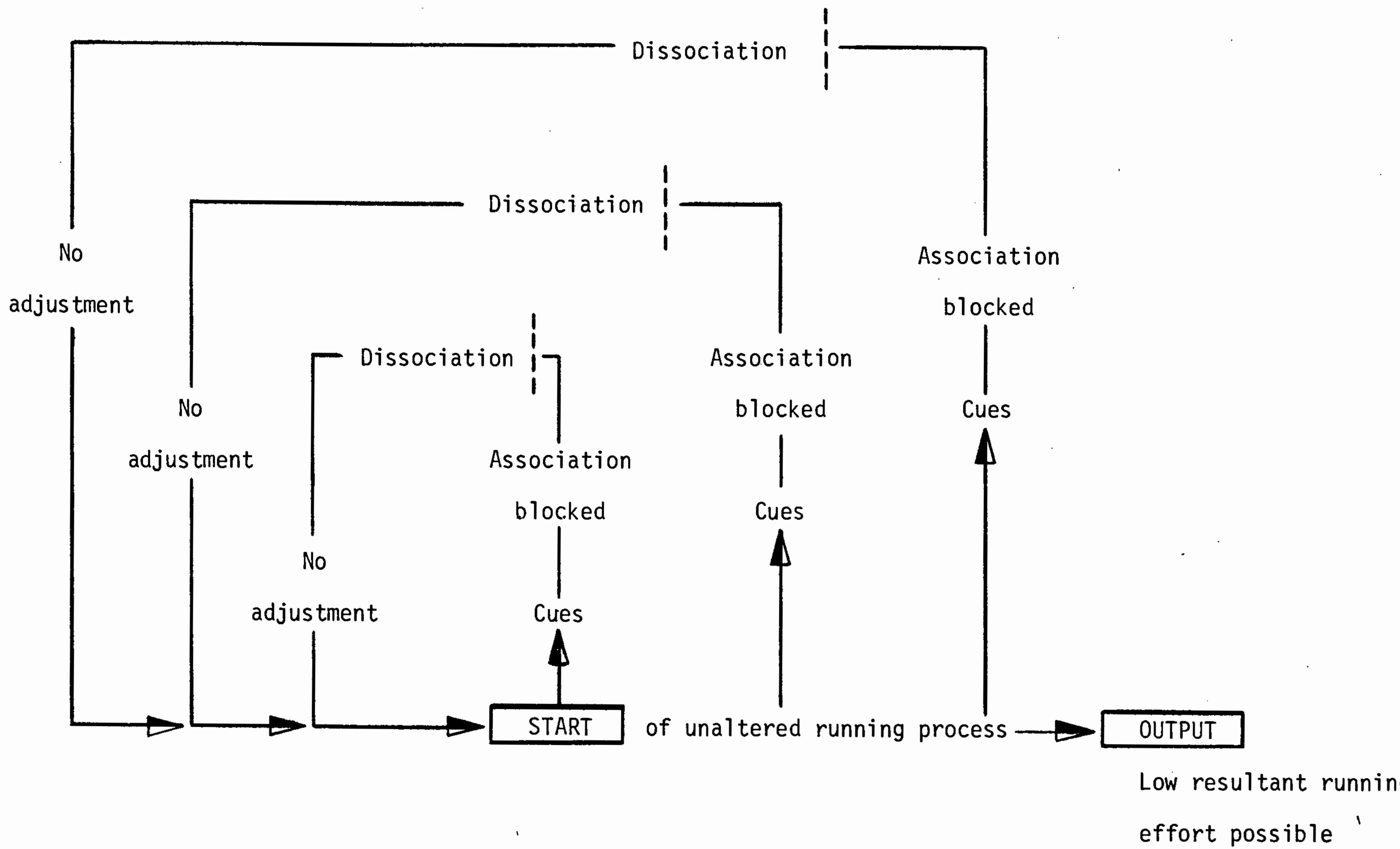


Figure 28. Dissociation concentration cycle.

had taken place after a body check. It seemed as if the novice and average runner (to a lesser extent) needed several co-existent sensory signals to begin acting upon those specific cues. As has been discussed earlier, superior runners enter into more body monitoring, followed by precise command and instruction. Though the average and novice runner also use command and instruction at high training effort, it is rather general and oblique. Superior runners seemed to react very swiftly to sensory cues and continued to manipulate the running process until satisfactory results were brought about.

Weinberg, Smith, Jackson & Gould (1984) speculated that the timing of associative/dissociative mental strategies is critical. For the superior runners in this study timing meant associating till all was well and under control, then allowing themselves to dissociate for a short time only. The persistent, efficient concentration cycle pattern was upheld for the entire duration of their training runs. Novice and average runners timed their associative interventions (specific command instruction) more haphazardly.

Commands and instructions like "push, push, push", or "go, go, go" appeared to fulfil a dual function, as their repetitious constellation resembled rhythm cues. The verbalization "one, two, three", for instance, served the vital pacing function directly without the forceful order to maintain or produce more effort. Pseudo-mantras like "down", as used by Morgan, Horstman, and Cymerman (cited in

Morgan & Pollock, 1977), quite easily could take on such a pacing function and, therefore, cannot be regarded as strictly task-unrelated. In this context their dissociative "meaning" take on associative properties for any marathoner interested in a steady running rhythm.

Though there was no statistically significant difference in the mean association score between novice and average and between novice and superior athletes (see Chapter 8), the average group's association mean score appeared to be appreciably lower than that of the superior runner group. Concentration cycles at low and medium training intensities involved rather few body monitoring thoughts, whereas at high intensity body monitoring assumed its significance in determining effort sense. For the novice runner body monitoring did not play such a significant part in the mental strategy-effort sense relationship at all. Although the mean B score was slightly higher for this group when compared to the average group, body monitoring happened at random, showing no clear connection to training effort. The ACP, ABCP, BCP constellation discussed earlier hints at a possible learning effect in that increased running experience shapes the athletes' thought flow to attend to body monitoring as the training effort seems to reach critical dimensions. This does not necessarily imply a higher quantity of associative thought occurs overall, but association assumes its relevence at high training effort qualitatively. Novice runners body monitor at all levels to the same extent. Average runners seem to have consolidated this thought pattern only to times when it matters, as effort sense increases. This trend accounts for the lower mean association score. Superior runners have taken the associative fine-tuning of their bodies in relation to effort expended to extremes both qualitatively and quantitatively. It is as if average runners have reached a running plateau inbetween the quantity association-oriented novice and the quantity- and quality-oriented superior runner. Average runners seem to dismiss the quantity of association and start to adopt the qualitative characteristics of superior runners. This trend indicates another possible effect of interest to be examined by a longitudinal study, in which a potential marathoner's progress from novice to superior status is documented.

Morgan (1978) suggested that average runners employ dissociation to negotiate a temporary pain zone (for a full discussion on pain and pain control see Chapter 4). Marathoners in this study preferred to deal with pain or discomfort associatively by talking about their origin, and adjusting pace and stride to eleviate the symptoms. Again, superior runners distinguished themselves from novice and average runners by their preciseness and perseverence at coping with such problems. Pain research has come up with a model profile of persons most likely to exhibit the greatest pain tolerance (Macy & Falkner, cited in Kristal, 1982; Sternbach, cited in Eysenck, Arnold & Meili, 1975): people whose perceptual judgement of other stimuli also err little, who are relaxed and whose body images are decidedly defined. In addition, pain tolerance increases with voluntary submission to pain, high motivation and anxiety reduction. Experienced runners again have the edge: their long running history has certainly exposed them voluntarily to frequent discomfort and pain, their motivation is high and through their positive self-encouragement on the run they persist at dealing with their emotions. Nideffer's (1981) warning that an internal narrow attentional focus has the potential of turning into a "choking" spiral certainly did not apply to the marathoners in this study. Internal narrow attention meant careful pace and body monitoring, affective feedback and positive, assertive command and instruction. During the recorded training session control and encouragement were the key factors for all runners, though qualitatively distinct at high training effort. Anxiety states were noticeably absent, to the clear advantage of the marathoners, as "the body has only so much energy and cannot afford to waste any on expenditures due to neuromuscular tension in muscles not requiring it" (Fisher, 1976, p.155). Jacobson (cited in Fisher, 1976) referred to such an energy waste as an "effort error". Relaxation was fostered at high effort to handle discomfort and pain. To be able to perform as optimally as possible under competitive conditions, training has to resemble the marathon race. The effect competitive stress can have on an athlete's performance has been well-documented (Bauer, 1977; Cratty, 1981; Martens, 1975; Singer, 1975; Steinbach, 1977; Syer & Connolly, 1984; Thomas, 1978; Weingarten, 1982). Under race conditions exceptional physical and psychological demands are made on the performer. The more similar the training is to the actual event, the better the chances that choking is avoided and the positive, controlling aspects of an internal narrow attentional style uphold an efficient running household. Of course, a simulation approach to training must be gradual to allow for the all-important behaviour shaping process to take place and be assimilated. Here the substantially more rigorous and time-consuming training schemes of the superior runners play a significant role in determining their race performance, in addition to their actual relatively frequent marathon competition experiences. Novice and average runners cannot be expected to uphold high effort intensities safely and efficiently by association if they have not been exposed often enough to racing conditions. Sheer ignorance or an unconsolidated learning process might also play havoc with their anxiety/relaxation states, further diminishing effective associative control over their running process and the resultant overall output.

Morgan and Pollock's (1977) original mental strategy classification was based on post-race interview data. The researchers came to the conclusion that elite runners associate, whereas average marathoners dissociate. Morgan (1978) stated that elite runners associate because they can afford to as their phenomenal physical constitution lets them suffer less during a race. In the light of the evidence presented here it is argued that superior runners go through an exacting learning process and through successive approximations achieve the capacity to effectively associate for prolonged periods of time, maintaining a high output of effort without the risk of crippling tissue, organ or system trauma. Gains in physical conditioning are amalgamated through the qualitative improvement in their mental strategy. Even novice and average runners associate when they produce a high training effort. Optimization of the running household consists of a dialectic between physical strain and mental strategy capacity. High training or racing effort is perceived to be sustained efficiently and safely through skilled task-related thinking. The connotation that only the anatomically and physiologically well-endowed can benefit from an associative mental strategy (Morgan, 1978) is wrong. When a novice or average runner has the intention to advance his/her marathon performance significantly without running the risk of overuse injury association has to be practised. The risk/benefit trade-off postulated by Morgan (1978) does not offer any real choices for the conscientious marathoner. Tissue, organ or system trauma are too great a price to pay. At high effort intensities no sensory warning signal is allowed to go unheeded. Sperryn (1984) sees the major limiting factor in many athletes' performance to be the "injury threshold". Overloading the system brings the system eventually to a premature, abrupt halt.

It is not as if training in associative thinking automatically brings about miracle performance increases. Association is practised at high effort intensities to deliver an injury-free and efficient running process. The risk of pushing oneself beyond the injury threshold by dissociating from the ongoing running process is prohibitive. During a competitive marathon event the majority want to give all they have. High effort intensities are turned out. Dissociation is out of place here. Only when relatively low output is wanted, is task-unrelated thinking pleasant and secure. Marathoners, regardless of their running status, seek those states from time to time. Problem solving, planning the future or reliving past histories have their place when running under low strain only. The substantial benefits of a mental strategy training programme are evident.

CHAPTER 10

MENTAL STRATEGY TRAINING PROGRAMME

Training and competing in marathon running make immense claims on personal time and effort. Training schedules that marathoners follow show a great variety. Nuances and modifications effected within training programmes are, as Reilly (1981a) pointed out, presently as much of an "art as a science" (p.89). Yet many of them have led to records. Aspiring runners meticulously study the training methods of record-holders and make, what Ryder et al. (1976) call, a "rather gross estimate at best" (p.118) of how much proportionately greater a training effort has to be exerted than the record-holder did in terms of speed and endurance. The key factor to success seems to be connected to the striking improvement in specific endurance: the capability to perform protracted work at a high input of energy (Ryder et al., 1976). The runner achieves the capability to run aerobically at an intense rate of work by repeated exposure to an increasing training effort causing complex adaptive mechanisms to shift his/her metabolic quilibrium to meet the energy demands efficiently.

Marathoners with articulate goals in mind organize their work-outs to become an integral part of their daily routines. Even with a regular habitual training pattern established, results cannot be expected overnight as improvement tends to be gradual (Reilly, 1981a). In terms of the principle of involvement, the higher the goals set for performance, the greater must be the time set for participation and the volume of training performed (Rushall, 1981). With today's standards of records, elite athletes spend between 1 and 6 hours a day for 12 months of the year in training (Rushall, 1981; Sperryn, 1984). Marathon records will continue to improve for quite some time to come; at quite a rapid rate anyway, if the elite can be more effectively protected from suffering, by now common, overuse injuries.

> Overuse injuries represent a gradual breakdown in the locomotor system - this is analogous to metallic stress fractures. A certain amount of stress is absorbed within the structure, but overload progressively weakens the same tissues by outstripping their ability to make compensatory changes, until finally structural disruption occurs and the athlete is brought to a halt. (Sperryn, 1984, p.27)

To steer clear of injuries from excessive overload, training effort has to be elevated in sensible increments. Especially during periods of tiresome competition light work-outs have to intersperse heavy training sessions. Only a circumspect approach to endurance training supports the body's exceptional adaptive potential to be actualized without the interference from trauma (Halberstadt, 1982; Reilly, 1981a). No longer can an athlete concentrate on the physiological aspects of training and presume to enhance performance optimally. To do so means to make an uninformed and irresponsible decision. A circumspect approach to endurance training has to be based on knowledge about the multitude of factors affecting physical performance. Knowledge about physiological, biomechanical and psychological factors that govern performance have to be integrated. Several sport scientists (Gowan, Botterill & Blimkie, 1980; Hickman, 1980; Klavora, 1980b; Rushall, 1981; Salmela, 1980) have pointed out that specifically psychological knowledge about sport performance has been neglected in research and application. It is with this back-drop in mind that the following mental strategy training programme was designed, explored and evaluated. Implications for the training of long-distance runners are discussed at the close of the chapter.

TRAINING IN ASSOCIATION OVER DISSOCIATION

To get anywhere near today's records, the quantity and quality of training has to be formidable. To beat future records the athlete has to work harder and longer than is presently being done. The tremendous training effort involved pushes the athlete closer to his/her physical and mental limits. A major concern of the sport scientist is to ensure that the athlete achieves and maintains his/her potential without the debilitating impact of overuse injury (Glover & Shepherd, 1979; Markham, 1981; Reilly, 1981b). Marathoners run a high risk of serious injury when adopting a dissociative mental strategy to cope with a high training or racing effort (Morgan, 1978;

Morgan & Pollock, 1977).

Though dissociation from discomforting and painful sensory signals appears to be more pleasant than dealing with the warning signals right there and then, there is the increased potential of stress fractures to go unheeded, and heat stroke or heat exhaustion to be fostered. Unless accessible medical services are provided, heat stroke or exhaustion can lead to permanent damage or even death. Psychological trauma and negative addictive effects have also been identified to originate from the runner's incessant quest to dissociate to such an extent as to produce "transcendent experiences" or other mystical adventures (Morgan, 1978, 1979). These risks must be spelled out to the runner, so that he/she can develop reasonable and realistic attitudes and skills to guard against wanton suffering (Sperryn, 1984). At best, dissociative thinking can be expected to sustain an inefficient running household at high training intensities. The potential hazards of dissociative thought fade with decreasing training effort. However, the athlete must "remember that in training, as in life, you get what you work for" (Sharkey, 1975, p.135), and that means, the aspiring marathoner, of whatever running status, has to expose him/herself to successively greater training intensities to enable his/her aerobic conditioning to improve significantly. One could argue that with increasing running status marathoners subject themselves to a proportionately greater risk of dissociation "misuse" as their training schemes demand more frequent and longer effort. This inclination, however, seems to be ameliorated by the protracted learning process experienced runners have gone through. Precise and decisive body monitoring has characterized the superior runners in this study.

Morgan, Horstman, and Cymerman (cited in Morgan & Pollock, 1977) claimed to have achieved an average 30% performance gain over base-line when young male adults were instructed to use a "pseudo-mantra" during an endurance task consisting of walking to complete exhaustion at 80% of VO_2 max. Modelled on the technique reportedly used by Tibetan Mahetang monks the above laboratory experiment seemed to suggest that a simple dissociation strategy can facilitate endurance performance. In a more recent account of this experimental manipulation, Morgan (1984) claimed a 19% superior performance for those utilizing pseudo-mantras in the laboratory. One has to caution, however, that a 30-minute run in a laboratory does not require the extreme amount of attentional control and stamina required to finish a 42.195 km marathon with its diverse course conditions in a safe and efficient manner. No direct way of measuring the subjects' adherence to the simple pseudo-mantra "down" was mentioned. The question is not so much whether under quasi-hypnotic suggestion one can coerce greater performance out of subjects, but whether extremely controlled (artificial) laboratory-type manipulations produce the same mental set that a runner builds up over long periods of time to adhere to and cope with long-distance running training and competing. There seems to be little relevance in comparing inconsequential one-treatment experiments with influential life-time endeavours. The self-protecting associative mental strategy developed by marathoners to cope with the effort demanded from high intensity running holds adaptive significance. The risks of overuse injury are too great. Efficient running is what aspiring marathoners are after and nobody wants to "drop dead" as they cross the finish line.

In an attempt to test whether association or dissociation produce greater performance increases, Okwumabua et al. (1983) instructed novice runners in the use of these mental strategies and observed the subjects' running improvements over a 1½-mile distance after 5 weeks of three times weekly, 1-hour coaching sessions. Mental strategy training consisted of a 10-minute set of instructions presenting a positive rationale and information on how to carry out the distinct strategy. Post-coaching questionnaires revealed that subjects did not adopt the experimenter-delivered mental strategy. Regardless of the instructional set, subjects reported increasingly more associative mental strategies as they gained running experience. Although a 1½-mile run has very little to do with a marathon, the task at hand seemed to be of sufficient intensity to shape the runners' effective mental coping capabilities. When disregarding the original group assignments and relying on the final post-coaching reports of how much of each strategy the subjects were using, it seemed that those initially engaged in relatively more dissociative thought improved the most. Of course, with this data manipulation the researchers brushed aside the apparent learning process the subjects indicated to have gone through.

In a one-treatment approach experiment, Weinberg, Smith, Jackson, and Gould (1984) let regular runners try and cover as much distance as possible in a 30-minute period utilizing either association, dissociation or positive self-talk. Again, subjects of similar abilities were presented with an instructional package explaining what the mental strategies are all about only just before the run. No significant differences were reported. The potential effectiveness of the particular mental strategies might have been negated as subjects did not produce the required "all out" effort, but carefully paced themselves. The researchers noted, however, that in a similar experiment conducted by Sachs (cited in Weinberg, Smith, Jackson & Gould, 1984) subjects seemed to be fairly set in their mental strategy approach and often expressed negative sentiments about the necessity of being required to use a strategy which was foreign or in opposition to their habitual thought processes.
In a subsequent experiment by Weinberg, Smith, Jackson, and Gould (1984) dissociation and positive self-talk appeared to produce better performances on an "all-or-none" leg-lift task. They pointed out that a leg-lift task allows no regulatory control on the part of the subject, pain and effort increase consistently with time, whereas during a running performance subjects can "slack off" and negotiate stressful episodes. The performance requirements are quite dissimilar and signify an essential distinguishing component in the tasks: the subjects' opportunity to actively intervene in the

effort application.

Morgan (1978) cited several examples of elite runners emphasizing how task-oriented thinking enables them to actively stay out of "trouble", avoid the "wall" and control their effort from within. For runners that closely listen to their body's signals the wall does not exist. It exists for those that let their watch determine their pace. At high training or racing intensities associative thinking provides the means to keep firm control on the power of the thoroughly trained athlete's body (Straus, 1981). For a maximum effort to be attainable during a marathon, the runner has to spend the available energy in such a way that the body's resources are just about exhausted as he/she crosses the finish line. An associative mental strategy obviates the marathoner from overextending him/herself too early and counteracts holding back too much (Orlick, 1980), and the potentially crippling danger of overuse injury is minimized (Morgan, 1978; Morgan & Pollock, 1977). To advocate and train marathoners in the use of dissociative thinking and ignore its potential harmful effects at high effort output presents a precarious and irresponsible undertaking. In some aspects, the prospects of dissociation training bring Richardson's (1980) article "How to ruin an athlete" to mind. Once dissociation has been (erroneously) taught, the effort involved in eliminating ingrained performance "errors" is well-known (Welford, 1976). As Weingarten (1982) rightly pointed out, sport psychologists are supposed to pre-identify and eradicate all sorts of unnecessary stress factors which are either energy-consuming or perplexing, and to establish and teach methods that let the athlete cope efficiently under strain and achieve his/her optimal performance. To bring out the long-distance runner's optimal physical skill in marathon running association has to be taught. In view of the findings presented in Morgan and Pollock's (1977) original study and the present investigation, training in dissociation in a real-life setting away from a controlled laboratory environment is untenable - it takes on an unethical flavour.

ASSOCIATIVE MENTAL STRATEGY TRAINING PROGRAMME DESIGN

Parker (1983) reported that a kind of associative concentration has been successfully taught by Powers to subjects in a laboratory using biofeedback equipment. The researcher speculated that this technique could be transferred to the athletic arena. The suggested technique would again rely on pre-activity intervention, apart from the sophisticated equipment needed to carry out such a training programme. It was the aim in this training programme to intervene in the thought processes of the marathoner during the activity of running and to shape the thought flow as to imitate the precise and directive associative thinking displayed by superior marathoners at high training intensities in this study. A conscious focus of relaxation is part and parcel of this associative thinking mode. The training effect is expected to yield a more efficient and safer running process, enabling the marathoner in the long-term to produce training efforts of higher intensity. Higher training efforts are expected to advance the marathoner's aerobic conditioning to a significant extent, if he/she wishes to pursue such a goal. Obviously, in the short-term, racing results are not foreseen to improve. The training programme's primary aim was to let the athlete experience and adopt a more efficient, safe mental approach to endurance training.

Mental strategy training during the activity of running was made feasible by the adapted, light-weight, two-way transceivers that permitted completely hands-free, continuous communication between trainer and athlete. With the help of the two-way radio link the trainer had immediate access to the marathoner's verbalized thoughts and could direct the runner's thoughts by means of positive suggestions and encouragement progressively towards a higher proportion of task-related issues. In addition to the two-way radio the trainer had to carry the light-weight microcassette recorder in order to record the progress of the intervention phase. The strategy shaping process was intended to be structured around each individual marathoner's distinct current mental strategy capacity and advance at a pace congruent with the marathoner's learning rate and needs. Weinberg, Smith, Jackson, and Gould (1984) cautioned about the apparent methodological pitfalls in ignoring runners' preferences and habitual thought processes. Therefore the mental strategy phase was designed to emphasize information that would normally be present during the activity of running and to wean trainees relatively quickly away from the additional cues provided by the trainer in order to secure optimal initial comprehension of the task. Welford (1976) stressed the inherent danger of over-reliance on extra performance information. Performance tends to deteriorate if a trainee has come to over-rely on such information and it has to be removed during subsequent training or competition. Intervention was, therefore, planned to be on a one-to-one basis, concentrated and concise.

Subjects

Several runners had indicated their interest in a possible training programme during the mental strategy recording phase. Of these, 10 runners could be accommodated whose private/work commitments did not require them to leave the Cape Town metropolitan area for the 5-week duration of the envisaged programme. The subject group was made up of 4 novice runners (marathon race times for males: above 4 hours; females: above 4½ hours), 2 average runners (marathon race times for males: 3-4 hours; females: 3½-4½ hours), and 4 superior marathoners including 2 elite runners (marathon race times for males: below 3 hours; females: below 3½ hours; elite marathon race times for males: below 2½ hours; females: below 3 hours).

Apparatus

The desired equipment had to meet the same strict selection criteria as those outlined in Chapter 7 for the recording apparatus.

Subsequently, several portable two-way radio models were tested. Talkman Model C900 FM transceivers by Standard Communications met all criteria. These portable two-way radios with a frequency of 49.830 to 49.890 MHz were extremely light-weight (250 g including battery and headset), small (101 x 63 x 19 mm), unobtrusive, comfortable to wear amd easy to operate. The voice-activated solid state circuitry enabled completely hands-free communication. The tranceiver box incorporated a removeable belt clip and a headset consisting of an earpiece, microphone and antenna. With the antenna extended a range of 400 m was realized. The Talkman transceiver set carried by the trainer was adapted to enable simultaneous recording of all communication on the Pearlcorder S901 microcassette recorder. The transceiver unit was clipped to the carry-belt that was used for the mental strategy recording phase (described in Chapter 7) and connected to the microcassette recorder. The marathoners only carried a transceiver unit clipped to their running shorts. The complete communication system is displayed in Figure 29. Bicycles were provided for the trainers to stay with ease within the 400 m transmission range of the system. Two complete transceiver-recorder sets were available to the author.

In addition to the equipment described above, a questionnaire was compiled in consultation with experienced marathoners to facilitate the evaluation of the training programme by the trainees (see Appendix 7). The questionnaire asked trainees to rate their immediate responses to the mental strategy training programme in regard to

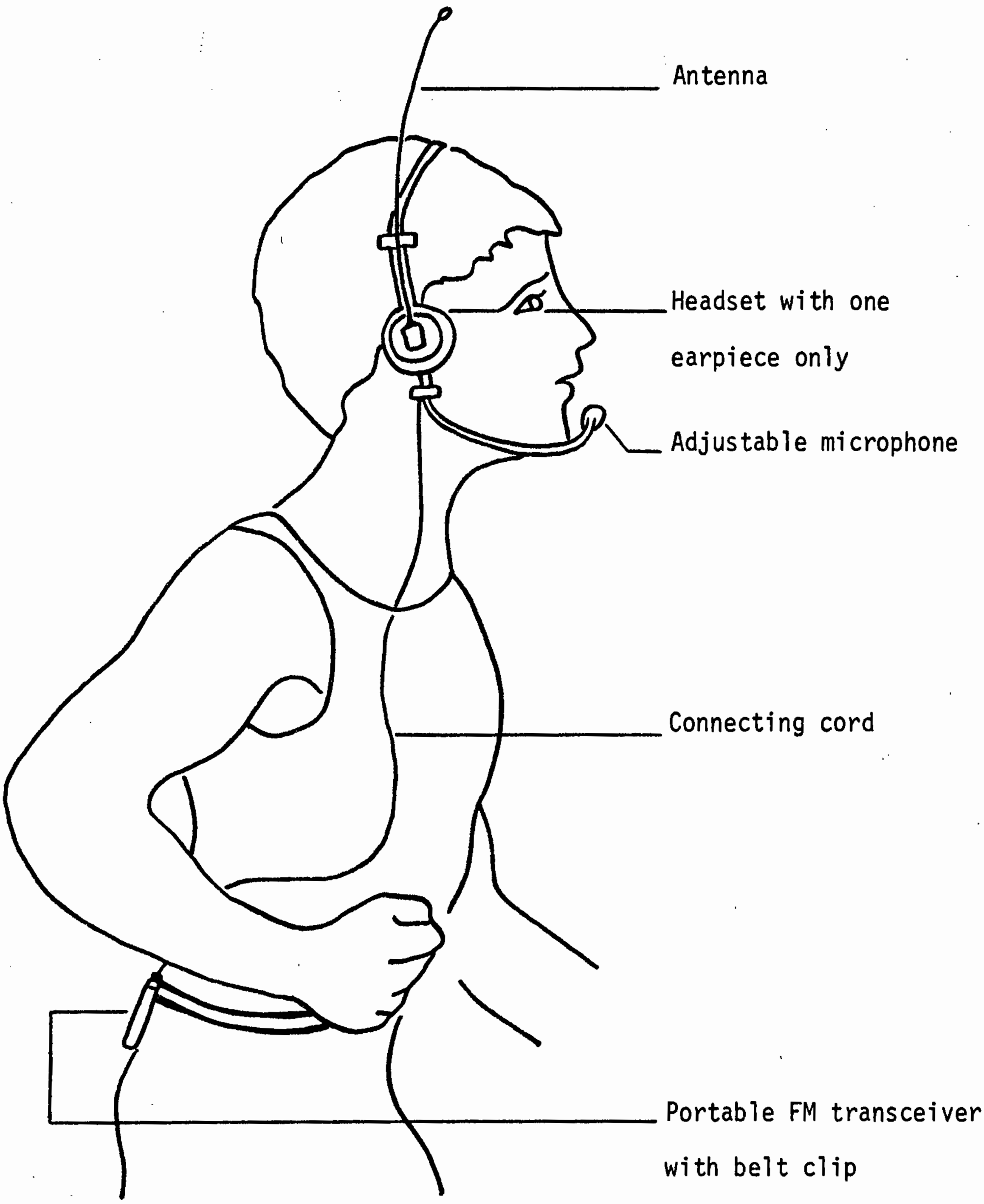


Figure 29. Marathoner carrying hands-free, two-way radio with headset consisting of an earpiece, microphone and antenna.

quantitative and qualitative performance improvements now and expected in future, the suitability of the equipment used, and duration and strength of the intervention. Additional comments and recommendations were welcomed.

Procedure

Mental strategy training sessions were arranged to fit into the habitual running scheme of the individual marathoners, spread equally over a 5-week period with a once-weekly 45-minute intervention. To monitor the progress and reaction of the marathoner to the training procedure, the first, third and fifth intervention sessions were recorded for prompt transcriptions and content analysis. The content analysis was conducted in the same fashion as that outlined in detail in Chapter 8. Pertinent information from the recorded sessions was made available to the trainer to allow for desired intervention adjustments.

Two research assistants, chosen for their high sense of responsibility and dedication, as well as their pleasantly dynamic personalities and personal running experience, were trained by the author to administer the mental strategy training programme. The assistants were fully briefed about the theoretical framework in which the author was operating and the rationale and the objectives for the intervention programme. As the assistants became proficient in the application of the apparatus and the intervention method, they were allocated to 5 marathoners each, randomly selected from within the three running grades. Thus each trainer introduced himself to 2 novice, 1 average and 2 superior marathoners. The initial meeting was regarded as a trial session to familiarize the marathoner with the apparatus, explain the rationale and objectives of the programme and establish a congenial relationship between trainer and trainee.

Trainees were informed about the general findings of the mental strategy recording investigation and that it was the author's intention to promote an associative mental strategy that would cultivate an efficient and safe running process at high training intensities; the training programme was designed to optimize the aspiring runner's potential without running the risk of tissue, organ or system trauma. Tangible results were expected in the long-term only, during which period the marathoners adopt, accommodate and consistently practise the recommended approach.

With the marathoners' consent the author was able to make use of the already existing mental strategy transcriptions (refer to Chapter 7 and 8) and treat that information as "base-line" mental strategy characteristics for each subject. Trainers were briefed about relevant idiosyncratic trends to facilitate rapport with the subjects. All communications between trainer, trainnee and author were regarded as strictly confidential.

