AN INVESTIGATION INTO THE NATURE OF PERCEPTUAL STYLE AND BODY AWARENESS IN RELATION TO PERCEPTUAL-MOTOR ABILITIES

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ABSTRACT

The thesis is an account of an investigative study into the nature of perceptual-motor abilities. Part one considers Witkin's construct of cognitive style, using it to predict the relationships between three tests of perceptual functioning from widely varying areas of psychology and sports science.

To some extent the results were as predicted; that is, those people demonstrating high levels of perceptual acuity on one test also showed similar acuity on one or more of the other perceptual tests. These results, however, only applied to the male subjects and then only when the opposite poles of one test-dimension were partitioned out and compared. The female subjects demonstrated no significant relationships between the three tests. As a result, it was proposed that the tests were indeed linked but by an array of underlying perceptual abilities rather than by a single, overlying cognitive or perceptual style.

In the ensuing search for these abilities, 76 measures of perceptual and perceptual-motor skills were factor analysed to reveal 8 oblique perceptual-motor factors of which one was interpreted as being perceptual style.

The nature of perceptual-motor abilities is discussed both in relation to clumsiness and to sports training with the emphasis being on whether such abilities are amenable to alteration. The thesis puts forward the proposal that an upper limit to each ability is fixed for each individual in early childhood but that this potential may be maximised through relevant training.

The Perceptual-Motor Ability Profile was devised as a tool with which to indicate the aptitude a person evidenced for a particular sport or physical activity and was used in demonstration to describe the group abilities of four dancers with respect to the requirements of their chosen activity.

Finally, a model of perceptual-motor functioning, relating the eight factors extracted, is suggested.

I, Andrew Simon Head, hereby certify that this thesis which is approximately forty-three thousand words in length has been written by me, that it is a record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

Date. 27th May 1987. Signature of candidate.

I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate to the degree of Ph.D. of the University of St Andrews and that he is qualified to submit this thesis in application for that degree.

Date. 27th May, 1987 Signature of supervisor.

I was admitted as a research student under Ordinance No. 12 in October, 1980 and as a candidate for the degree of Ph.D. on the same date; the higher study for which this is a record was carried out in the University of St Andrews between 1980 and 1983.

Date. 27th May 1987. Signature of candidate.

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Contents

Glossary

A.P.Q....................Attitude-Participation Questionnaire.

B.B.S..................................Body Barrier Score.

C.N.S...............................Central Nervous System.

E.F.T...............................Embedded Figures Test.

H.R...Heart Rate.

M.C.D..........................Minimal Cerebral Dysfunction.

P.S..Penetration Score.

P.M.A.P......................Perceptual-Motor Ability Profile.

P.I..Ponderal Index.

R.P.E............................Rating of Perceived Exertion.

R.P.E.l..................Rating of perceived Exertion - local.

R.P.E.c................Rating of Perceived Exertion - central.

R.P.E.o................Rating of Perceived Exertion - overall.

SPSS-X.........Statistical Package for the Social Sciences - X.

STAI............................State-Trait Anxiety Inventory.

TAIS..............Test of Attentional and Interpersonal Style.

V_E ....Volume of Expired air.

$\dot{V}O_2$...................................Rate of Oxygen uptake.

$\dot{V}O_2$max...Maximum Rate of Oxygen uptake (Max. Aerobic Capacity).

WkLd...Workload.

FOREWORD

The common factors to all self-regulating mechanisms are: (i) input information upon which the mechanism acts, (ii) the output behaviour which is the act itself, (iii) the "black box" situated between these two which, in one way or another, interprets the input and issues the output commands and (iv) the feedback which, by adding to the input, lets the mechanism "know" how appropriate its output behaviour has been to the situation. The human self-regulating mechanism has likewise been described in a similar manner (Fitts and Posner, 1967; Welford, 1968; Whiting, 1975). Human movement fits particularly easily into such a system. Input is predominantly visual but may also be via any of the other senses. Output is the voluntary motor behaviour or movement of the person; either the whole body or just a part. The black box where the criteria for the interpretation of the input and the decision for the output are to be found is, obviously, the central nervous system (C.N.S.). Lastly the feedback, this is through two channels. The first is external and is simply the change in the original input brought about by the output behaviour; this feedback may be either discrete or continuous. The second is internal and is the continuous monitoring of the state and position of the body while acting out its designated role. This perception of body position from receptors in the joints, tendons, muscles and vestibular apparatus is generally termed "proprioception" (Sherrington, 1906; Dickinson, 1974).

When a mechanism is working correctly (that is, its output is in accordance with its input) one can generally assume that all four parts of the system are working correctly, complementing each other in their designed fashion. When it is not working correctly, however, there may be a fault in any single part or any possible combination of the four parts with the end result still being an inappropriate response to the true requirements of the situation. This inability of the mechanism to function to preconceived criteria of performance is usually diagnosed as a fault in a machine or as a lack of skill in a human operator.

The term "skill" has often been the subject of varied definition but most appear to involve the task being complex and the concept of intentionality. Whiting (1975) uses the following "composite" definition. Skills are ...

> "complex, intentional actions involving a whole chain of sensory, central and motor mechanisms which through the process of learning have come to be organised and co-ordinated in such a way as to achieve pre-determined objectives with maximum certainty."

It is also the nature of skill to be task specific. A person, for example, may be skilled as a lathe operator but unskilled in circuit soldering even though both tasks involve a high degree of visually guided motor control. This component of both skills can be regarded, argues Fleishman (1966), as an underlying "ability". This distinction between skill and ability will be discussed more fully later on. It is, however, a product of modern folklore that someone who is able to perform well at one kind of sport is predisposed toward performing well in virtually all other kinds of sport, regardless of their similarity. This belief may well originate in schools where it often appears to be the case that one or two individuals are in, if not captain of, all the sports teams and are consequently deemed to have a natural propensity for sport. The concept of a general ability outwith the sporting context was generated principally by the British school of cognitive development which emphasized a hierarchical stucture of abilities culminating in an overall or "g" factor. This concept too will be discussed in later sections.

It would appear then, that from a consideration of a general model for a self-regulating mechanism and its relevance to the human operator, one has been brought of necessity to a deliberation on the motor aspects of skilled performance. This, however, is only a reflection of the historical perspective from which skilled performance has been studied. Indeed, the very definition of skill itself refers principally to particular performance criteria being met by motor output. Whiting (1975) makes particular reference to the fact that the presence or absence of skill can only be inferred from the correctness of the motor output. Consequently, studies of skilled behaviour have tended to emphasize the output part of the model. Thus, whilst individual differences in skill are measured by their variance in motor output (given the same task), it has seldom been the case that the workers concerned with skilled performance have attempted to look at individual differences in perception of that task. It is true that in a systems analysis approach to skilled behaviour the amount of information in terms of channel capacity is usually considered (in fact manipulation of the amount of input is more often than not the independent variable in the experiment) but this is normally a quantitative assessment of the input and not a qualitative one. Certainly, it is rarely the case that the idea of individual variance in perception of that input is taken into account when considering the nature of the output. That the ability to perceive the input information correctly is vital to any skilled task is self-evident. The perception of information is the start of the skilled behaviour sequence, consequently any perceptual difficulty is bound to result in a reduced level of skill in performing a particular task. This may be nothing to do with the information available but with the degree and efficiency with which each individual perceives that information.

Whilst it is important to bear in mind the generalised four-part systems-analysis model of skilled behaviour, this particular study approaches perceptual-motor ability very much from the consideration of individual differences. It also approaches it from the "perception" end of the equation rather than from the "motor output" end.

The following studies stemmed from Witkin's model of an overall perceptual style (Witkin, 1954). He regarded this construct as a way of explaining the similarity of perceptual processing shown by an individual regardless of perceptual modality. The principal aim of this thesis was to investigate perceptual-motor abilities, to see whether such functioning could be usefully considered as a singular style, as proposed by Witkin or, if not, to establish a more practical model. That this thesis is, in fact, a sequence of several studies will become evident. In each case, the discussion of one experiment leads into the introduction of the next since each subsequent study was formulated to answer problems created by the previous one.

As stated above, Witkin's construct of perceptual style was used as a starting point with the first study seeking to test its validity through the comparison of one of Witkin's own tests of perceptual style with tests from other fields of psychology and sports science.

1 STUDY ONE.

1.1 Introduction.

1.1.1 Self Perception.

The accuracy of a person's perceptions of himself and his interaction with the immediate environment determines the efficiency and propriety of his actions. A lack of this perceptual-motor efficiency is more commonly termed "clumsiness" and this use of a single word to cover a large range of motor-impairment has contributed to the idea that such impairment is a unitary quality; i.e. a lack of skill in one area of motor behaviour implies a general lack of skill in any other. That the very term "clumsy" has been shown to be open to wide interpretation (Keogh et al.,1979) indicates that perhaps a single word is insufficient to cover the large range of behaviour that has been subsumed beneath it. This investigation was to ascertain whether there is in fact a general trait of perceptivity from which could follow a general trait of motor efficiency or inefficiency.

In particular, this investigation was concerned with self-perception. This is not to be confused with self-esteem (i.e. the judgement value a person puts on their own perception of their self-image) but is rather the extent to which a person

Throughout this text the use of the words "him" or "his" will be meant to imply both sexes unless otherwise specified.

is aware of the physical presence of and perceptions relating and pertaining to his own body. Thus "self-perception" in this paper refers to the ability of an individual to sense and assimilate information from both the external and internal environment and is used interchangably with the terms "self-awareness" and "body-awareness".

1.1.2 Approaches to self-perception.

With reference to the model of the human operator mentioned in the foreword, there are several ways in which the analysis of perception can be approached and these can equally be applied to the province of self-perception. One of these ways is through a psycho-physical methodology. Such an approach has been used with all five of the classical senses as well as with various proprioceptive ones (Stevens, 1951; Wright et al., 1970) giving rise to various sensory thresholds and mathematical functions relating the strength of the stimulus to the degree of awareness or response that it elicits. This approach, however, is limited when it comes to attempting to explain the complexities of human behaviour rather than those of human physiology. It can not indicate how a person will interpret a stimulus once it has been sensed. A cognitive approach tries to place a more interpretive role upon self-perception; i.e. how different individuals will differentially perceive the same stimulus due to their differing psychological make-up. This immediately gives rise to questions about the consequent involvement of personality with perception and even about how psychiatric disorders may affect perception.

Certain theories on the development of personality complement the cognitive outlook and emphasize the individual nature of perception. Carl Rogers and George Kelly in particular (in Pervin, 1975) regard conscious perception of the world both as a product of the self-concept and as being integral in its production. This conceptualisation of self determines both how the world is understood in relation to the self and formulates how the person behaves in this world such that his behaviour is consistent with his self-concept. Theirs is a phenomenological approach to personality development, from which they regard the self-concept to be a single but complex construction built from precepts of the self and its world. The cognitive processes that organise these perceptions are, in their terminology, part of the self-concept too. That is, the self is self-promoting! Each new perception is perceived in a way that is consistent with the present conceptualisation of the self and goes to form an additional stay in the ever increasingly complex construction of the self-concept. Kelly regarded the increase in complexity of the self-concept as an increase in the ability to predict the effect of one's behaviour on one's environment. If one's prediction should prove correct then one has validated and strengthened the self-concept. The theories of both Rogers and Kelly, though more concerned with social than perceptual-motor behaviour, are firmly based on the idea of cognitive processes both affecting and being affected by perception of one's body in relation to the rest of one's world.

The functional requirements of sports science are such that psychophysical, cognitive and personality approaches can offer useful information toward an understanding of skilled behaviour. The psycho-physical can analyse such quantities as a person's pain threshold and tolerance levels, the acuity of their peripheral vision or, as used in this study, the perception of physical effort. The cognitive approach, on the other hand, would lend itself more to an understanding of such qualities as the perception of a pattern of play on a games field, the relative speed and position of oneself to that of one or more opponents or to the trajectory of a ball. The study of personality can throw light on the motivational aspects of a person's involvement in sport, to whom or what they attribute causality of outcome of their efforts or the subsequent effects of success or failure of a performance attempt on self-esteem. Each of these approaches, however, is concerned with the same array of body senses and how well or appropriately they function in a variety of environments or situations. It would seem likely therefore that there would be some connection and overlap between the three approaches and, in fact, a number of authors claim to have found such links.

1.1.3 Personality and perception of the self.

In 1966, Korvacic and Ryan conducted a research programme concerning pain tolerance, physical activity and a personality continuum between "reducers" at one pole and "augmenters" at the other. Reducers are those people who are more tolerant of pain and who tend to decrease subjectively what they perceive. Augmenters are the opposite in that they are intolerant of pain and subjectively increase what they actually perceive. This continuum was first suggested by Petrie (1960) who noticed a relationship between pain tolerance and personality whilst working with frontal lobotomy patients. In developing her work she found that individuals tended to either reduce or augment all stimulation, not just noxious stimuli. Those who reduce the perceptual intensity are able to tolerate pain well, are less tolerant of sensory deprivation, judge time as passing more slowly than augmenters, are more mesomorphic and tend to be extrovert. Ryan points out that all these characteristics have frequently been associated with athletic groups; the more so with those athletes involved in contact sports. Petrie's hypothesis provides some degree of causality behind the personality types of Introvert-Extrovert since a person who continually suffers from a lack of stimulation would actively need to seek out change, movement, speed and a general heightening of all sensory stimuli. Ryan takes this a stage further and suggests that certain people become more involved in an athletic pursuit than others since they are in need of greater sensory stimulation, sport being one avenue through which such enhancement is possible (Ryan, 1976). [Petrie has also shown that a significant percentage of delinquents are reducers, thus indicating a different avenue toward increased sensory stimulation (Petrie et al., 1962).] Other associations of the reducer-augmenter perceptual continuum are that reducers tend to have faster reaction and movement times and that males tend more toward the reducing end of the scale than do females. Ryan also suggested other possible connections between athletic performance and perceptual characteristics but pointed out that these were merely hypotheses and that all would require future experimental exploration. It is sufficient here to indicate the strong links already found between individual perceptual sensitivity, personality and physical activity.

The work of Fisher and Cleveland (1958), like Petrie's, began with hospitalised patients; this time due to their having arthritis rather than the need for a frontal lobotomy. A relationship was found between the patients' responses to the Rorschach Ink-blot test (a standard psychiatric test) and the degree of immobility or distress caused by the patients' conditions. They extended this to the "normal" population and found what they regarded to be a new form of personality dimension based on the receptivity of the individual to the various sensory stimuli both internal and external. They named this the Body Boundary dimension and it defines the extent to which the body is experienced as having definite limits or "barriers". The dimension, however, is not limited merely to the degree of differentiation between physical self and non-self but also marks a differentiation between an internal and an external perceptual focus within the body itself, i.e. it also gives a measure of how receptive an individual is to physiological changes of the viscera as opposed to their receptivity of physiological changes occurring on the skin or within the skeletal musculature. If a person's receptivity tends to be greater for the outer parts of their body then they will have a greater sense of their body as having a definite limit or boundary than a person whose perceptual focus is more internal. Consequently their body boundary score (B.B.S.) will be higher. What Fisher and Cleveland were saying therefore, was that there is a definite link between the locus of greater physiological receptivity and the clarity with which the individual regards himself within the environment. Fisher regards this body image as being both psychic and somatic and as possessing both a conscious and a subconscious nature. Consequently, this degree of body clarity should also be seen to have connections with a range of physiological and psychological phenomena. A high B.B.S. has been associated with a number of personality traits including autonomy, achievement motivation, task completion, warmth, friendliness, willingness to face hostility in group situations and communication with others (Fisher & Cleveland, 1958; Cleveland & Morton, 1962; Fisher, 1963). B.B.S. has also been shown to correlate with somatotype, with male mesomorphs having a clearer sense of self than endomorphs (Sugarman & Haronian, 1964). Fisher (1963) also found that high scorers on the body boundary dimension showed less likelihood of psychological disturbance and that they were better able to deal effectively with difficult and disturbing experiences. Similarly, Brodie (1959) had reported that those people with a high body boundary concept tended to be more controlled and guarded in response to stress whilst low scorers were more impulsive, uninhibited and assertive. The suggestion that those with a low B.B.S. tended toward panic behaviour when under stress was echoed by Zion (1965) who found that a strong sense of body concept was associated with a strong sense of security with which one faced up to the world.