The five intervention sessions, arranged individually with each runner, took on the following typical sequence: Once a tranceiver was comfortably fitted to a marathoner, and a transceiver plus recorder to the trainer, the runner was asked to commence with the training run at his/her habitual intensity and to verbalize whatever thoughts would come to his/her mind. The trainer kept a reasonable distance behind the runner, but stayed within good transmission range. The shaping process typically commenced a few minutes (maximally up to 5 minutes) into the training run. Trainers were instructed to start by positively reinforcing any associative thoughts, praising the runners for their general affective feedback, body monitoring, command and instruction, and pace monitoring. Dissociative thoughts were not commented on during the first training session.

A typical excerpt from a recorded first session shaping sequence follows:

Runner : "Can't get myself to go to the dentist. Yearly check-up and all that. Must be a childhood fear. Feeling great out here. Easy rhythm. Legs really working well."

Trainer: "That's good thinking. Tell me more about how your body feels."

Runner : "Shoulders really relaxed. No pain, no aches. Calf muscles working smoothly and warm. Going up that incline now. Pushing it. One, two, three. One, two, three. One, two, three."

Trainer: "You really sound as if you are concentrating on pace now - keep it going."

Runner : "Easy stride now. On top. And easy stride now. What a beautiful evening. Love to smell trees and things. Can you imagine living up here. The houses must cost a fortune. Had a good work-out yesterday, too. Got to slow down here a bit. Don't want to over-rev, do we? Slow, slow, slow. Easy swing. That's it."

Trainer: "Yes, excellent. Encourage yourself."

Runner : "Keep going, easy rhythm. Lots of energy left. Feel on top of the world. And into this side street for the home-stretch. Accelerating a bit. Strong stride, lots of energy. Legs relaxed and strong."

Trainer: "That sounds just the way to do it. Very good control."

Marathoners were encouraged to practise the level of associated thinking achieved in the preceding session for the remainder of their training week. Before each of the subsequent training sessions marathoners were reminded to run at an intensity level most natural to them and in line with their long-term conditioning goal.

This learning experience was consolidated in the second meeting as trainers began to politely interrupt runners from dwelling on dissociative thoughts. Runners were asked to revert to task-related thinking. The shaping process gained in momentum in the third session as trainers concentrated on developing body monitoring, command and instruction, and pace monitoring. General affective feedback was accepted but not positively reinforced. Only short dissociative episodes were tolerated.

Third session communication sequences characteristically sounded like the example given below:

Runner : "(Name of other runner) was stupid to run a marathon a week before you should run for your province. Western Province are ..."

Trainer: "Can you please try and concentrate on your running now. Narrow your attentional focus. Look inwards. How about some feedback on what your muscles feel like?"

Runner : "Okay, sure, thanks. Legs are still fine. Just a bit of a tightness in the left calf. Otherwise relaxed."

Trainer: "That's what I mean. Let's work on that tight calf muscle."

Runner : "Right. I'm slowing down a bit. Slow and easy now. Slow and easy. Calf muscles relax. Loosen up. That's right, loosen up. Warm and relaxed. Smooth stride. That's better, much better. Okay. Now for those calf muscles - a big cheer. Great."

Trainer: "That's solid positive feedback. Keep it up. Stay in control."

Runner : "Yes, I'm in control. Do you hear that, muscles, bones? I want to push a bit harder now. Relaxed, good work. Hell, what a feeling. Strong. Push, push, push. Tomorrow I'll run up Constantia Nek. I love that part. Just those dogs sometimes. Kelly is such a cute thing - never bothers joggers."

Trainer: "More thoughts on your pace, please. You know you are in control here."

Runner : "Sure, just look at my stride now. Come on. One, two. One, two. One, two. Getting stronger all the time."

In the fourth meeting the associative thinking characteristic of experienced runners was strengthened, and dissociative thinking discouraged right from the start. The fifth session focused entirely on precise body monitoring, positive assertive command and instruction and succinct pace monitoring, with diminishing interruptions from the trainer towards the end of the training session.

A true-to-type fifth session recording revealed focused thinking with relatively few interceptions from the trainer:

Runner : "Feeling a bit of a pain in the back of my heel. Achilles. It's those new shoes. Slow down a bit. That's it. Just right. Run them in well. That's it. Just relax and work. Pick up, pick up, pick up. Easy. Breathing deeply. Cross the road quickly here. Cars coming. Watch this uneven bit here. Keep the beat. That's it. Just listen to your feet hitting the ground. Good rhythm. Right-left, right-left, right-left. Don't let up. Bit of an uphill. Slow pace. Shorten stride. Shoulders and neck relaxed. Beautiful, keep on going. Legs are getting a bit heavy now."

Trainer: "You know you can work on that. Let's hear it."

Runner : "That's right. Control stride. Relax, relax, relax those legs. Relax, relax, relax those legs. Wind behind me now. Flat section ahead. Can stretch my pace a little bit. Steady pace. Deep, deep breathing. Running with fairly low action. My heels, my thighs, my legs have recovered. Now I am getting back in a great rhythm. Must be running at about 70% now. They've repaired the sidewalk here. Quite an improvement. Running at comfortable sort of marathon pace. Concentrating on my legs now. Dropping shoulders. Relax all the way. Relax all the way. Excellent pace. Strong stride."

Trainer: "Control in motion. Absolutely beautiful."

Runner : "And getting better all the time."

At the end marathoners were informed that what they had just produced was analogous to the mental approach adopted by superior runners at high effort intensity, and that the concentrated associative way of thinking could now be maintained and fostered by their very own effort without any outside help.

At the onset of each training session marathoners were complimented on their progress towards concentrated and disciplined thinking. Trainers also provided relevant information on trends recognized from the recorded and transcribed sessions at the start of the second and fourth meeting. Debriefing took place after the fifth session. All participants were thanked for their tremendous co-operation and achievement, and then strongly encouraged to maintain and apply the fostered associative strategy whenever they wished to procure a strong running output efficiently and safely.

Marathoners noted their perceived training intensity with the help of the Borg scale after the three recorded sessions (in the same manner as set out in Chapter 7). Trainees evaluated the training programme by means of a questionnaire immediately at the end of the 5-week intervention period and by means of a structured interview 6 months later. The interviews centred around the opinions and feelings expressed by individual subjects in the initial evaluation to gauge any change in sentiments. Additional information, suggestions or insights volunteered by the marathoners were welcomed.

The entire training programme sequence is depicted graphically in Figure 30. The reaction and progress of each individual marathoner are set out in the following case study reports. An overall evaluation is tendered and implications for the future training are examined in the discussion.

CASE STUDIES

In order to preserve the marathoners' identity case studies will refer to the subjects as he or she and in subsequent discussions as marathoner Case 1 to marathoner Case 10. Reports are arranged in descending running status. The abbreviation MSTP is used for mental strategy training programme.

CASE 1

Subject : 24-year old male athlete, rated among S.A. elite

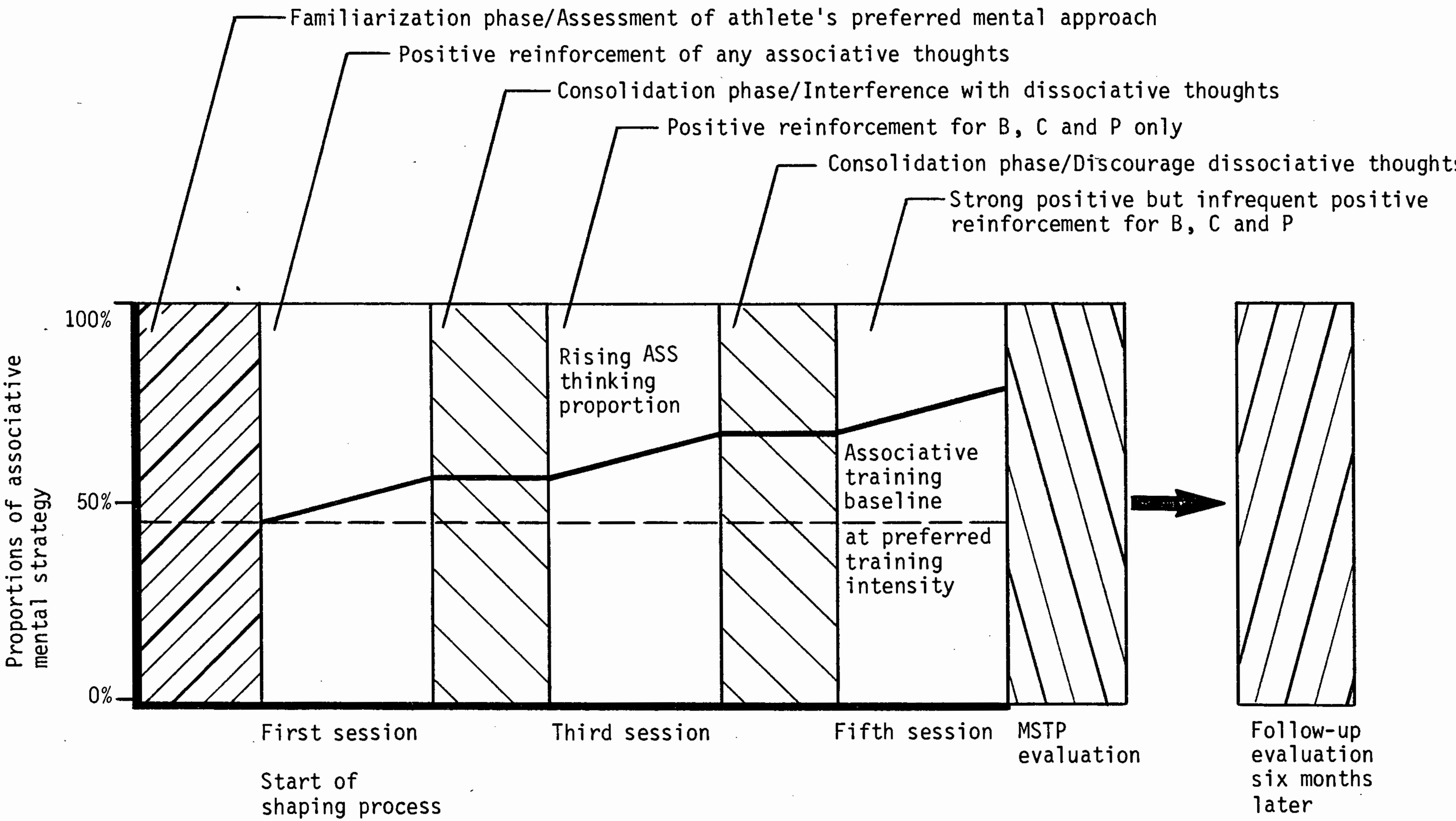


Figure 30. MSTP sequence.

marathoners.

Running history: 14 years experience; member of the Stellenbosch Athletic Club; best standard marathon time of 2:15:48 achieved in 1983 Peninsula marathon.

Training : 6 to 7 sessions a week covering approximately 120 km; regarded his approach to running as serious.

MSTP evaluation: The athlete's co-operation and enthusiasm for the programme was outstanding. He expressed a strong belief that the mental aspects of marathon running were as important to him as physical conditioning. His progress through the 5-week intervention is graphically represented in Figure 31. Although the athlete's initial use of associative mental strategy at high training intensities was already well-established, the marathoner felt that the thought verbalization in combination with the shaping process initiated by the trainer strongly advanced his ability to concentrate on relevant task-related issues. Perceived training intensity remained stable for the first two recordings and advanced in the last session. The athlete indicated that he expected the MSTP to improve his performance in the long-term only and that he would definitely make use of it in training as well as in competition. He emphasized that he had been thinking along similar lines already, but that the MSTP honed his ability to do so. The training method and duration were evaluated as optimal, as it was important to him not to become dependent on any externally controlled training technique. To him, serious marathoners in the end have to rely on their own resources. The MSTP was seen to contribute significantly

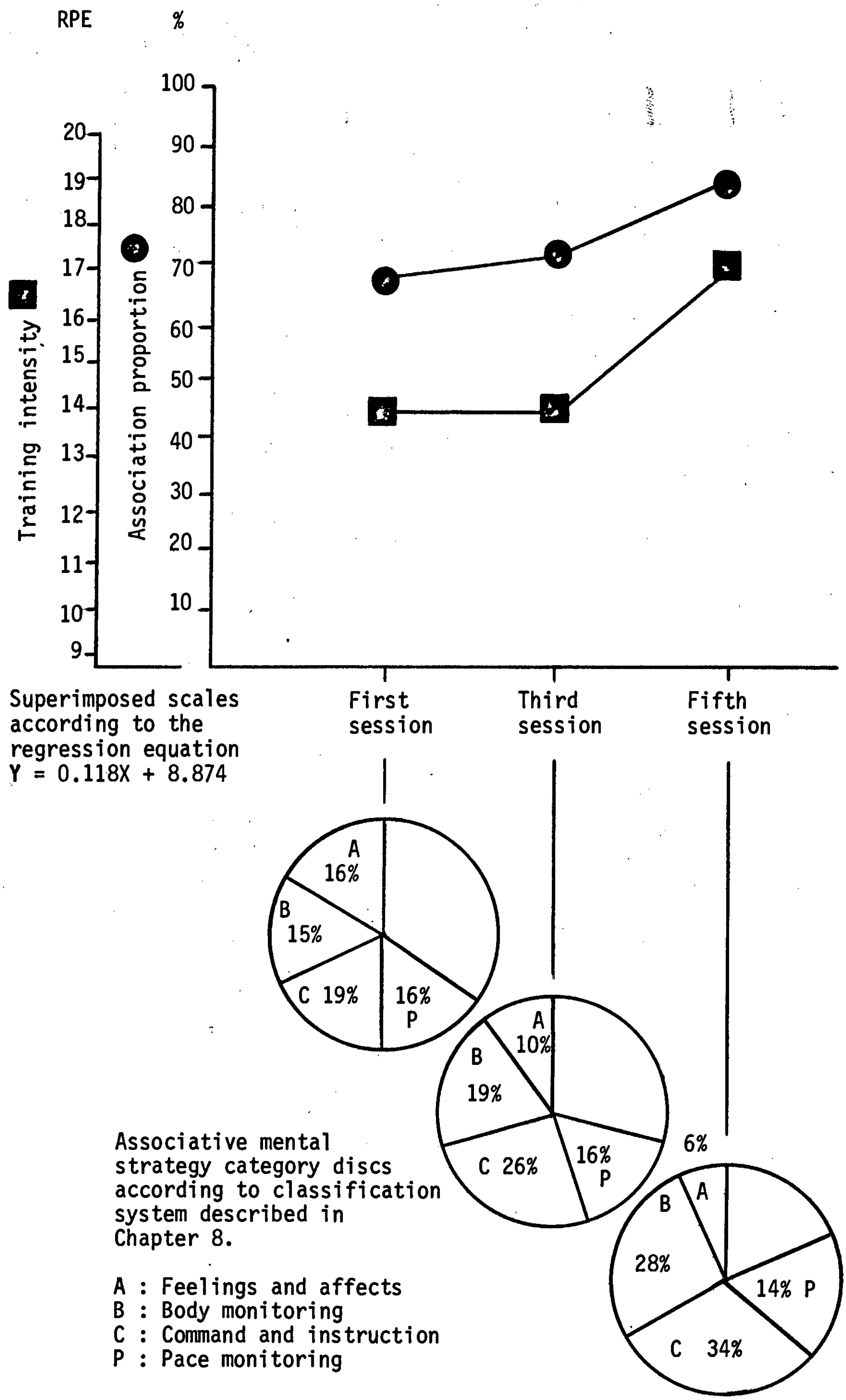


Figure 31. MSTP progress for marathoner of Case study 1.

to the realization of one's potential and he would positively recommend the programme to other long-distance runners.

Follow-up evaluation: Six months later the athlete had integrated precise and directive associative thinking into his daily training. The marathoner felt that the quality of his training had improved significantly and most of his track and shorter road race times had improved. He expected to better his personal marathon record within 6 months. To him the MSTP had initiated a more controlled and consistent performance at a higher effort level. Right after the MSTP he thought progress for him would be relatively slow, but he could now see results almost daily. Only the amalgamation of physical and psychological training principles could optimize performance for the serious athlete. To him the marked improvement in the quality of his running was symbolic of that amalgamation and could not just be weighed in running times.

CASE 2

Subject : 33-year old female athlete; achieved "elite" status in first-ever marathon.

Running history: Remarkable short-distance running career from 1965 to 1972; voted outstanding female athlete at 1968 Eleven Country Meet in Moscow; best times of 22.7 s over 200 m, 53.0 s over 400 m and 2 min 6 s over 800 m; troubled by recurrent sport injuries and congenital condition in joint of right and left ankle; corrective surgery did not have desired effect; retired from competition in 1972; joined UCT sport science marathon training programme in 1982; 1983 Peninsula marathon time of 2:59:07; Bellville marathon time of 2:56:29; member of Varsity Old Boys(VOB) running club.

Training : 6 days a week, covering between 70 and 90 km; rated approach to running as serious.

MSTP evaluation: Initial reaction to MSTP was extremely favourable. The athlete strongly believed that concentrated training in associative thinking had resulted and would in future result in performance increases. Mental aspects of running were seen to be crucial to performance maximization. She approved of the training method and the apparatus used. In her opinion the MSTP would most probably benefit novice and average runners even more as she thought that superior marathoners had to associate in some way or the other to maintain a high output. As can be seen from the graphical representation of her training programme progress (refer to Figure 32), proportions of associative thought rose relatively consistently, while the RPE increases were relatively larger but just as steady. She indicated that she would use the MSTP in future training and competing.

Follow-up evaluation: Half a year later the athlete confirmed her initial evaluation of the MSTP, though at the time of the follow-up evaluation she had reduced her running involvement to simply maintaining her fitness. She had entered another two standard marathons the same year, apart from several shorter races. Her

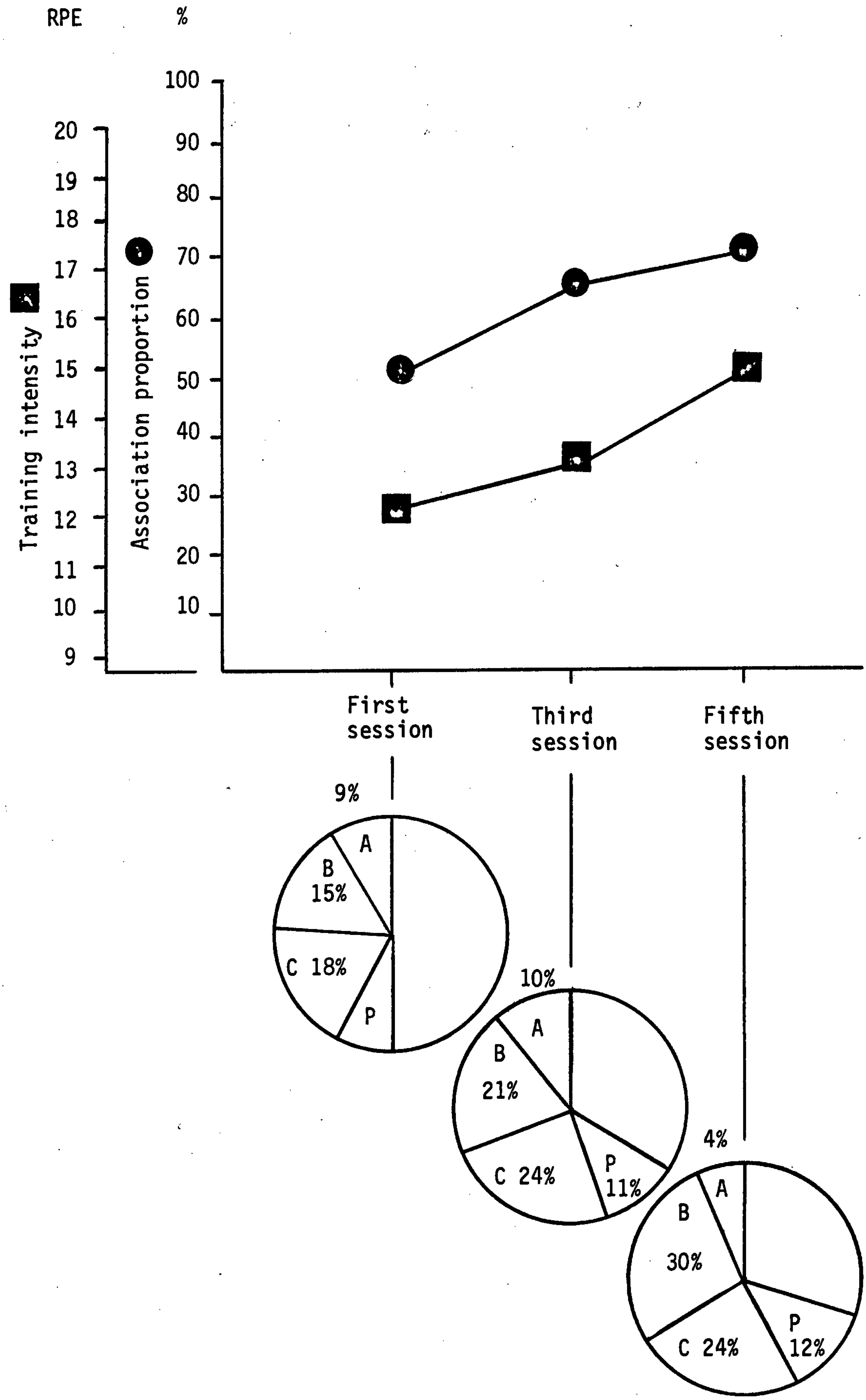


Figure 32. MSTP progress for the marathoner of Case study 2.

performance times in both the standard marathons did not live up to her expectations, clocking 3:09:16 and 3:04:25 respectively. At both events she felt extremely tired and overspent. She attributed her decreased performance to overtraining as she had stepped up her training rather hastily for these two events from 70 km to approximately 120 km per week on the recommendation of a fellow marathoner. Subsequent to this she became ill with a chest infection that only recently had shown signs of clearing up. Spending an average of 120 km per week on the road made too many demands on her and her family. Although she would try and run one marathon a year, competing was not that important to her anymore. She still believed that quality associative thinking definitely has a decisive role to play for the aspiring runner.

CASE 3

Subject : Male, 33 years of age, superior marathoner.

Running history: Has always been jogging for fitness; started marathon running in 1982; best marathon time of 2:47:- in 1983 Peninsula marathon; best ultra-marathon time of 7:25:- in 1983 Comrades race (88 km); VOB member.

Training : 3 to 4 days a week, covering between 30 and 70 km; rated his approach to running as moderate involvement mainly for fitness gain.

MSTP evaluation: The athlete appraised the MSTP as having a distinctly positive influence on his concentration and performance. The training method and duration suited him well. He appreciated the impact the MSTP made on the quality of his associative thinking that he reported to have used during races. Figure 33 depicts his progress. The athlete typically trained at a relatively moderate intensity, though his perceived training intensity increased steadily throughout the MSTP. He strongly recommended the MSTP to aspiring marathoners to improve the quality of their work-outs.

Follow-up evaluation: The athlete reported a shift in emphasis as far as competing was concerned. What was really important to him now was quality running, what he did now was "run for himself". His interest in quantity had decreased. The two marathons he had entered since the intervention illustrated this shift. His slower running times were 2:55:- and 3:08:- respectively. He emphasized that it was quite obvious to him that if he ever wanted to train hard again, he would have to adopt the kind of associative thinking demonstrated to him during the MSTP. Although heavy workloads were preventing him from doing so now, he expressed his goal and intention to better his standard marathon time by 10 minutes and his Comrades race time by 30 minutes. He would put the MSTP into practice in the near future as soon as his workload would ease off. To him associative thinking optimized performance by preventing him from over- or underspending his available energy resources. The athlete, being a sport physician by profession, expressed it in the following manner: "A pulse rate of 150 means quality effort by association; 180 is pushing it too far - you can only think pure

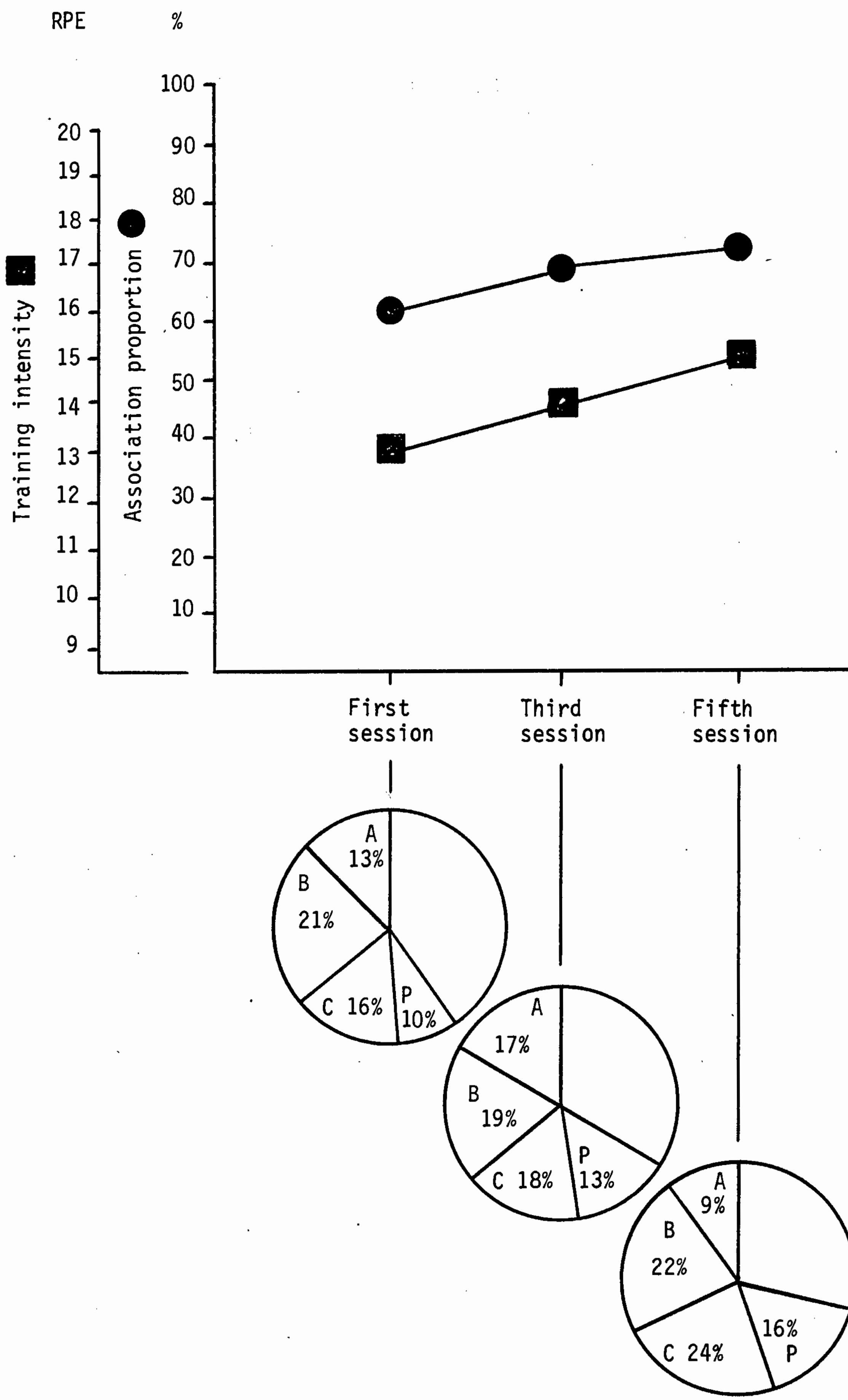


Figure 33. MSTP progress for the marathoner of Case study 3.

survival; and at 120 and below you can afford to dissociate." The athlete suggested that MSTP should be taught to groups of runners as it struck him as a valuable tool for every runner.

CASE 4

Subject : 31-year old female athlete, superior marathoner.

Running history: Commenced long-distance running in 1981; knee operation in 1982; best standard marathon time of 3:20:07 in the 1983 Appletizer marathon; member of VOB club.

Training : 6 sessions a week, covering 60 to 90 km; rated her approach to running as serious.

MSTP evaluation: The athlete perceived the MSTP to have an immediate, stimulating effect on her training performance. The way the programme emphasized the control aspect of the mental strategy essential for efficient running especially appealed to her. Although she initially reported that such concentrated task-related thinking was somewhat foreign to her, she enthusiastically adopted the mental strategy. It made sense to her that a serious runner has to stay in control and avoid "senseless" drifting. As can be seen from the graphical representation of her MSTP progress in Figure 34, her associative thinking advanced rather rapidly with a steady increase in training intensity. From the athlete's comments it was quite clear that the training method and duration were tailor-made for her. She expressed

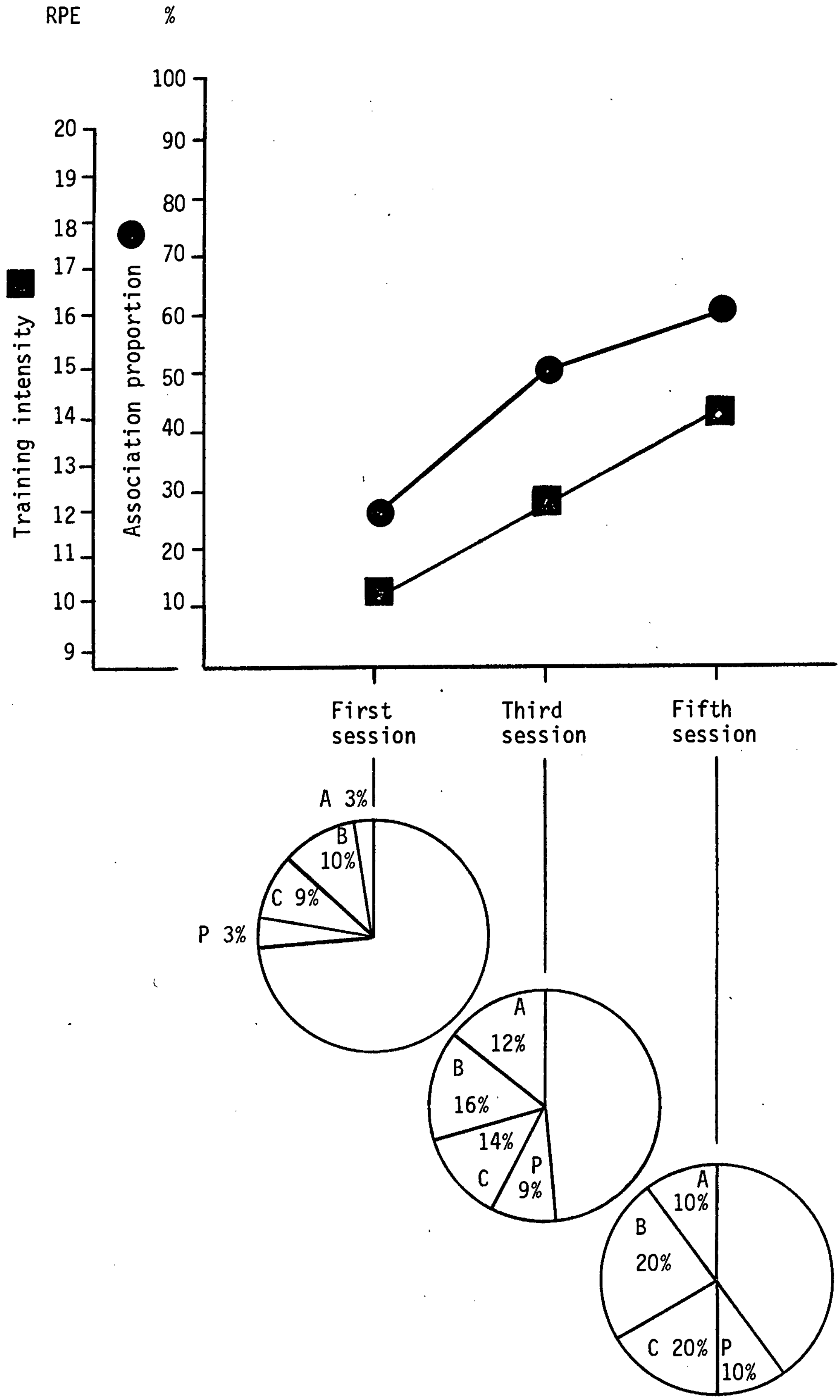


Figure 34. MSTP progress for the marathoner in Case study 4.

the hope that such a worthwhile training programme would not just be another scientific endeavour, but would be made available to more and more serious marathoners.

Follow-up evaluation: During the 6 months following the MSTP, the athlete kept on practising associative thinking and achieved a long-standing goal. She ran a half-marathon in under 90 minutes, her time being 89:29. She disclosed in detail how she had maintained absolute control by thinking associatively, "running from within", instead of running according to "whose in front and by how much". She was convinced that her next goal, to run a standard marathon under 3 hours, was within reach and that the MSTP had definitely made the difference. Her resolution to hone her mental strategy capacity was even stronger now than right after the MSTP. She also reiterated her opinion that the way the programme was conducted was highly professional and greatly contributed to her adopting it and eventually her success with it.

CASE 5

Subject : Female athlete, 44 years of age, average marathoner.

Running history: Began training in 1982; best time in 1982 Peninsula marathon of 3:54:-; VOB member.

Training : 6 weekly sessions, covering 60 to 90 km; rated her approach to running as serious.

MSTP evaluation: An exuberant reaction to the MSTP was recorded from this runner. She thought the programme had improved and would in future improve her performance substantially. Figure 35 depicts her progress through the MSTP graphically. This runner habitually practised at relatively moderate to high intensities. She admitted that she tended to avert pain. This, she thought, might be due to the fact that she latched onto the training programme of a much more experienced runner right from the start of her long-distance running career. The sensible, gradual approach to aerobic conditioning had never been impressed on her by the experienced marathoner. While her training intensities stabilized, her associative thinking advanced markedly. She reported that she had not thought in this concentrated manner during running. Her associative thinking was rather haphazard. Associative thinking generated an exhilerating feeling of power and control in her. She preferred the transceiver to be attached to a strap or belt instead of to her running shorts as they tended to be pulled down. Otherwise the training technique and duration suited her well. To her, especially superior runners would benefit from such a programme.

Follow-up evaluation: With the help of concentrated associative thinking she felt she had been able to reach her physical limits, which she discovered were not all that high. Task-related thinking really maintained her at that maximum, though she found that staying at her perceived maximum tired her tremendously. She rested for a while and thereafter attempted the Two-Oceans race (56 km), one of her long standing ambitions. This effort paid off. She achieved a "very satisfying" 5:50:- run with all the body monitoring

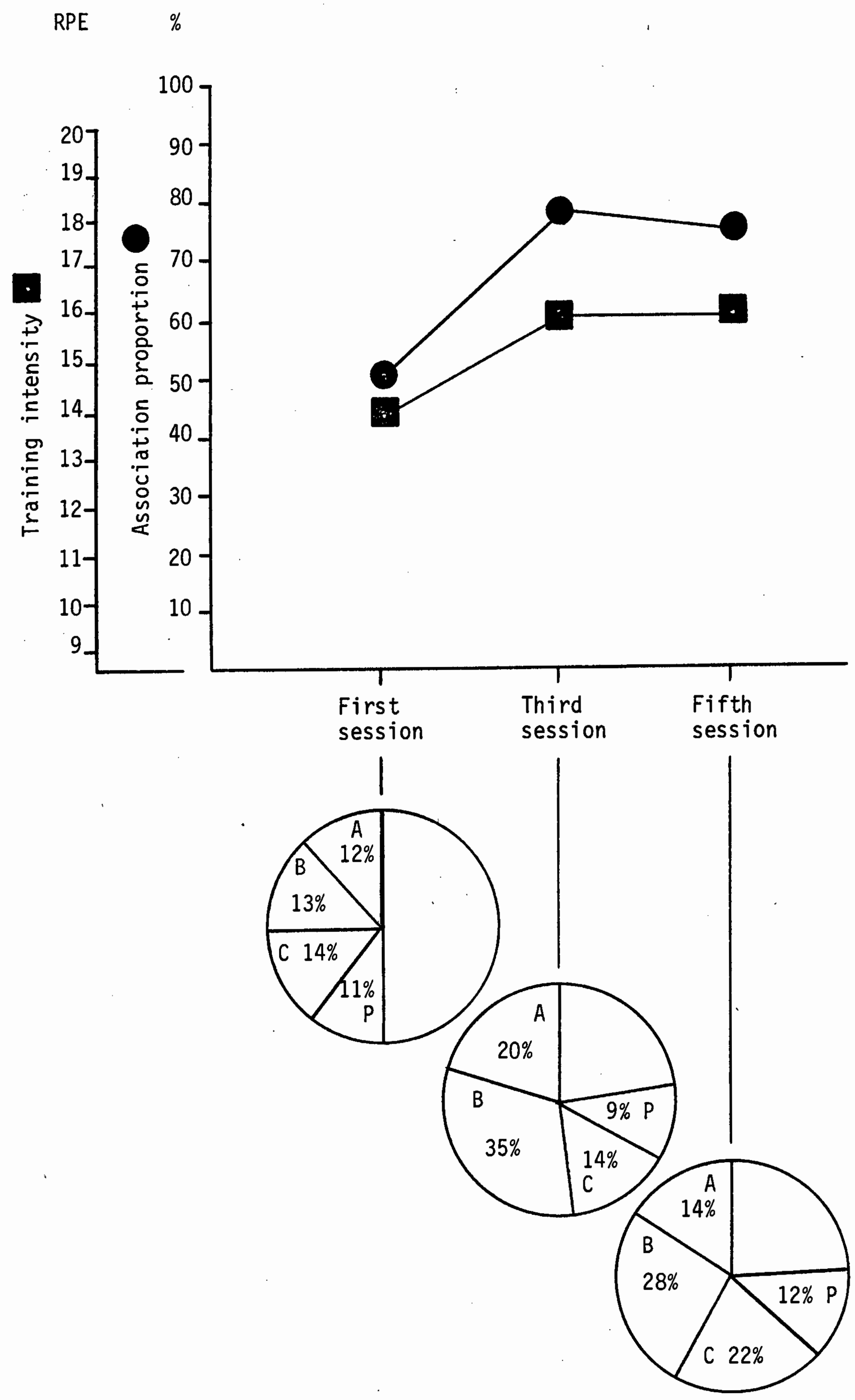


Figure 35. MSTP progress for the marathoner in Case study 5.

and assertive commands she was able to put into it. She recounted that she had never before experienced such reassuring control and could only guess at the difference an earlier exposure to the MSTP would have made to her running career. With added responsibilities in her work life she intended to reduce her involvement in running, but that she would always try and run one marathon a year. The most important point to her was that with the MSTP experience she would now train and perform intelligently.

CASE 6

Subject : Male athlete, 48 years of age, achieved "average" marathoner status with first-ever marathon.

Running history: Joined UCT sport science marathon training programme in 1982; ran the 1983 Peninsula marathon in 3:54:15; member of VOB club; plagued regularly by running injuries; pulled muscle in Peninsula marathon.

Training : Initially according to set training schedule (see Appendix 1), thereafter 6 weekly sessions, covering 50 km; rated his approach to running as moderate involvement for fitness gain.

MSTP evaluation: The athlete routinely trained at a low to moderate intensity. During the MSTP the trainer was perceived as an "intelligent monitor", and a kind of safeguard, and as a result training effort was sustained at a higher level throughout (see Figure 36). The

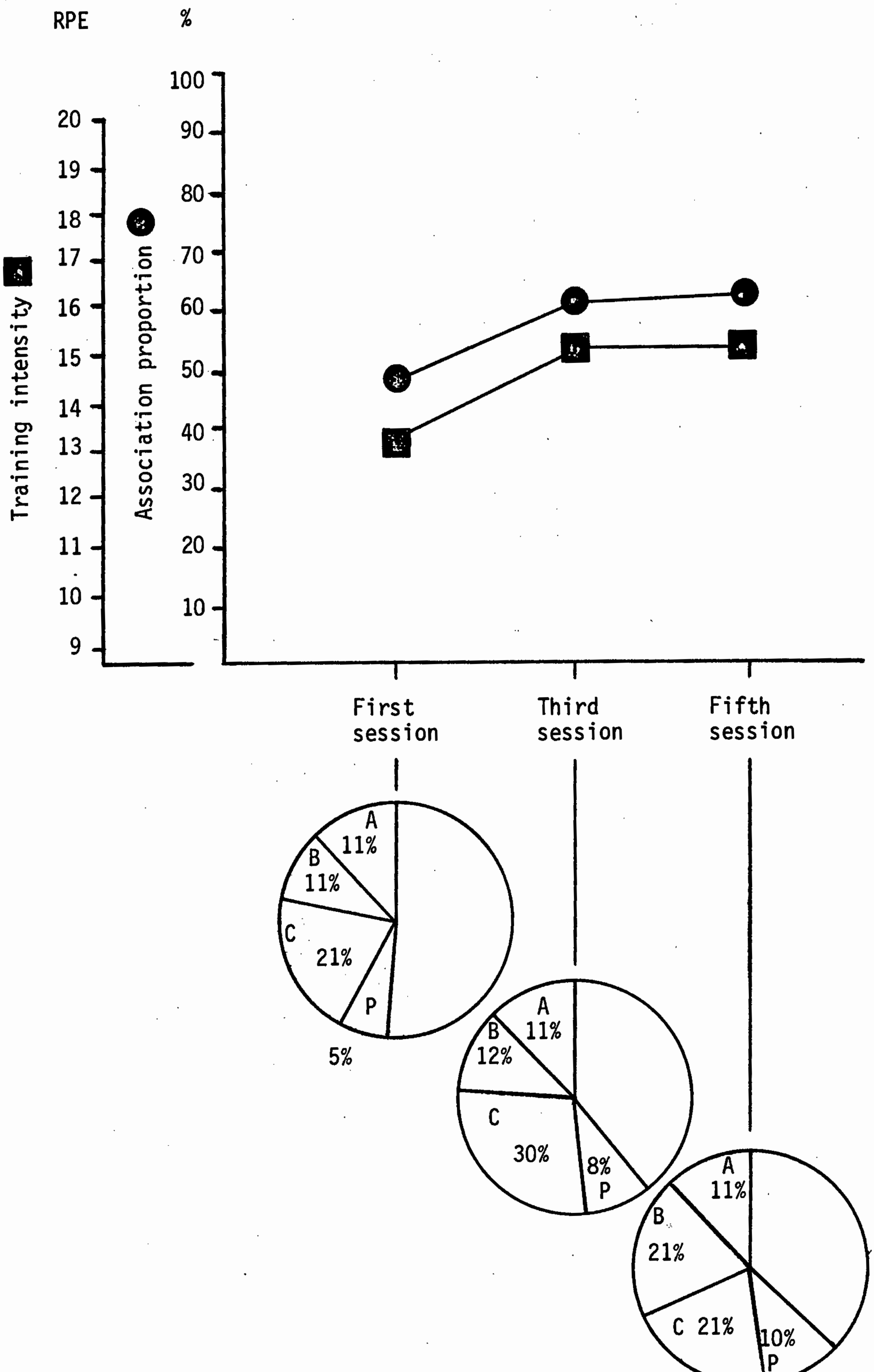


Figure 36. MSTP progress for the marathoner in Case study 6.

athlete enjoyed the MSTP and evaluated it very favourably and improvements in performance were definitely expected. This athlete perceived associative thinking to be an asset particularly during racing. Training method and duration were also seen as appropriate, and the practice of the fostered task-related concentration would be upheld. He stated that other runners should be made aware of the potential benefits such a MSTP could provide.

Follow-up evaluation: Right after the MSTP the athlete found it difficult to sustain concentrated associative thinking on his own. The stimulation and guidance provided by the trainer was seen as crucial. Nevertheless, the athlete reported that during racing associative thinking was engaged into whenever his energy reserves ran low. He experienced it to be extremely effective then and during the few times he had attempted hard training work-outs. He entered several shorter races and improved most of his previous running times. The "break-through" occurred in a recent half-marathon when he achieved to apply a larger proportion of associative thinking than before, reducing his pace from 5½ minutes/km to 5 minutes/km, his personal best so far. Since then, he disclosed to be feeling faster, stronger, more resilient and, most important of all, not as fragile as before. His injury rate had diminished drastically. He would like to attempt the standard triathlon soon where he intended to make extensive use of concentrated associative thinking to sustain his effort.

CASE 7

Subject : Male athlete, 41 years of age, novice marathoner.

Running history: Casual medium distance running since 1960; marathon training started with UCT marathon research programme; 1983 Peninsula marathon time of 4:16:-; VOB member.

Training : According to stipulated schedule (see Appendix 1), and thereafter 2 to 3 weekly sessions covering a maximum of 30 km; rated his approach to marathon running as moderate involvement for fitness gain.

MSTP evaluation: Definite, rather excessive results were expected by this athlete during and following the MSTP. The contact time served to induce additional enthusiasm into the runner with an otherwise rather despondent running attitude. The graphical representation of his progress in Figure 37 reflects his rather low intensity training effort at the beginning of the programme. According to his report that was exactly how low his interest in running was between the finish of his first marathon and the start of the MSTP. A radical increase in perceived exertion and somewhat sluggish advance in associative thinking succeeded. He appreciated the way the programme was conducted and the duration of the training. He would certainly try and use it to give his training a boost and other runners should also be exposed to such a "beneficial" mental strategy training.

Follow-up evaluation: Due to a job change and concomitant increases

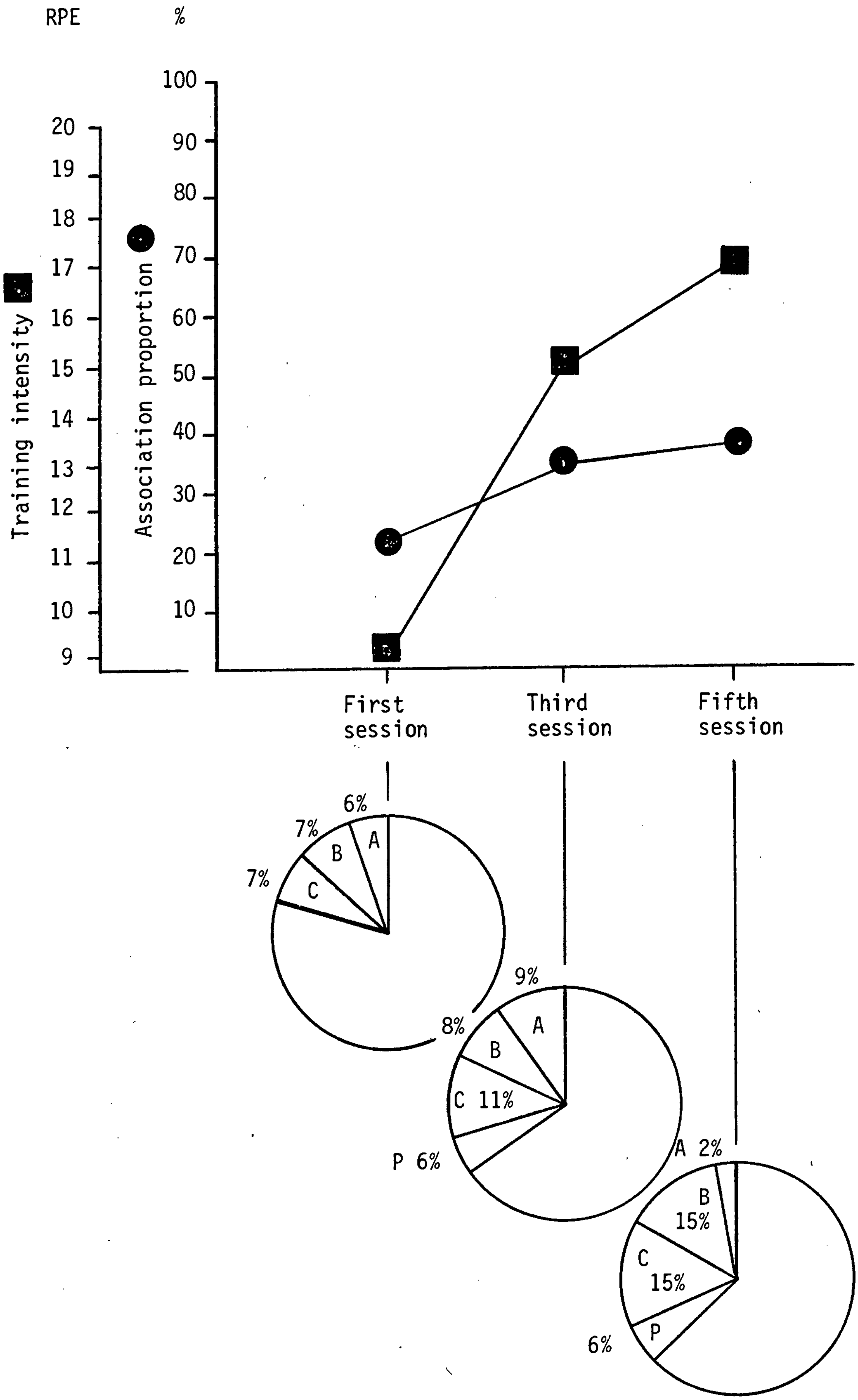


Figure 37. MSTP progress for the marathoner in Case study 7.

in work responsibilities, the athlete hardly trained for the first 5 months after the MSTP. He only occasionally ran with his wife for short distances during that time. As these times were mainly set aside to get a chance to talk, mental strategies did not come into the picture. All of these runs were perceived to be of very low intensity. Only fairly recently, as life around him seemed to settle down, did the athlete commence training more regularly, frequently and for longer durations. He felt that with increased effort associative thinking came into play and expressed the hope to be able to furnish somewhat more encouraging results in the near future. The "mental approach" to running would definitely feature in his "brighter" future. Doubts were, however, disclosed about the reality and possibility of that brighter future.

CASE 8

Subject : 41-year old female athlete, novice marathoner.

Running history: Joined UCT sport science marathon research programme in 1982; ran 1983 Peninsula marathon in a time of 5:10:-; VOB member.

Training : Followed set training schedule (see Appendix 1), thereafter 5 weekly sessions, covering 25 km per week.

MSTP evaluation: Similar extremely enthusiastic initial reaction as previous runner to the MSTP with similar expectations. Figure 38 depicts

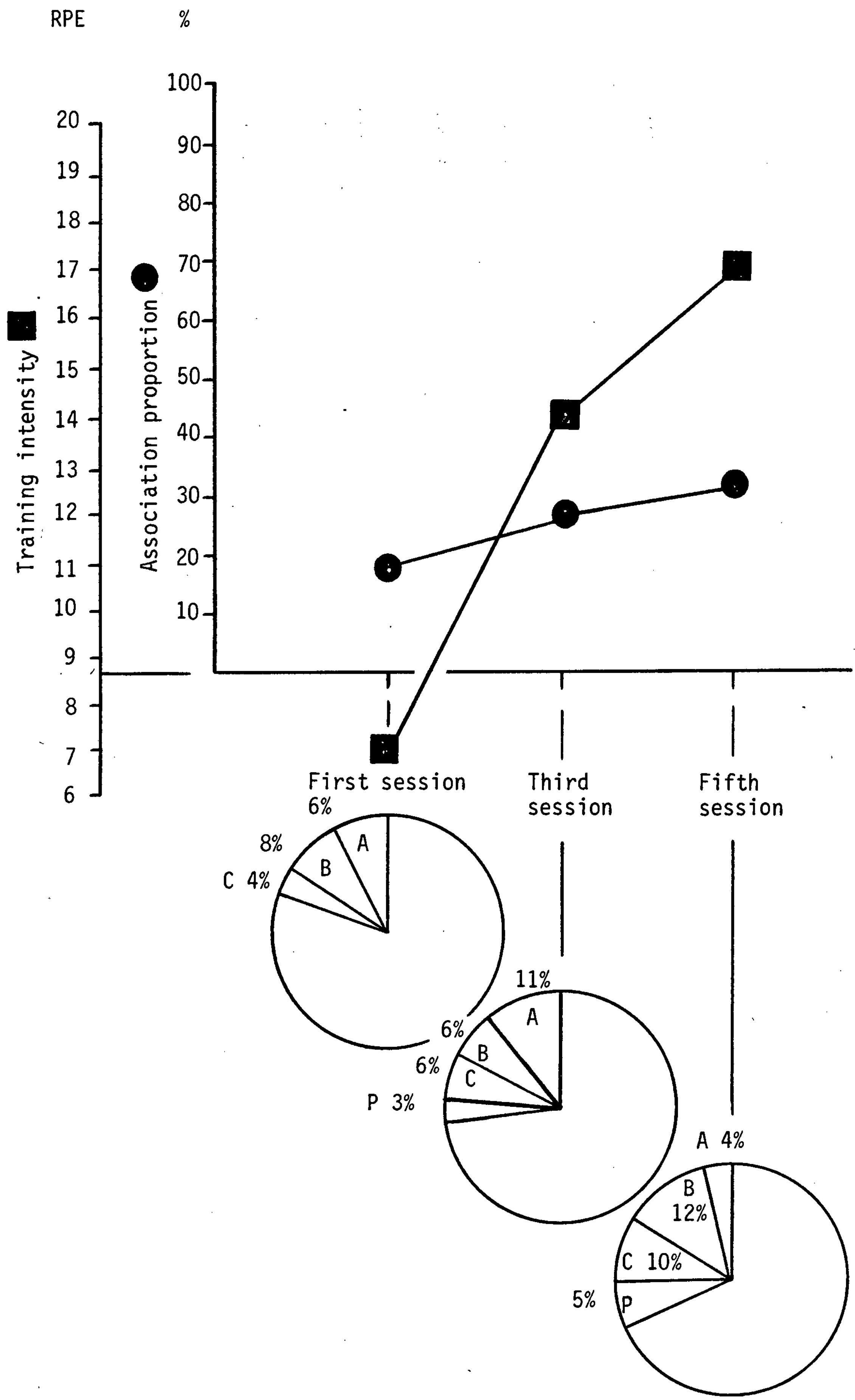


Figure 38. MSTP progress for the marathoner in Case study 8.

her progress graphically and shows a near copy to that of novice marathoner Case 7. The athlete also reported that the contact time helped her to get over a "slack" period. Training method and duration were perceived as effective. She expressed doubts about her ability to be able to maintain the high training effort achieved during the MSTP. The programme should definitely be recommended to other long-distance runners.

Follow-up evaluation: The runner did not try to enter any long-distance races. She felt that distances up to 10 km suited her more. She insisted that her initial reaction to the programme was most probably because she always needed somebody to run with. Her self-motivation was low. To her, associative thinking also played a role in shorter distances for aspiring runners, yet she had not been able to practise it as she lacked motivation to try for anything that demanded effort. On further inquiry this seemed to be the case for many other aspects of her life as well.

CASE 9

Subject : 27 year old female athlete; novice marathoner.

Running history: Joined UCT sport science marathon research programme in 1982; developed shinsplints early on and suffered a stress fracture in lower right leg halfway into programme; recovered well and completed 1983 Peninsula marathon in a time of 5:15:-; VOB member.

Training : According to set training schedule (see Appendix 1), thereafter 4 to 5 weekly sessions, covering on average 30 km; her running involvement was rated as moderate.

MSTP evaluation: The MSTP was welcomed and the athlete reported being able to push herself harder and develop a more serious attitude towards her running performance. The steady increase in training intensity, as depicted graphically in Figure 39, substantiates her assessment. Her progress in adopting larger proportions of associative thinking parallelled her increased effort. The athlete noted that associative thinking was particularly effective when running up hills, a task she had always dreaded. She liked the training method and duration, though at times felt a bit conspicuous carrying the transceiver and headset when encountering fellow runners. She also emphasized that running to her was definitely a therapy and that she would not like to let the development of an associative mental strategy make running "too mechanical", as she was not out to break anybody else's record, she would use associative thinking selectively. She expected the MSTP training to sensitize her and help to detect impending injuries early on. For this reason alone, the MSTP was recommendable to other marathoners.

Follow-up evaluation: Soon after the MSTP the athlete had orthotics fitted to her shoes. She was able to go for longer training runs. With a further build-up of the orthotics and a change in shoes, she was able to work on her running speed. She entered two half-marathons and achieved times of 2:05:- and 2:04:- respectively. During these

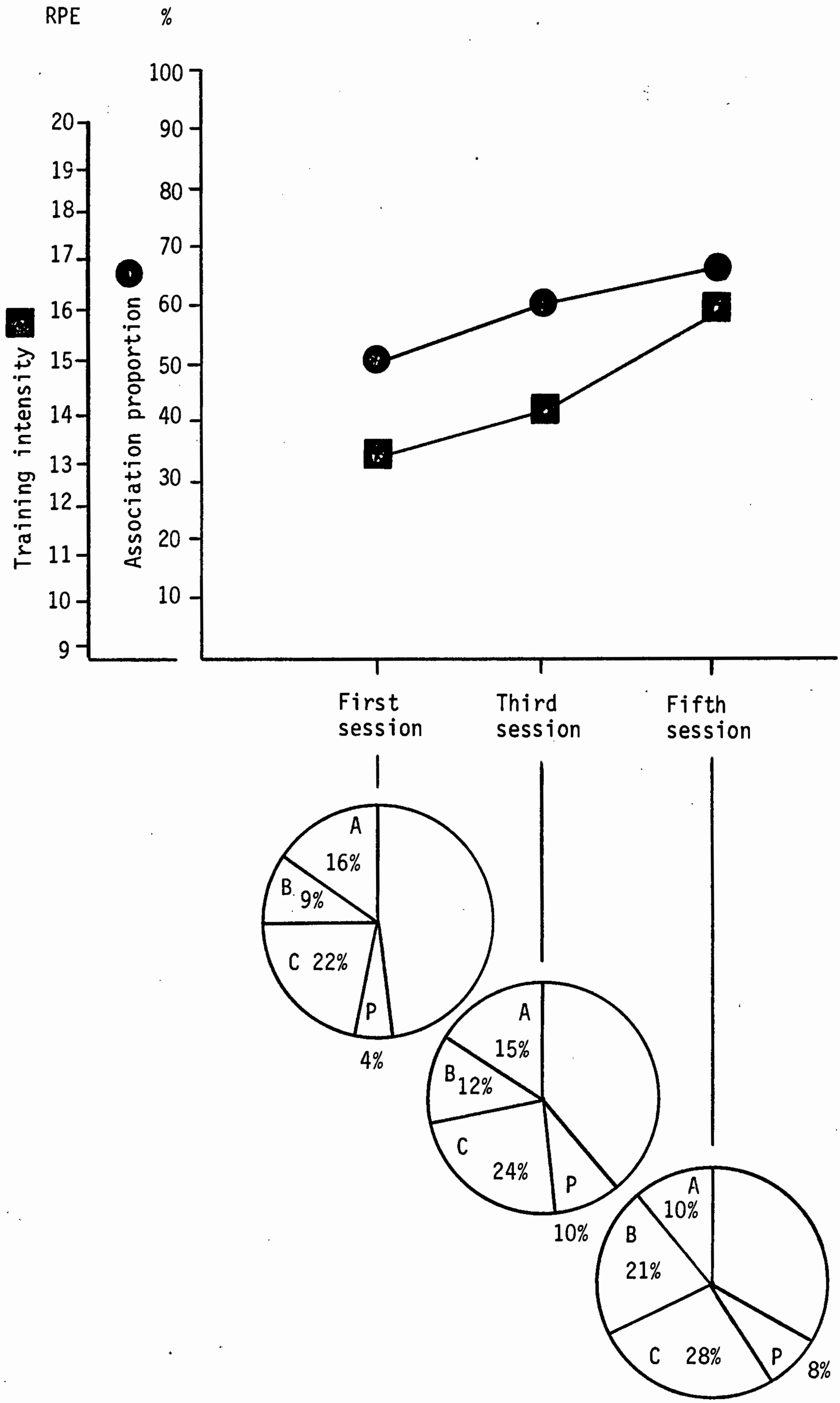


Figure 39. MSTP progress for the marathoner in Case study 9.

runs associative episodes featured quite prominently according to her recollections. She found whenever she had a specific goal in mind, like getting up an incline, "association was the way to get there". Her shinsplints still troubled her. If at all possible, she would appreciate a refresher course in the MSTP, as she expected that to help her on the way to more extensive training covering about 50 km per week.

CASE 10

Subject : Male, 27 years of age, novice marathoner.

Running history: Participated in 1982 UCT sport science marathon research programme; ilio-tibial tract syndrome detected early on in programme; completed 1983 Peninsula marathon in a time of 5:56:-; VOB club member.

Training Conformed to set training schedule (refer to Appendix 1), thereafter 3 weekly sessions covering 25 km; rated his approach to running as moderate involvement for fitness gain.

MSTP evaluation: The athlete's initial reaction to the MSTP was rather reserved. He reported immediate improvements to be moderate and did not expect future advancements to be drastic. He qualified his answer by stressing the to him incredibly limiting physiological condition of his knees. Perceived exertion climbed steadily from a rather low effort baseline together with a nearly parallel advance in associative thinking. The data is represented graphically in Figure 40. Both the training method and duration appealed to the athlete. He expressed the concern that this mental training programme might take the "fun out of running", as it epitomized the "science of running" to him and as such would only be of interest to serious marathoners. He nevertheless would recommend all runners to at least try it and know about it.