Fisher connected B.B.S. not only with personality but also with physiological response; high boundary scorers tending to react to stress with increases in skeletal muscle tension and galvanic skin response and low boundary scorers tending to react with increases in heart-rate, cadiac output and stomach/intestinal activity (Fisher & Fisher, 1964; Davis, 1960). In addition, he also reported that selective recall for body versus non-body words and a score on a body prominence test were highly correlated with B.B.S. (Fisher, 1964, 1970, 1978; Fisher & Cleveland, 1968.) A related test to the B.B.S. is the Penetration Score (P.S.) which is a measure of how vunerable an individual regards himself to be to the outside environment. Despite the apparent reciprocal nature of their definitions and that both are judged from responses made to the Rorshach

Ink-blot series, B.B.S. and P.S. are not reported to be significantly correlated with each other (Siegal, 1977). Fisher and Cleveland (1968) never regarded the two scores as mutually antagonistic, however, partly because of their differences in reliability: " ...the barrier score was largely a measure of persisting attitudes rather than of short-term variations in state. The penetration score, by contrast, seems to be more sensitive to immediate situational conditions."

The theoretical link between psyche and soma is perhaps best illustrated by describing how Fisher and Cleveland actually measured B.B.S. (a more detailed account of the scoring system can be found in the methodology section). The Rorschach ink-blot test consists of a series of cards each showing a different symmetrical abstract pattern, some multi-coloured, some just black and white. The subjects are shown each card and asked to say or write down what they think they see on the card. Many of the patterns contain certain shapes or colour combinations that are particularly evocative but the subjects' responses differ greatly depending on which parts of the pattern they direct their attention to.

According to Fisher and Cleveland, the visual attentional focus is directly linked to the overall perceptual focus one has with respect to one's own body. Thus people who tend to see barriers or coverings in the ink-blots or surfaces that display a definite texture, are being drawn to the visual limits of the patterns and this is a reflection of their enhanced attentiveness to the physical limits of their own bodies. That is, they have a strong sense of a barrier between the self and the outside world. On the other hand, people who preferentially attend to a more amorphous content of the pattern will be those who have a poorer sense of identity within the environment, both physiologically and psychologically.

1.1.4 Perception of Exertion.

Somewhat removed from concepts such as sense of identity or the self is the mathematical or psychophysical analysis of sensory ability. Much of the early work in this field was performed by Stevens (1951) who formulated a number of mathematical relationships between stimulus intensity and perceptual sensitivity. For all sense modalities that he studied he found a power function of the form $R = S^n$ where 'S' is the stimulus intensity, 'R' is the intensity of the perception and 'n' the exponent which was found to fall within the range 0.33 to 3.5 depending on which modality was being investigated. The application of Steven's ratio-scaling methods to work physiology was first made by Borg and Dahlstrom when investigating the subjective estimate of work capacity. It was found that the subjective estimation of actual work increased as a positively accelerating function as the real work intensity increased. Borg arrived at the general formula (in essence, the same as that of Stevens) $R = a + c.S^n$ where 'R', 'S' and 'n' have the same meaning as above, 'a' is basic perceptual noise and 'c' is a constant. The value of the exponent 'n' was found to be 1.6. These first experiments were performed using a cycle ergometer to provide the known work-load but since then other types of muscular work have also been investigated using the same ratio-scaling technique and have provided exponents of between 1.7 and 1.45 (Borg, 1973). From his initial work, Borg developed a fifteen-point scale to cover the subjective intensity range and from which the subject would select a number corresponding to the degree of effort that they felt they were making (Table 1.2.i). From his very first experiments Borg realised that both heart rate (H.R.) and rating of perceived exertion (R.P.E.) were highly correlated with respect to their change with work intensity, the coefficient of correlation, r, falling between 0.80 and 0.90. In effect, what Borg had done was to take a previously ignored perceptual ability, investigate it using validated psychophysical techniques and develop a quick and simple means to quantify subjective exertion. The question now arose about which physiological mechanisms were responsible for providing the feedback that would give rise to the feelings of effort or strain.

Although H.R. and R.P.E. had been found to be highly correlated over a wide range of workloads, it did not necessarily follow that the two had a causal relationship. Despite this, when the problem of the mechanism of perception was raised, heart rate appeared as one of the likeliest candidates for providing the physiological cues upon which the perception of exertion was based. Also, because of the known virtually linear relationship of oxygen consumption (VO_2) to heart rate (Åstrand & Rodahl, 1970), this too was put forward as a physiological response to exercise from which one may be able to judge the severity of that exercise. A number of studies were carried out in which the heart rate was manipulated (either by administering sympathetic or parasympathetic blocking drugs or by varying the ambient temperature) during exercise or in which the workload, H.R. and $\dot{V}O_2$ were kept constant whilst the type of exercise being performed was varied. All of these showed that R.P.E. was not dependent on H.R., $\dot{V}O_2$ or workload (Ekblom & Goldbarg, 1971; Pandolf et al., 1972; Henriksson et al., 1972; Michael & Hackett, 1972; Nobel et al., 1973; Pandolf & Nobel, 1973). Instead, both Henriksson and Nobel suggested that proprioceptive feedback from the skeletal musculature could be responsible for our awareness of effort rather than the general reactions of the cardiovascular system. Other suggestions concerning the physiological basis of the R.P.E. have included blood lactate concentration and catecholamine excretion. Both these follow a power function in relation to workload, as does R.P.E. Again, blood lactate was shown to vary over different pieces of apparatus (Michael & Hackett, 1972) whilst there was little change in catecholamine levels until the "somewhat hard" point on the R.P.E. scale indicating that this too could not explain all the variation in the perception of exertion (Frankenhaeuser et al., 1969). Ekblom and Goldbarg (1971) subsequently proposed a two-factor model of perceived exertion. They suggested that both central and local factors were involved, predominance of which was dependent on the type of work being performed. In a review article on R.P.E., Pandolf (1978) took the two-factor theory a stage further. He found that the majority of work supports the involvement of local factors in R.P.E., usually using blood lactate, muscular/proprioceptive feedback and mechano or chemoreceptor sensitivity. From those investigations supporting the importance of central mechanisms in effort perception, heart rate appears as the principal factor despite the number of experimental situations in which the H.R./R.P.E. ratio can be disrupted.

Pandolf (1978) concludes that central factors "are not the primary factors in the subjective estimate of exercise exertion. Nevertheless, the possible contributory roles these cardiopulmonary responses may play in the overall sense of effort during physical work remains unquestioned." What the evidence does show is that there are two distinct perceptual systems each lending itself in varying proportions, depending on the type of exercise being performed, to the awareness of effort. Consequently, the use of a single scale with which to measure this awareness is regarded by Pandolf as being too imprecise. He suggests that Borg's R.P.E. scale is of a "superordinate" level (i.e. relating to a type of awareness that results from the integration of a variety of discrete sensations and feelings) and so may not necessarily be connected directly to underlying physiological substrata. He says "that the relationships between subjective ratings and specific physiological events during different types of physical work can be more precisely defined and compared using subordinate differentiated ratings which are close to the level of the discrete symptoms." The practical implication of this is that there should be three R.P.E. scales; one to indicate the feelings of strain in the working muscles (a "local" R.P.E. scale), one for sensations involving the cardiopulmonary systems (a "central" R.P.E. scale) and an "overall" general rating. This last rating should result from an integration of the subject's local and central feelings "...with whatever weightings they deem appropriate." He suggests that the use of differentiated ratings allows a sharper definition of the subjective feelings from the different physiological activities during exercise.

It can be appreciated that there is a certain parallelism between the loci of physiological responsivity as determined through the body boundary dimension and the division of the mechanism responsible for effort perception into two separate areas of the body: "man does not directly attend to physiological processes, per se, as a basis for perceived exertion ratings but does attend to the externalisation of these processes; i.e. increases in metabolic rate result in increases in V_E, rate of respiration and skin temperature which can be directly perceived." (Noble et al., 1973.)

1.1.5 Cognitive Style.

A schema that happily enfolds both the clinically founded body boundary dimension and the mathematically derived rating of perceived exertion is that of H.A.Witkin. He proposed (1965) that each person has a distinctive cognitive style which embodies each and every aspect of cognitive functioning. The principal aspect of cognitive style is the degree to which that person has a sense of separate identity. A person with a high degree of self-identity has an awareness of needs, feelings and attributes which they recognise as their own and which they identify as distinct from those of others. It is also associated with experience of the self as being structured and with having internal frames of reference to act as guides for definition of the self. This style is principally one of perception but due to the dependence of behavioural output on perceptual input, certain patterns of behaviour, both in terms of motor behaviour and personality, will also come to be associated with particular cognitive styles. Witkin's earlier experiments (Witkin & Asch, 1949) used perceptual tests such as the tilting room/tilting chair test and the rod and frame test. The first of these is basically a test of predominance of sensory mechanism in the determination of the verticality of the body. The subject is seated in a chair that can rotate about a horizontal axis in a frontal plane. The chair is within a small "room" that can also be rotated, independently of the chair, in a frontal plane with respect to the subject. Either the subject, the room or both are slanted off-vertical and the subject has to right himself. In the second test the task is once again to judge verticality, this time of a movable rod within a square frame that can be rotated. This frame is used to provide a visual basis for judging the vertical which may be in discordance with the subject's own sense of gravitational vertical. The more the subject's judgement of the vertical, whether of himself or of the rod, is influenced by the tilted room or frame then the more that subject's perception is mediated by external visual factors over internal proprioceptive ones. A person who is more attentive to visual cues is said to be more field-dependent. That is, he is dependent on cues from the surrounding "field" for body orientation. The subject who is more attentive to internal cues is said to be field-independent. Witkin regarded this split of reliance upon either external or internal cues as being the basis of perception both in physical terms and in psycho-dynamic ones. Furthermore, he believed that the manner in which one perceives is necessarily connected to the concept one has of one's own body (Witkin, 1954), with field-independent people having a more articulated body-concept than have field-dependents. That is, they have a more sophisticated body-concept due to a greater degree of differentiation of the self (the physical limits of the body) from the surrounding field. Witkin's definition of the body-concept is not unlike that of Fisher and Cleveland. He regarded the body-concept as "...the systematic impression an individual has of his body, cognitive and affective, conscious and unconscious."

The all-important link between the perceptual distinction and the modus operandi of other cognitive functions is the ability to separate an item from its context. In perceptual terms this means being able to separate the self from the non-self and, further, being able to separate parts of the self clearly from other parts. In the sphere of intellectual functioning this manifests itself as the difference in ability in solving problems that require isolation of essential items from their context and then using or presenting them in a different context. For example, the person more able to separate item from context would perform better at comprehension-type tasks.

Witkin labelled the two extremes of cognitive style as a "global" style at one pole and an "articulated" style at the other. The more articulated a person's style then the more able he or she would be at separating an element from its context. In terms of the body-concept, the articulated individual experiences his body as having definite limits or boundaries and the parts within as being discrete yet inter-related within a definite structure. This is also termed a "sophisticated" body-concept. At the opposite extreme, the individual wih an unsophisticated body concept (i.e. with a global cognitive style) regards the limits of his body as being diffuse, with his actions always being perceived with respect to the environment. He would also have a poor sense of the relative parts and movements of his body.

In terms of personality or social behaviour, Witkin regarded the degree of sophistication of the body-concept as being vitally important. Those people influenced in visual perception by the field would be equally influenced by the immediate social context in their perception and experience of themselves. For example, a person with an articulated cognitive style will be more self-reliant both in terms of self-assessment and self-esteem. A person of a more global disposition tends to rely more on external sources for definitions of attitudes, judgements and views of themself. He attends and reacts more to human faces than does an articulated person since the human face provides most non-verbal information as to how that other person feels. Being more dependent on human reaction, the global style person tends to be more easily persuaded by others in their perceptual and value judgements.

Since all sensory modalities were regarded as functioning within the same stylistic framework, the ability to extract internal proprioceptive data from conflicting, external visual data should echo the ability to extract an item from its context or background in a purely visual stimulus and in fact Witkin (1950) has not only shown this but has used it to produce a more manageable test. He found signifcant correlations between the "verticality" tests and an Embedded Figures Test (E.F.T.). This is based on a series of figures in which a simple pattern is hidden or embedded in a more complex one, the complex pattern being the field from which the subject has to discern the simple pattern (Witkin, 1950). Field-dependent people find the task harder than do independent ones since they are less able to dissociate the shape from the field; they therefore take longer to complete the task (see Figure 1.2.ii).

It is not enough merely to draw parallels between the three approaches introduced above. According to Witkin's model, all three resulting measures are related to each other by the cognitive style of the individual. This would be so even if each of the perceptual tests were for a different and specific sensory modality. That all three tests described above are relatively gross tests of a general body receptivity, however, is tantamount to saying that they must all be measuring a similar, if not the same, ability; that is, a general trait of body perceptivity. Consequently, it was hypothesised that the three tests would overlap to produce two principal relationships. Before stating these hypotheses, however, a number of factors concerning the tests themselves should be considered. The hypotheses, whilst developed directly from the described theoretical backgrounds, must also be viewed in the light of the measurement tools themselves. If it was safe to assume that the instruments that have been developed to measure the constructs of R.P.E., B.B.S./P.S. and field-dependence/independence did so perfectly then one could indeed expect to find in practice a similar degree of overlap to that predicted from theory. It is, however, unwise to make this assumption. There are two basic problems here. The first is true of any test instrument and that is "does the instrument accurately measure the construct being studied?" That is, is the instrument valid?

The R.P.E. scale was developed directly from an algorithm equating physical stimulus and perceptual response intensities. The perception of that physical stimulus, however, varies amongst individuals. According to Morgan (1973) individual differences in personality (which includes cognitive style) account for up to 33% of the variance exhibited in R.P.E. data. Although the stimulus intensity can be objectively quantified, the intensity of exertion perceived by an individual can not be. It is consequently impossible to validate the use of such a self-report scale since it is measuring a uniquely individual subjective quality. Despite this, in an attempt to validate the R.P.E. scale, Skinner et al. (1973) gave subjects both a progressively increasing workload exercise protocol and a randomly assigned workload exercise protocol and compared the ratings of each individual across all six workloads. The mean correlation was 0.79. This study, however, merely indicates the reliability of the subjects' use of the R.P.E. scale across different exercise protocols and does nothing to show that the scale is being used to reflect perceived exertion and not some other, related variable.

The B.B.S./P.S. instrument was developed directly from the very means by which the construct was originally detected. That is, the tool came first with the construct being founded upon the data provided by the tool. In this instance, therefore, the validity of the tool is not open to question since the construct (either B.B.S. or P.S.) is what the tool measures.

The E.F.T. was developed specifically to provide an easier means of measurement of perceptual field-dependence/independence. Again, the whole construct of perceptual style (and subsequently, cognitive style) grew from the original test instruments. The question of the validity of the E.F.T., therefore, would appear to require the comparison of its discriminatory powers with those of the original measurement tool, the rod & frame test. This relationship has been quoted as having a correlation coefficient of 0.59 (Oltman, 1968). One must bear in mind, however, that what was originally being measured by the rod & frame test was individual differences in the adherence to visual-over-vestibular senses. This has since been expanded, first into individual differences in the perceptul ability to separate figure-from-background and then into individual differences in overall cognitive style, the ability to extract relevency-from-irrelevency. Retreating one step to perceptual style, it may well be that the E.F.T. is a better test for this construct than is the original rod & frame test. One should, perhaps, be estimating the validity of the rod & frame test against the E.F.T. as a tool for the measurement of perceptual style rather than visa versa.

The second problem is "does the instrument measure this construct consistently?" That is, is the test reliable? A test-retest study on the R.P.E. scale indicated a correlation coefficient of 0.80 using a progressive exercise protocol (Skinner et al., 1973).