Follow-up evaluation: During the 6-month period following the MSTP the runner did not train consistently or for any prolonged periods of time in fear of his injury recurring. He did not practise associative thinking as he enjoyed chatting away to other runners during the few training runs he had. All of these few runs were at low intensities. In retrospect, he knew that he had responded well to the training and had adopted the associative thinking shaped by the trainer, but he really dreaded and resisted the idea of having to think that way by himself. He was very scared of having to live through another injury. Then he had a 2-month break and suffered the same ilio-tibial tract injury to both legs when attempting to start running again. He knew that he did not try to monitor his sensory signals - in fact he remembered trying desperately to shun out all bodily feedback. He regretted his decision later on and now saw the value of association for any runner. Although he would like to continue running for health reasons, competition and serious running were out. Mental strategies that control the running process were to him for those that wanted to go far in running, for those that wanted to win. And that was not possible for him.

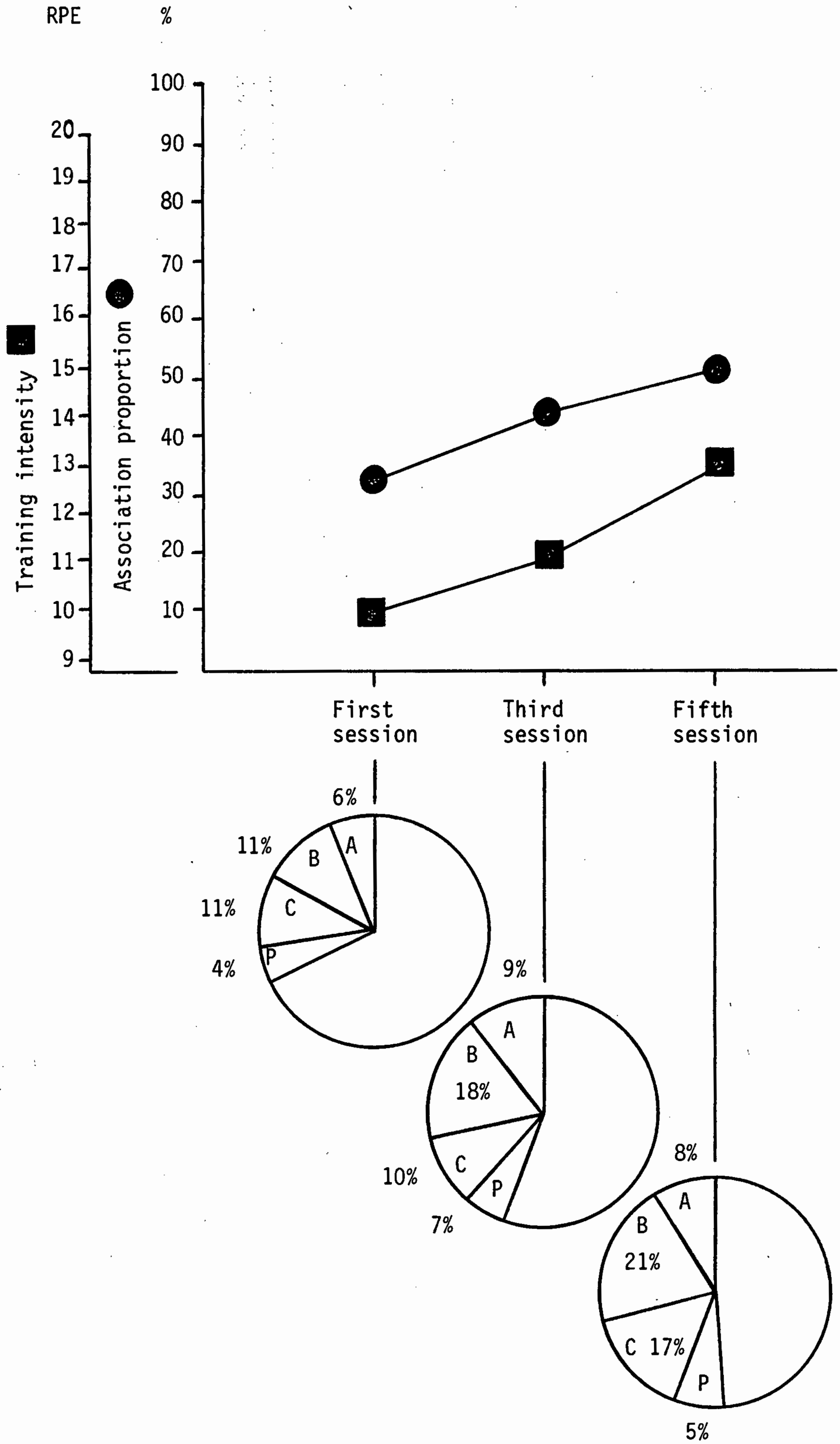


Figure 40. MSTP progress for the marathoner in Case study 10.

OVERALL EVALUATION

Two contrasting reactions to the MSTP emerged. On the one side there are 8 subjects that progressed relatively steadily from their habitual training approach to a more concentrated associative mental strategy with a concomitant even rise in training intensities. A characteristic feature in all these case studies is the convergence of the proportion of associative thinking with the perceived training effort. This trend is seen as a function of the athlete's shaping process: new salient information is processed, put to the test and then integrated into the runner's already existing memory bank that stores information on how an efficient and safe running household can be achieved, sustained and controlled. The relative potential for improvement for marathoners with high associative and high related training effort base-line measures was of course lessened in comparison to runners commencing with lower base-line dimensions. Nevertheless, the shaping process appeared to progress resolutely. Subsequent performance improvements emerged in the form of shortened race times, better training times, longer sustained training runs, higher training intensities, and minimized or eliminated injury occurrence. Only 1 of the 8 runners characterized by effort sense and association convergence did not take the MSTP further. The athlete avoided using associative thinking and high training input in fear of experiencing a repeat of an earlier traumatic injury.

On the other side there are 2 runners whose perceived training effort soared from relatively low base-line measures to extreme intensities right after the first MSTP recording and climbed even further in the subsequent recording. The proportion of associative thoughts did not emulate this radical reaction and rose rather reluctantly. The emerging trend is one of divergence between training intensity and proportion of associative mental strategy as the MSTP progressed. Here the shaping process is seen to stagnate. The rate of reinforcement and interception was nearly double that for the average noted in the previously discussed runners. The shaping process seemed to be blocked, and perceived effort was projected out of all proportions. Trainers registered a kind of resistance, an undeclared opposition and unwillingness on part of these subjects to put their "heart" into the proposed cognitive reconstruction. It appeared as if these runners were saying: "All that effort and you see, I knew, it would not really work." Follow-up evaluations substantiated this speculation.

Subjects were instructed to train at their routine intensity at the start of the programme when the rationale and objectives were made explicit to the trainees. The marathoners were made to understand that from the analysis of the previous phase of the research project it became apparent that there was a strong direct relationship between increases in associative thinking and training intensities and that the author interpreted this significant relationship to be of adaptive significance. High training intensities were seen to be achieved and sustained efficiently and safely by high proportions of associative mental strategy. Therefore, training in qualitative associative thinking, modelled on that engaged in by superior runners, was expected to optimize the performance output of marathoners in the long-term. Trainees were asked to train in their habitual way and at accustomed intensities. Trainees were told that they were not expected to train at higher intensities than they were used to or felt comfortable and safe with. Nevertheless training intensity ratings showed a distinct tendency to rise as the MSTP progressed. It was only for marathoners Case 7 and 8 that this rise appeared to be erratic and unconsolidated, totally out of proportion with the recorded advance in associative mental strategy. The author had the opportunity to discuss the results with some of the subjects and query the manifest rise in training intensities recorded for all trainees. The like-minded response was that the MSTP inspired them to try for harder work-outs, especially as the trainer's attitude was perceived to be totally committal and constructive, or as one marathoner put it: "It is hard not to give the best you can, when someone keeps on telling you how well you are doing and how much it is appreciated - and for all that time right into your ears." The presence of the trainer was perceived to be stimulating and, in some cases, even "protective". Still, the majority of marathoners did not indicate that they would have preferred a longer MSTP. They knew very well that the real test of the associative mental strategy came when they had to rely on their own resources. The suggestion by one marathoner to introduce MSTP refresher courses for those that wanted or needed them was welcomed by fellow runners. The rationale and objectives of the proposed MSTP when explained to trainees at the start of the programme were seen to be coherent and convincing. These perceptions are seen to be critical for the success of any cognitive intervention programme. If the athlete does not see sense or meaning in the proposed transformation, he/she will reject and resist such intervention. If the athlete believes change or alteration to be unneccessary or unprofitable, no time or effort will be invested. As Silva (1982) put it:

> Without the athlete demonstrating a belief in the need for such a modification, the covert conditioning and concentration cues provided in subsequent stages of intervention will hold little salience and may not be practiced with vigor. Belief entails a performance expectancy, and a strength of a belief is often reflected in the intensity of the action it initiates. In the author's opinion establishment of a belief in the potential benefit of the cognitive changes proposed to the athlete is fundamental to an effective program and improved performance. (p.448)

The programme placed a strong emphasis on the integration of the suggested adoption of high associative mental strategy proportions into the athlete's routine training approach. Seven runners reported to have achieved this successfully, though 2 of these said that consistently high proportions of associative thinking had always been a feature in their mental approach to sustain high training effort. For these 2 runners the MSTP presented an ability to hone their skill even further. The remaining 3 subjects reported to be either disillusioned with life as a whole and were, therefore, lacking motivation to train in a concentrated, structured fashion, or were unable to maintain their involvement in running due to pressing work/family commitments. One of these 3 runners could not tolerate the idea of sustaining a further running injury, as his initial experiences during long-distance training had been rather traumatic. The contention of the author that careful, consistent body monitoring was most probably responsible for the elimination or at least minimization of overuse injuries was described by the majority of subjects as a major motive to adapt or hone their associative thinking capacity. Subjects that profited in this respect from the MSTP are documented in Case studies 6 and 9. On the whole, all subjects appeared to be well-read on the subject of running, although primarily physiological or anecdotal "running knowledge" had been accumulated. Subjects agreed that psychological material was lacking, though all disclosed to have formulated their own private "psychological" theories with an advance in running exposure. Especially the experienced runners had no illusions about the usefulness of prolonged dissociative thinking episodes or other kinds of "mystical running forces". To them staying in conscious control was the way to better running, increased training output, and ultimately winning.

To corroborate the trainees subjective assessments further, a definite design improvement would include the recording of marathoners' mental strategies at regular monthly intervals after they have been exposed to the MSTP, instead of the impact evaluation by structured interview or questionnaire 6 months later. For this thesis this step could not be executed because of the protracted time-factor in such a venture.

An associative mental strategy establishes and maintains conscious control and as such optimizes performance. Association has been shaped, taught and fostered in a real-life exploratory setting. The outcomes reported by those that adopted the suggested mental strategy have been persuasive, even though it was well-recognized that only in the long-term application of concentrated association can concrete results materialize in the form of better marathon race times. The case emerging here for the training of associative mental strategy cannot be based on concrete race times alone. Indeed, although not every trainee was in the position to report improved race times 6 months after their concise and concentrated mental strategy training programme, the clear majority were able to report improvements in their training quality and approach to efficient and safe long-distance running. It would be unwarranted to imply that associative thinking is the key to marathon excellence. However, as a factor that lends itself to change, training in associative thinking holds important implications for the realization of an athlete's potential in long-distance running. Optimal performance is not the result of a physiological, biomechanical or psychological impetus occurring in isolation. Body, mind and emotions operate as one unit, or as Syer and Connolly (1984) put it: "What you think affects how you feel and move, what you feel affects how you move and think, and how you use your body affects how you think and feel" (p.8). Optimal performance is the amalgamation and fusion of all three factors. It is with this in mind that the results obtained have to be interpreted.

The investigation into the applicability and effect of associative mental strategy training documented here is fundamentally exploratory in nature. Based on a case study approach, the investigation is exposed to a certain degree of criticism as such an approach lacks strong control designs (Robinson, 1979). Yet, it has to be remembered, that it is not argued that the reported performance improvements are solely due to the mental strategy intervention. The effects are perceived to be a function of an interactive effect of the athlete's physiological, mental and emotional potential. Intervention of this nature brings with it the opportunity for the athlete to receive special attention and spend more time in the activity. These factors alone undeniably make a difference, however minute. Yet, it is the athlete's interpretation of what has contributed to what in which manner and how much, that will provide the impetus for the adoption of training methods and techniques designed by sport scientists. It is the athlete that puts the technique to the test and provides the verdict. The clear majority in this study came up with the verdict that the total impact of the intervention programme was instrumental in optimizing their performance. They experienced it as such. These marathoners perceived associative mental strategy training to help bring out and assist in achieving their optimal physical skill and because of that all-important experience, associative mental strategy training should be made known and available to all aspiring long-distance runners.

Realistic concerns about time and equipment commitments will quite obviously necessitate certain adjustments to the training technique. To offer a MSTP on a one-to-one basis and with the same equipment as has been done in the current investigation would be placing a prohibitive time burden on sport scientists and coaches. More practical mental strategy training methods will be outlined in the discussion section.

It is also prudent to keep in mind that psychological training methods of this nature are extremely unlikely to succeed with uncommitted or "problem" athletes. In this investigation the dedicated marathoner used the provided tool intelligently.

DISCUSSION

Sport scientists recognize that a single instance of a successful skill execution is not evidence that a skill has been effectively learned (Rushall, 1981). Rather, what is required are repetitive executions to substantiate performance increments. This holds for the physical as well as the psychological realm of skill execution. To think associatively for prolonged periods of time under high performance output constitutes a formidable skill. The athlete is required to produce and hold a predominantly positive internal narrow focus of attention, to accumulate and manipulate intimate knowledge of his/her idiosyncratic sensory perceptions, and to reinforce and exhibit a positive belief in his/her capabilities and performance. Prerequisite to all this is, of course, the athlete's will to sustain or exceed his/her performance standard (Pezer & Brown, 1980). In this light, the mere "exposure" to associative mental strategy is not beneficial, at least from a performance point of view. This can be seen in the outcomes obtained in Case studies 7 and 8, and to some extent, Case study 10, where the athletes were exposed to the mental strategy but did not perform the repetitive executions required to corroborate performance increments. It is only where positive outcomes from performance have been received that satisfaction is achieved. Satisfaction from mental strategy training can be assumed to occur relatively late in the performance curve. The general impact on skill acquisition is that far more trials of skill practice are required than has previously been considered necessary (Rushall, 1981). The rate of improvement, and therefore indirectly the recognition of positive performance outcomes slows down with an increase in the difficulty of the task. The implication for associative mental strategy training is, therefore, to provide additional performance incentives on the way to concrete marathon race advances.

This is proposed to take place in the shape of qualitative performance increments. The athlete has to be made aware of the satisfaction he/she can derive from conscious control aspects of associative thinking, and from the real possibility to reduce his/her overuse injury rate.

Extensive research in performance development points to the fact that athletes' learning performance curves are generally S-shaped, yet highly individual (Kohl, 1977; Robb, 1972; Rushall, 1981; Thomas, 1978). Marathoners in this investigation certainly manifested to be at different stages of their performance curves. Their rates of skill development differed considerably, as can be made out from their diverse reactions to the MSTP. Although the aim of the MSTP was to maximize associative thinking, no maximum was predicted. The way each athlete acquired or fostered the skill was highly individual. Trainers delivered athlete-specific instructional cues and thereby optimized the cognitive reconstructing process by moulding the MSTP to the instructional requirement of each individual athlete. The mental strategy training has to be accommodative to the athlete's idiosyncratic learning process and instructional requirements.

Apart from differences on the above discussed factors athletes bring to the training situation a host of other factors that have to be acknowledged and incorporated into the mental strategy training. The runner's training history, competition record, level of fitness, genetic predisposition, age, reasons for participation, and cognitive abilities all provide valuable clues to the researcher where the marathoner's strength and weaknesses lie and how they could possibly be amalgamated through the MSTP.

Qualitative differences within associative mental strategy training can boost the runner's overall determinination to implement conscious control. It was noted by the author that the marathoners in Case studies 1 and 3 manifested relatively well-established associative approaches to running, yet positive command and instruction were weakly developed. Trainers were able to shape this integral associative skill to the marathoner's advantage.

Marathoners in Case 2 and 9 manifested quite differing mental skill levels for instance. The elite runner demanded far more exact and immediate shaping to foster his already existing associative repertoire, than did the novice runner in Case 9 who required more general guidelines and encouragement.

Subjects with extensive competition experience reported to simulate race conditions far more often than novice runners, who were primarily concerned with "hanging in there". Trainers noticed the difference in precise and directive pace monitoring verbalized by superior runners. Marathoners in Case 1 and 3, for example, compared their present performance to previous race experiences or other known runners of compatible calibre and made adjustments according to whether they wanted to exceed the past performance. Thus the need to engineer individualized associative mental strategy training becomes apparent.

The amount of attention afforded to physiological and biomechanical performance considerations has to be extended to psychological ones to optimize performance (Hickman, 1980; Rushall, 1981). Thus, the higher the goal of the marathoner, the more prepared he/she has to be to spend time and effort in updating and expanding his/her psychological preparation. No athlete can hope to optimize performance by concentrating solely on the physiology or biomechanics of training. A balanced preparation is a prerequisite to performance optimization. Part and parcel of this preparation will be the emphasis of task-specific training, reducing the use of auxilliary, non-specific training activities and techniques. In the psychological realm simulation during training provides task-specific preparation (Railo & Unestahl, 1980; Vanek & Cratty, 1970). Athletes run the event the way they have conditioned themselves to run in training (Lilliefors, 1978; Orlick, 1980). To enable the athlete to utilize associative thinking during competition, it has to be persistently emulated in practice. Simulation lets the athlete get as close to the real event as feasible. Athletes are advised to fill in as many details as possible that make their training run look and feel like the competition experience. Orlick (1980) recommended practising running tactics with friends, each playing and behaving like a potential real-event opponent. The runner can also imagine certain race situations where, for instance, he/she is challenged by an opponent three-quarters into the race and has to hold him/her off or settle back for a later comeback. Only the imagination is a limit to simulation. Of course, an integral part of effective psychological preparation is the constant utilization of associative thinking during such simulation training runs. Body monitoring and pace monitoring are not allowed to cease because of unforeseen race tactics implemented by other runners. Positive command and instruction or affective feedback are also not allowed to be superceded by negative suggestions, anxiety or doubts. It is the unprepared athlete that lets him/herself be thrown off balance by such external circumstances. The athlete would be well-advised to prepare a little space in his/her routine association concentration cycle for assertive and directive competition tactics. Diverse scenarios should be played through to prepare for the widest range of real-life possibilities. As Orlick (1980) pointed out: "The best way to convince yourself that you can do something is to do it" (p.216). That does not mean that aspiring marathoners should force themselves to endure one race after the next in rapid succession. Rest is essential for adequate recovery. The majority of superior runners in this study indicated that they did not "race" more than twice a year. Jackson (1974) reported that superior marathoners did not race for more than 6% of their total mileage. Next to the experience of the real event, simulation is the best way to find out what one can and cannot do. "Simulation will give you added confidence in your ability to do what you set out to do. It will help you believe in yourself, and that is critical in all sports" (Orlick, 1980, p.217).

The associative mental strategy training explored here relies on the availablity of a trained sport scientist or coach and access to hands-free, two-way radio communication equipment. With these resources at hand, the impact of the mental shaping process is, of course, maximized. Nevertheless, with a few practical adaptations the technique can be made accessible to a far wider runner spectrum.

The role of the sport scientist or coach can be taken by an interested fellow runner. Both marathoners would benefit as the role of "thought monitor" and "thought verbalizer" can be exchanged as the participants see fit, both enhancing each others associative thought pattern. As one should try for an uninhibited, unrestricted thought verbalization flow, one would naturally choose a trusted running colleague. At no stage should the marathoner feel that his/her thought flow is open for misinterpretation or misuse. Once a clear understanding has been reached between two marathoners that the training programme aims at the mutual development of a more efficient and safe mental approach to running, and therefore all communications between them during the training sessions have to be treated in confidence; runners have to familiarize themselves with the thought classification system discussed in Chapter 8 and 9 of this thesis. Personal examples of thoughts that seem to match the individual categories should be volunteered and discussed. The marathoner has to be certain and clear him/herself about what kind of thoughts belong where before attempts should be made to distinguish and categorize another marathoner's thoughts. Firstly, thoughts should be classified as task-related or task-unrelated. Then, the specific categorization should be applied. Attentional focus distinctions can be drawn on to elucidate possible "problem" thoughts - ambiguous material that appears to dodge categorization. Once the classification system is internalized, marathoners can procede to employ the categorization task on the run, where one marathoner verbalizes his/her thoughts for an agreed period of time and the other calls out whether the verbalized thoughts are task-related or unrelated. The next step is to initiate the shaping process gradually. The "thought monitor" starts to reinforce task-related material, progressively encouraging and demanding more and more associative thinking. The emphasis is on a positive shaping attitude: the runner's strengths have to be highlighted before the following step is engaged into, where task-unrelated thoughts are discouraged, interrupted, and eventually stopped and prohibited. Finally, precise and directive body monitoring, pace monitoring, and command and instruction should be reinforced and insisted upon, with only minimal dissociative flashes being tolerated. It is recommended to swop roles at quite regular, short intervals at the start of such a dyadic associative mental strategy training programme. Progressively larger intervals in one and the same role can be arranged as the participants see fit, till in the end, one of the marathoners can have a complete training run intelligently monitored and shaped by his/her running colleague. Roles would evidently be swopped for the next meet.

A typical training sequence at an advanced stage of the shaping process in a dyadic set-up would sound like this:

Thought verbalizer:		"There is nothing to touch this. Out here, what a feeling. Can't think of going back to the office tomorrow. Got a new girl in the office ..."
Thought monitor	:	"Hold it! Lets's hear you scan your body."
Verbalizer	:	"Okay, here we go. Legs feel great. Calves are warm and smooth. Shoulders and neck relaxed. Good rhythm. Easy stride. Feel very confident. Strong, really strong."
Monitor	:	"Good, that's it. More of those positive thoughts please."
Verbalizer	:	"Strong stride. Picking up a bit of speed on the flat stretch ahead. That's it. Strong stride. Still relaxed, very powerful. Breathing deeply. Calf muscles feel a bit tight now. Adjust pace. Slow down a bit, slow down."
Monitor	:	"Work on those calf muscles. Help them relax."
Verbalizer	:	"Calf muscles relax. Feeling warm and relaxed. Relax, relax, relax. Fall in with the body rhythm and relax, relax. Easy, controlled rhythm. Much better. Smoothness coming back. Flowing movements. Neck and shoulders feel great, really relaxed. Arms relaxed. Slight incline coming up. Going strong. Smaller steps. Stronger steps."
Monitor	:	"Really sounds like you are in control here. Good. Very good."

Verbalizer : "Pushing up the incline. Push, push, push. Strong stride. Oh, look at that power. Well done. On top, adjust pace, adjust stride. Loosen up legs a bit. Relax legs. One, two, three. Maintain rhythm."

Monitor : "Well done. Really controlling it there."

OR

"My turn now to put it into words - ready?"

The transition from random thinking to concentrated, controlled task-related thinking has to be slow and deliberate to allow for maximal internalization. The acquisition and subsequent storage of the newly developed or fostered skill has to be consolidated and personalized to allow the marathoner to modify his/her running behaviour effectively in the future. Repetitive applications of the dyadic mental strategy training are recommended. Only if practised consistently can a mental strategy training programme pay off during competition. The marathoner should not expect his/her mind to leap into a disciplined mode of task-oriented thinking while under the additional influence of competitive stress, without having practised the process of disciplining it. Under stress, only well-rehearsed, dominant responses survive.

Very few marathoners will be in the position to shape their own thought processes without the initial promoting and "objective" outside assistance. There are easily too many tasks to be attended to and a marathoner might well find him/herself flooded with information. Monitoring, adjusting and reinforcing the correct responses can be done more effectively and efficiently by somebody who does not have to evolve the thoughts that have to be monitored, adjusted and reinforced. For these marathoners that do have a highly disciplined mind or have no choice but to embark on a mental strategy training programme completely on their own, thorough tabulation renders a functional aid. The aim is to recognize before and immediately after a training session what predominant thoughts could occur or have occurred on that particular run. Thoughts would have to be classified into associative and dissociative sets and specific task-related categories would have to be underlined, expressing the runner's intention to enhance and boost their occurrence. The "after" run list would have to be critically compared with the "before" list to enable the runner to weigh his/her progress to the target behaviour: higher and higher proportions of associative thinking to achieve and sustain efficient and safe running at high training effort. The object of this exercise is to make the marathoner as aware as possible of the prevailing thought pattern. Of course, this tabulation technique could easily be amplified into a log-book system, carefully keeping track of the thought shaping process from day to day. On the run reminders to think associatively could be carried in the form of flashcards or simply written on the back of the hands or forearms. The marathoner should always remember to praise him/herself for the next small advance in the progress to larger and larger proportions of task-related thinking. The suggested tabulation and log-book system can naturally be used by the dyadic mental training partners as well. Discussion of the documented prevailing thought patterns can enhance the fine-tuning of the shaping process.

The afore-mentioned mental training suggestions have been adopted and tried out by a limited number of long-distance runners. The preliminary results are encouraging. The proposed techniques deserve further scientific validation. For the author this is an ongoing process. Future research could involve the assessment of the impact of the MSTP on carefully matched pairs of subjects, where physiological parameters, training schedule and competition experiences are streamlined, while one subject receives training in associative thinking and the other is left to his/her own resources as far as mental preparation is concerned. At the same time a longitudinal study is envisaged to trace, document and analyze the progress of aspiring novice long-distance runners over the period of years. Physiological, biomechanical and psychological parameters will come under close scrutiny as they pertain to the making of a successful marathoner. The complex and perplexing interrelationships between physiological, biomechanical and psychological factors that govern performance have to be further unravelled. It is hoped that the present study will find wide application on the road and contribute to many runners achieving and sustaining their optimal sporting potential in an efficient and safe manner. Just as the aspiring athlete continually seeks to evaluate, adjust and elevate his/her performance, there will be sport scientists to analyze, develop and expand the knowledge and methods that let the athlete realize his/her prime potential.

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APPENDICES

APPENDIX 1

UCT sport science marathon training schedule

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1	20	15/5	10	10/20	30	60	90	10
2	-	-	20/10	10/10	-	-	40	20
3	20	10	-	10/20	30	30	90	-
4	-	20/5	20/10	-	30	55	40	-
5	20	-	-	5/15	-	30	120	-
6	-	15/5	20/10	5/25	20	55	-	RACE
7	20	-	-	-	40	30	40	
8	-	15/5	15/5	5/25	20	80	90	
9	20	-	20/10	10/10	-	-	40	
10	-	5/5	-	5/25	20	35	90	
11	20	15/5	20/10	-	45	60	40	
12	-	-	-	10/10	-	35	120	
13	20	15/5	20/10	5/25	20	60	-	
14	-	-	-	-	40	35	40	
15	20	15/5	10/10	30	20	90	90	
16	20	-	15/15	5/15	-	-	40	
17	-	5/5	-	30	20	35	90	
18	20	20/5	20/10	-	50	70	40	
19	10	-	-	5/15	-	35	150	
20	20	15/5	15/15	30	30	70	-	
21	-	-	-	-	45	35	40	
22	FUN RUN	20/5	10/10	30	30	100	90	
23	20	-	10/20	20	-	FUN RUN	40	
24	-	15/5	FUN RUN	30	30	40	90	
25	20	20/5	15/15	-	50	80	40	

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
26	10	FUN RUN	-	20	FUN RUN	40	120	
27	-	10/10	10/20	30	30	80	FUN RUN	
28	20	-	-	FUN RUN	45	40	40	
29	-	15/10	10/10	30	30	110	20	
30	20	-	10/20	20	50	-	-	
31	-		-		-	40	20	

NOTES:

1. The above figures are expressed in MINUTES.

2. Single figures prior to 15 November 1982 (except for 1 October) indicate "walking", thereafter they indicate "running".

3. Divided figures - the first figure indicates "walking" and the second indicates "running".

APPENDIX 2

Abstract of M.Sc.(Med.) thesis by J.R. Cowling

MSc (Med) Thesis

J.R. COWLING

THE EFFECTS OF ENDURANCE TRAINING

ON

BLOOD LACTATE LEVELS

TREADMILL RUNNING PERFORMANCE

AND BODY COMPOSITION

IN

PREVIOUSLY SEDENTARY ADULTS

Abstract

Twenty four previously sedentary adults were endurance trained for 26 weeks leading to their completing a standard 42km marathon. Several pre and post training measurements were made:

a) venous blood lactate levels were measured during a progressive treadmill test. From a lactate curve drawn for each subject, the so-called lactate "Turn Point" and "Anaerobic" Threshold were determined. Peak treadmill running speeds and lactate values were recorded.

b) Anthropometric measurements included body mass and percent body fat.

c) An analysis of training distance, time and speed was made for each subject.

The results showed that with endurance training:

i) Blood lactate levels are lower in submaximal exercise

ii) Maximal blood lactate levels are lower

iii) Maximum work capacity is increased.

iv) There was a signficiant shift of the lactate "Turn point" to higher work loads indicating a greater aerobic capacity.

v) No change occurred in absolute lactate levels at the lactate "Turnpoint".

vi) In addition it was found that:

a) inter-individual difference existed in the pre-training lactate "Turnpoint" which could not be explained on the basis of differences in training.

b) subjects ran the marathon at a pace below their lactate "Turnpoint" pace.

The conclusion here is that genetic factors, as well as training, influence blood lactate accummulation during progressive treadmill running.

APPENDIX 3

Table of training run recording time durations for all groups

Novice marathoner group (time in minutes)	Average marathoner group (time in minutes)	Superior marathoner group (time in minutes)
50	58	60
52	58	62
56	65	63
57	66	68
64	67	69
70	69	73
71	72	74
71	76	80
71	79	81
75	83	93
78	85	97
79	88	99
80	90	100
80	95	109
84	96	112
85	97	115
86	98	118
92	115	120
94	116	
95	117	
100		
102		
108		
110		

APPENDIX 4

Mallow's C_p and squared multiple correlation coefficient R^2

Mallow's C_p

Suppose we have n observations on an endogenous (dependent) variable Y and on each of k exogenous (independent) variables $X_1, X_2, \ldots, X_k$. Then a possible model for such data indicating a linear dependence of Y on the X_i can be written as

$$y = X\beta + \varepsilon \qquad \ldots (1)$$

The vector y is the known n-vector of Y-values and ε is an unknown n-vector of residual terms which are assumed to independently but identically distributed with zero mean. The matrix X is n x (k + 1) consisting of a column of n ones and the n k-tuples of observed X_i values, and the first entry of the (k + 1) - vector β is β_o, an intercept (constant) term. Simpler sub-models can be obtained by eliminating some of the variables X_i. This is equivalent to removing columns from X and corresponding entries from β, or to setting some β_i entries in β equal to zero. Thus, rewriting (1)

$$y = \begin{bmatrix} X_p : X_r \end{bmatrix} \begin{bmatrix} \beta_p \\ \beta_r \end{bmatrix} + \varepsilon \qquad \ldots (1)(A)$$

where p + r = k + 1 and β_o is an entry in β_p, allows us to generally consider all simpler submodels of (1) in the form

$$y = X_p\beta_p + \varepsilon \qquad \ldots (2)$$

The RSS be the residual sum of squares from (1) and (1)(A) and RSS_p be the residual sum of squares from (2). In general

$$RSS_p > RSS$$

Mallow's C_p is defined by

$$C_p = \frac{RSS_p}{S^2} - (n - 2p) \qquad \text{... (3)}$$

$$= (n - (k + 1)) \frac{RSS_p}{RSS} - n + 2p \qquad \text{... (3)(A)}$$

For a good model p = k + 1 so that $C_p \doteqdot p$ gives a criterion for selecting adequate subsets of variables. However since the well known F-statistic for testing $H_o : \beta_r = 0$ is given by

$$F_{r,\, n - (k + 1)} = \frac{n - (k + 1)}{r} \cdot \frac{RSS_p - RSS}{RSS} \qquad \text{... (4)}$$

$$= \frac{n - (k + 1)}{} \left[\frac{RSS_p}{RSS} - 1 \right] \qquad \text{... (4)(A)}$$

and

$$rF_{r,\, n - (k + 1)} = C_p - 2p + (k + 1)$$

$$= C_p - p + r$$

so $C_p \leqslant p$ is equivalent to $F_{r,\, n - (k + 1)} \leqslant 1$. The implication is that variables are rejected in the regression when they give rise to sufficiently small F-values. Sets of variables with moderate values are not discarded under the C_p criterion. However $F_{r,\, n - (k + 1)}$ is not to be confused with $F_{p,\, n - p}$ which is calculated after the subset has been chosen. The latter statistic serves to test

$$H_o\ (\beta_p = 0, \text{ given } \beta_r = 0).$$

In the BMDP9R program output, equation (4) is not utilized, but (3) generates the reported C_p value. The F-statistic given in the output is $F_{p,\, n - p}$ and may be thought of as an indicator of the adequacy of the corresponding model (2). The tail probabilities indicates the probability of a chance value of $F_{p,\, n - p}$ exceeding that of the chosen data subset of p variables (Draper & Smith, 1981).

Squared multiple correlation coefficient R^2

By defining $R^2 = \frac{RSS_1 - RSS_p}{RSS_1} = 1 - \frac{RSS_p}{RSS_1}$

the ratio of additional sums of squares for fitting a set of variables after an intercept $term_1$ to the residual sum of squares for no variables other than an intercept term. As the set of p variables is increased R^2 increases.

Adjusted R^2 : R^2_a

We define the adjusted R^2 as

$$R^2_a = 1 - \frac{RSS_p}{RSS_1} \cdot \frac{(n - 1)}{(n - p)}$$

$$= 1 - (1 - R^2) \frac{(n - 1)}{(n - p)}$$

It is always slightly smaller than R^2, and represents a conservative view of the explanatory potential of a model for the data under consideration (Draper & Smith, 1981).

Both values of R^2 are reported in the BMDP9R output.

APPENDIX 5

BMDP1D : Runstream output

```
PAGE    1 BMDP1D

BMDP1D - SIMPLE DATA DESCRIPTION AND DATA MANAGEMENT
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
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TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
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PROGRAM CONTROL INFORMATION

/ PROBLEM
    TITLE = '( SCHOMER DATA CHECK )'.
/ INPUT
    VAR = 19.
    FORMAT = '(I1,1X,I2,2F7.1,1X,4F7.1,1X,11F7.1)'.
    UNIT = 12.
    CASE = 62.
    RECLEN = 129.
/ VARIABLE
    NAME = G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
    GROUP = G.
/ GROUP
    CODE(G) = 1,2,3.
    NAME(G) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
    NT  = A+B+C+P+E+R+S+W+I.
     T  = 100-NT.
    ASS = A+B+C+P.
    DIS = 100-ASS.
    IN  = A+B+C.
    EN  = P+E.
    EB  = I+T.
    IB  = 100-IN-EN-EB.
/ SAVE
    UNIT = 11.
    NEW.
    FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
/ END
```

PAGE 4 BMDP1D (SCHOMER DATA CHECK)

VARIABLE NO. NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN
1 G			62	1.903	.824	.1047
	G	BEGINNER	24	1.000	.000	.0000
		AVERAGE	20	2.000	.000	.0000
		ELITE	18	3.000	.000	.0000
2 Y			62	12.774	2.020	.2565
	G	BEGINNER	24	12.625	1.884	.3845
		AVERAGE	20	12.350	1.899	.4247
		ELITE	18	13.444	2.255	.5315
3 ASS			62	32.942	15.837	2.0113
	G	BEGINNER	24	32.712	14.999	3.0617
		AVERAGE	20	28.005	13.689	3.0609
		ELITE	18	38.733	17.942	4.2289
4 DIS			62	67.058	15.837	2.0113
	G	BEGINNER	24	67.288	14.999	3.0617
		AVERAGE	20	71.995	13.689	3.0609
		ELITE	18	61.267	17.942	4.2289
5 IN			62	23.453	13.657	1.7344
	G	BEGINNER	24	24.142	15.474	3.1586
		AVERAGE	20	17.930	10.835	2.4229
		ELITE	18	28.672	12.193	2.8739
6 EN			62	12.108	8.364	1.0623
	G	BEGINNER	24	10.304	5.373	1.0967
		AVERAGE	20	12.830	9.927	2.2197
		ELITE	18	13.711	9.692	2.2844
7 IB			62	21.744	15.100	1.9178
	G	BEGINNER	24	19.933	13.192	2.6928
		AVERAGE	20	26.940	17.881	3.9983
		ELITE	18	18.383	13.306	3.1362
8 EB			62	42.695	14.419	1.8312
	G	BEGINNER	24	45.621	14.922	3.0459
		AVERAGE	20	42.300	14.685	3.2836
		ELITE	18	39.233	13.372	3.1518
9 A			62	9.195	5.499	.6984
	G	BEGINNER	24	9.454	5.916	1.2076
		AVERAGE	20	8.440	6.223	1.3916
		ELITE	18	9.689	4.105	.9676
10 B			62	6.600	5.138	.6526
	G	BEGINNER	24	6.025	3.508	.7160
		AVERAGE	20	4.065	2.463	.5507
		ELITE	18	10.183	7.049	1.6614

COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
.43296	1.000	-1.10	3.000	1.33	2.000
.00000	1.000	.00	1.000	.00	.000
.00000	2.000	.00	2.000	.00	.000
.00000	3.000	.00	3.000	.00	.000
.15811	7.000	-2.86	18.000	2.59	11.000
.14922	8.000	-2.46	16.000	1.79	8.000
.15380	7.000	-2.82	16.000	1.92	9.000
.16773	10.000	-1.53	18.000	2.02	8.000
.48076	2.300	-1.93	71.700	2.45	69.400
.45852	8.200	-1.63	65.000	2.15	56.800
.48880	2.300	-1.88	59.200	2.28	56.900
.46321	15.900	-1.27	71.700	1.84	55.800
.23617	28.300	-2.45	97.700	1.93	69.400
.22291	35.000	-2.15	91.800	1.63	56.800
.19014	40.800	-2.28	97.700	1.88	56.900
.29284	28.300	-1.84	84.100	1.27	55.800
.58230	1.800	-1.59	61.600	2.79	59.800
.64096	2.800	-1.38	61.600	2.42	58.800
.60431	1.800	-1.49	43.900	2.40	42.100
.42525	12.200	-1.35	59.500	2.53	47.300
.69082	.500	-1.39	50.600	4.60	50.100
.52140	3.400	-1.29	24.300	2.61	20.900
.77370	.500	-1.24	50.600	3.80	50.100
.70688	4.200	-.98	32.600	1.95	28.400
.69448	2.200	-1.29	75.700	3.57	73.500
.66182	4.400	-1.18	49.800	2.26	45.400
.66374	2.400	-1.37	75.700	2.73	73.300
.72379	2.200	-1.22	46.000	2.08	43.800
.33772	16.900	-1.79	78.300	2.47	61.400
.32709	24.100	-1.44	78.300	2.19	54.200
.34715	16.900	-1.73	72.400	2.05	55.500
.34083	21.600	-1.32	63.600	1.82	42.000
.59805	.000	-1.67	24.500	2.78	24.500
.62573	.900	-1.45	22.700	2.24	21.800
.73736	.000	-1.36	24.500	2.58	24.500
.42372	3.700	-1.46	20.800	2.71	17.100
.77851	.000	-1.28	33.500	5.24	33.500
.58216	1.600	-1.26	14.300	2.36	12.700
.60586	.000	-1.65	10.300	2.53	10.300
.69219	1.800	-1.19	33.500	3.31	31.700

PAGE 5 BMDP1D (SCHOMER DATA CHECK)

VARIABLE NO. NAME	GROUPING VARIABLE	LEVEL	TOTAL FREQUENCY	MEAN	STANDARD DEVIATION	ST.ERR OF MEAN
11 C			62	7.658	8.544	1.0851
	G	BEGINNER	24	8.662	10.902	2.2255
		AVERAGE	20	5.425	5.809	1.2989
		ELITE	18	8.800	7.399	1.7439
12 P			62	9.489	8.044	1.0216
	G	BEGINNER	24	8.571	4.749	.9693
		AVERAGE	20	10.075	9.683	2.1652
		ELITE	18	10.061	9.743	2.2966
13 E			62	2.619	2.167	.2752
	G	BEGINNER	24	1.733	1.431	.2921
		AVERAGE	20	2.755	2.316	.5180
		ELITE	18	3.650	2.415	.5692
14 R			62	13.206	9.412	1.1953
	G	BEGINNER	24	11.908	7.606	1.5526
		AVERAGE	20	13.430	8.262	1.8475
		ELITE	18	14.689	12.591	2.9677
15 S			62	6.239	10.424	1.3238
	G	BEGINNER	24	6.138	3.597	1.7549
		AVERAGE	20	10.195	14.670	3.2804
		ELITE	18	1.978	3.420	.8060
16 W			62	2.298	3.372	.4283
	G	BEGINNER	24	1.886	2.667	.5443
		AVERAGE	20	3.315	4.399	.9836
		ELITE	18	1.717	2.782	.6558
17 I			62	6.874	5.723	.7269
	G	BEGINNER	24	4.667	3.295	.6726
		AVERAGE	20	5.225	3.803	.8504
		ELITE	18	11.650	7.242	1.7069
18 T			62	35.821	16.560	2.1032
	G	BEGINNER	24	40.954	15.488	3.1614
		AVERAGE	20	37.075	14.867	3.3243
		ELITE	18	27.583	17.367	4.0933
19 NT			62	64.179	16.560	2.1032
	G	BEGINNER	24	59.046	15.488	3.1614
		AVERAGE	20	62.925	14.867	3.3243
		ELITE	18	72.417	17.367	4.0933

VARIABLE NO. NAME	CATEGORY NAME	CATEGORY FREQUENCY	TOTAL FREQUENCY	NO. OF VALUES MISSING OR OUTSIDE THE RANGE
1 G			62	0
	BEGINNER	24		
	AVERAGE	20		

COEFF. OF VARIATION	SMALLEST VALUE	SMALLEST Z-SCORE	LARGEST VALUE	LARGEST Z-SCORE	RANGE
1.11569	.000	-.90	29.400	2.54	29.400
1.25858	.000	-.79	29.400	1.90	29.400
1.07079	.000	-.93	24.400	3.27	24.400
.84076	1.100	-1.04	25.300	2.23	24.200
.84775	.500	-1.12	46.900	4.65	46.400
.55405	1.700	-1.45	22.000	2.83	20.300
.96112	.500	-.99	46.900	3.80	46.400
.96843	1.600	-.87	31.500	2.20	29.900
.82737	.000	-1.21	9.000	2.94	9.000
.82553	.000	-1.21	4.600	2.00	4.600
.84080	.000	-1.19	7.300	1.96	7.300
.66157	.900	-1.14	9.000	2.22	8.100
.71268	.000	-1.40	46.000	3.48	46.000
.63673	.000	-1.57	31.000	2.51	31.000
.61522	2.400	-1.33	34.000	2.49	31.600
.85717	.000	-1.17	46.000	2.49	46.000
1.67085	.000	-.60	57.800	4.95	57.800
1.40078	.000	-.71	37.500	3.65	37.500
1.43899	.000	-.69	57.800	3.24	57.800
1.72909	.000	-.58	10.700	2.55	10.700
1.46715	.000	-.68	12.200	2.94	12.200
1.41285	.000	-.71	10.000	3.04	10.000
1.32695	.000	-.75	12.200	2.02	12.200
1.62079	.000	-.62	8.900	2.58	8.900
.83257	.000	-1.20	25.000	3.17	25.000
.70613	.400	-1.29	12.700	2.44	12.300
.72791	.000	-1.37	13.000	2.04	13.000
.62163	2.600	-1.25	25.000	1.84	22.400
.46231	2.700	-2.00	74.800	2.35	72.100
.37817	21.000	-1.29	74.800	2.19	53.800
.40099	16.900	-1.36	72.400	2.38	55.500
.62960	2.700	-1.43	61.000	1.92	58.300
.25803	25.200	-2.35	97.300	2.00	72.100
.26230	25.200	-2.19	79.000	1.29	53.800
.23626	27.600	-2.38	83.100	1.36	55.500
.23981	39.000	-1.92	97.300	1.43	58.300

PAGE 6 BMDP1D (SCHOMER DATA CHECK)

ELITE 18

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1540
CPU TIME USED 8.070 SECONDS

PAGE 7 BMDP1D

~~BMDP1D — SIMPLE DATA DESCRIPTION~~ AND ~~DATA MANAGEMENT~~

PROGRAM CONTROL INFORMATION

NO MORE CONTROL LANGUAGE.

PROGRAM TERMINATED

@DATA,L 11.
DATA 9R1 SL74T9 05/19/84 09:11:23 (0)

1.	2.	7.	2.3	97.7	1.8	.5	75.7	22.0	1.8	80.3
2.	1.	8.	16.6	83.4	13.0	5.6	44.0	37.4	6.0	72.6
3.	1.	9.	12.6	87.4	8.3	6.0	29.1	56.6	2.9	45.9
4.	2.	10.	13.8	86.2	2.7	11.1	13.8	72.4	.0	27.6
5.	3.	10.	15.9	84.1	12.2	11.6	46.0	30.2	8.6	87.6
6.	3.	10.	17.0	83.0	12.6	6.6	25.1	55.7	8.9	48.0
7.	1.	11.	8.2	91.8	2.8	7.8	11.1	78.3	.9	29.0
8.	2.	11.	14.1	85.9	10.2	5.1	20.5	64.2	4.7	41.7
9.	2.	11.	15.1	84.9	8.0	8.2	54.1	29.7	4.4	76.3
10.	2.	11.	17.2	82.8	8.8	14.8	50.7	25.7	4.8	76.7
11.	1.	11.	24.4	75.6	18.7	8.6	33.3	39.4	13.0	66.3
12.	3.	11.	23.1	76.9	20.0	8.4	34.6	37.0	6.3	80.9
13.	1.	12.	18.2	81.8	7.1	11.9	5.4	75.6	5.2	25.2
14.	3.	12.	18.7	81.3	13.1	9.0	45.2	32.7	4.3	81.1
15.	2.	12.	18.9	81.1	14.9	8.9	28.0	48.2	7.7	55.4
16.	3.	12.	20.1	79.9	16.1	7.0	21.4	55.5	9.6	50.5
17.	1.	12.	20.4	79.6	13.4	7.4	35.2	44.0	8.8	60.9
18.	2.	12.	20.4	79.6	15.0	11.5	21.1	52.4	2.7	60.6
19.	2.	12.	21.4	78.6	14.7	8.8	25.7	50.8	10.5	53.4
20.	2.	12.	21.5	78.5	11.7	12.0	11.2	65.1	3.7	39.3
21.	1.	12.	21.7	78.3	9.3	13.6	16.8	60.3	6.8	40.3
22.	2.	12.	22.3	77.7	14.9	7.4	34.6	43.1	4.3	65.2
23.	1.	12.	23.5	76.5	12.2	11.9	17.9	58.0	7.7	47.1
24.	1.	12.	24.9	75.1	16.9	9.2	49.8	24.1	4.9	78.1

.0	.0	.5	.0	8.3	57.8	9.6	2.3	19.7
5.0	2.0	3.6	2.0	31.0	13.0	.0	10.0	27.4
5.4	.0	4.3	1.7	8.3	10.8	10.0	2.5	54.1
2.7	.0	11.1	.0	13.8	.0	.0	.0	72.4
1.8	1.8	3.7	7.9	46.0	.0	.0	17.8	12.4
2.6	1.1	4.4	2.2	10.0	10.7	4.4	3.7	52.0
1.9	.0	5.4	2.4	6.3	.9	3.9	7.3	71.0
4.3	1.2	3.9	1.2	8.3	.0	12.2	5.9	58.3
3.0	.6	7.1	1.1	19.4	32.2	2.5	6.0	23.7
2.8	1.2	8.4	6.4	10.8	28.7	11.2	2.4	23.3
4.3	1.4	5.7	2.9	11.6	14.5	7.2	5.7	33.7
8.4	5.3	3.1	5.3	29.0	.0	5.6	17.9	19.1
1.6	.3	11.1	.8	4.3	.3	.8	.8	74.8
5.0	3.8	5.6	3.4	39.6	4.3	1.3	13.8	18.9
4.5	2.7	4.0	4.9	15.4	1.8	10.8	3.6	44.6
3.0	3.5	4.0	3.0	7.6	4.9	8.9	6.0	49.5
4.2	.4	7.0	.4	16.9	14.4	3.9	4.9	39.1
4.8	7.5	5.4	6.1	12.3	1.3	7.5	13.0	39.4
1.7	2.5	6.7	2.1	11.8	13.9	.0	4.2	46.6
4.7	3.3	9.8	2.2	7.7	2.8	.7	4.4	60.7
2.5	.0	12.4	1.2	16.8	.0	.0	.6	59.7
6.3	4.3	7.4	.0	33.7	.0	.9	8.3	34.8
2.4	2.1	11.3	.6	11.9	3.9	2.1	5.1	52.9
3.4	8.6	8.0	1.2	9.5	37.5	2.8	2.2	21.9

25. 54.4	1.	12.	25.3	74.7	11.1	18.8	22.4	47.7	6.1
26. 39.0	3.	12.	26.4	73.6	20.0	7.9	8.5	63.6	10.3
27. 39.3	1.	12.	26.9	73.1	19.7	10.1	6.2	64.0	5.7
28. 53.6	1.	12.	27.9	72.1	21.0	7.6	23.2	48.2	14.1
29. 79.0	1.	12.	30.0	70.0	24.0	6.0	39.0	31.0	15.0
30. 76.6	2.	12.	31.3	68.7	17.1	15.8	38.3	28.8	8.0
31. 63.7	3.	13.	29.8	70.2	24.4	9.5	9.5	56.6	8.1
32. 58.2	2.	13.	30.9	69.1	24.5	7.5	25.5	42.5	11.0
33. 66.0	3.	13.	31.5	68.5	29.9	4.3	21.7	44.1	8.9
34. 64.4	1.	13.	31.7	68.3	14.3	21.5	27.6	36.6	6.1
35. 60.0	2.	13.	32.6	67.4	26.2	8.3	21.7	43.8	11.5
36. 63.1	2.	13.	32.7	67.3	13.2	20.1	26.3	40.4	5.3
37. 52.9	1.	13.	33.8	66.2	25.3	8.5	6.4	59.8	21.3
38. 58.5	3.	13.	34.8	65.2	29.9	5.8	15.2	49.1	7.1
39. 61.3	1.	13.	35.0	65.0	26.4	12.4	18.7	42.5	16.3
40. 49.0	3.	13.	38.3	61.7	35.5	4.2	5.7	54.6	11.3
41. 57.3	1.	13.	39.8	60.2	29.1	14.9	7.5	48.5	9.4
42. 93.1	3.	13.	41.5	58.5	28.0	18.0	25.8	28.2	13.5
43. 58.9	2.	14.	37.0	63.0	27.4	13.7	15.1	43.8	17.8
44. 81.2	3.	14.	38.0	62.0	33.0	6.0	24.2	36.8	10.3
45. 74.4	2.	14.	40.0	60.0	27.3	14.1	25.6	33.0	9.4
46. 57.0	1.	14.	40.7	59.3	36.1	6.5	10.2	47.2	3.2
47. 83.1	2.	14.	41.5	58.5	30.2	17.0	35.9	16.9	24.5
48. 63.0	2.	14.	41.6	58.4	33.8	11.5	5.2	49.5	17.2
49. 75.6	1.	14.	44.0	56.0	42.3	4.0	21.1	32.6	4.7
50. 63.3	2.	14.	46.3	53.7	43.9	9.7	2.4	44.0	14.6
51. 86.5	3.	14.	49.0	51.0	37.5	17.8	14.6	30.1	20.8
52. 78.8	1.	15.	48.9	51.1	26.9	24.3	21.3	27.5	17.0
53. 62.0	1.	15.	51.5	48.5	38.6	13.7	4.5	43.2	4.5
54. 97.3	3.	15.	55.3	44.7	35.6	24.9	11.8	27.7	14.5
55. 63.8	1.	15.	56.4	43.6	51.1	5.7	6.6	36.6	13.7

3.6	1.4	14.2	4.6	18.5	.0	3.9	2.1	45.6
7.4	2.3	6.4	1.5	8.2	.3	.0	2.6	61.0
5.7	8.3	7.2	2.9	5.4	.8	.0	3.3	60.7
2.9	4.0	6.9	.7	23.2	.0	.0	1.8	46.4
9.0	.0	6.0	.0	21.0	16.0	2.0	10.0	21.0
7.0	2.1	14.2	1.6	18.4	16.3	3.6	5.4	23.4
12.2	4.1	5.4	4.1	9.5	.0	.0	20.3	36.3
10.3	3.2	6.4	1.1	14.8	5.7	5.0	.7	41.8
14.0	7.0	1.6	2.7	15.1	4.7	1.9	10.1	34.0
8.2	.0	17.4	4.1	17.4	5.1	5.1	1.0	35.6
3.2	11.5	6.4	1.9	12.1	9.6	.0	3.8	40.0
2.9	5.0	19.5	.6	9.9	14.9	1.5	3.5	36.9
4.0	.0	8.5	.0	.0	6.4	.0	12.7	47.1
9.8	13.0	4.9	.9	13.0	1.3	.9	7.6	41.5
5.3	4.8	8.6	3.8	18.7	.0	.0	3.8	38.7
12.8	11.4	2.8	1.4	5.7	.0	.0	3.6	51.0
6.8	12.9	10.7	4.2	5.9	1.4	.2	5.8	42.7
10.0	4.5	13.5	4.5	25.8	.0	.0	21.3	6.9
.0	9.6	9.6	4.1	6.9	8.2	.0	2.7	41.1
6.9	15.8	5.0	1.0	13.8	9.4	1.0	18.0	18.8
6.9	11.0	12.7	1.4	16.5	8.8	.3	7.4	25.6
5.6	27.3	4.6	1.9	9.7	.0	.5	4.2	43.0
1.9	3.8	11.3	5.7	34.0	1.9	.0	.0	16.9
5.7	10.9	7.8	3.7	4.7	.0	.5	12.5	37.0
6.2	29.4	1.7	2.3	13.5	4.7	2.9	8.2	24.4
4.9	24.4	2.4	7.3	2.4	.0	.0	7.3	36.7
10.4	6.3	11.5	6.3	14.6	.0	.0	16.6	13.5
5.3	4.6	22.0	2.3	11.9	9.4	.0	6.3	21.2
12.7	21.4	12.9	.8	4.5	.0	.0	5.2	33.0
15.8	5.3	19.7	5.2	11.8	.0	.0	25.0	2.7
10.6	26.8	5.3	.4	.4	6.2	.0	.4	36.2

56.	1.	15.	57.7	42.3	50.2	7.9	16.7	25.2	10.9
76.5									
57.	3.	16.	55.4	44.6	27.7	29.3	9.2	33.8	14.1
71.1									
58.	2.	16.	59.2	40.8	12.3	50.6	7.4	29.7	4.9
81.4									
59.	1.	16.	65.0	35.0	61.6	3.4	4.4	30.6	22.7
75.8									
60.	3.	16.	68.2	31.8	40.9	31.9	3.3	23.9	6.5
86.5									
61.	3.	17.	71.7	28.3	40.2	32.6	2.2	25.0	7.6
81.5									
62.	3.	18.	62.5	37.5	59.5	12.0	6.9	21.6	3.7
82.0									

END DATA. ERRORS: NONE. TIME: 0.848 SEC. IMAGE COUNT: 62

@BMDP*82.BMDP BMDP9R

@BMDP*PROGRAMS.P9R

11.7	27.6	7.5	.4	14.7	2.0	.0	1.7	23.5
7.6	6.0	27.7	1.6	9.2	.0	.0	4.9	28.9
3.7	3.7	46.9	3.7	7.4	.0	.0	11.1	18.6
14.3	24.6	3.4	.0	4.4	.0	.0	6.4	24.2
9.1	25.3	27.3	4.6	3.3	.0	.0	10.4	13.5
13.0	19.6	31.5	1.1	2.2	.0	.0	6.5	18.5
33.5	22.3	3.0	9.0	.0	.0	6.9	3.6	18.0

BMDP9R : Runstream output : All groups x variable sets

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL     1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 17.
            METHOD IS CP.
/ END

PROBLEM TITLE IS
 SCHOMER DATA : ALL SUBSETS

NUMBER OF VARIABLES TO READ IN. . . . . . . . . .          19
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. .           0
TOTAL NUMBER OF VARIABLES . . . . . . . . . . . .          19
NUMBER OF CASES TO READ IN. . . . . . . . . . . .      TO END
CASE LABELING VARIABLES . . . . . . . . . . . . .
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. .       NEITHER
BLANKS ARE. . . . . . . . . . . . . . . . . . . .     MISSING
INPUT UNIT NUMBER . . . . . . . . . . . . . . . .          11
REWIND INPUT UNIT PRIOR TO READING. . DATA. . .           YES
NUMBER OF WORDS OF DYNAMIC STORAGE. . . . . . .        14998
NUMBER OF CASES DESCRIBED BY INPUT FORMAT . . .             1

INPUT FORMAT IS
(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)