A number of test-retest studies have been performed on the B.B.S. instrument as have inter-scorer reliability studies. (It is a commonly held opinion that such projective tests have notoriously low reliabilities. Furthermore, this opinion is sometimes used as a "reason" for the tests present lack of use when it is more likely that such unpopularity is simply part of the ever-changing vogue in psychology, cognitive viewpoints presently enjoying general acceptance.) Of these studies, one found a correlation coefficient of 0.89. Three other studies found coefficients between 0.80 and 0.90, a fifth found a coefficient of 0.78, a sixth of 0.65 and a seventh of 0.40. All seven studies were by different authors, none of which were either Fisher or Cleveland. Inter-scorer reliabilities range from 0.97 to 0.82 for B.B.S. and from 0.99 to 0.83 on P.S. [All reliabilty coefficients quoted in Fisher & Cleveland, 1968.]

The E.F.T. has been shown to have a test-retest coefficient of 0.89 for a group of male and female college students over a period of three years (Bauman in Witkin et al., 1976).

Sources of variation between test and retest may be due to measurement error and/or to changes in the construct being measured; that is, they are dependent on the stability of the construct. Only if the construct is absolutely stable can test-retest variance be considered as being due entirely to measurement error. The question of stability will be returned to in due course, for the moment it is more practical to assume that there will be some individual variation in the "quantity" of a construct between tests, however small or for whatever reason. If these variations are similar across all subjects then the test-retest correlation coefficient will not suffer even though the means of the test on the two occassions may be different. In such instances, inter-test correlation can at best only equal the minimum test-retest coefficient. If this variance does not occur in a linear fashion, however but is subject to fluctuation on an individual basis ,that is the "error" variance is not due just to measurement error but also to unknown sources of variation, then there is a possibility of a greater inter-test correlation coefficient than would be obtained from the separate test-retest correlation coefficients. (As an illustrative example, suppose two measurement tools, "inches" and "centimetres", are being used to measure the lengths of several metal bars, the bars being of different lengths and metals. Further, suppose that the temperature between trial 1 and trial 2 of a test-retest experiment were different. The test-retest correlation coefficient would fall in correspondance to the temperature difference but if it was not known that temperature affected the length of metal bars then this variance would be classified as "error" variance. The inter-test correlation coefficient [between inches and centimetres], however, would remain as high on trial 2 as it was on trial 1 since the "unknown" source of error affects both measurement tools equally.) Whilst the different perceptual tests are not presumed to be as similar as "inches" and "centimetres", the same argument still holds albeit to a lesser degree. If Witkin is correct in his consideration of an overall perceptual style, one that would influence both R.P.E. and B.B.S./P.S., then as individual fluctuations in E.F.T. occur (that is, not neccesarily linearly consistent fluctuations across subjects), for whatever reason, parallel fluctuations in both R.P.E. and B.B.S./P.S. will follow. In these circumstances, whilst test-retest coefficients on each separate test may drop, inter-test correlations could still remain high. To assume linear variance across subjects when looking at individual differences is an assumption that is not necessarilly applicable. If one can not assume linear variation across subjects with time then test-retest correlation coefficients do not exact a true measure of test reliability.

Perceptual style, being a style, is thought to be fairly stable but it is open to cognitive influences which will fluctuate however well controlled the test-retest enviroment. The perception of exertion is dependent on personality and cognitive state. This too could be expected to fluctuate, the more so the greater the period between tests. Finally, B.B.S. is thought by Fisher & Cleveland to be trait-like but not absolutely fixed. P.S. is thought to be more susceptible to experiential occurances and is more of a state-like construct. It may well be, therefore, that the variation observed in test-retest studies is not all "error" variance but is, in part, to be expected due to the nature of the construct being measured.

In the case of these three perceptual tests, even if either absolute construct stability is assumed or if linear construct variation amongst subjects over time is assumed then the minimum test-retest coefficient of approximately 0.80 would mean that only 64% of the data variance is available for a possible association with other test measures. Without knowing or having an estimate of the population correlation coefficient (since the theory proposes an overlap but can not indicate to what degree) it is not possible to estimate objectively the number of subjects required to obtain such a result at the 0.05 level. Should it be decided, however, that an overlap of at least an eighth of the whole data variance, for example, is required before considering the two tests to be associated then the required N can be calculated. 0.125 of the whole variance is equivalent to 0.1953 of 64% of the whole variance. To obtain this level of shared variance requires a correlation coefficient of 0.4419. At the 0.5 level of significance (two-tailed) this would require at least 23 subjects. It is not felt, however, that the 36% "error" variance is necessarily unavailable for correlation (as argued above) and that only that error due to measurement (which can not be separated out) would not be available. If one were to allow 10% measurement error then 90% of the total variance would still be available for possible interaction. An eighth of the whole variance is equivalent to 0.1389 of 90% of the whole variance. This level of shared variance requires a correlation coefficient of 0.3727. At the 0.05 significance level this would require at least 29 subjects. The use of more than 29 subjects tends to increase the power of the "r" statistic; that is, one is less likely to reject a true, non-null hypothesis.

1.1.6 Hypotheses.

i) A person showing high field-independence on the E.F.T. would also show a well defined body-concept as measured by the B.B.S. and would demonstrate a high degree of accuracy of R.P.E.

ii) Differences in B.B.S. between subjects should be paralleled by differences in "central" and "local" R.P.E.accuracy scores such that those with a high B.B.S. would have a greater local over central R.P.E.

accuracy score than those subjects with a low B.B.S.

1.2 Method.

1.2.1 Exercise protocol and Rating of Perceived Exertion.

Exercise was performed on a "Powerjog" motorised treadmill and followed Astrand's protocol for determining $\dot{V}O_2max$. (Åstrand & Rodahl, 1970) in which the speed remains constant whilst the workload is increased by raising the slope 1.5 degrees every 3 minutes until the subject is unable to continue or a heart-rate of 200 bts/min is reached. Exercise testing was preceded by a 3 - 5 minute warm-up period which also allowed the subject to get used to the novel sensation of running on a treadmill. The initial speed for each subject was determined during this warm-up period, being based upon the subject's heart-rate response to the very low warm-up work-load. V_E and $\%O_2$ were continuously monitored using Washington respiratory flow and oxygen transducers; heart-rate was recorded for the last fifteen seconds of each minute of exercise on an Ormed (Devices) heart-rate meter and chart recorder. The R.P.E. scale was shown and explained to the subject and the division into local, central and overall R.P.E. was defined. Each subject was given a practice use of the scale during their warm-up. R.P.E. was taken after each minute, the scale (Figure 1.2.i) being positioned so the subject could see it for reference whilst running. Using data from all completed workloads, a Pearson correlation matrix was obtained for each subject of heart-rate, $\dot{V}O_2$, V_E, workload and the three R.P.E.

measures (overall, local and central). The correlation coefficient "r" between R.P.E. and each of the physiological variables thus obtained was used as a measure of the ability of the individual to perceive their own exertion accurately; this accuracy score was based upon the assumption that the physiological activity of the body gave a "true" indication of the physical exertion.

[The R.P.E.scale was arranged by Borg to correspond to approximately one-tenth of the subjects's heart-rate; for example, at a workload that elicited an heart-rate of 170, the subject would give a R.P.E. of 17. It should be noted that the scale was constructed using data from work performed solely on a bicycle ergometer and by healthy, middle-aged men performing moderate to hard work. Consequently, it must be expected that for a different population performing a different type of activity, the constant relating H.R. and R.P.E. will change even though the degree of correlation should not.]

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 1.2.i: "Borg's R.P.E. scale (1970)."

1.2.2 The Embedded Figures Test.

Witkin's Embedded Figures Test was administered following his own protocol (1950) in which the complex figure is shown to the subject for 15 seconds, followed by the simple figure for 10 seconds and then the complex figure again until the subject correctly perceives and indicates the hidden simple shape within it (Figure 1.2.ii). The time taken to find the embedded figure is the score for that card; there were 24 cards in total.

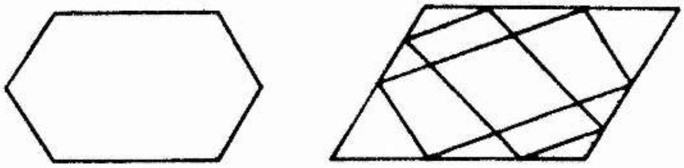


Figure 1.2.ii: "A simple and complex figure pair from Witkin's E.F.T."

1.2.3 Body Barrier Score & Penetration Score.

Fisher and Cleveland's B.B.S. and P.S. were scored from responses to the Rorshach Ink-blots following their own specific instructions (Fisher & Cleveland, 1958/68); this test, like the others, was administered individually. Each subject was shown the ten cards (some twice, some three times according to the test's instructions), giving a total of twenty-four responses. The actual marking system employed by Fisher and Cleveland is fairly involved and it would serve little purpose to reiterate it here in its entirety; its major guidelines, however, are relatively simple and will provide some idea of the links between the perceived image and the resultant barrier or boundary score. Fisher and Cleveland found two broad categories of response that related to boundaries or surfaces. "One group of references had to do with assigning definite structure, definite substance, and definite surface qualities to the bounding peripheries of things. These references took such diverse forms as noting the unusual fuzziness of the skin of an animal, emphasizing the decorative pattern of a surface, or elaborating upon the clothing worn by a person. The emphasis here was upon the positiveness and definiteness of boundaries. Percepts containing such references were labelled 'Barrier responses'. A second group of references, which was the basis for another boundary score, had to do with boundary peripheries only in the negative sense of emphasizing their weakness, lack of substance, and penetrability. Responses of this sort concerned surfaces being broken, destroyed, or absent. They were labelled 'Penetration of Boundary responses'."

1.2.4 Subjects.

The subjects were all students (25 male and 18 female subjects) aged between 18 and 30 (mean = 20.4) and of widely varying athletic backgrounds and VO_2 max. Height and weight were measured and the Ponderal Index (P.I.= $Ht/\sqrt[3]{Wt}$) was calculated for each subject. This last index is commonly used in the somatotyping of body shape and is a measure of relative linearity. These physical parameters of body size and shape were incorporated into the study since it was felt that they may be influential in the formation of an overall body concept. Strong relationships between P.I. and self-efficacy, self-esteem and R.P.E. have been found (Doust et al., 1986).

1.3 Results.

Throughout this thesis, two-tailed tests of probability have been used unless the direction of the relationship under consideration has been previously hypothesized following sound theoretical bases. The hypotheses concerning this section have been given above.

1.3.1 Overall Pearson Correlations.

The high degree of correlation usually found between workload, heart-rate, $\dot{V}O_2$ and V_E during exercise (Åstrand & Rodahl, 1970; Matthews & Fox, 1974) was observed. The various "accuracy" scores relating R.P.E. to workload, V_E, $\dot{V}O_2$ and Heart-rate (Table 1.3.i) were consequently fairly similar.

	R.P.E.c	R.P.E.o	R.P.E.l
V_E	0.8601	0.8842	0.8881
Workload	0.8562	0.8735	0.8841
$\dot{V}O_2$	0.8340	0.8410	0.8547
Heart-rate	0.8257	0.8297	0.8404

Table 1.3.i: "Mean R.P.E.accuracy scores (R.P.E. compared to underlying physiological changes)."

[R.P.E.c = central; R.P.E.o = overall; R.P.E.l = local.]

All correlation coefficients underwent Fisher's Z transformation before the following statistical tests were carried out. An analysis of variance was performed on the transformed data. (Only R.P.E.l and R.P.E.c data were used since it was felt that the R.P.E.o data could not realistically be considered as being independent of the other two, this because the "overall" rating is formed from a combination of central and local perceptual inputs.)

Source of Variation	F	Significance of F
R.P.E. type	0.032	0.859
Physiological measure type	3.691	0.012
Sex	4.021	0.046

None of the interactions were statistically significant though that between Sex and R.P.E. type indicated a tendency for the pattern of R.P.E. accuracy scores between the male and female subjects to differ ($F = 3.32$, $p = 0.069$). This relationship is examined more closely below.

Of the twelve effort-estimate accuracy scores (three R.P.E.s for each of heart-rate, workload, $\dot{V}O_2$ and V_E) only those for $\dot{V}O_2$ and V_E were found to correlate significantly with any other awareness measures. All twelve had many inter-correlations with each other indicating the closeness with which changes in physiological function accompanied the changes in the physical workload (see Appendix Ai).

1.3.2 Separate data analyses for each sex.

Fisher & Cleveland (1968) reported differences in mean B.B.S. scores such that female subjects scored significantly higher than did male subjects. Witkin (1950) reported differences in the variance of E.F.T scores between male and female subjects (such that the female subjects showed greater variance) though this did not quite achieve significance at the 0.05 level (var. ratio = 1.53, df = 50,50). The above data also tend to suggest differences between the sexes in the use of the local and central R.P.E. scales. Furthermore, an initial scan of the separate correlations matrices (Appendices Aii & Aiii) suggested that sex played a decisive and possibly divisive role in the relationships between the various perceptual tests and physiological measures. Consequently, it was decided initially to analyse the data separately for each sex and then, subsequently, to compare across the subject groups. Tables 1.3.ii and 1.3.iii are the mean R.P.E.accuracy scores for male and female subjects. Since this split of the subject group was not anticipated in the above hypotheses, all probabilities quoted below are two-tailed.

	R.P.E.c	R.P.E.o	R.P.E.l
V_E	0.9370	0.9226	0.9117
Workload	0.8791	0.8763	0.8896
$\dot{V}O_2$	0.9261	0.9061	0.8963
Heart-rate	0.8670	0.8580	0.8562

Table 1.3.ii: "Mean R.P.E.accuracy scores of male subjects (R.P.E. judgements compared to underlying physiological changes)."

	R.P.E.c	R.P.E.o	R.P.E.l
V_E	0.7534	0.8308	0.8553
Workload	0.8226	0.8696	0.8759
$\dot{V}O_2$	0.7062	0.7506	0.7969
Heart-rate	0.7683	0.7903	0.8185

Table 1.3.iii: "Mean R.P.E.accuracy scores of female subjects (R.P.E. judgements compared to underlying physiological changes)."

It can immediately be seen that there are basic differences in the pattern of the tables. The male subjects generally showed greater accuracy in their central R.P.E. judgments than in their local R.P.E. judgements whilst the female subjects demonstrated a greater accuracy in their local R.P.E. judgements over their central ones. It was these pattern differences that were indicated by the interaction of Sex with R.P.E.type noted earlier ($F = 3.32$, $p = 0.069$). Separate Oneway analyses of variance failed to find statistically significant differences between R.P.E.type for either sex.

An ordering of the data can also be observed across the types of physiological measurement such that the male subjects were most accurate when V_E, was being used as the physiological parameter against which R.P.E. was being compared, with H.R. being associated with the least accurate estimates of effort (the complete order from most to least accurate being: V_E, $\dot{V}O_2$, WkLd., H.R.). For the female subjects the order was different (most accurate to least accurate generally being: WkLd., V_E, H.R., $\dot{V}O_2$).

Separate oneway analyses of variance for each R.P.E. scale (overall, local and central) indicated, however, that this patterning was only statistically significant for the male subject data and only when R.P.E.c was the dependent variable ($F = 4.45$, $p < 0.025$).

Separate Pearson correlations for male and female subject groups yielded a number of different relationships, many of which were hidden in the original, overall correlation matrix (see Appendices Aii and Aiii). The splitting of the subject pool into male and female sub-groups causes some problems with respect to significance levels of the correlation coefficient. Firstly, a correlation coefficient as low as 0.3727 (corresponding to a sharing of one-eighth of the total sub-group data variance) could only be statistically significant at > 0.05 level if less than 29 subjects were available. This means that for both sub-groups an overlap of more than one-eighth would have to be required before a sufficient association between the tests to support the theoretical background could be said to exist. That is, the power of the statistical test is greatly reduced and it becomes more likely that a true, non-null hypothesis will be wrongly rejected. Secondly, the two sub-groups are unequal in size. This has the effect of making it less likely for the female sub-group to show statistically significant associations than for the male sub-group. Whilst both these factors must be considered when examining these results, it is generally the case that the non-significant correlation coefficients are very low and that the size of N makes little difference in the acceptance or non-acceptance of the correlation coefficient as being statistically significant.

1.3.2.1 R.P.E.accuracy and B.B.S./P.S.

(a) Male subjects.

There were no significant correlations between any of the R.P.E.accuracy scores and either B.B.S. or P.S.