MAXIMUM LENGTH DATA RECORD IS  127 CHARACTERS.
```

```
PAGE    3  BMDP9R  SCHOMER DATA : ALL SUBSETS

DATA AFTER TRANSFORMATIONS
--------------------------

 C A S E                  9          10          11          12          13
 NO. LABEL               A           B           C           P           E
----- --------    ---------   ---------   ---------   ---------   ---------
   1                 1.800          0           0         .500         0
   2                 6              5           2        3.600         2
   3                 2.900       5.400          0        4.300       1.700
   4                 0           2.700          0       11.100         0
   5                 8.600       1.800       1.800       3.700       7.900
```

14 R	15 S	16 W	17 I	2 Y
8.300	57.800	9.600	2.300	7
31	13	0	10	8
8.300	10.800	10	2.500	9
13.800	0	0	0	10
46	0	0	17.800	10

AGE 4 BMDP9R SCHOMER DATA : ALL SUBSETS

UMBER OF CASES READ. 62

MMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
9 A	9.19516	5.49919	.598053	.00000	24.50000	-1.67	2.78	.81	.09
0 B	6.60000	5.13819	.778513	.00000	33.50000	-1.28	5.24	2.44	9.81
1 C	7.65806	8.54403	1.115691	.00000	29.40000	-.90	2.54	1.25	.28
2 P	9.48871	8.04402	.847746	.50000	46.90000	-1.12	4.65	2.31	6.59
3 E	2.61935	2.16718	.827372	.00000	9.00000	-1.21	2.94	.89	.08
4 R	13.20645	9.41202	.712684	.00000	46.00000	-1.40	3.48	1.34	1.89
5 S	6.23871	10.42392	1.670846	.00000	57.80000	-.60	4.95	2.76	9.04
6 W	2.29839	3.37209	1.467154	.00000	12.20000	-.68	2.94	1.47	1.03
7 I	6.87419	5.72323	.832568	.00000	25.00000	-1.20	3.17	1.24	.92
2 Y	12.77419	2.01973	.158110	7.00000	18.00000	-2.86	2.59	-.07	.60

LUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS
TH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS

CORRELATIONS

		A 9	B 10	C 11	P 12	E 13	R 14	S 15	W 16	I 17	Y 2
A	9	1.000									
B	10	.075	1.000								
C	11	.097	.496	1.000							
P	12	.031	-.003	-.021	1.000						
E	13	.083	.225	.052	.016	1.000					
R	14	-.001	-.227	-.359	-.149	.159	1.000				
S	15	-.193	-.311	-.253	-.176	-.248	-.010	1.000			
W	16	-.386	-.074	-.295	-.305	.160	-.070	.366	1.000		
I	17	.151	.225	-.007	.064	.349	.270	-.211	-.180	1.000	
Y	2	.380	.603	.656	.485	.168	-.372	-.469	-.417	.102	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
 9 A   ■
10 B    ■
11 C   .■■
 2 Y   X■■■
12 P      M■
15 S   -++M-■
16 W   X +M+X■
14 R    -XX.  ■
13 E   .- - +..■
17 I   .- . --+X■
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

	LESS THAN OR EQUAL TO	.082
.	.082 TO AND INCLUDING	.164
-	.164 TO AND INCLUDING	.246
+	.246 TO AND INCLUDING	.328
X	.328 TO AND INCLUDING	.410
M	.410 TO AND INCLUDING	.492
■	.492 TO AND INCLUDING	.574
■	GREATER THAN	.574

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	
.430423	.420930	200.66	C
.363560	.352953	231.02	B
.235109	.222360	289.36	P
.220207	.207211	296.12	S
.174046	.160280	317.09	W
.144371	.130111	330.56	A
.138217	.123854	333.36	R
.028116	.011918	383.36	E
.010409	-.006085	391.40	I

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP		
.679522	.668658	89.54	C	P
.532756	.516918	156.19	B	C
.531329	.515442	156.84	A	C
.528651	.512673	158.05	C	S
.485334	.467888	177.72	C	W
.451730	.433145	192.98	C	R
.448251	.429548	194.56	C	E
.441827	.422906	197.48	C	I

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.778951	.767517	46.38	B	C	P
.770146	.758257	50.38	A	C	P
.729603	.715617	68.79	C	P	S
.695130	.679361	84.45	C	P	E
.685257	.668978	88.93	C	P	W
.685142	.668856	88.99	C	P	I
.683524	.667155	89.72	C	P	R

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP				
.863998	.854454	9.76	A	B	C	P
.803735	.789962	37.13	B	C	P	S
.790223	.775502	43.27	B	C	P	W
.781885	.766579	47.05	B	C	P	E
.780938	.765565	47.48	B	C	P	R
.779018	.763510	48.35	B	C	P	I

SUBSETS WITH 5 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.876004	.864933	6.31	9 A	.100766	5.71
			10 B	.127457	5.83
			11 C	.105983	8.20
			12 P	.116920	9.71
			15 S	-.0232557	-2.33
			INTERCEPT	9.23046	

R-SQUARED	ADJUSTED R-SQUARED	CP					
.867324	.855478	10.25	A	B	C	P	R
.866681	.854777	10.54	A	B	C	P	I
.865078	.853032	11.27	A	B	C	P	E
.864071	.851935	11.73	A	B	C	P	W

SUBSETS WITH 6 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP						
.881807	.868913	5.67	VARIABLE	COEFFICIENT	T-STATISTIC			
			9 A	.101257	5.83			
			10 B	.124058	5.74			
			11 C	.0989396	7.36			
			12 P	.113008	9.34			
			14 R	-.0180471	-1.64			
			15 S	-.0258751	-2.60			
			INTERCEPT	9.59412				
.880623	.867600	6.21	VARIABLE	COEFFICIENT	T-STATISTIC			
			9 A	.103935	5.91			
			10 B	.134875	6.07			
			11 C	.102826	7.92			
			12 P	.117485	9.85			
			15 S	-.0253141	-2.53			
			17 I	-.0254388	-1.46			
			INTERCEPT	9.35889				
.877491	.864126	7.63	A	B	C	P	S	W
.876142	.862630	8.25	A	B	C	P	E	S

SUBSETS WITH 7 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP							
.883973	.868933	6.69	VARIABLE		COEFFICIENT	T-STATISTIC			
			9 A		.103443	5.91			
			10 B		.130085	5.80			
			11 C		.0980753	7.28			
			12 P		.114199	9.40			
			14 R		-.0144318	-1.25			
			15 S		-.0268339	-2.68			
			17 I		-.0183342	-1.00			
			INTERCEPT		9.61383				
.882516	.867286	7.35	VARIABLE		COEFFICIENT	T-STATISTIC			
			9 A		.100882	5.77			
			10 B		.121460	5.46			
			11 C		.0992011	7.33			
			12 P		.112912	9.28			
			13 E		.0265699	.57			
			14 R		-.0192604	-1.71			
			15 S		-.0249083	-2.45			
			INTERCEPT		9.55402				
.882245	.866980	7.48	A	B	C	P	R	S	W
.877491	.861610	9.63	A	B	C	P	E	S	W

SUBSETS WITH 8 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP

.885487	.868202	8.00	A	B	C	P	E	R	S	I
.884285	.866819	8.55	A	B	C	P	R	S	W	I
.882663	.864951	9.29	A	B	C	P	E	R	S	W
.882027	.864220	9.57	A	B	C	P	E	S	W	I
.872795	.853594	13.77	A	B	C	P	E	R	W	I
.821426	.794472	37.09	B	C	P	E	R	S	W	I
.818799	.791448	38.29	A	C	P	E	R	S	W	I
.787319	.755217	52.58	A	B	P	E	R	S	W	I
.719704	.677395	83.29	A	B	C	E	R	S	W	I

SUBSETS WITH 9 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP									
.885494	.865676	10.00	A	B	C	P	E	R	S	W	I

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	5.67
SQUARED MULTIPLE CORRELATION	.88181
MULTIPLE CORRELATION	.93905
ADJUSTED SQUARED MULT. CORR.	.86891
RESIDUAL MEAN SQUARE	.534745
STANDARD ERROR OF EST.	.731262
F-STATISTIC	68.39
NUMERATOR DEGREES OF FREEDOM	6
DENOMINATOR DEGREES OF FREEDOM	55
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.59412	.358949	4.750	26.73	.000		
9	A	.101257	.0173786	.276	5.83	.000	.959815	.07295
10	B	.124058	.0216218	.316	5.74	.000	.710252	.07074
11	C	.0989396	.0134391	.419	7.36	.000	.664889	.11647
12	P	.113008	.0120958	.450	9.34	.000	.925985	.18758
14	R	-.0180471	.0109825	-.084	-1.64	.106	.820449	.00580
15	S	-.0258751	.00996702	-.134	-2.60	.012	.812127	.01448

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 2523
CPU TIME USED 8.778 SECONDS

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PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS            '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
     NT  = A+B+C+P+E+R+S+W+I.
     T   = 100-NT.
     ASS = A+B+C+P.
     DIS = 100-ASS.
     IN  = A+B+C.
     EN  = P+E.
     EB  = I+T.
     IB  = 100-IN-EN-EB.
     IF (G EQ 3) THEN USE = 1.
     IF (G NE 3) THEN USE = 1.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 12.
            METHOD IS CP.
/ END
```

```
PAGE    3  BMDP9R  SCHOMER DATA : ALL SUBSETS

* * * WARNING * * * IN PARAGRAPH VARIABLE THE FOLLOWING TEXT IS IGNORED:
GROUP = G.
* * * NOTE THAT THE FOLLOWING STATEMENTS WERE NOT FOUND:
ADD      LAB      USE      RET      MIS      MAX      MIN      BL
BEF      AFT      CHEC     WEIG

* * * WARNING * * * IN PARAGRAPH GROUP    THE FOLLOWING TEXT IS IGNORED:
/ GROUP CODES(1) = 1,2,3. NAMES(1) = BEGINNER,AVERAGE,ELITE.
* * * THIS PARAGRAPH IS TOTALY IGNORED.

THE MOST COMMON EXPLANATIONS FOR EXTRANEOUS CONTROL LANGUAGE ARE:
- MISSPELLED PARAGRAPH OR SENTENCE NAME
- SENTENCE IN THE WRONG PARAGRAPH
- SENTENCE OR PARAGRAPH REPEATED UNEXPECTEDLY
- OPTION NOT DEFINED IN THIS PROGRAM
- MUTUALLY EXCLUSIVE OPTIONS SELECTED

BASED ON INPUT FORMAT SUPPLIED    1 RECORDS READ PER CASE.
```

PAGE 4 BMDP9R SCHOMER DATA : ALL SUBSETS

DATA AFTER TRANSFORMATIONS

CASE NO.	LABEL	9 A	10 B	11 C	12 P	2 Y
1		1.800	0	0	.500	7
2		6	5	2	3.600	8
3		2.900	5.400	0	4.300	9
4		0	2.700	0	11.100	10
5		8.600	1.800	1.800	3.700	10

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS

NUMBER OF CASES READ. 62

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
9 A	9.19516	5.49919	.598053	.00000	24.50000	-1.67	2.78	.81	.09
10 B	6.60000	5.13819	.778513	.00000	33.50000	-1.28	5.24	2.44	9.81
11 C	7.65806	8.54903	1.115691	.00000	29.40000	-.90	2.54	1.25	.28
12 P	9.48871	8.04402	.847746	.50000	46.90000	-1.12	4.65	2.31	6.59
2 Y	12.77419	2.01973	.158110	7.00000	18.00000	-2.86	2.59	-.07	.60

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

```
PAGE    6  BMDP9R - SCHOMER DATA : ALL SUBSETS

CORRELATIONS
------------

               A          B          C          P          Y
                  9         10         11         12          2

A        9     1.000
B       10      .075      1.000
C       11      .097       .496      1.000
P       12      .031     -.003      -.021      1.000
Y        2      .380       .603       .656       .485      1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM
----------------------------------------------

   9 A          ■
  10 B           ■
  11 C          .@■
   2 Y          X■■■
  12 P             M■


THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME
                      LESS THAN OR EQUAL TO              .082
        .          .082   TO AND INCLUDING               .164
        -          .164   TO AND INCLUDING               .246
        +          .246   TO AND INCLUDING               .328
        X          .328   TO AND INCLUDING               .410
        M          .410   TO AND INCLUDING               .492
        @          .492   TO AND INCLUDING               .574
        ■                     GREATER THAN               .574
```

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	
.430423	.420930	180.72	C
.363560	.352953	208.74	B
.235109	.222360	262.57	P
.144371	.130111	300.60	A

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.679522	.668658	78.32	VARIABLE	COEFFICIENT	T-STATISTIC
			11 C	.157625	9.05
			12 P	.125345	6.77
			INTERCEPT	10.3777	
.600236	.586685	111.55	B P		
.532756	.516918	139.83	B C		
.531329	.515442	140.43	A C		
.368279	.346865	208.76	A P		

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.778951	.767517	38.64	VARIABLE	COEFFICIENT	T-STATISTIC
			10 B	.142706	5.11
			11 C	.115084	6.85
			12 P	.124617	8.04
			INTERCEPT	9.76856	
.770146	.758257	42.33	VARIABLE	COEFFICIENT	T-STATISTIC

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.111154	4.78
			11 C	.150615	10.07
			12 P	.122800	7.76
			INTERCEPT	9.43347	
.703062	.687704	70.45	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.118162	4.48
			10 B	.228078	8.09
			12 P	.119601	6.65
			INTERCEPT	9.04751	
.627636	.608376	102.06	A B	C	

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.863998	.854454	5.00	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.107729	5.97
			10 B	.138710	6.27
			11 C	.109481	8.21
			12 P	.122172	9.95
			INTERCEPT	8.87046	

PAGE 8 BMDP9R SCHOMER DATA : ALL SUBSETS

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	5.00
SQUARED MULTIPLE CORRELATION	.86400
MULTIPLE CORRELATION	.92951
ADJUSTED SQUARED MULT. CORR.	.85445
RESIDUAL MEAN SQUARE	.593729
STANDARD ERROR OF EST.	.770538
F-STATISTIC	90.53
NUMERATOR DEGREES OF FREEDOM	4
DENOMINATOR DEGREES OF FREEDOM	57
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND
ASSOCIATED SIGNIFICANCE TEND TO BE
LIBERAL WHENEVER A SUBSET OF VARIABLES
IS SELECTED BY THE CP OR ADJUSTED
R-SQUARED CRITERIA.

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	8.87046	.250849	4.392	35.36	.000		
9	A	.107729	.0180443	.293	5.97	.000	.988513	.08505
10	B	.138710	.0221168	.353	6.27	.000	.753694	.09385
11	C	.109481	.0133305	.463	8.21	.000	.750305	.16094
12	P	.122172	.0122749	.487	9.95	.000	.998340	.23636

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1617
CPU TIME USED 9.027 SECONDS

```
PAGE    1 BMDP9R


BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM    TITLE = ' SCHOMER DATA : ALL SUBSETS             '.
/ INPUT      VARIABLES ARE 19.
             FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
             UNIT = 11.
             RECLEN = 129.
/ VARIABLE   NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
             GROUP = G.
/ GROUP      CODES(1) = 1,2,3.
             NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
     NT   = A+B+C+P+E+R+S+W+I.
      T   = 100-NT.
     ASS  = A+B+C+P.
     DIS  = 100-ASS.
     IN   = A+B+C.
     EN   = P+E.
     EB   = I+T.
     IB   = 100-IN-EN-EB.
     IF (G EQ 3) THEN USE = 1.
     IF (G NE 3) THEN USE = 1.
/ REGRESS    DEPENDENT IS Y.
             INDEPENDENT ARE 5 TO  7.
             METHOD IS CP.
/ END
```

```
PAGE    4   BMDP9R   SCHOMER DATA : ALL SUBSETS


DATA AFTER TRANSFORMATIONS
--------------------------

 C A S E                  5           6           7          2
 NO. LABEL               IN          EN          IB          Y
 ----- --------    ---------- ---------- ---------- ----------
    1                  1.800        .500     75.700          7
    2                 13           5.600     44              8
    3                  8.300       6.000     29.100          9
    4                  2.700      11.100     13.800         10
    5                 12.200      11.600     46             10
```

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS

NUMBER OF CASES READ. 62

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
5 IN	23.45323	13.65677	.582298
6 EN	12.10806	8.36445	.690816
7 IB	21.74355	15.10044	.694479
2 Y	12.77419	2.01973	.158110

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
1.80000	61.60000	-1.59	2.79	.74	.08
.50000	50.60000	-1.39	4.60	2.14	6.00
2.20000	75.70000	-1.29	3.57	1.03	1.14
7.00000	18.00000	-2.86	2.59	-.07	.60

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS

CORRELATIONS

		IN 5	EN 6	IB 7	Y 2
IN	5	1.000			
EN	6	.037	1.000		
IB	7	-.519	-.281	1.000	
Y	2	.790	.510	-.649	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
5 IN     ■
2 Y      ■■
7 IB     M■■
6 EN     M-■
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

```
         LESS THAN OR EQUAL TO     .099
.   .099 TO AND INCLUDING          .198
-   .198 TO AND INCLUDING          .296
+   .296 TO AND INCLUDING          .395
X   .395 TO AND INCLUDING          .494
M   .494 TO AND INCLUDING          .593
■   .593 TO AND INCLUDING          .692
■        GREATER THAN              .692
```

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.624587	.618330	115.82	VARIABLE	COEFFICIENT	T-STATISTIC
			5 IN	.116881	9.99
			INTERCEPT	10.0330	
.420972	.411321	210.09	IB		
.259845	.247509	284.69	EN		

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.855539	.850642	10.88	VARIABLE	COEFFICIENT	T-STATISTIC
			5 IN	.114225	15.60
			6 EN	.116124	9.71
			INTERCEPT	8.68922	
.702430	.692343	81.77	VARIABLE	COEFFICIENT	T-STATISTIC
			5 IN	.0918090	7.47
			7 IB	-.0436664	-3.93
			INTERCEPT	11.5704	
.537433	.521753	158.17	VARIABLE	COEFFICIENT	T-STATISTIC
			6 EN	.0858596	3.85
			7 IB	-.0734254	-5.95
			INTERCEPT	13.3311	

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.874729	.868250	4.00	VARIABLE	COEFFICIENT	T-STATISTIC
			5 IN	.101395	12.50
			6 EN	.105359	8.93
			7 IB	-.0227742	-2.98
			INTERCEPT	9.61565	

PAGE 8 BMDP9R SCHOMER DATA : ALL SUBSETS

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	4.00
SQUARED MULTIPLE CORRELATION	.87473
MULTIPLE CORRELATION	.93527
ADJUSTED SQUARED MULT. CORR.	.86825
RESIDUAL MEAN SQUARE	.537452
STANDARD ERROR OF EST.	.733111
F-STATISTIC	135.00
NUMERATOR DEGREES OF FREEDOM	3
DENOMINATOR DEGREES OF FREEDOM	58
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.61565	.384890	4.761	24.98	.000		
5	IN	.101395	.00811375	.686	12.50	.000	.717580	.33730
6	EN	.105359	.0117962	.436	8.93	.000	.905008	.17230
7	IB	-.0227742	.00764043	-.170	-2.98	.004	.661904	.01919

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1481
CPU TIME USED 8.923 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS           '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
   NT  = A+B+C+P+E+R+S+W+I.
   T   = 100-NT.
   ASS = A+B+C+P.
   DIS = 100-ASS.
   IN  = A+B+C.
   EN  = P+E.
   EB  = I+T.
   IB  = 100-IN-EN-EB.
   IF (G EQ 3) THEN USE = 1.
   IF (G NE 3) THEN USE = 1.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT IS       3.
            METHOD IS CP.
/ END
```

```
PAGE    3  BMDP9R  SCHOMER DATA : ALL SUBSETS

* * * WARNING * * * IN PARAGRAPH VARIABLE THE FOLLOWING TEXT IS IGNORED:
GROUP = G.
* * * NOTE THAT THE FOLLOWING STATEMENTS WERE NOT FOUND:
ADD       LAB       USE       RET       MIS       MAX       MIN       BL
BEF       AFT       CHEC      WEIG

* * * WARNING * * * IN PARAGRAPH GROUP    THE FOLLOWING TEXT IS IGNORED:
/ GROUP CODES(1) = 1,2,3. NAMES(1) = BEGINNER,AVERAGE,ELITE.
* * * THIS PARAGRAPH IS TOTALY IGNORED.

THE MOST COMMON EXPLANATIONS FOR EXTRANEOUS CONTROL LANGUAGE ARE:
- MISSPELLED PARAGRAPH OR SENTENCE NAME
- SENTENCE IN THE WRONG PARAGRAPH
- SENTENCE OR PARAGRAPH REPEATED UNEXPECTEDLY
- OPTION NOT DEFINED IN THIS PROGRAM
- MUTUALLY EXCLUSIVE OPTIONS SELECTED

BASED ON INPUT FORMAT SUPPLIED    1 RECORDS READ PER CASE.
```

PAGE 4 BMDP9R SCHOMER DATA : ALL SUBSETS

DATA AFTER TRANSFORMATIONS

CASE NO.	LABEL	3 ASS	2 Y
1		2.300	7
2		16.600	8
3		12.600	9
4		13.800	10
5		15.900	10

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS

NUMBER OF CASES READ. 62

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
3 ASS	32.94194	15.83712	.480759
2 Y	12.77419	2.01973	.158110

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
2.30000	71.70000	-1.93	2.45	.56	-.44
7.00000	18.00000	-2.86	2.59	-.07	.60

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS

CORRELATIONS

		ASS 3	Y 2
ASS	3	1.000	
Y	2	.928	1.000

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS

STATISTICS FOR 'BEST' SUBSET

SQUARED MULTIPLE CORRELATION	.86079
MULTIPLE CORRELATION	.92779
ADJUSTED SQUARED MULT. CORR.	.85847
RESIDUAL MEAN SQUARE	.577366
STANDARD ERROR OF EST.	.759846
F-STATISTIC	370.99
NUMERATOR DEGREES OF FREEDOM	1
DENOMINATOR DEGREES OF FREEDOM	60
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	8.87644	.224196	4.395	39.59	.000		
3	ASS	.118322	.00614306	.928	19.26	.000	1.000000	.86079

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1288
CPU TIME USED 7.265 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS              '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
      NT   = A+B+C+P+E+R+S+W+I.
       T   = 100-NT.
      ASS  = A+B+C+P.
      DIS  = 100-ASS.
      IN   = A+B+C.
      EN   = P+E.
      EB   = I+T.
      IB   = 100-IN-EN-EB.
      IF (G EQ 3) THEN USE = 1.
      IF (G NE 3) THEN USE = 1.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT IS       18.
            METHOD IS CP.
/ END
```

```
PAGE    3  BMDP9R   SCHOMER DATA : ALL SUBSETS

* * * WARNING * * * IN PARAGRAPH VARIABLE THE FOLLOWING TEXT IS IGNORED:
GROUP = G.
* * * NOTE THAT THE FOLLOWING STATEMENTS WERE NOT FOUND:
ADD       LAB       USE       RET       MIS       MAX       MIN       BL
BEF       AFT       CHEC      WEIG

* * * WARNING * * * IN PARAGRAPH GROUP     THE FOLLOWING TEXT IS IGNORED:
/ GROUP CODES(1) = 1,2,3. NAMES(1) = BEGINNER,AVERAGE,ELITE.
* * * THIS PARAGRAPH IS TOTALY IGNORED.

THE MOST COMMON EXPLANATIONS FOR EXTRANEOUS CONTROL LANGUAGE ARE:
- MISSPELLED PARAGRAPH OR SENTENCE NAME
- SENTENCE IN THE WRONG PARAGRAPH
- SENTENCE OR PARAGRAPH REPEATED UNEXPECTEDLY
- OPTION NOT DEFINED IN THIS PROGRAM
- MUTUALLY EXCLUSIVE OPTIONS SELECTED

BASED ON INPUT FORMAT SUPPLIED     1 RECORDS READ PER CASE.
```

```
PAGE    4  BMDP9R   SCHOMER DATA : ALL SUBSETS

DATA AFTER TRANSFORMATIONS
--------------------------

 C A S E              18          2
 NO. LABEL            T           Y
----- --------  ---------- ----------
    1              19.700          7
    2              27.400          8
    3              54.100          9
    4              72.400         10
    5              12.400         10
```

```
PAGE    5  BMDP9R   SCHOMER DATA : ALL SUBSETS

NUMBER OF CASES READ. . . . . . . . . . . . .              62

SUMMARY STATISTICS FOR EACH VARIABLE
------------------------------------
```

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
18 T	35.82097	16.56025	.462306
2 Y	12.77419	2.01973	.158110

```
VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS
WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.
```

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
2.70000	74.80000	-2.00	2.35	.33	-.53
7.00000	18.00000	-2.86	2.59	-.07	.60

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS

CORRELATIONS

		T 18	Y 2
T	18	1.000	
Y	2	-.353	1.000

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS

STATISTICS FOR 'BEST' SUBSET

SQUARED MULTIPLE CORRELATION	.12450
MULTIPLE CORRELATION	.35285
ADJUSTED SQUARED MULT. CORR.	.10991
RESIDUAL MEAN SQUARE	3.630970
STANDARD ERROR OF EST.	1.905511
F-STATISTIC	8.53
NUMERATOR DEGREES OF FREEDOM	1
DENOMINATOR DEGREES OF FREEDOM	60
SIGNIFICANCE (TAIL PROB.)	.0049

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	14.3157	.580577	7.088	24.66	.000		
18	T	-.0430341	.0147326	-.353	-2.92	.005	1.000000	.12450

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1288
CPU TIME USED 7.269 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS          '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = 6.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
     NT  = A+B+C+P+E+R+S+W+I.
     T   = 100-NT.
     ASS = A+B+C+P.
     DIS = 100-ASS.
     IN  = A+B+C.
     EN  = P+E.
     EB  = I+T.
     IB  = 100-IN-EN-EB.
     IF (G EQ 3) THEN USE = 1.
     IF (G NE 3) THEN USE = 1.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT IS       8.
            METHOD IS CP.
/ END
```

```
PAGE    4   BMDP9R   SCHOMER DATA : ALL SUBSETS

DATA AFTER TRANSFORMATIONS
--------------------------

 C A S E                     8           2
 NO. LABEL               EB           Y
----- --------       ---------- ----------
   1                    22.000          7
   2                    37.400          8
   3                    56.600          9
   4                    72.400         10
   5                    30.200         10
```

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS

NUMBER OF CASES READ. 62

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
8 EB	42.69516	14.41904	.337721
2 Y	12.77419	2.01973	.158110

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS
WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
16.90000	78.30000	-1.79	2.47	.44	-.56
7.00000	18.00000	-2.86	2.59	-.07	.60

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS

CORRELATIONS

		EB 8	Y 2
EB	8	1.000	
Y	2	-.365	1.000

STATISTICS FOR 'BEST' SUBSET

SQUARED MULTIPLE CORRELATION	.13304
MULTIPLE CORRELATION	.36475
ADJUSTED SQUARED MULT. CORR.	.11859
RESIDUAL MEAN SQUARE	3.595548
STANDARD ERROR OF EST.	1.896193
F-STATISTIC	9.21
NUMERATOR DEGREES OF FREEDOM	1
DENOMINATOR DEGREES OF FREEDOM	60
SIGNIFICANCE (TAIL PROB.)	.0036

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	14.9556	.758149	7.405	19.73	.000		
8	EB	-.0510918	.0168376	-.365	-3.03	.004	1.000000	.13304

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1288

CPU TIME USED 7.266 SECONDS

BMDP9R : Runstream output : Novice group x variable sets

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL     1982
MANUAL REVISED -- 1981
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TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : BEGINNERS '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
    NT   = A+B+C+P+E+R+S+W+I.
    T    = 100-NT.
    ASS  = A+B+C+P.
    DIS  = 100-ASS.
    IN   = A+B+C.
    EN   = P+E.
    EB   = I+T.
    IB   = 100-IN-EN-EB.
    IF (G EQ 1) THEN USE = 1.
    IF (G NE 1) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 17.
            METHOD IS CP.
/ END
```

```
PAGE    4  BMDP9R  SCHOMER DATA : ALL SUBSETS : BEGINNERS

DATA AFTER TRANSFORMATIONS
--------------------------
```

C A S E NO.	LABEL	9 A	10 B	11 C	12 P	13 E
2		6	5	2	3.600	2
3		2.900	5.400	0	4.300	1.700
7		.900	1.900	0	5.400	2.400
11		13	4.300	1.400	5.700	2.900
13		5.200	1.600	.300	11.100	.800

14 R	15 S	16 W	17 I	2 Y
31	13	0	10	8
8.300	10.800	10	2.500	9
6.300	.900	3.900	7.300	11
11.600	14.500	7.200	5.700	11
4.300	.300	.800	.800	12

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 38
REMAINING NUMBER OF CASES 24

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE		MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
9	A	9.45417	5.91578	.625733
10	B	6.02500	3.50754	.582164
11	C	8.66250	10.90249	1.258584
12	P	8.57083	4.74868	.554051
13	E	1.73333	1.43092	.825532
14	R	11.90833	7.60623	.638732
15	S	6.13750	8.59731	1.400784
16	W	1.88750	2.66675	1.412850
17	I	4.66667	3.29528	.706130
2	Y	12.62500	1.88386	.149216

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
.90000	22.70000	-1.45	2.24	.68	-.65
1.60000	14.30000	-1.26	2.36	.83	-.39
.00000	29.40000	-.79	1.90	.89	-.97
1.70000	22.00000	-1.45	2.83	1.02	.67
.00000	4.60000	-1.21	2.00	.53	-1.02
.00000	31.00000	-1.57	2.51	.47	-.34
.00000	37.50000	-.71	3.65	2.04	4.65
.00000	10.00000	-.71	3.04	1.45	1.48
.40000	12.70000	-1.29	2.44	.64	-.43
8.00000	16.00000	-2.46	1.79	-.37	.01

CORRELATIONS

		A	B	C	P	E	R	S	W	I	Y
		9	10	11	12	13	14	15	16	17	2
A	9	1.000									
B	10	.315	1.000								
C	11	.045	.712	1.000							
P	12	.042	-.149	-.333	1.000						
E	13	-.307	-.214	-.183	.314	1.000					
R	14	-.075	-.195	-.323	.014	.196	1.000				
S	15	-.033	-.143	-.216	-.118	-.172	.136	1.000			
W	16	-.363	-.216	-.367	-.121	.260	.044	.340	1.000		
I	17	.317	.061	-.083	-.261	-.158	.037	.142	-.099	1.000	
Y	2	.428	.640	.701	.231	-.197	-.440	-.313	-.496	-.112	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
 9 A     ■
10 B     +■
11 C      ■■
 2 Y     X■■■
16 W     X-XM■
14 R      -+X ■
15 S      .-++.■
12 P      .+-. .■
17 I     +  .. .-■
13 E     +-----.+.■
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

	LESS THAN OR EQUAL TO	.089
.	.089 TO AND INCLUDING	.178
-	.178 TO AND INCLUDING	.267
+	.267 TO AND INCLUDING	.356
X	.356 TO AND INCLUDING	.445
M	.445 TO AND INCLUDING	.534
■	.534 TO AND INCLUDING	.623
■	GREATER THAN	.623

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	
.492045	.468956	54.07	C
.409261	.382409	66.14	B
.246026	.211755	89.94	W
.193373	.156709	97.62	R
.182787	.145641	99.16	A
.098250	.057261	111.49	S
.053380	.010351	118.03	P
.038720	-.004974	120.17	E
.012558	-.032326	123.99	I

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP		
.734433	.709140	20.72	C	P
.649330	.615933	33.13	A	C
.557983	.515886	46.45	C	W
.542799	.499256	48.67	C	R
.532081	.487518	50.23	B	C
.519550	.473793	52.06	C	S
.496893	.448978	55.36	C	E
.494951	.446851	55.64	C	I

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP				
.869400	.849810	3.04	VARIABLE		COEFFICIENT	T-STATISTIC
			9 A		.117324	4.55
			11 C		.146997	9.91
			12 P		.197699	5.81
			INTERCEPT		8.54799	
.779427	.746341	16.16	C	P	E	
.765007	.729759	18.27	C	P	R	
.752935	.715875	20.03	B	C	P	
.750105	.712621	20.44	C	P	W	
.744829	.706553	21.21	C	P	I	
.738742	.699554	22.10	C	P	S	

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP				
.893091	.870584	1.59	VARIABLE		COEFFICIENT	T-STATISTIC
			9 A		.114483	4.77
			11 C		.136973	9.37
			12 P		.191121	6.01
			14 R		-.0405684	-2.05
			INTERCEPT		9.20116	
.878364	.852756	3.74	A	C	P	E
.873184	.846486	4.49	A	C	P	S
.870430	.843152	4.89	A	C	P	I
.869548	.842084	5.02	A	C	P	W
.869546	.842082	5.02	A	B	C	P

SUBSETS WITH 5 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP		COEFFICIENT	T-STATISTIC
.897833	.869453	2.90	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.106780	4.18
			11 C	.136856	9.33
			12 P	.201139	5.96
			13 E	-.103308	-.91
			14 R	-.0373503	-1.85
			INTERCEPT	9.32989	
.895983	.867089	3.17	VARIABLE	COEFFICIENT	T-STATISTIC

			11 C	.134362	8.80
			12 P	.186475	5.67
			14 R	-.0398484	-1.99
			15 S	-.0123511	-.71
			INTERCEPT	9.33218	
.894141	.864735	3.44	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.118463	4.51
			11 C	.135619	8.88
			12 P	.186095	5.38
			14 R	-.0405852	-2.01
			17 I	-.0209226	-.42
			INTERCEPT	9.31618	

.893216	.863553	3.57	A	C	P	R	W
.893101	.863406	3.59.	A	B	C	P	R

SUBSETS WITH 6 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP						
.902595	.868217	4.20	A	C	P	E	R	S
.898787	.863064	4.76	A	C	P	E	R	I
.897868	.861822	4.89	A	C	P	E	R	W
.897833	.861775	4.90	A	B	C	P	E	R
.894180	.856831	5.43	A	B	C	P	R	I

SUBSETS WITH 7 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP							
.903554	.861359	6.06	A	C	P	E	R	S	W
.903225	.860886	6.11	A	C	P	E	R	S	I
.902599	.859986	6.20	A	B	C	P	E	R	S
.894534	.848392	7.38.	A	B	C	P	R	W	I
.874797	.820021	10.26	A	B	C	P	S	W	I

SUBSETS WITH 8 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP								
.903948	.852720	8.01	A	C	P	E	R	S	W	I
.903649	.852262	8.05	A	B	C	P	E	R	S	W
.903244	.851641	8.11	A	B	C	P	E	R	S	I

.898793	.844816	8.76	A	B	C	P	E	R	W	I	
.896868	.841864	9.04	A	B	C	P	R	S	W	I	
.889827	.831069	10.06	A	B	C	P	E	S	W	I	
.829901	.739181	18.80	B	C	P	E	R	S	W	I	
.767349	.643269	27.92	A	B	C	E	R	S	W	I	
.754109	.622967	29.85	A	B	P	E	R	S	W	I	

SUBSETS WITH 9 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP									
.903989	.842267	10.00	A	B	C	P	E	R	S	W	I

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	1.59
SQUARED MULTIPLE CORRELATION	.89309
MULTIPLE CORRELATION	.94503
ADJUSTED SQUARED MULT. CORR.	.87058
RESIDUAL MEAN SQUARE	.459288
STANDARD ERROR OF EST.	.677708
F-STATISTIC	39.68
NUMERATOR DEGREES OF FREEDOM	4
DENOMINATOR DEGREES OF FREEDOM	19
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND
ASSOCIATED SIGNIFICANCE TEND TO BE
LIBERAL WHENEVER A SUBSET OF VARIABLES
IS SELECTED BY THE CP OR ADJUSTED
R-SQUARED CRITERIA.