The differences for the four pairs of R.P.E.l and R.P.E.c accuracy scores were calculated for each subject. None of these were significantly correlated with B.B.S. (see Appendix Aiv).

(b) Female subjects.

Only the relationship between B.B.S. and V_E/R.P.E.c was significant but this was in the opposite direction to that expected ($r = -0.5940$, $p < 0.01$). Although not statistically significant, the other associations of R.P.E.accuracy and B.B.S. were similarly negative.

Pearson correlation of B.B.S. with the V_E/R.P.E. difference and the $\dot{V}O_2$/R.P.E difference (local - central) were both significant ($r = 0.4838$ and $r = 0.4911$ respectively, $p < 0.05$ for both).

1.3.2.2 B.B.S./P.S. and E.F.T.

(a) Male subjects.

There was a negative correlation between B.B.S. and E.F.T. ($r = -0.4314$, $p < 0.05$). Despite the statistical significance of this correlation, the scatter diagram of these data (Appendix Av) does not appear to be evenly distributed along both axes. It was consequently decided to examine this relationship in more detail.

(b) Female subjects.

There were no significant correlations between these perceptual tests.

In order to further examine the B.B.S./E.F.T. relationship, the subject pool was re-grouped according to sex and B.B.S. score, each sex being split into a high and a low B.B.S. group. (High B.B.S. group were those subjects with a score of six or over, the low B.B.S. group were defined as those with a score of three or less.) This gave N = 6 & 10 for male high and low B.B.S. groups respectively and N = 7 & 4 for female high and low B.B.S. groups respectively. Analysis of this data re-emphasized the sex related differences. The male B.B.S. groups showed non-homogeneity of variance such that the high B.B.S. group data had a significantly smaller variance than did the low B.B.S. group data ($F = 32.02$, $p = 0.001$). This inequality of variance can be seen in the scatter diagram of the data and indicates that although male subjects who are field-independent also tend to have higher Body Barrier Scores, the equivalent can not be said for the other end of the scales. Thus it would seem that only those (male) people with a greater sophistication of body concept would demonstrate as much across different types of perceptual-awareness tests whereas those with a lower level would tend to score more randomly across different tests. A Mann-Whitney U test was used to test whether the two groups were drawn from the same population with respect to their scores on the E.F.T. Significant differences were found ($U = 10$, $p < 0.05$) such that the high B.B.S. group took less time to complete the E.F.T.; that is, they were more field-independent. The female B.B.S. groups did not show a significant difference in E.F.T. scores ($t = -0.88$, $p > 0.4$). Given the small size of the t statistic, it is not thought that the differences in subject numbers between the male and female groups contributed significantly to the different associations between E.F.T and B.B.S that were found. The female subjects did, however, show a significant difference in P.S. scores (which the males did not) with the high B.B.S. group having significantly lower P.S. scores than the low B.B.S. group ($t = 2.99$, $p < 0.025$).

1.3.2.3 E.F.T. and R.P.E.accuracy.

Only one R.P.E.accuracy score showed a significant correlation with E.F.T. This was for the male data only and involved the Workload/R.P.E.c score ($r = 0.3978$, $p < 0.05$). It should perhaps be noted, however, that for the female data, the Workload/R.P.E.o score approached statistical significance ($r = 0.4240$, $p = 0.09$). It may be that had there been a similar number of female subjects as there were male then this too would have achieved statistical significance. It is of course equally possible that more female subject data would have resulted in a lower correlation coefficient. The disparity between the male and female subject numbers and therefore between the ability of the correlation coefficient to indicate divergence from the null hypothesis should, however, be borne in mind. Having said this, it can be seen from the correlation matrix (Appendix Aiv) that the other R.P.E.accuracy scores had very little association with the other perceptual test scores. It is not felt, therefore, that the different patterns of relationships found between the two sexes is due to differences in the power of the statistics used.

1.3.2.4 Other relationships.

(a) Male subjects.

B.B.S. correlated with age ($r = -0.4025$, $p < 0.05$).
P.I. was seen to correlate positively and significantly with P.S. ($r = 0.5266$, $p < 0.01$) and with height ($r = 0.4655$, $p < 0.025$).

(b) Female subjects.

E.F.T. tended to be positively correlated with age ($r = 0.4506$, $p = 0.060$).

1.3.3 Comparison of the two sexes.

(a) There were no significant differences in mean E.F.T. scores between male and female subjects ($t = 0.2$, $p > 0.5$) which is contrary to Witkin's own findings (1950). It should be noted, however, that differences in the variances of the male and female data approached statistical significance (variance ratio = 2.507 and $F_{.975}(24,17) = 2.55$). This tendency does echo that found by Witkin (1950).

(b) A t-test on the mean B.B.S. scores for the male and female subject groups showed no significant differences though the trend ($t = 1.56$, $p = 0.118$) was for the female subjects to have higher barrier scores than the male subjects (female mean = 5.39 ± 2.6, male mean = 4.20 ± 2.3).
There were no significant differences in P.S. between the two sexes.

(c) As well as the differences in order of R.P.E.accuracy scores with respect to R.P.E. type and physiological measurement (as described above), a Oneway analysis of variance using only R.P.E.1 and R.P.E.c data from Tables 1.3.ii and 1.3.iii ($F = 20.74$, $p = 0.001$) indicated that there were differences in R.P.E.accuracy between the two sexes with the male subjects being generally more accurate in their effort estimates than the female subjects.

1.4 Discussion

The highest agreements between R.P.E. and physiological function for the male subject group and also for the combined subjects group were those involving measures of pulmonary function. Whilst this does not prove a direct link between the two it does imply that a person is more likely to be basing their judgement of bodily exertion upon some aspect of pulmonary functioning rather than upon heart-rate. [It has since been shown in a related study (Davis, 1983) that a person's estimate of perceived exertion follows his cumulative volume significantly more closely than it does heart-rate during treadmill exercise.] This may be because the act of breathing would initiate both central (e.g. carbon dioxide content of the blood) and local (e.g. proprioceptive feedback from the intercostal muscles) perceptions of effort thus providing more information from which to draw a subjective estimate of that effort.

It is perhaps worthy of note that the interaction of sex on R.P.E.accuracy across R.P.E. type (cental and local) does tend to support hypothesis ii in that the female subjects, who are more accurate when estimating local R.P.E.s than central R.P.E.s, also score more highly than the men (whose R.P.E.accuracy tends to be in the reverse order) on B.B.S. That is, the female subjects are more receptive or attentive to the outside of their bodies than they are to the inside. Hypothesis ii was further supported, for the female subjects at least, by the significant association of B.B.S. with the diference between local and central R.P.E.accuracy scores on two of the physiological parameters.

The male subjects demonstrated a lack of association between body awareness as measured by any of the R.P.E.accuracy scores per se and that measured by B.B.S. or P.S. The female subjects, however, tended to demonstrate an association in the opposite direction to that predicted. One possible explanation of this phenomenon is that the task itself (treadmill running under the given protocol) may tend to invoke central rather than local physiological cues. Consequently, people who attend more to central activity (i.e. male subjects) would have generally better estimates of effort since they would have more information at their disposal upon which to base their estimates. Thus the differences between the two sexes in degree of awareness for the outside of the body as opposed to the inside could cause the different ordering effects observed between central, overall and local R.P.E.s whilst the nature of the task itself could amplify this difference so that all effort estimates to do with this particular task would be more accurate the more one is centrally attentive.

It would seem from the present study that the relationship of B.B.S. and P.S. with E.F.T. is associated with sex differences with men exhibiting a definite connection between

E.F.T. and B.B.S in the theoretically predicted direction and women exhibiting a definite inverse connection between B.B.S. and P.S. (This is different from previous work by Siegal (1977) in which no correlation between E.F.T. and B.B.S. was shown, with the same study also finding no correlation between B.B.S. and P.S. though at the same time predicting that there should be.) Interactions of sex on body perception may account for the lack of overall correlation found in previous studies.

1.4.1 Summary of findings.

1.4.1.1 Hypothesis I:

Male subjects demonstrated the predicted relationships between E.F.T. and B.B.S.; i.e. that field independent people would have higher B.B.Scores. The predicted relationship between E.F.T and R.P.E.accuracy and between R.P.E.accuracy and B.B.S. were not, however, apparent.

The female subjects demonstrated a totally different pattern of relationships. No association was found between E.F.T. and B.B.S. nor between E.F.T. and R.P.E.accuracy. A negative correlation was found between B.B.S. and R.P.E.c acccuracy with the other R.P.E.accuracy scores showing non-significant associations in the same direction (i.e. a higher B.B.S. was correlated with a lower R.P.E.accuracy). Such relationships are contrary to that predicted.

1.4.1.2 Hypothesis II:

Again, marked differences between the sexes were demonstrated. Whereas the male subjects showed no relationships between B.B.S. and a predisposition toward greater R.P.E.l accuracy over R.P.E.c accuracy, significant relationships in the predicted direction were found for the female subjects indicating that those females with a greater awareness of their body boundary showed greater local (i.e. muscular) than central (i.e. visceral) R.P.E.accuracy.

The results from this first investigation could be regarded as being indicative of a lack of an overall perceptual style influencing the many perceptual abilities subsumed beneath it. The fact that some parts of the original hypotheses were shown to be correct, however, still indicated that perceptual style as measured by the E.F.T. did share some form of relationship with certain other perceptual measures and since no definite relationship between R.P.E.accuracy and E.F.T. had so far been found, it was decided to look at this area more closely.

1.5 Experiment Two:

1.5.1 Method.

The top and bottom scorers on the E.F.T. (fast and slow groups), both male and female, were re-tested for R.P.E.accuracy. It was hoped to be able to use the top and bottom twelve people of each sex but problems of subject availability reduced the numbers to n = 9 male subjects and n = 7 female subjects. A different treadmill protocol was used. Using data from the previous study, a workload was calculated for each subject such that it should elicit an R.P.E. of approximately 13; i.e. each subject would be working at subjectively the same workload. Each subject was then given eight trials of three minutes running separated by five minutes rest. Of the eight trials, five were the same physical workload whilst three were varied by changing either the slope, the speed or both of the treadmill. The subjects were told that the physical workload would change randomly for each trial and were given no indication that five of the trials would be the same. In between each trial the speed and slope were set back to zero, thus each trial began with a "new" setting of the workload.

Heart-rate was measured over the last fifteen seconds of the third minute and the three R.P.E.s were asked for immediately upon completion of each trial.

Only the five similar trials were used in the analysis. The variance over the R.P.E. scores was calculated for each subject and this was used as the new R.P.E.accuracy score; the lower the variance then the higher the ability to perceive exertion accurately. The variance of the heart-rate measures over the five trials was also calculated for each subject. The mean R.P.E.accuracy score was then calculated for each of the four groups.

1.5.2 Results.

The mean variances in heart-rates of each group were not significantly different, nor were the mean R.P.E. values.

Subject	FAST			SLOW		
	RPEc	RPEo	RPEl	RPEc	RPEo	RPEl
1	0.843	0.422	0.527	2.669	2.593	2.669
2	0.816	0.816	0.699	1.476	1.506	1.229
3	0.823	0.738	0.876	0.782	0.707	0.866
4	0.567	0.422	0.527	2.757	2.584	2.584
5				0.675	0.675	0.667

Table 1.5.i: "R.P.E.accuracy scores (variance over five trials) for Male Fast and Slow E.F.T. groups."

Subject	FAST			SLOW		
	RPEc	RPEo	RPEl	RPEc	RPEo	RPEl
1	1.287	1.287	1.418	2.108	1.936	1.414
2	1.075	0.928	1.059	1.197	1.001	0.422
3	0.817	1.000	1.500	1.265	1.370	1.160
4	2.098	1.663	1.509			

Table 1.5.ii: "R.P.E.accuracy scores (variance over five trials) for Female Fast and Slow E.F.T. groups."

The relationship between the two tests of perception was different for the two sexes. There were no differences in effort-estimate accuracy scores between the female high and low E.F.T. groups. The male group data demonstrated

non-homogeneity of variance for all three R.P.E.accuracy scores between the fast and slow groups thus the t-test was inappropriate. Instead the randomisation test (Siegal, 1956) was performed on the male data, this being a non-parametric equivalent of the t-test that can utilize interval level data. It indicated a significant differences in R.P.E.1 accuracy scores between the high and low E.F.T. groups and in R.P.E.o accuracy scores between the two groups ($p < 0.05$, one-tailed, for both accuracy scores).
When an average of all three R.P.E.accuracy scores for each subject was calculated, the randomisation test indicated an overall significant difference between the fast and slow E.F.T. groups such that the field-independent subjects showed greater accuracy in their R.P.E. judgements.

The mean variances in heart-rates of each group were not significantly different nor were the mean R.P.E. values.

1.5.3 Discussion of Experiment Two.

The relationships between E.F.T. and R.P.E.accuracy for the male subjects follows the original hypothesis that the more field-independent an individual then the more accurate would be his perception of physical exertion. This difference in accuracy scores between the two groups was not due to physiological differences nor to differences in the level of the subjective rating of the workload since these measures were homogenous across the experimental groups.

The female subjects, however, continued to demonstrate no relationship between the two measures. This, together with the fact that it required the polarisation of the field-dependent/independent continuum to demonstrate a relationship in the male subjects, indicates that whilst the two tests do show some overlap, they are by no means measuring the exact same quality of body awareness.

1.6 Overall Inter-relations Of Body Awareness Measures.

The relationships between the various perceptual tests are best explained separately for each sex; Figures 1.6.i and 1.6.ii summarize the findings from both experiments.

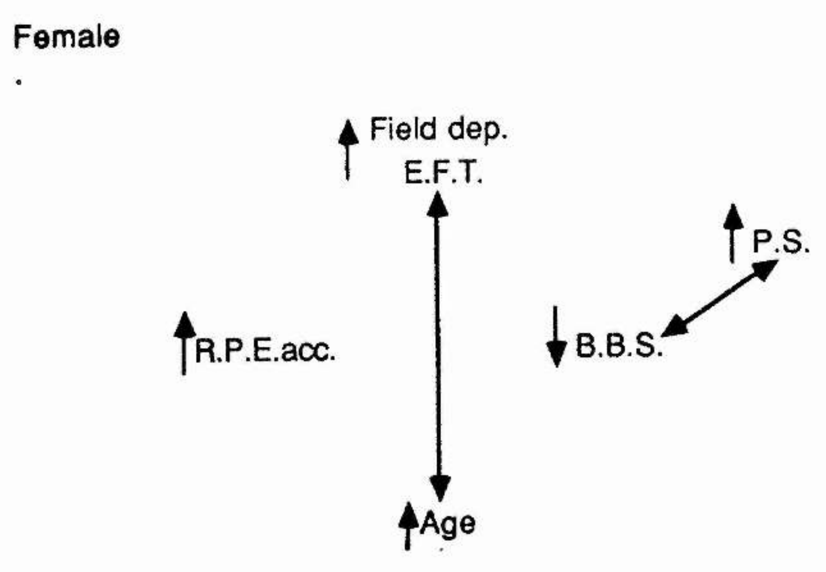


Figure 1.6.i: "Relationships between perceptual tests for female subjects."

Male

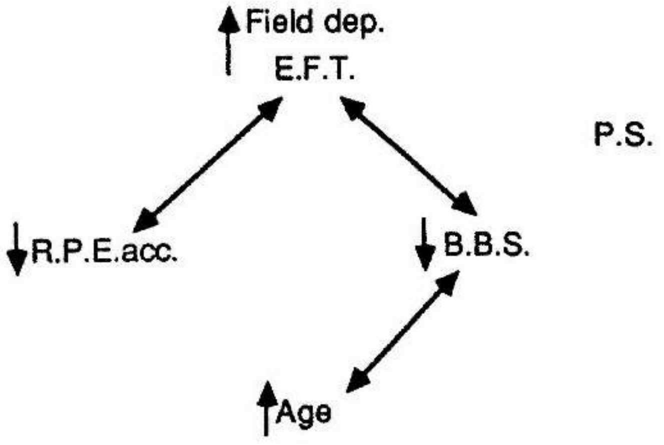


Figure 1.6.ii: "Relationships between perceptual tests for male subjects."

As can be seen from the diagrams, the variable age also seems to play a contributing role in the variation in the data, generally being associated with an increase in field-dependence (the more so in women) and with a reduction in body barrier score (the more so in men). Thus as one gets older one's body concept sophistication tends to drop. Considering the age range of the subject population (mean = 20.4; stnd.dev. = 1.45 years) this is quite an unexpected finding. For a larger age range it could be suggested that as one gets older and participates in less physical activity so one's body awareness is reduced accordingly but over the small age range in this study this seems an unlikely explanation.

1.7 Conclusion.

The lack of strong relationships between the three perceptual tests found in the original correlation matrix was due principally to the differences in these relationships exhibited by the two sexes. Upon more detailed analysis of the data and a further study to clarify one of the relationships, it was found that whilst men are fairly consistent in their performance across the various tests, women showed results that conflicted with the hypothesized relationships between them. These differences between the perceptual abilities of the two sexes echo to some extent those found in other tests of spatial and perceptual abilities but do little to throw light upon any causal relationships.

Despite the possible clouding of any precise relationships between the various perceptual tests due to the interactions of sex on the data, it is quite apparent that the original hypothesis concerning an all-encompassing style of perceptual functioning is not strongly borne out. On the other hand, the three principal perceptual tests are not totally orthogonal to each other either. Thus, each would appear to be measuring some aspect or aspects of perceptual functioning which are similarly being measured, at least in part, by one or more of the other two tests. Any differences between the sexes in the relative importance of even one of these aspects, with respect to an overall perceptual test, would tend to cause differences in the general relationships between such composite perceptual abilities. These differences would be too subtle to be detected clearly when using the "parent" test but may be quite marked should it be possible to separate these various aspects into individual, measurable perceptual abilities.

Despite the apparent plausability (not to say "appeal") therefore, of Witkin's conception of a single cognitive and perceptual style governing all avenues of our behaviour and which should theoretically be measurable via a number of different body-awareness measurement techniques, it consequently may be more profitable to break down these overall perceptual styles into more specific perceptual abilities and analyse an individual's behaviour in terms of a perceptual ability profile rather than in terms of a single perceptual style. Section two will endeavour to do just this.

2 STUDY TWO

2.1 Introduction.

It was contended in the foreword that there is no way in which motor output can be appropriate to real motor needs if the perception of those needs is incorrect. This is simply because the perceptual act comes before the motor act. If the feedback from the motor act is also incorrectly perceived then the motor output will be doubly damned in that it can not be adequately rectified. If Witkin's theory of cognitive (and consequently perceptual) style is to be accepted then this double fault is to be expected since an inability to perceive external stimuli with clarity will be necessarily associated with an inability to perceive internal stimuli, i.e. proprioceptive feedback, with clarity. What is more, the ensuing lack of motor control would be expected to be apparent in all aspects of motor behaviour because of the all-pervasive nature of the perceptual inaccuracy.

A more common term for the inefficiency of movement is "clumsiness" and this very use of a single word to cover a wide range of inappropriate motor behaviour has led to a linguistic understanding of the concept of motor inability as being a unitary one. Upon deeper examination of the term's usage, however, it was found that even though people assume that they are all referring to the same qualities of behaviour in assigning the adjective "clumsy", the criteria for judgement can in fact be quite different. Keogh et al.(1979) asked three groups to assess the motor efficiencies of a number of school children. The classroom teachers rated the children on a movement skill checklist. Physical Education teachers did the same and the third group, the experimenters, examined the children on a number of movement skill tests. None of the three groups agreed on which children had movement problems leading Keogh to conclude: "Lack of agreement among identification procedures indicates the need to use a multiple measurement process and demonstrates the difficulty in characterising the nature of movement problems."

Gubbay (1975), approaching the subject of children's motor behaviour problems from a more clinical background, had found similar difficulties with the usage of the word "clumsy", saying that "abnormally clumsy" would be a more precise way of defining those children with movement inabilities since everybody could be placed on a motor ability continuum on which clumsy is but a relative term. Furthermore, he regards clumsy behaviour as usually being but a "manifestation of a broader concept of dysfunction affecting all skills that have developed as a part of the total intellect" and goes on to say: "Clumsiness could be regarded therefore as an all-inclusive end-product of differing aetiologies implying heterogenous pathophysiology." Despite this heterogenous pathophysiology, Gubbay regards abnormal clumsiness as stemming principally from a single cause, this being minor brain damage caused by anoxia during a troubled delivery at birth. The point about minor damage should be emphasized since overt physical damage to brain or nervous tissue is evidence of a clinical condition and does not come under the umbrella of clumsiness. Gubbay, who adopted the term minimal cerebral dysfunction (M.C.D.) as a generic expression for clumsiness, gives the following definition of a clumsy child: "...one who is mentally normal, without bodily deformity and whose physical strength, sensation and co-ordination are virtually normal by the standards of routine conventional neurological assessment, but whose ability to perform skilled, purposive movement is impaired. This type of clumsiness is designated by the neurological term 'apraxia'. As praxis and gnosis are so closely allied and are interdependent in the performance of skilled movement, a defect in one will result in a disturbance of the other."

The terms "apraxia" and "agnosia" cover slightly different aspects of perceptual-motor inability. Gubbay describes apraxia as "the inability to move a certain part of the body in accordance with the proposed purpose, the motility of the part being otherwise presrved." It should be emphasised that apraxic individuals have perfectly sound motor control, their difficulty is in deciding which movements are applicable to the situation. Thus the defect of apraxia is not in the organisation of movement but in the ability to translate a proposition into movement (Denny-Brown, 1966 in Gubbay, 1975). Agnosia on the other hand, is "an inability to recognise the significance of sensory stimuli" (Ellis, 1967). The condition of agnosia is characterised by the loss of ability to comprehend the meaning or recognise the importance of various types of stimulation and is actually a perceptive defect (Gubbay, 1975). Others, reasoning that perception and the plan of action can not be realistically separated, used "apractognosia" as a more inclusive term for clumsiness (Kephart, 1971).

Despite the general use of the term clumsy implying a general state of impaired perceptual-motor functioning, data concerning the symptoms of clumsiness indicate rather the nature of its specificity. In fact, clumsy children tend to show an inability to perform one physical act whilst demonstrating normal levels of dexterity for another. Furthermore, most clumsy children demonstrate normal or above-average intelligence. Both these points echo Keogh et al. (1979) in that they serve to indicate that there is no single, general perceptual-motor cum intellectual cognitive ability but rather an array of more specialised abilities, each being concerned with a specific sphere of operations. Since there is no observable damage to nerve tissue, supposition about the location of dysfunction has generally come from observations of more obviously brain damaged patients who exhibit similar, if more intense, symptoms to those of clumsy people. In a survey of relevant material on visual agnosias, Ettinger et al. (1957) conclude that the problem lay in a restriction of the field of visual attention rather than of visual perception with the principal damage site being the right occipito-parietal region of the cortex. More recently other areas of the cortex have been associated with agnosias specific to particular visual stimuli (for example, prosopagnosia, the inability to recognise faces, has been found to be associated with damage to certain parts of the occipitotemporal lobes (Gilinsky, 1984). Cells located in similar visual projection areas have recently been found that are receptive specifically to limb articulation and motion in particular orientations (Perrett et al., 1985). It is conceivable that damage to this area of the cortex could have a marked influence on a person's perception of the relevance of body movement, both of another individual and of oneself.

The clinically based approach tends, therefore, to support the contention that perceptual-motor ability is multi-faceted in that the causes are, even in the simplest analysis, dual ones (apraxia and agnosia) with the more specific nature of each of these being subject to specific pathological defects.

The experimental study of skilled performance has also tended to promote the idea that perceptual-motor tasks require the correct combination of a number of more basic abilities, a dysfunction in any of which would lead to an inability to perform the designated task. Unfortunately, most of the work concerning perceptual-motor performance in adults has been heavily biased toward the motor skill aspects rather than the perceptual ability aspects. Whilst the two are undoubtedly related, it is the perceptual abilities that are the antecedents of the motor skills and, as such, should be foremost in the analysis of perceptual-motor behaviour. Much of the motor flavour of previous work can be ascribed to the fact that the objective of the research was to find practical answers to specific perceptual-motor problems and whilst a motor analysis does seem to have been useful in many cases this process is somewhat akin to a doctor treating the symptoms of an illness whilst never understanding their cause. Over a number of years, Fleishman (1966) conducted many perceptual-motor tests for the United States Air Force with the emphasis being on finding tasks that would act as good predictors of future pilot success. Most of these tasks were thus directly related to actual motor tasks a pilot would have to accomplish within a cockpit and were consequently limited in their range of movement requirements. Despite, therefore, looking at what were undoubtedly tasks requiring both perceptual and motor skills, Fleishman's analysis of such skills tended to be limited and biased toward their motor similarity.

During the sixties and early seventies a number of test batteries were created to screen for perceptual-motor problems in children (Brenner & Gillman, 1967; Stott from Whiting et al., 1969; Kephart, 1971; Gubbay, 1972; Orpet, 1972; Arnheim & Sinclair, 1974; Keogh et al., 1979). The majority of these were developed following Piaget's theories concerning the developmental stages of perceptual and cognitive functioning.

The reasons for the intense interest in the correction of movement disorders in children are principally two-fold. The first is the supposed neurological maleability of young children compared to that of adults. If damage to a particular area of the brain results in the loss of potential perceptual or motor pathways then it was thought that particular forms of training will promote the formation of alternative pathways via undamaged areas of the brain. The sooner such stimulation is begun then the more likelihood there is of success since the brain's preferred pathways will not have become stabilized. The ages of 3 to 6 years old are perhaps the main years for corrective therapy since before this it is difficult to detect the relatively slight perceptual-motor defects due to M.C.D. and after this the neuronal stability renders any corrective therapy that much more difficult (Gubbay, 1975). The second reason is the supposed importance of movement ability in children with respect to their peer group sociability. Though conclusive evidence has yet to be found, physical athleticism is generally seen as being important in the determination of the regard that boys have for each other, though not necessarily for girls. The self-esteem consequent upon such athleticism and its associated peer approval is similarly regarded as being an important influence upon the subsequent integration and socialisation of the child (Kagan & Moss, 1962; Cratty, 1967; Dibiase & Hjelle, 1968; Whiting, 1973; Harris, 1973).

Despite the intense interest in the detecton and treatment of perceptual-motor disorders in children, a similar regard for the clumsy adult does not appear to exist. This could be because adults have been regarded as being "untreatable" for this condition or, more likely, because the problem was not seen as being sufficiently serious to deserve attention; this point is discussed at greater length in Section 2.4.8.1. Whatever the reasons for this dearth of interest, test batteries for a normal adult population, similar to those for children, have not been devised. The requirements for the child tests were all far too simple to be useful as tools in discerning the perceptual-motor range of adults (e.g. hopping three times on one foot). Furthermore, all the child tests were geared towards detecting the low achiever rather than measuring both ends of the ability continuum. Since the purpose of this series of studies was to examine perceptual style and perceptual-motor abilities, it was necessary to have a range of tests that were able to quantify all types of style or levels of ability.

In the absence of a coherent series of perceptual-motor tests for "normal" adults, it was decided that such a battery would need to be created. In order to work within some form of validated framework, recourse was initially made to the children's test batteries referred to above.

In addition to the perceptual-motor ability test battery, it was felt that a questionnaire concerning a person's attitudes towards and participation in sport or similarly active pursuits may provide additional information with respect to the nature of these abilities. It was hypothesized that, generally, those people taking part in more active and more skillful pursuits would score more highly on the perceptual-motor ability factors. Similarly, it was felt that those people indicating a more positive attitude toward physical activity would also tend to score more highly on the ability factors.

To summarize so far; the basis of this second section was to devise and administer a number of perceptual and perceptual-motor tests and to analyse the resulting relationships between them in order to arrive at a set of more or less fundamental areas of perceptual and motor functioning. It was hoped that the nature of these facets and their inter-relations, if any, might allow a more informed dissection of perceptual style.

Before proceeding, however, it would be as well to discuss the nature of the analysis to be performed since interpretation of the data is dependent on an understanding of the assumptions upon which the analysis is based. Factor analysis was considered the appropriate technique for eliciting the perceptual-motor abilities underlying the various movement skills being tested. This is a statistical procedure in which all the test measurements are correlated against each other.

The relative strengths of these interactions are then used as a basis for grouping the tests into sets or factors of functionally related tests (Cattell, 1977). Thus each test in any single factor would be testing a similar perceptual-motor ability as every other test within that factor. A consideration of the use made of the factor analysis technique in general and, more particularly, of the use made of it in this part of the study would consequently be appropriate.

There are several forms of factor analysis though they can all essentially be reduced to one of two types. Even here the differences are primarily in the theoretical assumptions underlying them. These differences stem from the purpose behind using factor analysis on the data set. It can be used simply as a tool to reduce large amounts of data into more easily manageable amounts, regardless of the meaning of the derived factors; it can be used as a technique for confirming theoretically based hypotheses concerning the structure of relationships between variables or it can be used as an initial, exploratory technique for investigating the possible structure of relationships between variables. The latter two uses are but two sides of the same coin and differ not in the analytical technique but in the experimenter's use of the factor pattern afterwards.

It is the basic tenet of all factor analysis techniques that the total variance in the scores of any variable is equal to the sum of the common variance (that variance shared with one or more other variables), the unique variance (that variance due entirely to the unique properties of that variable) and the error variance (variance due to the possible errors in measurement). The total variance is regarded as being equal to one. For the purposes of simple data reduction, however, the assumption is made that each test or variable is entirely mimicked by some combination of all the other tests used in the study thus the unique and error variances are regarded as being zero and the common variance accounts for all the variation in the data concerning that variable. This common variance, termed the communality, is also equal to the sum of the squares of the loadings of the factors on that variable. In other words, the total variation in the scores of a variable is spread throughout the factors. Furthermore, the exact amount of variation in the data as a whole accounted for by each factor can be calculated; exact, that is, if one accepts the initial assumption concerning the non-existence of unique or error variance. Factor analytical techniques working on such assumptions are termed principal component analyses.

For hypothesis testing or for analysis of an exploratory nature all three types of variance are assumed to exist. This means that the common variance of a variable must be less than one. The actual value of the communality has to be estimated (usually by taking the square of the multiple correlation that that variable has with the rest of the variables in the correlation matrix) and then refined through successive calculation from the loadings on each factor. Since only an estimated proportion of a variable's total variance is spread amongst the factors, an exact prediction of a variable cannot be made from its factor scores. This fact is not particularly important in either of the latter two reasons for using factor analysis since all that is really required is to know which variables are grouped together, how many factors there are and their relative importance to each other.

The assumption that neither unique nor error variance is associated with any of the variables is totally unrealistic; it is simply a mathematician's method for treating the data and has little relevance to the real world. Consequently, despite the fact that this principle component method is very commonly used, it was decided to adopt the second approach.

After the initial factoring, the next stage in the analysis is the rotation of the axes of the factors to minimise the spreading of a variable's loadings across the factors. Again, there are two principal forms of rotation, each with their inherent assumptions; they are orthogonal and oblique rotations. If one believes one's factors to be totally independent of each other, that is, there is no correlation between factors, then one chooses an orthogonal rotation which maintains the rotating factor axes at 90* to each other. This option is probably the best if one is merely trying to reduce or simplify the data; it leaves the factors more easily conceptualized and, again, is the most common type of rotation used. If one has reason to suspect that there may be some relationship between two or more factors (which would generate higher order factors if sought) then an oblique rotation is used in which the factor axes are allowed to rotate freely with virtually no angular restraints. Since it was felt that there was no good reason for assuming that the factors discerned from the data would be independent, an oblique rotation was used. In the Statistical Package for the Social Sciences program (SPSS-X, 1986) through which the data were analysed, one is able to control just how oblique the final solution is allowed to be. In fact, three separate analyses were originally performed on the data, each allowing a different minimum angle between the axes. Each solution was then examined to determine which rotation best fitted the data and best minimised the cross-products of the factor loadings (i.e. produced high loadings on one or two factors and low loadings on the rest). It should be noted that what is being controlled is the minimum angle allowed between factor axes. Consequently, if the factors really are independent of each other, an oblique rotation will still allow them to be orthogonal whereas an orthogonal rotation would force related factors apart; i.e. it would produce a false solution. Another consequence of using an orthogonal rotation is that the factor loadings shown in the factor pattern matrix are identical to the correlation coefficients between each variable and each factor (i.e. the factor structure matrix). This allows a rather simpler test for the significance of the loading than in an obliquely rotated factor pattern matrix for which the correlations between factors have to be taken into account. As a result, higher loadings in an obliquely rotated factor pattern matrix tend to be required to achieve significance than in an orthogonally rotated solution.