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.20116	.519843	4.884	17.70	.000		
9	A	.114483	.0239953	.360	4.77	.000	.991016	.12808
11	C	.136973	.0146113	.793	9.37	.000	.786916	.49449
12	P	.191121	.0317744	.482	6.01	.000	.877112	.20357
14	R	-.0405684	.0197709	-.164	-2.05	.054	.883006	.02369

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 2711
CPU TIME USED 9.439 SECONDS

```
PAGE    1 BMDP9R

BMDP9R -- ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL        1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA.

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : BEGINNERS '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
     NT  = A+B+C+P+E+R+S+W+I.
     T   = 100-NT.
     ASS = A+B+C+P.
     DIS = 100-ASS.
     IN  = A+B+C.
     EN  = P+E.
     EB  = I+T.
     IB  = 100-IN-EN-EB.
     IF (G EQ 1) THEN USE = 1.
     IF (G NE 1) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 12.
            METHOD IS CP.
/ END
```

```
PAGE    4  BMDP9R   SCHOMER DATA : ALL SUBSETS : BEGINNERS

DATA AFTER TRANSFORMATIONS
--------------------------
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CASE NO.	LABEL	9 A	10 B	11 C	12 P	2 Y
2		6	5	2	3.600	8
3		2.900	5.400	0	4.300	9
7		.900	1.900	0	5.400	11
11		13	4.300	1.400	5.700	11
13		5.200	1.600	.300	11.100	12

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 38
REMAINING NUMBER OF CASES 24

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE		MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
9	A	9.45417	5.91578	.625733
10	B	6.02500	3.50754	.582164
11	C	8.66250	10.90249	1.258584
12	P	8.57083	4.74868	.554051
2	Y	12.62500	1.88366	.149216

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
.90000	22.70000	-1.45	2.24	.68	-.65
1.60000	14.30000	-1.26	2.36	.83	-.39
.00000	29.40000	-.79	1.90	.89	-.97
1.70000	22.00000	-1.45	2.83	1.02	.67
8.00000	16.00000	-2.46	1.79	-.37	.01

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

CORRELATIONS

		A 9	B 10	C 11	P 12	Y 2
A	9	1.000				
B	10	.315	1.000			
C	11	.045	.712	1.000		
P	12	.042	-.149	-.333	1.000	
Y	2	.428	.640	.701	.231	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
 9 A   █
10 B   +█
11 C   ▓▓
 2 Y   X▓██
12 P   .+-█
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

	LESS THAN OR EQUAL TO		.089
.	.089	TO AND INCLUDING	.178
-	.178	TO AND INCLUDING	.267
+	.267	TO AND INCLUDING	.356
X	.356	TO AND INCLUDING	.445
▓	.445	TO AND INCLUDING	.534
▓	.534	TO AND INCLUDING	.623
█		GREATER THAN	.623

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	
.492045	.468956	53.98	C
.409261	.382409	66.04	B
.182787	.145641	99.02	A
.053380	.010351	117.87	P

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.734433	.709140	20.68	11 C	.151203	7.34
			12 P	.207299	4.38
			INTERCEPT	9.54017	
.649330	.615933	33.07	9 A	.126419	3.07
			11 C	.118141	5.29
			INTERCEPT	10.4064	
.532081	.487518	50.15	B C		

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.869400	.849810	3.02	9 A	.117324	4.55
			11 C	.146997	9.91
			12 P	.197699	5.81
			INTERCEPT	8.54799	
.752935	.715875	19.98	10 B	.104908	1.22
			11 C	.126078	4.36
			12 P	.199446	4.23
			INTERCEPT	9.19136	
.651224	.598907	34.85	A B C		
.561118	.495286	47.92	A B P		

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.869546	.842082	5.00	9 A	.119009	4.12
			10 B	-.0101642	-.15
			11 C	.149371	6.70
			12 P	.198306	5.64
			INTERCEPT	8.56754	

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	3.02
SQUARED MULTIPLE CORRELATION	.86940
MULTIPLE CORRELATION	.93242
ADJUSTED SQUARED MULT. CORR.	.84981
RESIDUAL MEAN SQUARE	.533012
STANDARD ERROR OF EST.	.730077
F-STATISTIC	44.38
NUMERATOR DEGREES OF FREEDOM	3
DENOMINATOR DEGREES OF FREEDOM	20
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	8.54797	.442742	4.537	19.31	.000		
9	A	.117324	.0258064	.368	4.55	.000	.994325	.13497
11	C	.146997	.0148345	.851	9.91	.000	.885953	.64119
12	P	.197699	.0340551	.498	5.81	.000	.886134	.22007

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1617
CPU TIME USED 8.986 SECONDS

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PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL     1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : BEGINNERS '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
    NT  = A+B+C+P+E+R+S+W+I.
    T   = 100-NT.
    ASS = A+B+C+P.
    DIS = 100-ASS.
    IN  = A+B+C.
    EN  = P+E.
    EB  = I+T.
    IB  = 100-IN-EN-EB.
    IF (G EQ 1) THEN USE = 1.
    IF (G NE 1) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 5 TO 7.
            METHOD IS CP.
/ END
```

PAGE 4 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

DATA AFTER TRANSFORMATIONS

CASE NO.	LABEL	5 IN	6 EN	7 IB	2 Y
2		13	5.600	44	8
3		8.300	6.000	29.100	9
7		2.800	7.800	11.100	11
11		18.700	8.600	33.300	11
13		7.100	11.900	5.400	12

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 38
REMAINING NUMBER OF CASES 24

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
5 IN	24.14167	15.47393	.640964	2.80000	61.60000	-1.38	2.42	.79	-.36
6 EN	10.30417	5.37259	.521400	3.40000	24.30000	-1.29	2.61	1.04	.30
7 IB	19.93333	13.19221	.661817	4.40000	49.80000	-1.18	2.26	.60	-.72
2 Y	12.62500	1.88386	.149216	8.00000	16.00000	-2.46	1.79	-.37	.01

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS
WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

CORRELATIONS

		IN 5	EN 6	IB 7	Y 2
IN	5	1.000			
EN	6	-.301	1.000		
IB	7	-.392	-.068	1.000	
Y	2	.603	.152	-.558	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
5 IN    █
2 Y     ██
7 IB    +M█
6 EN    +. █
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

	LESS THAN OR EQUAL TO		.100
.	.100	TO AND INCLUDING	.201
-	.201	TO AND INCLUDING	.301
+	.301	TO AND INCLUDING	.401
X	.401	TO AND INCLUDING	.502
M	.502	TO AND INCLUDING	.602
▩	.602	TO AND INCLUDING	.702
█		GREATER THAN	.702

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.644310	.628142	26.65	5 IN	.0977225	6.31
			INTERCEPT	10.2658	
.311455	.280157	70.31	7 IB	-.0796944	-3.15
			INTERCEPT	14.2136	
.023044	-.021363	108.14	EN		

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.814632	.796978	6.31	5 IN	.113591	9.47
			6 EN	.151756	4.39
			INTERCEPT	8.31901	
.714432	.687235	19.46	5 IN	.0839966	5.44
			7 IB	-.0410992	-2.27
			INTERCEPT	11.4164	
.324449	.260110	70.61	EN IB		

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.847520	.824648	4.00	5 IN	.102457	8.28
			6 EN	.137273	4.18
			7 IB	-.0288024	-2.08
			INTERCEPT	9.31115	

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	4.00
SQUARED MULTIPLE CORRELATION	.84752
MULTIPLE CORRELATION	.92061
ADJUSTED SQUARED MULT. CORR.	.82465
RESIDUAL MEAN SQUARE	.622309
STANDARD ERROR OF EST.	.788866
F-STATISTIC	37.05
NUMERATOR DEGREES OF FREEDOM	3
DENOMINATOR DEGREES OF FREEDOM	20
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
.	INTERCEPT	9.31115	.699734	4.943	13.31	.000		
5	IN	.102457	.0123695	.842	8.28	.000	.738532	.52307
6	EN	.137273	.0328556	.391	4.18	.000	.868345	.13339
7	IB	-.0288024	.0138677	-.202	-2.08	.051	.808417	.03289

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1481
CPU TIME USED 8.919 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : BEGINNERS '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
    NT  = A+B+C+P+E+R+S+W+I.
     T  = 100-NT.
    ASS = A+B+C+P.
    DIS = 100-ASS.
    IN  = A+B+C.
    EN  = P+E.
    EB  = I+T.
    IB  = 100-IN-EN-EB.
    IF (G EQ 1) THEN USE = 1.
    IF (G NE 1) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT  IS 3.
            METHOD IS CP.
/ END
```

```
PAGE   4  BMDP9R  SCHOMER DATA : ALL SUBSETS : BEGINNERS

DATA AFTER TRANSFORMATIONS
--------------------------

 C A S E                  3          2
 NO. LABEL               ASS         Y
----- --------   ---------- ----------
    2                16.600          8
    3                12.600          9
    7                 8.200         11
   11                24.400         11
   13                18.200         12
```

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 38
REMAINING NUMBER OF CASES 24

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
3 ASS	32.71250	14.99937	.458521
2 Y	12.62500	1.88386	.149216

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
8.20000	65.00000	-1.63	2.15	.49	-.78
8.00000	16.00000	-2.46	1.79	-.37	.01

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

CORRELATIONS

		ASS 3	Y 2
ASS	3	1.000	
Y	2	.901	1.000

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS : BEGINNERS

STATISTICS FOR 'BEST' SUBSET

SQUARED MULTIPLE CORRELATION	.81222
MULTIPLE CORRELATION	.90123
ADJUSTED SQUARED MULT. CORR.	.80368
RESIDUAL MEAN SQUARE	.696719
STANDARD ERROR OF EST.	.834697
F-STATISTIC	95.16
NUMERATOR DEGREES OF FREEDOM	1
DENOMINATOR DEGREES OF FREEDOM	22
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	8.92225	.416068	4.736	21.44	.000		
3	ASS	.113191	.0116036	.901	9.75	.000	1.000000	.81222

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1292
CPU TIME USED 7.259 SECONDS

BMDP9R : Runstream output : Average group x variable sets

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : AVERAGE '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
     NT  = A+B+C+P+E+R+S+W+I.
     T   = 100-NT.
     ASS = A+B+C+P.
     DIS = 100-ASS.
     IN  = A+B+C.
     EN  = P+E.
     EB  = I+T.
     IB  = 100-IN-EN-EB.
     IF (G EQ 2) THEN USE = 1.
     IF (G NE 2) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 17.
            METHOD IS CP.
/ END
```

PAGE 4 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

DATA AFTER TRANSFORMATIONS

CASE NO.	LABEL	9 A	10 B	11 C	12 P	13 E
1		1.800	0	0	.500	0
4		0	2.700	0	11.100	0
8		4.700	4.300	1.200	3.900	1.200
9		4.400	3	.600	7.100	1.100
10		4.800	2.800	1.200	8.400	6.400

CASE NO.	14 R	15 S	16 W	17 I	2 Y
1	8.300	57.800	9.600	2.300	7
4	13.800	0	0	0	10
8	8.300	0	12.200	5.900	11
9	19.400	32.200	2.500	6	11
10	10.800	28.700	11.200	2.400	11

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

NUMBER OF CASES READ. 62	
CASES WITH USE SET TO ZERO	42
REMAINING NUMBER OF CASES	20

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE		MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
9	A	8.44000	6.22333	.737362
10	B	4.06500	2.46283	.605863
11	C	5.42500	5.80906	1.070794
12	P	10.07500	9.68324	.961116
13	E	2.75500	2.31641	.840803
14	R	13.43000	8.26241	.615221
15	S	10.19500	14.67047	1.438986
16	W	3.31500	4.39884	1.326949
17	I	5.22500	3.80331	.727905
2	Y	12.35000	1.89945	.153801

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
.00000	24.50000	-1.36	2.58	.92	.05
.00000	10.30000	-1.65	2.53	.47	.12
.00000	24.40000	-.93	3.27	1.73	2.99
.50000	46.90000	-.99	3.80	2.69	7.60
.00000	7.30000	-1.19	1.96	.52	-1.17
2.40000	34.00000	-1.33	2.49	1.27	1.04
.00000	57.80000	-.69	3.24	1.85	3.02
.00000	12.20000	-.75	2.02	.94	-.84
.00000	13.00000	-1.37	2.04	.59	-.64
7.00000	16.00000	-2.82	1.92	-.74	1.13

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

CORRELATIONS

		A 9	B 10	C 11	P 12	E 13	R 14	S 15	W 16	I 17	Y 2
A	9	1.000									
B	10	-.030	1.000								
C	11	.490	.154	1.000							
P	12	-.086	.004	-.120	1.000						
E	13	.455	-.101	.480	-.013	1.000					
R	14	.141	.154	-.329	-.053	-.179	1.000				
S	15	-.292	-.422	-.354	-.218	-.270	-.078	1.000			
W	16	-.398	.007	-.409	-.354	.109	-.121	.346	1.000		
I	17	-.104	.284	.362	.258	.223	-.209	-.291	-.085	1.000	
Y	2	.590	.293	.539	.552	.416	-.021	-.667	-.561	.363	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
 9 A    #
15 S    +#
 2 Y    ###
16 W    XXW#
12 P    .-WX#
11 C    MXWX.#
13 E    M+X. M#
10 B     M+  ..#
17 I    .+X.+X-+#
14 R    .  . +-.-#
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

	LESS THAN OR EQUAL TO	.083
.	.083 TO AND INCLUDING	.167
-	.167 TO AND INCLUDING	.250
+	.250 TO AND INCLUDING	.334
X	.334 TO AND INCLUDING	.417
M	.417 TO AND INCLUDING	.500
W	.500 TO AND INCLUDING	.584
#	GREATER THAN	.584

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	
.445197	.414375	73.48	S
.347616	.311372	89.22	A
.314335	.276242	94.58	W
.304614	.265981	96.15	P
.290140	.250704	98.49	C
.173436	.127516	117.31	E
.131768	.083533	124.03	I
.085865	.035080	131.43	B
.000434	-.055098	145.21	R

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP		
.713832	.680165	32.15	A	P
.618539	.573661	47.52	P	S
.615684	.570470	47.98	A	S
.568762	.518028	55.55	S	W
.549663	.496683	58.63	C	S
.505469	.447289	65.76	E	S
.476365	.414761	70.45	S	I
.450571	.385933	74.61	R	S

.445357	.380105	75.45	B	S			

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.854916	.827713	11.40	A	P	S
.810142	.774544	18.62	A	B	P
.797833	.759926	20.61	C	P	S
.695975	.638970	37.03	P	E	S
.674274	.613200	40.53	P	S	W
.626962	.557018	48.16	P	S	I
.621513	.550547	49.04	B	P	S
.620436	.549268	49.22	P	R	S

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP				
.914887	.892190	3.73	VARIABLE		COEFFICIENT	T-STATISTIC
			9 A		.121391	4.54
			11 C		.0962575	3.25
			12 P		.107967	6.94
			15 S		-.0423105	-3.84
			INTERCEPT		10.1468	
.887857	.857952	8.09	A	P	S	I
.878323	.845876	9.62	A	B	P	S
.864877	.828844	11.79	A	P	R	S
.863048	.826527	12.09	A	P	E	S
.856779	.818586	13.10	A	P	S	W

SUBSETS WITH 5 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP					
.933367	.909570	2.75	VARIABLE		COEFFICIENT	T-STATISTIC	
			9 A		.131631	5.26	
			10 B		.118837	1.97	
			11 C		.0924524	3.40	
			12 P		.111338	7.76	
			15 S		-.0326729	-7.92	
			INTERCEPT		9.46578		
.920430	.892012	4.83	A	C	P	S	I

.916013	.886018	5.55	A	C	P	S	W
.915635	.885505	5.61	A	C	P	R	S
.915143	.884837	5.69	A	C	P	E	S
.902685	.867930	7.69	A	B	P	S	I

SUBSETS WITH 6 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE		COEFFICIENT	T-STATISTIC		
.936075	.906571	4.31	VARIABLE		COEFFICIENT	T-STATISTIC		
			9	A	.138617	5.11		
			10	B	.110967	1.78		
			11	C	.0815505	2.61		
			12	P	.107893	7.05		
			15	S	-.0319392	-2.79		
			17	I	.0325189	.74		
			INTERCEPT		9.35527			
.935734	.906073	4.36	VARIABLE		COEFFICIENT	T-STATISTIC		
			9	A	.127382	4.86		
			10	B	.128916	2.04		
			11	C	.0858113	2.93		
			12	P	.111206	7.60		
			13	E	.0490026	.69		
			15	S	-.0313473	-2.71		
			INTERCEPT		9.34951			
.933697	.903096	4.69	VARIABLE		COEFFICIENT	T-STATISTIC		
			9	A	.133358	4.98		
			10	B	.117013	1.86		
			11	C	.0948248	3.20		
			12	P	.113112	6.89		
			15	S	-.0330520	-2.83		
			16	W	.0101411	.25		
			INTERCEPT		9.39812			
.933374	.902624	4.75	A	B	C	P	R	S

SUBSETS WITH 7 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP							
.937581	.901170	6.07	A	B	C	P	E	S	I
.936157	.898916	6.30	A	B	C	P	S	W	I
.936079	.898792	6.31	A	B	C	P	R	S	I
.933710	.895041	6.69	A	B	C	P	R	S	W
.918983	.871723	9.07	A	B	P	E	R	S	W
.917577	.869496	9.29	A	C	P	E	R	S	W

.897613	.837887	12.51	A	P	E	R	S	W	I
.854092	.768979	19.53	A	C	P	E	R	W	I

SUBSETS WITH 8 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP							
.937976	.892867	8.00	A	B	C	P	E	S	W	I
.937588	.892197	8.07	A	B	C	P	E	R	S	I
.936159	.889729	8.30	A	B	C	P	R	S	W	I
.936040	.889523	8.32	A	B	C	P	E	R	S	W
.926221	.872564	9.90	A	B	P	E	R	S	W	I
.921991	.865257	10.58	A	C	P	E	R	S	W	I
.907843	.840820	12.86	A	B	C	P	E	R	W	I
.856478	.752098	21.15	B	C	P	E	R	S	W	I
.784008	.626923	32.83	A	B	C	E	R	S	W	I

SUBSETS WITH 9 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP									
.937996	.882192	10.00	A	B	C	P	E	R	S	W	I

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	2.75
SQUARED MULTIPLE CORRELATION	.93337
MULTIPLE CORRELATION	.96611
ADJUSTED SQUARED MULT. CORR.	.90957
RESIDUAL MEAN SQUARE	.326262
STANDARD ERROR OF EST.	.571193
F-STATISTIC	39.22
NUMERATOR DEGREES OF FREEDOM	5
DENOMINATOR DEGREES OF FREEDOM	14
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.46578	.491696	4.983	19.25	.000		
9	A	.131631	.0250233	.431	5.26	.000	.708071	.13178
10	B	.118837	.0603081	.154	1.97	.069	.778378	.01848
11	C	.0924524	.0271858	.283	3.40	.004	.688521	.05504
12	P	.111338	.0143481	.568	7.76	.000	.889577	.28659
15	S	-.0326729	.0112073	-.252	-2.92	.011	.635221	.04045

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 2711
CPU TIME USED 9.484 SECONDS

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PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
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TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : AVERAGE   '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
    NT  = A+B+C+P+E+R+S+W+I.
     T  = 100-NT.
    ASS = A+B+C+P.
    DIS = 100-ASS.
    IN  = A+B+C.
    EN  = P+E.
    EB  = I+T.
    IB  = 100-IN-EN-EB.
    IF (G EQ 2) THEN USE = 1.
    IF (G NE 2) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 12.
            METHOD IS CP.
/ END
```

```
PROBLEM TITLE IS
 SCHOMER DATA : ALL SUBSETS : AVERAGE

NUMBER OF VARIABLES TO READ IN. . . . . . . . . . .      19
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. .           0
TOTAL NUMBER OF VARIABLES . . . . . . . . . . . .        19
NUMBER OF CASES TO READ IN. . . . . . . . . . . . TO END
CASE LABELING VARIABLES . . . . . . . . . . . . .
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. . NEITHER
BLANKS ARE. . . . . . . . . . . . . . . . . . . . MISSING
INPUT UNIT NUMBER . . . . . . . . . . . . . . . .        11
REWIND INPUT UNIT PRIOR TO READING. . DATA. . .         YES
NUMBER OF WORDS OF DYNAMIC STORAGE. . . . . . .       14998
NUMBER OF CASES DESCRIBED BY INPUT FORMAT . . .           1

***** TRAN     PARAGRAPH IS USED *****

INPUT FORMAT IS
(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)

MAXIMUM LENGTH DATA RECORD IS 127 CHARACTERS.

I N P U T   V A R I A B L E S . . . . .
```

VARIABLE INDEX	VARIABLE NAME	RECORD NO.	COLUMNS BEGIN	COLUMNS END	FIELD WIDTH	TYPE
1	G	1	1	2	2	F
2	Y	1	4	6	3	F
3	ASS	1	7	13	7.1	F
4	DIS	1	14	20	7.1	F
5	IN	1	22	28	7.1	F
6	EN	1	29	35	7.1	F
7	IB	1	36	42	7.1	F
8	EB	1	43	49	7.1	F
9	A	1	51	57	7.1	F
10	B	1	58	64	7.1	F
11	C	1	65	71	7.1	F
12	P	1	72	78	7.1	F
13	E	1	79	85	7.1	F
14	R	1	86	92	7.1	F
15	S	1	93	99	7.1	F
16	W	1	100	106	7.1	F
17	I	1	107	113	7.1	F
18	T	1	114	120	7.1	F
19	NT	1	121	127	7.1	F

```
INDEPENDENT VARIABLES ARE
    9 A          10 B          11 C          12 P

DEPENDENT VARIABLE. . . . . . . . . . . . . . . . . . .       2 Y
NUMBER OF 'BEST' REGRESSIONS. . . . . . . . . . .             5
SELECTION CRITERION . . . . . . . . . . . . . . .   CP
WEIGHT VARIABLE . . . . . . . . . . . . . . . . .
PRECISION . . . . . . . . . . . . . . . . . . . . .   DOUBLE
TOLERANCE FOR MATRIX INVERSION. . . . . . . . .    .0001000
```

PAGE 4 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

DATA AFTER TRANSFORMATIONS

CASE NO.	LABEL	9 A	10 B	11 C	12 P	2 Y
1		1.800	0	0	.500	7
4		0	2.700	0	11.100	10
8		4.700	4.300	1.200	3.900	11
9		4.400	3	.600	7.100	11
10		4.800	2.800	1.200	8.400	11

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 42
REMAINING NUMBER OF CASES 20

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
9 A	8.44000	6.22333	.737362
10 B	4.06500	2.46283	.605863
11 C	5.42500	5.80906	1.070794
12 P	10.07500	9.68324	.961116
2 Y	12.35000	1.89945	.153801

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
.00000	24.50000	-1.36	2.58	.92	.05
.00000	10.30000	-1.65	2.53	.47	.12
.00000	24.40000	-.93	3.27	1.73	2.99
.50000	46.90000	-.99	3.80	2.69	7.60
7.00000	16.00000	-2.82	1.92	-.74	1.13

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

CORRELATIONS

		A 9	B 10	C 11	P 12	Y 2
A	9	1.000				
B	10	-.030	1.000			
C	11	.490	.154	1.000		
P	12	-.086	.004	-.120	1.000	
Y	2	.590	.293	.539	.552	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
 9 A   ■
 2 Y   ■■
12 P   .■■
11 C   ■■.■
10 B   + -■
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

	LESS THAN OR EQUAL TO		.074
.	.074	TO AND INCLUDING	.147
-	.147	TO AND INCLUDING	.221
+	.221	TO AND INCLUDING	.295
X	.295	TO AND INCLUDING	.368
M	.368	TO AND INCLUDING	.442
▪	.442	TO AND INCLUDING	.516
■		GREATER THAN	.516

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	
.347616	.311372	75.38	A
.304614	.265981	81.41	P
.290140	.250704	83.43	C
.085865	.035080	112.05	B

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE		COEFFICIENT	T-STATISTIC
.713832	.680165	26.09	VARIABLE		COEFFICIENT	T-STATISTIC
			9 A		.195979	4.93
			12 P		.119153	4.66
			INTERCEPT		9.49547	
.676084	.637977	31.37	C	P		
.444318	.378944	63.84	A	B		
.429822	.362742	65.87	A	C		
.389305	.317458	71.54	B	P		

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE			COEFFICIENT	T-STATISTIC
.831093	.799423	11.66	VARIABLE			COEFFICIENT	T-STATISTIC
			9 A			.137880	3.83
			11 C			.128930	3.33
			12 P			.125231	6.17
			INTERCEPT			9.22515	
.810142	.774544	14.59	VARIABLE			COEFFICIENT	T-STATISTIC
			9 A			.198832	5.96
			10 B			.239457	2.85
			12 P			.119089	5.55
			INTERCEPT			8.49865	
.715649	.662333	27.83	VARIABLE			COEFFICIENT	T-STATISTIC
			10 B			.155286	1.49
			11 C			.190464	4.29
			12 P			.121868	4.63
			INTERCEPT			9.45768	
.497688	.403505	58.36	A	B	C		

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.892916	.864360	5.00	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.148550	4.98
			10 B	.195566	2.94
			11 C	.110421	3.41
			12 P	.124306	7.44
			INTERCEPT	8.44984	

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	5.00
SQUARED MULTIPLE CORRELATION	.89292
MULTIPLE CORRELATION	.94494
ADJUSTED SQUARED MULT. CORR.	.86436
RESIDUAL MEAN SQUARE	.489374
STANDARD ERROR OF EST.	.699553
F-STATISTIC	31.27
NUMERATOR DEGREES OF FREEDOM	4
DENOMINATOR DEGREES OF FREEDOM	15
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	8.44984	.424831	4.449	19.89	.000		
9	A	.148550	.0298109	.487	4.98	.000	.748324	.17727
10	B	.195566	.0664559	.254	2.94	.010	.961501	.06182
11	C	.110421	.0324281	.338	3.41	.004	.725828	.08277
12	P	.124306	.0167065	.634	7.44	.000	.984176	.39523

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1617
CPU TIME USED 8.996 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL     1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : AVERAGE '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
     NT  = A+B+C+P+E+R+S+W+I.
     T   = 100-NT.
     ASS = A+B+C+P.
     DIS = 100-ASS.
     IN  = A+B+C.
     EN  = P+E.
     EB  = I+T.
     IB  = 100-IN-EN-EB.
     IF (G EQ 2) THEN USE = 1.
     IF (G NE 2) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 5 TO 7.
            METHOD IS CP.
/ END
```

```
PAGE    4   BMDP9R   SCHOMER DATA : ALL SUBSETS : AVERAGE

DATA AFTER TRANSFORMATIONS
--------------------------
```

CASE NO.	LABEL	5 IN	6 EN	7 IB	2 Y
1		1.800	.500	75.700	7
4		2.700	11.100	13.800	10
8		10.200	5.100	20.500	11
9		8.000	8.200	54.100	11
10		8.800	14.800	50.700	11

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

```
NUMBER OF CASES READ. . . . . . . . . . . . . . .         62
   CASES WITH USE SET TO ZERO . . . . . . . . .         42
      REMAINING NUMBER OF CASES . . . . . . . . .         20
```

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
5 IN	17.93000	10.83533	.604313
6 EN	12.83000	9.92663	.773705
7 IB	26.94000	17.88114	.663739
2 Y	12.35000	1.89945	.153801

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
1.80000	43.90000	-1.49	2.40	.60	-.43
.50000	50.60000	-1.24	3.80	2.63	7.65
2.40000	75.70000	-1.37	2.73	.97	.61
7.00000	16.00000	-2.82	1.92	-.74	1.13

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

CORRELATIONS

		IN 5	EN 6	IB 7	Y 2
IN	5	1.000			
EN	6	.005	1.000		
IB	7	-.510	-.348	1.000	
Y	2	.694	.636	-.695	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
   5 IN        ■
   7 IB        N▩
   2 Y         ■■■
   6 EN         X▩■
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

```
                 LESS THAN OR EQUAL TO          .087
     .      .087   TO AND INCLUDING             .174
     -      .174   TO AND INCLUDING             .261
     +      .261   TO AND INCLUDING             .347
     X      .347   TO AND INCLUDING             .434
     N      .434   TO AND INCLUDING             .521
     ▩      .521   TO AND INCLUDING             .608
     ■                GREATER THAN              .608
```

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.482986	.454263	71.48	7 IB	-.0738243	-4.10
			INTERCEPT	14.3368	
.481662	.452866	71.70	IN		
.403946	.370832	84.85	EN		

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.881162	.867181	6.11	5 IN	.121101	8.26
			6 EN	.120945	7.56
			INTERCEPT	8.62693	
.659303	.619221	43.65	6 EN	.0857084	2.97
			7 IB	-.0572687	-3.57
			INTERCEPT	12.7930	
.638922	.596442	47.10	5 IN	.0804662	2.71
			7 IB	-.0489662	-2.72
			INTERCEPT	12.2264	

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.905439	.887709	4.00	5 IN	.103487	6.45
			6 EN	.107869	6.72
			7 IB	-.0210083	-2.03
			INTERCEPT	9.67648	

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	4.00
SQUARED MULTIPLE CORRELATION	.90544
MULTIPLE CORRELATION	.95155
ADJUSTED SQUARED MULT. CORR.	.88771
RESIDUAL MEAN SQUARE	.405135
STANDARD ERROR OF EST.	.636502
F-STATISTIC	51.07
NUMERATOR DEGREES OF FREEDOM	3
DENOMINATOR DEGREES OF FREEDOM	16
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.67648	.618036	5.094	15.66	.000		
5	IN	.103497	.0160360	.590	6.45	.000	.706272	.24614
6	EN	.107869	.0160631	.564	6.72	.000	.838654	.26652
7	IB	-.0210033	.0103654	-.198	-2.03	.060	.620699	.02428

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1481
CPU TIME USED 8.921 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : AVERAGE '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
     NT  = A+B+C+P+E+R+S+W+I.
      T  = 100-NT.
     ASS = A+B+C+P.
     DIS = 100-ASS.
     IN  = A+B+C.
     EN  = P+E.
     EB  = I+T.
     IB  = 100-IN-EN-EB.
     IF (G EQ 2) THEN USE = 1.
     IF (G NE 2) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT  IS 3.
            METHOD IS CP.
/ END
```