It can be deduced from the above arguments that use of the factor analysis technique was being made for its exploratory capabilities and the only criterion one has in such explanations is common sense; i.e. one has finally to decide through examination of the data whether or not the factor solution was appropriate. This does seem, at first, somewhat inaccurate and has given rise to much distrust of factor analysis as a research tool. Much of this criticism would perhaps be more usefully levelled not at the factor analysis technique but at the researchers who have used it with relatively little understanding of what they are doing. To assume zero unique and error variances in their data and then to complain of unrealistic factor (component) extraction is unjustified. If one uses it as a technique for simply grouping together variables that share some common variance, however, then the potential ambiguity is to be expected. Such use of the technique also allows for further manipulation of the factors since the original purpose (of exploring the nature of the relationships between variables) is still being maintained.

2.2 Method.

2.2.1 Development of the adult test battery.

The actual test items used in the children's test batteries, being based upon Piaget's developmental theories or adaptations of them and empirically derived through a trial and error process, were unsuitable for normal adults. Each of these batteries, however, was subjectively analysed in terms of the underlying areas of perceptual-motor ability that its author was attempting to illuminate. Having obtained various catagories for each test battery they were compared. The areas which seemed common to the majority were used as a starting point for the adult battery.

These were:

1. Static Balance
2. Dynamic Balance
3. Posture
4. Rhythm
5. Motor Dexterity
6. Visual-motor Co-ordination
7. Body Awareness

Following the extraction of these common areas of perceptual-motor functioning, it was necessary to create a variety of tests within each category, suitable for normal adult abilities and of sufficient diversity to allow a wide range of factors to be extracted should they exist.

The tests used came from a number of sources. Some were standard psychological tests, some came from dance/martial arts exercises and others were made up specifically for the project. The tests were as follows:

[For full test details see appendix B.]

1. Static Balance:

   a number of tests requiring standing without wobbling on one or both feet, with eyes open and closed.

2. Dynamic Balance:

   similar to above but whilst walking along a narrow beam;
   walking in a straight line for ten yards with eyes closed after an initial dis-orientation : the measure was the deviation from the straight line.

3. Posture: see appendix B.

4. Rhythm:

   a four-beat clapping task given a simple. numerical pattern to follow;
   skipping tasks, maintaining the rhythm imposed by a metronome.

5. Motor Dexterity:

a finger 'drumming' task for fine-motor control;
putting shaped blocks into shaped holes whilst blindfolded;
a gross-motor task involving locomotion following a simple, demonstrated pattern.

6. Visual-motor Co-ordination:

a 'steadiness' circuit consisting of passing a small diameter wire loop along a second, convoluted wire without touching it : contact completed an electrical circuit operating a digital timer thus providing a record of the total time in contact as the test measure;
a rotary-pursuit task in which a light-sensitive rod is used to follow a light travelling in a star-shaped pattern : again, time in contact with the light was the test measurement;
a gross-motor task requiring running, jumping and hopping from one point to another marked out on the ground.

7. Body Perception:

this consisted of two tests similar to those of Stone (1968) in which a picture of a particular body posture was shown to the subject who had then either to identify that posture from a set of four choices or, in the second test, had to imitate that posture exactly; these tests were diffrent from Stone's in that she used stick-figure drawings whilst in this study photographs of a real person were used.

The placing of each test into a particular category, whilst not arbitrary, was not necessarily exact. There was a number of tests for instance that included some degree of decision making; these could consequently have been grouped together in a category of their own. Similarly, other sets of tests could have been used to form different or more catagories. The use of the six catagories extracted from the child-clumsiness test batteries served principally as an initial structure within which to work and not as a rigid, definitive catagorisation that could not be changed. The creation of such a structure was left to the statistical treatment.

The three gross perceptual tests from study one were also utilized in order to study their component parts as suggested in the conclusion above (Section 1.7). The B.B.S./P.S. test, however, was changed to a "self" versus "non-self" awareness test. This was used instead since it took much less time for the subject to complete yet correlated highly with the former projection technique (Fisher & Cleveland, 1968). Another category of perceptual-motor functioning often used in adults is that of reaction-time. Accordingly, a number of reaction-time measurements to both visual and auditory cues were utilized.

As in study one, the physical parameters of height, weight, age and sex were noted and the ponderal index was calculated.

Most of the gymnasium tests were recorded onto video tape since instantaneous analysis was often impossible. The stop-frame facilities that this provided were essential in some of the tests such as the assessment of accuracy in the gross-motor task of category five. Many of the tests were measured along more than one dimension; for example, the skipping tests were assessed for adherence to the imposed rhythm and the number of stoppages. Consequently there were many more measures than there were individual tests. The main purpose behind this was due to the exploratory nature of the study (about which more will be discussed in a later section) which was intended to look at a diverse set of potentially relevant measurements of perceptual-motor functioning. That many measurements were later discarded does not detract from their being made in the first place.

The ordering of the test sessions varied according to the availability of the subject and the time-tabling of the gymnasium thus, whilst not strictly randomised, there was no consistent ordering of the sessions. Full details of each test are given in appendix A along with any administrative problems encountered.

2.2.2 Data Analysis.

Analysis of the resultant test battery was performed using both factor analyses and partial correlation techniques. The factor analysis was conducted using the "Factor" program from the Statistical Package for the Social Sciences (SPSS-X, 1986). The PA2 analysis was used which puts communality estimates in the diagonal of the correlation matrix and uses successive iteration to modify these initial estimates. An oblique rotation was used ("Oblimin") with delta at the default value of 0. The additional use of partial correlation to "check" the resultant factors is discussed below.

2.2.3 Attitude-Preference Questionnaire (A.P.Q.)

All subjects were asked to complete a short activity-preference questionnaire. This consisted of just four questions. The first asked for the subject's favourite pastime; the second for their favourite activity; the third for their attitude toward physical activity and the fourth asked whether they regarded themselves as clumsy or not.

Q1) The favourite pastime was classified as either "active" or "passive" and assigned a value 1 or 0 accordingly. Classification, though generally straight forward, was based on the classification by Durnin & Passmore (1967) of activities into sedentary, light, moderate or heavy work. Sedentary pastimes made up the passive category whilst light, moderate and heavy pastimes made up the active. Thus, a pastime such as playing chess would be classed as passive along with drinking or meeting friends. Most sports, however, and pastimes such as hill walking would be classed as active.

Q2) The favourite activity/sport was classified into one of five categories dependent upon the level and type of skills required by the game "were it to be played optimally". This classification proved to be far more difficult than had been originally assumed with no previous classification along the "skill" dimension being found.

In an attempt to create such a classification, a number of members of the physical education profession were asked to rate a list of 36 sports and activities along a dimension of "degree of requirement of co-ordinated perceptual and motor functioning". There was no correspondence in their replies whatsoever. It was evident that those activity areas in which each respondent taught or had experience were rated more highly than other areas. This may have been because they felt that the high skill ratings of their particular specialization would reflect upon their own ability. Less harshly and more likely, however, is that their more intimate understanding of the nuances of their specialist areas made them more aware of just how much skill or what types of skills were really needed to play the game at its highest level. Whatever the reasons, this approach did not yield any useful information and may be likened perhaps to the findings of Keogh et al. (1979) mentioned above. Instead it was necessary to start from scratch and create just such a classification. The details and arguments are presented fully in appendix C.

The five categories represent various skills which cannot be meaningfully compared; e.g. skills requiring visual perception versus those requiring kinaesthetic perception. The score is therefore at a categorical data level only though it is likely that one's individual bias may tempt one into viewing them with rather more "order" than they can reasonably deserve.

Q3) Four statements of attitude toward physical activity and participation were given. The subject had to indicate which statement was the most applicable to him and this was scored such that "one" indicated a more positive attitude toward activity and "four" a more negative. The data from Q3 were consequently regarded as being of an ordinal level.

Q4) Subjects were asked whether or not they would describe themselves as clumsy (the definition being left upto themselves). The "yes" or "no" answer was assigned 0 or 1 accordingly.

[The questionnaire can be found at the end of appendix C.]

2.2.4 Subjects.

Subjects were all university students (n = 26, average age = 21.23 $\pm$ 4.1 years) each volunteering to take part in the study. As with any potential group of volunteer subjects, there must tend to be a bias between those who will volunteer and those who will not. In this study it would seem reasonable to expect that bias to pick out the more sport orientated people. Despite this expectancy, however, it was felt that a wide range of people did volunteer, showing an equally wide range of abilities. This may well be because the reasons for being "sport orientated" are not based just on ability or performance level but upon enjoyment of an activity for its own sake.

The testing took approximately three hours in total so was split into a number of testing sessions, some of which were laboratory based tests and some gymnasium based (see appendix A). Despite the duration of the testing sessions all the subjects, regardless of skill level, appeared to enjoy the challenge and/or stimulation of the various tests.

To summarize and perhaps clarify, the analysis of the data was to be as follows:

(1) Create Pearson Correlation matrix for all original test measurements.

(2) Remove some variables due to skewness and/or repeated measures.

(3) Create smaller Pearson Correlation matrix with remaining variables.

(4) Factor analyse matrix.

(5) Check factors using partial correlation and factor analyses on each group of variables; obtain relative factor loadings (Table 2.3.iv).

(6) Create factor scores and analyse relationships using Pearson correlations, t-tests and ANOVAs.

2.3 Results.

Analysis of the test data was performed in four stages:

(1) Descriptive statistics and Pearson Correlation on all test scores leading to elimination of certain measurements.

(2) Factor Analysis of remaining test scores.

(3) Multiple partial correlations to 'check' factors.

(4) Calculation of Perceptual-Motor Profiles from factor components.

2.3.1 Descriptive statistics and Pearson correlations.

The means, standard deviations and frequency distributions of each test measurement were computed and a Pearson correlation matrix created including all the test measurements. Consideration of this matrix led to a number of test scores being discarded since their extremely high inter-correlations indicated that they were measuring the same parameter as each other; i.e. it could be seen that a number of measurements could be adequately replaced by a single measure. For example, in test 5a there were seven measurements for even finger tapping. Since all of these correlated highly significantly ($p < 0.005$) with the sum of the measures it was decided to use just the sum, test 5a7b. Other tests were dropped because the distributions of their raw scores were so skewed as to render them useless as analytical tools.

2.3.2 Factor analysis.

The remaining test scores were subjected to factor analysis using principal axis analysis and the resulting factors were subjected to an oblique rotation. The commonly used criterion for selecting the number of relevent factors (i.e. an eigenvalue of >= 1) was passed over in favour of Cattell's Scree method which has been shown empirically (through the extensive use of plasmode data) to be more meaningful than the above arbritary criterion of Guttman and Kaiser (Cattell, 1977). In this method, a graph is plotted of eigenvalue (the sum of the squares of the loading of each variable on that factor) against factor number. The scree is detected by finding the first set of four or more points through which a straight line may be drawn. The factors above this line are regarded as being meaningful factors.

Factor	Eigenvalue	Cumulative % of variance
1	5.66655	20.2
2	3.63523	33.2
3	2.69085	42.8
4	2.35286	51.2
5	2.25647	59.3
6	1.96609	66.3
7	1.77469	72.7
8	1.54245	78.2
9	1.12548	82.2
10	1.02165	85.8
11	0.80242	88.7
12	0.78896	91.5
13	0.69695	94.0
14	0.47282	95.7
15	0.41826	97.2
16	0.38281	98.6
17	0.32788	99.7
18	0.18554	100.4
19	0.14076	100.9
20	0.12246	101.3

Table 2.3.i: "Eigenvalue and Cummulative % of Variance."

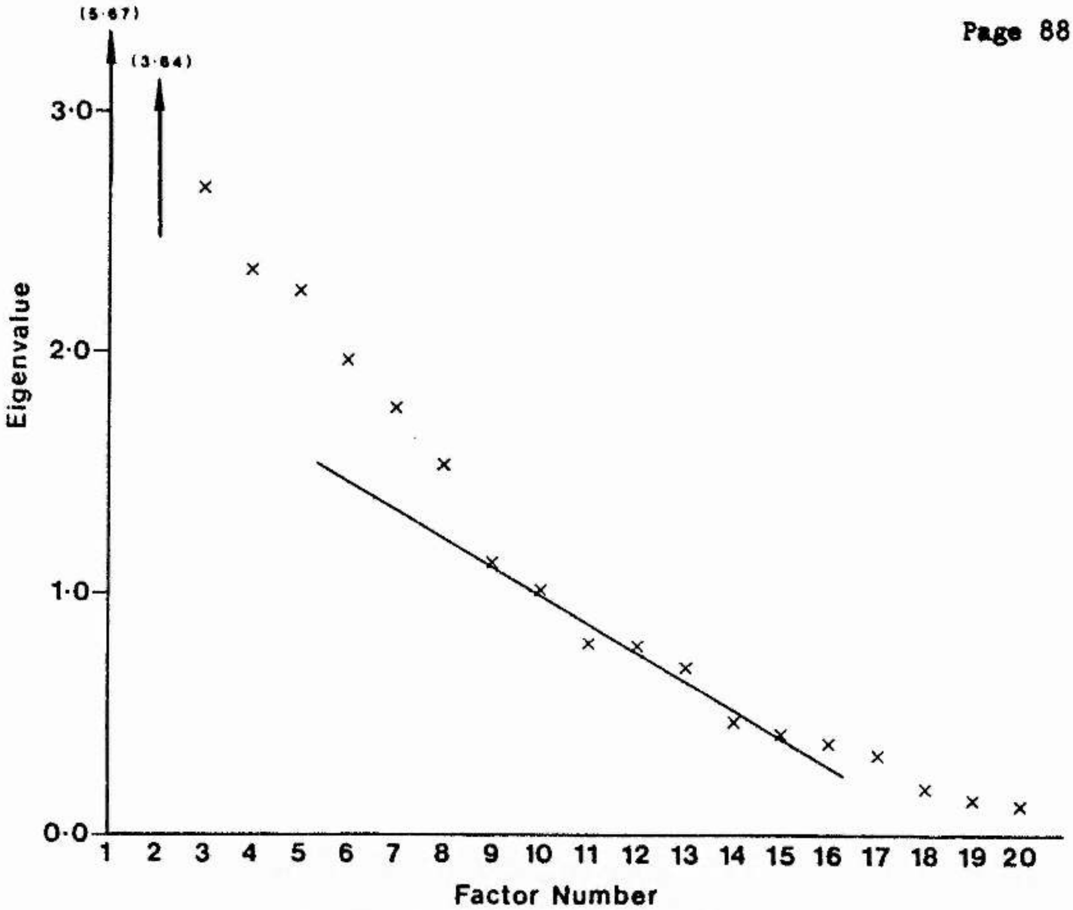


Figure 2.3.i: "Graph of Factor number against eigenvalue."

The scree method indicated that there were 8 factors though it was possible that these included an error factor (a factor created by the analysis technique from apparently random measurement errors). According to Cattell these can appear as quite important factors (i.e. have large eigenvalues) though the relatively small number of subjects renders this unlikely in this instance (Cattell, 1977).

These 8 factors were subjected to an oblique rotation (i.e. a mathematical process to reduce the spread of variable loadings on each factor and allowing for correlation between the factors. See below for a fuller discussion).

Appendix C(i) shows the loadings of the remaining variables on each factor after rotation.

To test for the significance of the loadings in the factor pattern the following formula was used:

$$t_a = a_{jf} \div \left[\frac{(1 - h_j^2)c_{ff}}{N - n - 1}\right]^{1/2}$$

where t_a is distributed following the t-distribution.

a_{jf} = primary order pattern coefficient (the loading of variable j on factor f).

h_j^2 = communality of variable j.

N = the number of subjects.

n = the number of factors.

c_{ff} is the diagonal element (column and row of factor f) in the inverse matrix of the correlations among the factors [see appendix C(ii)].

Thus, if the right-hand part of the formula is less than t, the loading is not significant (degrees of freedom for t = N - n - 1).

The above formula is credited by Cattell to Harris (Cattell, 1977) and is taken from an unpublished article by him. It is the equivalent to the better known Burt-Banks formula (Burt & Banks, 1947) but is applicable to factor loadings found after oblique rotation rather than orthogonal. After applying the appropriate cut-off points to the data in appendix C(i) the following table was obtained:

	FACTORS							
	F1	F2	F3	F4	F5	F6	F7	F8
VARIABLES	2di	1a	1bi	5a7b	1cii	-1bii	1a	-2a
	-4a	-10a	1ci	6aiii	1eiii	10bii	-6ciii	-2c
	-6ciii	-10c	1cii		6b		-8a	-5a7a
	-7a	10e	2dii		7a		-8diii	8b
	-7b		-5c		-8a		-10d	8diii
	-10bii				10e			

Table 2.3.ii: "Distribution of variables with significant loadings over the 8 factors."

2.3.3 Individual factor analyses and partial correlations.

Individual factor analyses were then performed on each of the eight groups of variables in order to check that they did indeed constitute just one factor each and were not the result of a forced combination of two or more independent sets of variables. Furthermore, where groupings of variables were made for which the initial Pearson correlation matrix showed little or no association and in order to try and ascertain whether the factor structure had been distorted by the presence of an error factor, a number of partial correlations were performed.

The separate factor analyses indicated three changes. Variable 1a was shown to belong to a separate factor from variables 10a, 10c and 10e and was left out of Factor 2. Factor 5 was shown to be a combination of three factors with variable 7a forming a single factor in its own right. Accordingly, variable 7a was removed. Of the other two, Pearson and partial correlations indicated that the factor of 1eiii, 6b and 8a was the principle combination and this was duly substituted in place of the original Factor 5.
Factor 7 too was split into two factors, again with both Pearson and partial correlations indicating little association between many of the variables.
Pearson correlations indicated also that the combination of variables 1bii and 10bii into Factor 6 was erroneous. Multiple partial correlations of these and other high-loading variables on Factor 6 served merely to substantiate this conclusion. It was therefore decided that Factor 6 was an error factor and was dropped from further consideration.

The variables within the initial factors were re-ordered and are shown in Table 2.3.iii. It will be noted that some of the signs of the variables have been altered. This was to make all the factors "abilities" rather than some of them representing "inabilities". This merely renders interpretation of a person's perceptual-motor profile easier to interpret.

FACTORS

	F1	F2	F3	F4	F5	F6	F7	F8
VARIABLES	-6ciii	-10e	1ci	-5a7b	1eiii	-8diii	1a	-2c
	-4a	10c	1bi	-6aiii	-8a	-8a	-8diii	-2a
	2di	10a	2dii		6b	-10d		-5a7a
	-10bii		-5c			-6ciii		-8diii
	-7b		1cii					8b
	-7a							

Table 2.3.iii: "Final groupings of variables within each factor."

To obtain the relative loadings of each variable within the same factor, separate factor analyses were performed using only those variables already designated as belonging to that factor. Thus the final loadings of each variable upon the relevant factor were as follows:

Factor 1:

6ciii	4a	2di	10bii	7b	7a
-0.94008	-0.81158	0.73410	-0.58198	-0.48748	-0.37878

Factor 2:

10e	10c	10a
-0.74162	0.64229	0.62424

Factor 3:

1ci	1bi	2dii	5c	1cii
0.87722	0.69191	0.62357	-0.59889	0.51140

Factor 4:

5a7b	6aiii
-0.78978	-0.78978

Factor 5:

1eiii	8a	6b
0.77206	-0.72274	0.51585

Factor 6:

8diii	8a	10d	6ciii
-0.72432	-0.60258	-0.52936	-0.46297

Factor 7:

1a	8diii
0.64951	-0.64951

Factor 8:

2c	2a	5a7a	8diii	8b
-0.75583	-0.70597	-0.60829	-0.57525	-0.51014

Table 2.3.iv: "Loadings of variables on each factor after individual factor analysis."

2.3.4 Factor score correlations.

Factor scores were calculated for each subject. [A subject's score on each factor is calculated by summing the weighted Z-score of each variable within that factor. In the case of an orthogonal rotation or when no rotation is required (as is the case when only one factor has been extracted such as here) then the weighting of each variable is equal to its loading on that factor. The Z-score transformation (see Section 2.3.7) is used to render all the raw scores into scores of the same units, that is, standard deviations from the population mean. These calculations were part of the computor program (SPSS-X, 1986)].

Pearson correlations were made between the factor scores in order to see how oblique the final abilities really were. Ability scores 1, 5 and 7 correlated significantly with ability score 6. Ability scores 2, 6 and 7 correlated significantly with ability score 8.

These were:

A1/A6	$r = 0.65$, $p < 0.010$ two-tailed.
A5/A6	$r = 0.56$, $p < 0.025$ two-tailed.
A7/A6	$r = 0.75$, $p < 0.010$ two-tailed.
A2/A8	$r = 0.46$, $p < 0.025$ two-tailed.
A6/A8	$r = 0.53$, $p < 0.025$ two-tailed.
A7/A8	$r = 0.56$, $p < 0.025$ two-tailed.

Table 2.3.v: "Significant factor score correlations."

[For the full correlation matrix see appendix D(iii).]

2.3.5 Factor scores in relation to physical parameters.

In order to assess the relationship of body size or shape with the eight factors, a Pearson correlation matrix was calculated. This is shown below.

	FACTOR							
Parameter	F1	F2	F3	F4	F5	F6	F7	F8
Height	-0.25	-0.25	-0.33	-0.16	0.23	0.25	0.15	-0.11
Weight	-0.70**	-0.05	-0.58*	0.00	-0.19	-0.03	-0.05	-0.20
P.I.	0.63**	-0.11	0.56*	-0.14	0.47	0.40	0.25	0.17
Sex	0.29	0.20	0.55*	-0.03	0.08	0.18	0.13	0.29
Age	-0.18	0.17	-0.07	0.06	-0.68**	-0.23	-0.06	-0.41*

Table 2.3.vi: "Pearson correlation matrix of factor scores with physical parameters." (* = $P < 0.05$; ** = $p < 0.01$)

2.3.6 Factor scores and the Attitude-Preference Questionnaire.

The relationships between the eight factor scores and the answers to the A.P.Q. had to be assessed using a number of statistical techniques.

t-tests on Q1 (active versus passive past-time) and on Q4 (clumsy versus non-clumsy) of the A.P.Q. with the factor scores indicated no significant relationships.

Oneway analyses of variance of Q2 (skill category of preferred sport) and Q3 (positive attitude toward sport) with the factor scores similarly indicated no relationships. Inspection of mean scores for each category of Q2, however, indicated that there may have been differences between the means of groups 1 and 3 and between the means of groups 1 and 4 on certain ability scores.

t-tests between these preference groups did in fact indicate a number of significant differences but only between groups 1 and 3; these were with ability scores 3, 4 and 6 ($p < 0.05$, $p < 0.005$ and $p < 0.025$, two-tailed, respectively). It should be noted that t-tests could be used on the data since the assumption of homogeneity of variance across the groups was supported by the non-significant F-ratios in the ANOVA.

Similar inspection led to differences in Q3 being found to be significant on several ability scores. These were between attitudes 1 and 2 on ability 1 and between attitudes 1 and 3 on ability 2 ($p < 0.05$ for both, one-tailed). Both these differences were such that the subjects expressing a more positive attitude scored more highly, as was hypothesized earlier (Section 2.1).

		Average raw factor scores			
		Dancers	Non-dancers	S.D.	Z-score
A B I L I T Y	1	0.416	0.090	0.206	1.5825
	2	0.318	0.068	0.849	0.2945
	3	0.763	0.181	0.634	0.9180
	4	0.108	-0.060	1.242	0.1353
N U M B E R	5	0.090	0.130	0.496	-0.0807
	6	0.408	-0.106	0.994	0.5171
	7	0.478	-0.110	0.710	0.8282
	8	0.389	0.402	0.379	-0.0343

Table 2.3.vii: "Mean factor scores for female subjects, dancers and non-dancers; standard deviations for non-dancer group and resultant dancer group Z-scores for all eight factors."

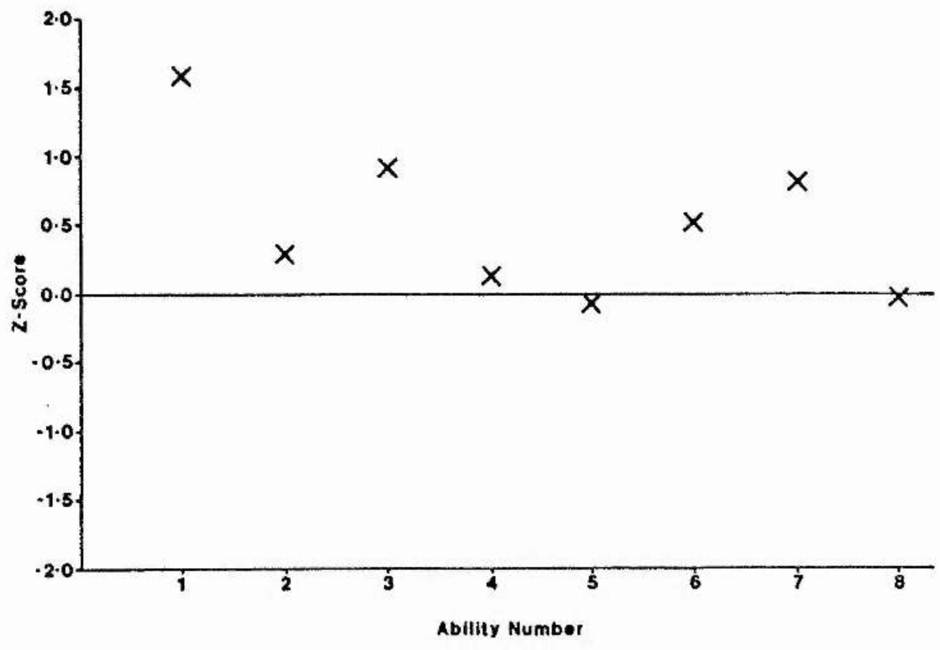


Figure 2.3.viii: "Perceptual-Motor Profile of female dancers."

t-tests between the dancers and non-dancers on each of the eight ability scores showed significant differences only on Factor 1 ($p < 0.006$, one-tailed) with both Factors 3 and 7 showing trends ($p < 0.1$ and $p < 0.08$, one-tailed, respectively).

[The analysis of this profile will be discussed in the next section.]

2.4 Discussion.

2.4.1 Factor analysis.

It will be recalled that a factor analytic method was selected such that it allowed a more exploratory analysis of the data. This automatically leads to a potential ambiguity concerning both the variables assigned to each factor and the interpretations subsequently placed upon these factors. In that the factor structure can not be objectively fixed, smaller factor analyses and partial correlations were used both to "check" those tests grouped together and to see whether certain tests which loaded significantly on a number of factors really did have such diverse connections. As a direct result of these analyses, several of the factors were rearranged (see Section 2.3.3). It is hoped that a more realistic factor solution has been achieved as a result. Such manipulation leaves one open to the criticism of having prejudiced the results but this is already true without such manipulation. The very choice of tests used and those left out (or unthought of) has already manipulated the resulting factors. The inclusion in the test battery of the three general perception tests used in the first part of the study will have automatically predisposed the first few factors in the extraction to be perceptual in nature. It has already been argued that clumsiness owes more to perceptual than motor inaccuracies and that the make-up of the test battery merely reflects this. It must be pointed out, however, that the larger the range of tests used in the battery (and it is believed that the range used in this study covered the majority of perceptual-motor functioning as inferred from the child clumsiness tests), the more likelihood there is of extracting all the useful factors. The intentional bias toward perception, therefore, will not have obliterated the more "motor flavoured" factors but will merely have placed them further down the extraction than they might otherwise have been.

The final grouping of test variables is shown in table 2.3.iii. The use of factor analysis as an exploratory tool, as it was used in this study, requires the assumption that the common variance amongst the variables within a given factor is a direct result of their shared reliance upon a single, underlying, common denominator, in this case a perceptual-motor ability. This assumption allows the speculative interpretation of each ability from the common aspects of its associated skills.

2.4.2 Factor interpretation

Factor 1 : -6ciii, -4a, 2di, -7b, -10bii, -7a

Factor 1 accounted for approximately 28% of the common variance exhibited by the data.
Test 6ciii represents the number of extra steps taken in the "stepping-stone" test (see appendix B) which was part of the original gross perceptual-motor test battery. Extra steps are superfluous to the movement requirements and are therefore

considered as errors. Test 4a was part of the original rhythm test battery, requiring clapping of the hands to a regularly structured rhythm; it is scored as errors. Test 2di was part of the original dynamic balance test battery and represents the skills required to walk along a balance beam forwards without imbalance. Test 7b, scored as errors, measures the skills required to perceive and adopt a set body position. Test 10bii was part of the reaction-time test battery and is the number of errors incurred during the choice-light test. Finally, test 7a requires the recognition (and selection from similar others) of body shape or position; it was originally designated as being part of the body image test battery. It too is measured as errors thus a high score implies an inability to perceive body shape in a discriminatory fashion.

The variable order given above follows the factor loadings (Table 2.3.iv) thus 6ciii is the most representative variable within this factor and 7a the least.

Despite all the tests being performed with the possible use of visual cues, the rhythm test (4a) does not really require them (since most people can clap their hands without looking at them). It is felt, therefore, that vision as the informational input channel is not a vital component of this factor.

In each of the six tests there is the need to assimilate environmental structure. In most cases, this is in order to plan movements to fit within the structure (e.g. an imposed timing structure as in the clapping test or an imposed spatial structure as in the stepping-stone test). In the case of 7a the assimilation is simply to recognise the structure and it is consequently thought that this could account for its low loading on this factor; i.e. it shares only perceptual similarities with the other tests in what would seem to be a perceptual-motor factor. [Perhaps it should be noted that the concept of perception being used includes the assignment of meaning to what has been sensed. The term "assimilation" implies the systemisation of these meaningful perceptions such that they can be further utilized.] What is being suggested, therefore, is that this factor represents the ability to create a model of the external world from which an appropriate output can be determined. The existence of such a model is examined below in relation to Higgins' contention that efficient movement can only occur when both the physical structure of the surround and the physical limitations of the body are taken into account to produce a resultant movement form (Higgins, 1980). Since the factor contains tests that demonstrate a wide variety and complexity of structure (from a single row of lamps in 10bii to the irregularities of the human form in 7a and 7b) it seems plausible that the arrays are perceived not as a collection of many discrete parts (since differences in complexity would be maximized were this the case) but as single patterns.

Repetitions of particular organisations of items could, through gradual recognition and learning, lead to their being perceived as a whole, single unit and thus the internal complexity of the whole would become irrelevant. This would mean that people who had greater involvement in activities for which such interpretation was a necessary requirement should be "more able" on this factor than those people who had not. This point will be discussed shortly when considering the dancers' profile.

In summary, Factor 1 seems to be the perception/recognition and assimilation of structure within the environment to generate a model of the external world and which allows the planning of appropriate actions to cope with this structure.

<u>Factor 2</u> : -10e, 10c, 10a

This second factor accounted for approximately 17% of the exhibited variance remaining.

Both Test 10a and Test 10c are straightforward reaction-time tests, the former requiring action upon a light stimulus, the latter upon a sound stimulus. Test 10e is an error score given when the subject reacts to a sound stimulus when asked to react to and expecting only a light stimulus. It seems reasonable to find the relationship that those subjects with quicker reaction-times tend to be less accurate but 10e is less an "inaccuracy" score than an "inappropriate action" score.