```
PAGE    4  BMDP9R   SCHOMER DATA : ALL SUBSETS : AVERAGE

DATA AFTER TRANSFORMATIONS
--------------------------

 C A S E                 3          2
NO. LABEL              ASS          Y
----- --------    ---------- ----------
    1                 2.300         7
    4                13.800        10
    8                14.100        11
    9                15.100        11
   10                17.200        11
```

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 42
REMAINING NUMBER OF CASES 20

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
3 ASS	28.00500	13.68893	.488803
2 Y	12.35000	1.89945	.153801

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
2.30000	59.20000	-1.88	2.28	.32	-.54
7.00000	16.00000	-2.82	1.92	-.74	1.13

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : AVERAGE

CORRELATIONS

		ASS 3	Y 2
ASS	3	1.000	
Y	2	.940	1.000

STATISTICS FOR 'BEST' SUBSET

SQUARED MULTIPLE CORRELATION	.88314
MULTIPLE CORRELATION	.93976
ADJUSTED SQUARED MULT. CORR.	.87665
RESIDUAL MEAN SQUARE	.445024
STANDARD ERROR OF EST.	.667102
F-STATISTIC	136.04
NUMERATOR DEGREES OF FREEDOM	1
DENOMINATOR DEGREES OF FREEDOM	18
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
INTERCEPT	8.69818	.346817	4.579	25.08	.000		
3 ASS	.130399	.0111801	.940	11.66	.000	1.000000	.88314

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1292
CPU TIME USED 7.256 SECONDS

BMDP9R : Runstream output : Superior group x variable sets

```
PAGE   1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : ELITE '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
    NT  = A+B+C+P+E+R+S+W+I.
    T   = 100-NT.
    ASS = A+B+C+P.
    DIS = 100-ASS.
    IN  = A+B+C.
    EN  = P+E.
    EB  = I+T.
    IB  = 100-IN-EN-EB.
    IF (G EQ 3) THEN USE = 1.
    IF (G NE 3) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 17.
            METHOD IS CP.
/ END
```

PAGE 4 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

DATA AFTER TRANSFORMATIONS

CASE NO.	LABEL	9 A	10 B	11 C	12 P	13 E
5		8.600	1.900	1.800	3.700	7.900
6		8.900	2.600	1.100	4.400	2.200
12		6.300	8.400	5.300	3.100	5.300
14		4.300	5	3.800	5.600	3.400
16		9.600	3	3.500	4	3

14 R	15 S	16 W	17 I	2 Y
46	0	0	17.600	10
10	10.700	4.400	3.700	10
29	0	5.600	17.900	11
39.600	4.300	1.300	13.800	12
7.600	4.900	8.900	6	12

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 44
REMAINING NUMBER OF CASES 18

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
9 A	9.68889	4.10536	.423718
10 B	10.18333	7.04884	.692194
11 C	8.80000	7.39865	.840756
12 P	10.06111	9.74348	.968430
13 E	3.65000	2.41472	.661568
14 R	14.68889	12.59089	.857171
15 S	1.97778	3.41976	1.729093
16 W	1.71667	2.78235	1.620786
17 I	11.65000	7.24197	.621629
2 Y	13.44444	2.25499	.167726

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
3.70000	20.80000	-1.46	2.71	.93	.68
1.80000	33.50000	-1.19	3.31	1.80	3.95
1.10000	25.30000	-1.04	2.23	.96	-.51
1.60000	31.50000	-.87	2.20	1.11	-.38
.90000	9.00000	-1.14	2.22	.66	-.67
.00000	46.00000	-1.17	2.49	1.17	.33
.00000	10.70000	-.58	2.55	1.44	.72
.00000	8.90000	-.62	2.58	1.38	.48
2.60000	25.00000	-1.25	1.84	.26	-1.50
10.00000	18.00000	-1.53	2.02	.34	-.82

```
PAGE    6  BMDP9R   SCHOMER DATA : ALL SUBSETS : ELITE
```

CORRELATIONS

		A 9	B 10	C 11	P 12	E 13	R 14	S 15	W 16	I 17	Y 2
A	9	1.000									
B	10	-.162	1.000								
C	11	-.337	.549	1.000							
P	12	.244	.025	.384	1.000						
E	13	-.034	.403	.027	-.145	1.000					
R	14	-.075	-.471	-.527	-.319	.307	1.000				
S	15	-.139	-.373	-.160	-.361	-.380	.016	1.000			
W	16	-.385	.151	-.019	-.430	.234	-.125	.338	1.000		
I	17	.277	-.099	-.246	.012	.380	.517	-.140	-.301	1.000	
Y	2	.025	.789	.766	.629	.083	-.623	-.366	-.120	-.149	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
  9 A     ■
 10 B     .■
 11 C     +M■
  2 Y      ■■■
 12 P     - X#■
 14 R      XM#+■
 17 I     -.-. M■
 16 W     X. .X.+■
 13 E      X   .++-■
 15 S     .+.++ .++■
```

```
THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME
                 LESS THAN OR EQUAL TO          .096
     .      .096  TO AND INCLUDING              .191
     -      .191  TO AND INCLUDING              .287
     +      .287  TO AND INCLUDING              .383
     X      .383  TO AND INCLUDING              .479
     M      .479  TO AND INCLUDING              .574
     #      .574  TO AND INCLUDING              .670
     ■                GREATER THAN              .670
```

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	
.586447	.560600	40.65	C
.502945	.471879	51.69	B
.395542	.357763	65.88	P
.387892	.349636	66.89	R
.134186	.080072	100.42	S
.022238	-.038872	115.21	I
.014477	-.047119	116.24	W
.006919	-.055148	117.24	E
.000642	-.061817	118.07	A

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP		
.877054	.860662	4.25	B	P
.717805	.680179	25.29	C	P
.705974	.666770	26.86	B	C
.676943	.633869	30.69	A	C
.653085	.606830	33.85	C	R
.647280	.600251	34.61	C	S
.597642	.543995	41.17	C	W
.590310	.535685	42.14	C	E

.508058	.533133	42.44	C	I		

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP				
.917045	.899268	.96	VARIABLE		COEFFICIENT	T-STATISTIC
			10 B		.175994	5.88
			11 C		.0813443	2.60
			12 P		.113680	5.97
			INTERCEPT		9.74236	
.760565	.709258	21.64	C	P	R	
.743656	.688725	23.88	A	C	P	
.736031	.679466	24.88	C	P	S	
.733455	.676338	25.22	C	P	E	
.722381	.662891	26.69	C	P	W	
.717815	.657346	27.29	C	P	I	

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP					
.925959	.903177	1.78	VARIABLE		COEFFICIENT	T-STATISTIC	
			9 A		.0616938	1.25	
			10 B		.170303	5.66	
			11 C		.102065	2.93	
			12 P		.106397	4.87	
			INTERCEPT		9.14381		
.923620	.900118	2.09	VARIABLE		COEFFICIENT	T-STATISTIC	
			10 B		.192714	5.65	
			11 C		.0720257	2.22	
			12 P		.129308	5.82	
			15 S		.0647284	1.06	
			INTERCEPT		9.41915		
.923530	.900000	2.11	VARIABLE		COEFFICIENT	T-STATISTIC	
			10 B		.191643	5.68	
			11 C		.0746260	2.34	
			12 P		.117301	5.91	
			13 E		-.0850933	-1.05	
			INTERCEPT		9.96658		
.922594	.898776	2.23	VARIABLE		COEFFICIENT	T-STATISTIC	
			10 B		.166611	5.22	
			11 C		.0735496	2.27	
			12 P		.114263	5.59	
			14 R		-.0166600	-.97	
			INTERCEPT		10.1957		
.918424	.893323	2.78	B	C	P	I	

.917658	.892322	2.88	B	C	P	W

SUBSETS WITH 5 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP					
.932677	.904626	2.90	A	B	C	P	S
.932193	.903940	2.96	A	B	C	P	E
.928958	.899357	3.39	A	B	C	P	W
.928881	.899249	3.40	A	B	C	P	I
.928721	.899021	3.42	A	B	C	P	R
.924300	.892758	4.00	B	C	P	S	I

SUBSETS WITH 6 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP						
.936799	.902325	4.35	A	B	C	P	E	W
.935685	.900604	4.50	A	B	C	P	E	S
.934527	.898814	4.65	A	B	C	P	S	I
.933599	.897380	4.78	A	B	C	P	S	W
.933343	.896984	4.81	A	B	C	P	R	S
.926161	.885886	5.76	B	C	P	R	S	I

SUBSETS WITH 7 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP							
.938089	.894751	6.18	A	B	C	P	E	R	W
.938032	.894654	6.19	A	B	C	P	E	S	W
.936190	.891438	6.44	A	B	C	P	E	S	I
.935709	.890704	6.50	A	B	C	P	E	R	S
.926223	.874579	7.75	B	C	P	R	S	W	I

SUBSETS WITH 8 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP								
.939258	.885265	8.03	A	B	C	P	E	R	S	W

.938141	.883156	8.17	A	B	C	P	E	R	W	I
.938033	.882950	8.19	A	B	C	P	E	S	W	I
.936461	.879982	8.40	A	B	C	P	E	R	S	I
.934964	.877154	8.59	A	B	C	P	R	S	W	I
.927640	.863321	9.56	B	C	P	E	R	S	W	I
.902578	.815980	12.87	A	B	P	E	R	S	W	I
.818393	.656965	24.00	A	C	P	E	R	S	W	I
.815659	.651800	24.36	A	B	C	E	R	S	W	I

SUBSETS WITH 9 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP									
.939463	.871359	10.00	A	B	C	P	E	R	S	W	I

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	.96
SQUARED MULTIPLE CORRELATION	.91704
MULTIPLE CORRELATION	.95762
ADJUSTED SQUARED MULT. CORR.	.89927
RESIDUAL MEAN SQUARE	.512216
STANDARD ERROR OF EST.	.715693
F-STATISTIC	51.59
NUMERATOR DEGREES OF FREEDOM	3
DENOMINATOR DEGREES OF FREEDOM	14
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.74236	.348354	4.320	27.97	.000		
10	B	.175994	.0303506	.550	5.80	.000	.658317	.19924
11	C	.0813443	.0313118	.267	2.60	.021	.561413	.03999
12	P	.118680	.0198848	.513	5.97	.000	.802666	.21107

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 2711
CPU TIME USED 9.419 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : ELITE      '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
       NT   = A+B+C+P+E+R+S+W+I.
       T    = 100-NT.
       ASS  = A+B+C+P.
       DIS  = 100-ASS.
       IN   = A+B+C.
       EN   = P+E.
       EB   = I+T.
       IB   = 100-IN-EN-EB.
       IF (G EQ 3) THEN USE = 1.
       IF (G NE 3) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 9 TO 12.
            METHOD IS CP.
/ END
```

PROBLEM TITLE IS
SCHOMER DATA : ALL SUBSETS : ELITE

NUMBER OF VARIABLES TO READ IN. 19
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. . 0
TOTAL NUMBER OF VARIABLES 19
NUMBER OF CASES TO READ IN. . . . . TO END
CASE LABELING VARIABLES . . . .
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. . NEITHER
BLANKS ARE. MISSING
INPUT UNIT NUMBER 11
REWIND INPUT UNIT PRIOR TO READING. . DATA. . . YES
NUMBER OF WORDS OF DYNAMIC STORAGE. 14998
NUMBER OF CASES DESCRIBED BY INPUT FORMAT . . . 1

***** TRAN PARAGRAPH IS USED *****

INPUT FORMAT IS
(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)

MAXIMUM LENGTH DATA RECORD IS 127 CHARACTERS.

I N P U T V A R I A B L E S . . . . .

VARIABLE INDEX	NAME	RECORD NO.	COLUMNS BEGIN	END	FIELD WIDTH	TYPE
1	G	1	1	2	2	F
2	Y	1	4	6	3	F
3	ASS	1	7	13	7.1	F
4	DIS	1	14	20	7.1	F
5	IN	1	22	28	7.1	F
6	EN	1	29	35	7.1	F
7	IB	1	36	42	7.1	F
8	EB	1	43	49	7.1	F
9	A	1	51	57	7.1	F
10	B	1	58	64	7.1	F
11	C	1	65	71	7.1	F
12	P	1	72	78	7.1	F
13	E	1	79	85	7.1	F
14	R	1	86	92	7.1	F
15	S	1	93	99	7.1	F
16	W	1	100	106	7.1	F
17	I	1	107	113	7.1	F
18	T	1	114	120	7.1	F
19	NT	1	121	127	7.1	F

INDEPENDENT VARIABLES ARE
9 A 10 B 11 C 12 P

DEPENDENT VARIABLE. . . . . 2 Y
NUMBER OF 'BEST' REGRESSIONS. 5
SELECTION CRITERION . . . . CP
WEIGHT VARIABLE . . . .
PRECISION . . . . DOUBLE
TOLERANCE FOR MATRIX INVERSION. 0001000

```
PAGE    3  BMDP9R   SCHOMER DATA : ALL SUBSETS : ELITE

* * * WARNING * * * IN PARAGRAPH VARIABLE THE FOLLOWING TEXT IS IGNORED:
GROUP = G.
* * * NOTE THAT THE FOLLOWING STATEMENTS WERE NOT FOUND:
ADD      LAB      USE      RET      MIS      MAX      MIN      BL
BEF      AFT      CHEC     WEIG

* * * WARNING * * * IN PARAGRAPH GROUP    THE FOLLOWING TEXT IS IGNORED:
/ GROUP CODES(1) = 1,2,3. NAMES(1) = BEGINNER,AVERAGE,ELITE.
* * * THIS PARAGRAPH IS TOTALY IGNORED.

THE MOST COMMON EXPLANATIONS FOR EXTRANEOUS CONTROL LANGUAGE ARE:
- MISSPELLED PARAGRAPH OR SENTENCE NAME
- SENTENCE IN THE WRONG PARAGRAPH
- SENTENCE OR PARAGRAPH REPEATED UNEXPECTEDLY
- OPTION NOT DEFINED IN THIS PROGRAM
- MUTUALLY EXCLUSIVE OPTIONS SELECTED

BASED ON INPUT FORMAT SUPPLIED    1 RECORDS READ PER CASE.
```

```
PAGE    4  BMDP9R   SCHOMER DATA : ALL SUBSETS : ELITE

DATA AFTER TRANSFORMATIONS
--------------------------
```

CASE NO.	LABEL	9 A	10 B	11 C	12 P	2 Y
5		8.600	1.800	1.800	3.700	10
6		8.900	2.600	1.100	4.400	10
12		6.300	8.400	5.300	3.100	11
14		4.300	5	3.800	5.600	12
16		9.600	3	3.500	4	12

```
PAGE    5  BMDP9R   SCHOMER DATA : ALL SUBSETS : ELITE

NUMBER OF CASES READ. . . . . . . . . . . . . . . .    62
   CASES WITH USE SET TO ZERO . . . . . . . . . .    44
      REMAINING NUMBER OF CASES . . . . . . . . .    18

SUMMARY STATISTICS FOR EACH VARIABLE
------------------------------------
```

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
9 A	9.68889	4.10536	.423718
10 B	10.18333	7.04884	.692194
11 C	8.80000	7.39865	.840756
12 P	10.06111	9.74348	.968430
2 Y	13.44444	2.25499	.167726

```
VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS
WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.
```

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
3.70000	20.80000	-1.46	2.71	.93	.68
1.80000	33.50000	-1.19	3.31	1.80	3.95
1.10000	25.30000	-1.04	2.23	.96	-.51
1.60000	31.50000	-.87	2.20	1.11	-.38
10.00000	18.00000	-1.53	2.02	.34	-.82

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

CORRELATIONS

		A 9	B 10	C 11	P 12	Y 2
A	9	1.000				
B	10	-.162	1.000			
C	11	-.337	.549	1.000		
P	12	.244	.025	.384	1.000	
Y	2	.025	.709	.766	.629	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
 9 A   █
10 B   .█
11 C   +M█
 2 Y   ███
12 P   - X██
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

	LESS THAN OR EQUAL TO	.096
.	.096 TO AND INCLUDING	.191
-	.191 TO AND INCLUDING	.287
+	.287 TO AND INCLUDING	.383
X	.383 TO AND INCLUDING	.479
M	.479 TO AND INCLUDING	.574
█	.574 TO AND INCLUDING	.670
█	GREATER THAN	.670

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP			
.586447	.560600	58.61	C		
.502945	.471879	73.27	B		
.395542	.357763	92.13	P		
.000642	-.061817	161.47	A		

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.877054	.860662	9.59	VARIABLE	COEFFICIENT	T-STATISTIC
			10 B	.222056	7.66
			12 P	.141599	6.76
			INTERCEPT	9.75853	
.717805	.680179	37.55	C	P	
.705974	.666770	39.62	B	C	
.676943	.633869	44.72	A	C	
.523153	.459573	71.72	A	B	

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.917845	.899268	4.57	VARIABLE	COEFFICIENT	T-STATISTIC
			10 B	.175994	5.80
			11 C	.0813443	2.60
			12 P	.118680	5.97
			INTERCEPT	9.74236	
.877195	.850880	11.56	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	-.00682018	-.13
			10 B	.221388	7.27
			12 P	.142312	6.35
			INTERCEPT	9.82425	
.790639	.745776	26.76	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.169812	2.38
			10 B	.129074	2.76
			11 C	.197671	4.23
			INTERCEPT	8.74525	
.743656	.688725	35.01	A	C	P

SUBSETS WITH 4 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.925959	.903177	5.00	VARIABLE	COEFFICIENT	T-STATISTIC
			9 A	.0616938	1.25
			10 B	.170303	5.66
			11 C	.102065	2.93
			12 P	.106397	4.87
			INTERCEPT	9.14381	

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	4.57
SQUARED MULTIPLE CORRELATION	.91704
MULTIPLE CORRELATION	.95762
ADJUSTED SQUARED MULT. CORR.	.89927
RESIDUAL MEAN SQUARE	.512216
STANDARD ERROR OF EST.	.715693
F-STATISTIC	51.59
NUMERATOR DEGREES OF FREEDOM	3
DENOMINATOR DEGREES OF FREEDOM	14
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND ASSOCIATED SIGNIFICANCE TEND TO BE LIBERAL WHENEVER A SUBSET OF VARIABLES IS SELECTED BY THE CP OR ADJUSTED R-SQUARED CRITERIA.

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	9.74236	.348354	4.320	27.97	.000		
10	B	.175994	.0303506	.550	5.80	.000	.658317	.19924
11	C	.0813443	.0313118	.267	2.60	.021	.561413	.03999
12	P	.118680	.0198848	.513	5.97	.000	.802666	.21107

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1617
CPU TIME USED 8.987 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL    1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM   TITLE = ' SCHOMER DATA : ALL SUBSETS : ELITE '.
/ INPUT     VARIABLES ARE 19.
            FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
            UNIT = 11.
            RECLEN = 129.
/ VARIABLE  NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
            GROUP = G.
/ GROUP     CODES(1) = 1,2,3.
            NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
    NT   = A+B+C+P+E+R+S+W+I.
     T   = 100-NT.
    ASS  = A+B+C+P.
    DIS  = 100-ASS.
    IN   = A+B+C.
    EN   = P+E.
    EB   = I+T.
    IB   = 100-IN-EN-EB.
    IF (G EQ 3) THEN USE = 1.
    IF (G NE 3) THEN USE = 0.
/ REGRESS   DEPENDENT IS Y.
            INDEPENDENT ARE 5 TO 7.
            METHOD IS CP.
/ END
```

```
PAGE    4   BMDP9R   SCHOMER DATA : ALL SUBSETS : ELITE

DATA AFTER TRANSFORMATIONS
--------------------------
```

CASE NO.	LABEL	5 IN	6 EN	7 IB	2 Y
5		12.200	11.600	46	10
6		12.600	6.600	25.100	10
12		20.000	8.400	34.600	11
14		13.100	9.000	45.200	12
16		16.100	7	21.400	12

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

NUMBER OF CASES READ. 62
CASES WITH USE SET TO ZERO 44
REMAINING NUMBER OF CASES 18

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
5 IN	28.67222	12.19285	.425250
6 EN	13.71111	9.69208	.706878
7 IB	18.38333	13.30569	.723791
2 Y	13.44444	2.25499	.167726

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
12.20000	59.50000	-1.35	2.53	.56	-.01
4.20000	32.60000	-.98	1.95	.87	-.84
2.20000	46.00000	-1.22	2.08	.74	-.58
10.00000	18.00000	-1.53	2.02	.34	-.82

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

CORRELATIONS

		IN 5	EN 6	IB 7	Y 2
IN	5	1.000			
EN	6	.391	1.000		
IB	7	-.688	-.427	1.000	
Y	2	.883	.653	-.709	1.000

ABSOLUTE VALUES OF CORRELATIONS IN SHADED FORM

```
5 IN    ■
2 Y     ■■
7 IB    ■■■
6 EN    +M+■
```

THE ABSOLUTE VALUES OF
THE MATRIX ENTRIES HAVE BEEN PRINTED ABOVE IN SHADED FORM
ACCORDING TO THE FOLLOWING SCHEME

		LESS THAN OR EQUAL TO	.110
.	.110	TO AND INCLUDING	.221
-	.221	TO AND INCLUDING	.331
+	.331	TO AND INCLUDING	.442
X	.442	TO AND INCLUDING	.552
M	.552	TO AND INCLUDING	.662
■	.662	TO AND INCLUDING	.773
■		GREATER THAN	.773

PAGE 7 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

FOR EACH SUBSET SELECTED BY YOUR CRITERION, THE R-SQUARED, ADJUSTED R-SQUARED, MALLOWS' CP, AND THE VARIABLE NAMES ARE PRINTED. THE REGRESSION COEFFICIENTS AND T-STATISTICS ARE PRINTED TO THE RIGHT OF THE VARIABLE NAMES.

MANY OTHER SUBSETS MAY ALSO BE REPORTED THAT ARE NOT ACCOMPANIED BY REGRESSION COEFFICIENTS AND T-STATISTICS. SOME OF THESE SUBSETS MAY BE QUITE GOOD ALTHOUGH THEY ARE NOT NECESSARILY BETTER THAN ANY SUBSET THAT HAS NOT BEEN PRINTED.

SUBSETS WITH 1 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.780063	.766317	15.58	5 IN	.163344	7.53
			INTERCEPT	8.76101	
.502199	.471086	52.94	IB		
.426385	.390534	63.13	EN		

SUBSETS WITH 2 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.892019	.877622	2.52	5 IN	.137089	8.04
			6 EN	.0845658	3.94
			INTERCEPT	8.35430	
.799521	.772791	14.96	5 IN	.138906	4.72
			7 IB	-.0325634	-1.21
			INTERCEPT	10.0603	
.652564	.606239	34.72	6 EN	.0997471	2.55
			7 IB	-.0891112	-3.12
			INTERCEPT	13.7150	

SUBSETS WITH 3 VARIABLES

R-SQUARED	ADJUSTED R-SQUARED	CP	VARIABLE	COEFFICIENT	T-STATISTIC
.895888	.873578	4.00	5 IN	.127062	5.72
			6 EN	.0807434	3.60
			7 IB	-.0149421	-.72
			INTERCEPT	8.96888	

STATISTICS FOR 'BEST' SUBSET

MALLOWS' CP	2.52
SQUARED MULTIPLE CORRELATION	.89202
MULTIPLE CORRELATION	.94447
ADJUSTED SQUARED MULT. CORR.	.87762
RESIDUAL MEAN SQUARE	.622289
STANDARD ERROR OF EST.	.788853
F-STATISTIC	61.96
NUMERATOR DEGREES OF FREEDOM	2
DENOMINATOR DEGREES OF FREEDOM	15
SIGNIFICANCE (TAIL PROB.)	.0000

NOTE THAT THE ABOVE F-STATISTIC AND
ASSOCIATED SIGNIFICANCE TEND TO BE
LIBERAL WHENEVER A SUBSET OF VARIABLES
IS SELECTED BY THE CP OR ADJUSTED
R-SQUARED CRITERIA.

VARIABLE NO. NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
INTERCEPT	8.35430	.497622	3.705	16.79	.000		
5 IN	.137089	.0170454	.741	8.04	.000	.847453	.46563
6 EN	.0845658	.0214436	.363	3.94	.001	.847453	.11196

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT
BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE
REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1481
CPU TIME USED 8.895 SECONDS

```
PAGE    1 BMDP9R

BMDP9R - ALL POSSIBLE SUBSETS REGRESSION
BMDP STATISTICAL SOFTWARE, INC.
1964 WESTWOOD BLVD. SUITE 202
(213) 475-5700
PROGRAM REVISED APRIL      1982
MANUAL REVISED -- 1981
COPYRIGHT (C) 1982 REGENTS OF UNIVERSITY OF CALIFORNIA

TO SEE REMARKS AND A SUMMARY OF NEW FEATURES FOR
THIS PROGRAM, STATE NEWS. IN THE PRINT PARAGRAPH.

PROGRAM CONTROL INFORMATION

/ PROBLEM    TITLE = ' SCHOMER DATA : ALL SUBSETS : ELITE '.
/ INPUT      VARIABLES ARE 19.
             FORMAT = '(F2.0,1X,F3.0,2F7.1,1X,4F7.1,1X,11F7.1)'.
             UNIT = 11.
             RECLEN = 129.
/ VARIABLE   NAMES ARE G,Y,ASS,DIS,IN,EN,IB,EB,A,B,C,P,E,R,S,W,I,T,NT.
             GROUP = G.
/ GROUP      CODES(1) = 1,2,3.
             NAMES(1) = BEGINNER,AVERAGE,ELITE.
/ TRANSFORM
      NT   = A+B+C+P+E+R+S+W+I.
      T    = 100-NT.
      ASS  = A+B+C+P.
      DIS  = 100-ASS.
      IN   = A+B+C.
      EN   = P+E.
      EB   = I+T.
      IB   = 100-IN-EN-EB.
      IF (G EQ 3) THEN USE = 1.
      IF (G NE 3) THEN USE = 0.
/ REGRESS    DEPENDENT IS Y.
             INDEPENDENT  IS 3.
             METHOD IS CP.
/ END
```

```
PAGE    4  BMDP9R   SCHOMER DATA : ALL SUBSETS : ELITE

DATA AFTER TRANSFORMATIONS
--------------------------

 C A S E                  3          2
NO. LABEL                ASS         Y
----- --------        ---------- ----------
    5                  15.900       10
    6                  17.000       10
   12                  23.100       11
   14                  18.700       12
   16                  20.100       12
```

PAGE 5 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

NUMBER OF CASES READ.	62
CASES WITH USE SET TO ZERO	44
REMAINING NUMBER OF CASES	18

SUMMARY STATISTICS FOR EACH VARIABLE

VARIABLE	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	SMALLEST VALUE	LARGEST VALUE	SMALLEST STANDARD SCORE	LARGEST STANDARD SCORE	SKEWNESS	KURTOSIS
3 ASS	38.73333	17.94157	.463208	15.90000	71.70000	-1.27	1.84	.40	-1.24
2 Y	13.44444	2.25499	.167726	10.00000	18.00000	-1.53	2.02	.34	-.87

VALUES FOR KURTOSIS GREATER THAN ZERO INDICATE DISTRIBUTIONS WITH HEAVIER TAILS THAN THE NORMAL DISTRIBUTION.

PAGE 6 BMDP9R SCHOMER DATA : ALL SUBSETS : ELITE

CORRELATIONS

		ASS 3	Y 2
ASS	3	1.000	
Y	2	.942	1.000

STATISTICS FOR 'BEST' SUBSET

SQUARED MULTIPLE CORRELATION	.88692
MULTIPLE CORRELATION	.94177
ADJUSTED SQUARED MULT. CORR.	.87985
RESIDUAL MEAN SQUARE	.610934
STANDARD ERROR OF EST.	.781623
F-STATISTIC	125.50
NUMERATOR DEGREES OF FREEDOM	1
DENOMINATOR DEGREES OF FREEDOM	16
SIGNIFICANCE (TAIL PROB.)	.0000

VARIABLE NO.	NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT.	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
	INTERCEPT	8.85974	.448813	3.929	19.74	.000		
3	ASS	.118366	.0105660	.942	11.20	.000	1.000000	.88692

THE CONTRIBUTION TO R-SQUARED FOR EACH VARIABLE IS THE AMOUNT BY WHICH R-SQUARED WOULD BE REDUCED IF THAT VARIABLE WERE REMOVED FROM THE REGRESSION EQUATION.

PROBLEM NUMBER 1 COMPLETED.

NUMBER OF INTEGER WORDS OF STORAGE USED IN PRECEDING PROBLEM 1292
CPU TIME USED 7.255 SECONDS

APPENDIX 6

<u>Regression equations for the proportions of association-perceived exertion levels data</u>

All	$Y = 0.118X + 8.874$
Novice	$Y = 0.113X + 8.925$
Average	$Y = 0.130X + 8.698$
Superior	$Y = 0.118X + 8.858$

with X = proportion of association

Y = perceived exertion level

APPENDIX 7

Questionnaire for MSTP participants

1. Name : ....
2. Age : ....
3. Weight : ....
4. Number of years/months you've been running :

   ....
5. Do you represent a club and if so which one?

   ....
6. What is your best standard marathon time?

   ....
7. How do you rate your running approach? Tick whichever is appropriate :

   (a) serious
   (b) moderate involvement for fitness gain
   (c) low involvement for fun aspect
8. How many times do you typically train a week? And how many kilometres do you cover?

   ....
9. Do you feel that the MSTP helped increase your overall performance? Ring the appropriate answer :

   Not at all 1 2 3 4 5 Definitely

   Moderately
10. Do you feel that, as you had to concentrate more on your body, pace, etc. your level of performance increased? Ring the appropriate answer :

    Not at all 1 2 3 4 5 Definitely

    Moderately

11. Did you find having to talk while you were running made you more conscious of your concentration?

Not at all 1 2 3 4 5 Definitely

Moderately

12. (a) Did you practice using the taught mental strategy without the trainer?
(b) Would you use it in a race?

(a) ....

(b) ....

13. Do you feel the presence of the trainer is essential?

....

14. Do you feel that using associative mental strategies might have been a hindrance to your usual thought patterns?

....

15. Do you expect any increased times of fun runs, marathons or half-marathons due to your mental strategy training?

....

16. Did you think that the equipment (ie. headphones and transmitter/receiver) could be improved? Suggestions please.

....

17. Would you please comment on any other beneficial (or otherwise) effect this programme has had on you and your running performance :

....

....

18. In future, will you be employing the taught/fostered mental technique?

....

19. Would you recommend this training programme to other long-distance runners?

....

20. Would you have liked this programme to be longer? If so, for how many sessions?

....

THANK YOU FOR YOUR INTEREST, DEDICATION AND CO-OPERATION.