It may be, therefore, that those subjects with the lower factor scores are over-reactive and tend to "leap before looking". This tendency could be a performance deficit due to over-arousal though whether this would be a chronic trait or a phasic state caused by the experimental situation could not be assessed without back-up personality tests (e.g. the STAI from Spielberger, 1971). This factor will require careful examination since a particular score may have a number of interpretations. For example, a person scoring highly on this factor may do so because (i) they have a slow reaction-time, (ii) they have not made a mistake in reacting to an inappropriate stimulus or (iii) they have both a slow reaction-time and have not made a mistake. In terms of all round efficient movement it would be more advantageous if one could have a fast reaction-time and yet not make errors of stimulus recognition. Such a combination, however, would counteract each other in terms of scoring on this factor and result in a score close to zero. This conflict can only be resolved if one chooses instead to assume that the "ability" being portrayed is one of physical relaxation and ease; i.e. an appropriate level of arousal. Should this definition be adopted then a high score (positive) would indicate physical (and perhaps attentional) relaxation; a low score (negative) indicating physical arousal. Which of these is preferable is dependent on the nature of the movement task being undertaken at any particular time.

In summary, Factor 2 seems to represent the degree of physical and possibly mental relaxation with which a subject approaches movement tasks. It may well be a manifestation of personality showing itself through physical performance.

<u>Factor 3</u> : -5c, 1ci, 2dii, 1bi, 1cii

Factor 3 accounted for approximately 12% of the remaining variance exhibited by the data.

Tests 1bi and 1ci were both tests from the static balance test battery; standing motionless on the right and left foot respectively and both are in the presence of visual cues. Test 1cii was also a static balance test, this time standing motionless on the left leg but in the absence of visual cues (i.e. the eyes are closed). Test 2dii was part of the dynamic balance test battery and is a measure of performance in walking backwards along a balance beam. Test 5c requires the locomotion of the whole body following a pre-set pattern. It particularly incorporates the dextrous movement of the lower limbs and necessitates an "unusual" change of balance in order to put the feet in the required positions. Test 5c is marked as errors.

All these tests require perception and control of the whole body either in performing a set of pre-determined movements or in remaining stationary. Tests 2dii and 5c require the fitting of movements into a pre-set pattern.

Although the maintenance of static balance may not seem to fit too well within the term "movement", on the neuromuscular control level there is little difference since patterns of muscular tensions are required both to move and to remain motionless (unless supported against gravity by an external construction). Furthermore, tests 1bi and 1ci also involve the use of spatial information in the maintenance of non-movement in that any change in the visual pattern is indicative of a movement and an impending imbalance. Test 1cii would appear at first to be the "odd one out" but here too it could be argued that the pattern is a kinaesthetic one, deviation from which would, again, be indicative of ensuing imbalance.

It is of note that test 7b loaded highly on this factor though not sufficiently so as to be significant at the 0.01 level (it was significant at the 0.05 level). This test involves whole body movements, again fitting them into a spatial pattern but this time a static body shape. It is suggested that test 7b also requires kinaesthetic information since the subject had no direct visual feedback as to the body shape they had actually adopted. This necessity for knowing where the limbs are in relation to the trunk and other limbs is obviously a prerequisite for all whole body actions. It is felt that factor 3 is the ability to use the body's constant flow of information concerning its physiological state and its position both to generate the initial motor output and to modify previous output until the feedback (F7) indicates that the motor output fits requirements.

In summary, despite its initial appearance of being a "balance" factor, Factor 3 is the ability to use the perceptions of the body's position, both in terms of its shape and in its orientation to fit the body into a pre-set pattern. It differs from Factor 1 in that the environmental structure does not first have to be assimilated in order to create the pattern to be fitted.

<u>Factor 4</u> : -5a7b, -6aiii

This factor accounted for approximately 10% of the remaining common variance.

Test 5a7b is a composite score from a number of tests (see appendix B for details) and represents the error in a task invoving finger dexterity. Being an error score, the smaller the score, the greater the dexterity demonstrated.
Test 6aiii is also a composite score and represents the relative error time during a hand-eye co-ordination task involving fine control of the hand and fingers. As such this task also requires a fair degree of steadiness since undue shaking of the hand would similarly cause errors to be counted.

The two tests are positively correlated indicating that errors caused on the "steadiness" circuit are echoed by errors in the maintenance of an even periodicity in the finger dexterity task. It is felt that the common ground of these two tests involves their motor rather than their perceptual aspects;

more precisely, the tremor accompanying voluntary movement. In most tasks this would be too small to be of any importance but in these particular tasks, designed to test fine motor control, this tremor results in involuntary motion during execution of the task which affects the final outcome detrimentally.

Although both tasks involve the co-ordination of fine hand and finger movements within a designated task, similarities other than motor control are not so obvious. Test 5a7b requires sequenced movements to a regular, self-imposed, temporal pattern whilst test 6aiii requires movements to an irregular, imposed, spatial pattern. It is because of these dissimilarities in the perceptual requirements of the tests that the emphasis for this factor has been put on their motor aspects.

In pathological cases of certain cerebellar lesions, marked tremor, often accompanied by hypotonia, can be seen. This is due to the loss of the cerebellum's modifying influence on the motor cortex (Bell, Davidson & Emslie-Smith, 1972). Whilst the tremor being described here does not begin to approach the amplitude of cerebellar ataxia, imperceivable damage to the cerebellum due to anoxia at birth (as was suggested above concerning the cerebral cortex) could result in a less obvious but physically similar "intention" tremor. It is also possible that the cause of the tremor may lie in a fault of the muscle spindle system which is thought to have a smoothing action on voluntary movement. In whichever of the two sites the cause of the tremor may lie, it would still appear that this is a predominantly motor factor.

In summary, Factor 4 is a motor factor, the importance of which only becomes apparent when dealing specifically with tasks requiring voluntary, fine motor adjustments. It is not concerned just with the fine adjustments per se but with a dysfunction of the smoothing circuit overlaying these adjustments.

Factor 5 : 1eiii, -8a, 6b

Factor 5 accounted for approximately 10% of the variance remaining in the data.

Test 1eiii was a static balance test in which the normal visual cues are disturbed by a constant moving of the head. This makes it difficult to focus the eyes on any potentially stabilizing object. (Movement of the head to looking up at the ceiling in one of the other static balance tests in the original battery proved so disturbing to maintaining balance that it was disregarded due to the heavily skewed distribution of scores that it produced.) Test 8a is Witkin's E.F.T., the negative sign indicating that a shorter time to complete the test (increasing field-independence) is associated with the ability to balance in the absence or disturbance of visual cues. A possible argument to follow from this association is that people who are used to relying predominantly on visual cues (the field) become more disorientated upon their removal. Test 6b is the score on the Rotary Pursuit task (time in contact with the target). A high score corresponds to a greater hand-eye co-ordinative skill, its negative correlation with test 8a indicating that the more field-independent subjects have greater hand-eye co-ordination. Since neither Test 8a nor Test 6b require balance, it would seem evident that the shared aspect of these tests must be their visual dependency.

Due to the construction of the Rotary Pursuit apparatus, the speed of the light "along" the star stencil varies even though the angular velocity of the underlying rod is constant. This produces the effect of the light speeding up at the points of the star and slowing down along the straight sections. The change in velocity, however, has a regular periodicity and can be perceived despite the impression that the light "should" travel up and down the lines of the star at a constant speed. Although the Rotary Pursuit apparatus is classically regarded as a test of hand-eye co-ordination, it is felt that its inclusion within this factor has little to do with its motor following aspects at all. Instead, it is thought that the ability to dissociate visually the actual speed of the light from the expected speed of the light is the common aspect it shares with the other two tests; i.e. it shares the ability not to be distracted by the irrelevant parts in a visual display. Test 8a is testing this ability by definition and Test 1eiii demonstrates this ability in that the subject is able to dismiss confusing visual cues and either extract the useful ones (e.g. the vertical lines) or rely instead on kinaesthetic cues.

In summary, Factor 5 is the ability to dismiss irrelevant or ambiguous visual information and to focus instead on cues that are important with respect to the task in hand.

Factor 6 : -8diii, -8a, -10d, -6ciii

Factor 6 accounted for approximately 8% of the remaining common variance.

Test 8diii is the R.P.E. accuracy measure from repeated effort estimates at the same workload thus a low score is indicative of high accuracy of perception. Test 8a is the E.F.T. measure. Test 10d is the time difference between the choice light reaction-time test and the "any light" reaction-time test; i.e. it represents the choice time. 6ciii is the number of extra steps taken in the "stepping-stone" test thus a high score is indicative of poor movement control.

Despite being a seemingly logical combination of variables, the teasing-out of their common perceptual-motor ability is not at all straightforward. Three of the tests, 8a, 10d and 6ciii, all require discriminatory visual functioning with 8a and 10d in particular sharing a need for visual pattern discrimination; i.e. a particular pattern is being sought from an array containing wrong or misleading information. It could similarly be argued that the ability to see items as discrete yet integral parts of a whole pattern would allow anticipation of the direction in which one has to move next, thus causing fewer mistakes in Test 6ciii.

Test 8diii requires no visual functioning whatsoever. It is essentially a measure of the clarity of perception of the array of kinaesthetic and proprioceptive cues pertinent to the estimation of the degree of fatigue. Furthermore, both Tests 8a and 6ciii may both be measuring this same body awareness; 6ciii since it would be necessary to enable appropriate limb movement to land properly upon the "stones" and 8a since relatively greater reliance on proprioceptive cues (as is implied from Witkin's original conception of field-dependence/independence) would tend to cause greater awareness of proprioceptive cues. Test 10d, however, has no need of such cues.

One is left, then, with something of a dilemma. Four variables have been grouped together from which only groups of three have anything in common. It is suggested, therefore, that this factor must represent some form of integration of sensory function, both visual and kinaesthetic.

In summary, Factor 6 is a mixture of visual and proprioceptive/kinaesthetic awareness and would seem to be indicative of the true "articulated" cognitive style.

<u>Factor 7</u> : 1a, -8diii

This factor accounted for approximately 8% of the variance remaining in the data.

Test 1a was from the static balance test battery and requires the subject to stand without imbalance on both feet when no visual cues are available. Test 8diii, as described above, is the R.P.E. accuracy score. The combination of these tests is such that as R.P.E. accuracy increases so the skills demonstrated in the balance task increase also.

Having already argued that Test 8diii is essentially one of interoceptive and proprioceptive awareness, it would appear that Factor 7 is just that; the ability to perceive cues pertaining to the general state, both internal and external, of the body. These cues would then feed back to allow appropriate changes in the motor output pattern. It follows that such changes can only be appropriate to needs if the kinaesthetic information is correctly perceived.

In summary, Factor 7 is the awareness of body position/orientation and physiological state which becomes the feedback to Factor 3.

Factor 8 : -2c, -2a, -5a7a, 8b, -8diii

This factor accounted for the final 7% of the common variance in the data.

Test 2c is part of the dynamic balance battery and is a form of obstacle course, scored in errors (see appendix B for details of the scoring procedures). Test 2a is also part of the original dynamic balance battery and involves walking in a straight line, blindfolded, after being disorientated (see appendix B). It is scored as the distance deviated from a centre line after having walked ten metres, thus a low score is indicative of greater accuracy. Test 5a7a is a composite score from a number of trials in which fast finger drumming was required (again, see appendix B for details). It is scored such that a low score is indicative of greater finger control. Test 8b is one of the body awareness tests and is closely related to the body-barrier score of the first part of the study. It concerns the constant sense of the self as a separate entity from its surroundings and utilizes somatic and kinaesthetic perceptions in creating this sense of identity. Test 8diii has already been described above and is the R.P.E. accuracy score.

Two of the tests, 8b and 8diii, require the concentrated application of attention to the various perceptions in order either to rate the level of some of these perceptions or to write down just what is being perceived. This ability to narrow the attention upon demand is a vital part of any sports person's repetoire of abilities (Nideffer, 1979).

Nideffer (1976a) proposed that people demonstrated a predisposition toward a particular attentional style, this basic predisposition being overlaid with changes in attentional state depending on the requirements of a specific situation and the person's ability to change attentional mode as appropriate. He considered this style as existing along two dimensions, width and direction. Width of attention referred to "broad" versus "narrow" whilst direction referred to whether the focus of attention was on "external" events or "internal" thoughts or sensations. Despite the wide publicity afforded this model (due principally to Nideffer himself), Van Schoyck & Grasha (1981) suggest his data did not in fact yield the neat, two-dimensional model that he read into it. Using both Nideffer's original data and their own which included a sports-specific version of Nideffer's Test of Attentional and Interpersonal Style (TAIS), they showed that the direction of focus was not particularly important and that the dimension of width cut across internal and external orientated situations. Furthermore, width was not uni-dimensional but, at least, bi-dimensional. With reference to earlier work on attention (notably that of Wachtel, 1967) they proposed that the two dimensions are "scan" and "focus". The width of scan refers to the amount of information within the stimulus field, both internal and external, that is processed. The width of focus refers to the number of perceived factors that can be used simultaneously to create a unified understanding of the stimulus field.

Returning to Factor 8, all the tests require a relatively narrow focus of attention; i.e. none of them require large amounts of information to be processed at the same time. (One has to be careful here to remember that broad and narrow are relative terms and thus open to ambiguity. In the present context, however, a broad focus refers to that needed for highly complex tasks such as driving in busy traffic or judging the speed and direction of one's run to make a tackle the instant after your opponant catches the ball.) Although it is not known how many discrete sensations go toward a rating of effort, such sensations would be present, if not consciously perceived, during any activity and must therefore be considered as requiring a more narrow focus of attention. Of the other tests, all require the concentration of focus onto a narrow band of variables and all but 8b require a narrow scan of either the external or internal fields.

In summary, Factor 8 is the ability to concentrate the attention into a narrow focus in order to deal the more effectively with a particular problem; this also implies the ability to cut out extraneous and diverting events.

2.4.3 Summary of factor interpretations.

Ability 1: the ability to formulate a perceptual model of the structure of the environment with which to plan the appropriate movement output and to put this plan into effect. Accounting for nearly 30% of the data variance, this is the nearest one could get to an overall, single perceptual-motor ability. Either apraxia or agnosia would show up as deficits in this ability.

Ability 2: the degree of "ease" accompanying involvement in physical activity.

Ability 3: the translation of kinaesthetic feedback into appropriate movement patterns.

Ability 4: the lack of tremor or shake accompanying fine motor voluntary movements.

Ability 5: the ability to dismiss irrelevant or ambiguous visual information; virtually a visual field-independence.

Ability 6: an integration of visual and kinaesthetic awareness; an articulated perceptual style.

Ability 7: the awareness of interoceptive and proprioceptive cues; the feedback loop to ability 3.

Ability 8: the ability to use a narrow focus of attention.

2.4.4 Factor score correlations.

The various factor interpretations suggest that there may well be an overlap of the functions they represent and that this should mainfest itself with correlations amongst the factor scores. The reasons for these correlations are two-fold. The first is that since an oblique rotation was used in the factor analysis, the possibility that correlated factors would be extracted was always present. This possibility was probably amplified, however, by the second reason, namely that the ability scores were constructed from a small number of variables (only those variables that loaded significantly on each factor) and some of these were common to more than one factor. Despite the different weightings used in the calculation of the various factor scores, this repetition would tend to increase the factor score correlations.

All significant correlations (see Section 2.3.4) were with Factor 6, defined as representing articulated perceptual style or with Factor 8, defined as the ability to use a narrow focus of attention.

Ability 6:

Given Witkin's claims concerning the all-pervasive nature of this construct it should not be surprising to learn that it overlaps a number of other abilities. The significant correlations of Ability 6 scores are those with Abilities 1, 5, 7 and 8. The first three of these abilities concern perception and discrimination; 5 of visual cues, 7 of kinaesthetic cues and

1 uses both visual and kinaesthetic cues to create a perceptual model of the environmental structure. (Ability 8 will be discussed below.) This suggests that Ability 6 may well represent an integration of the otherwise separate perceptual modalities.

Ability 8:

Ability score 8 had significant correlations with scores 2, 6 and 7; these were all positive. Ability 2 was interpreted as the maintenance of relaxation or ease during the performance of a physically active task thus the positive correlation indicates that this lack of arousal is associated with an ability to change to or maintain a narrow attention. This relationship seems, therefore, somewhat odd in that high arousal or anxiety is normally associated with a narrowing of perceptual attention. Van Schoyck & Grasha (1981), however, suggest that the effects of over-arousal on the attention are different depending on whether one is considering the focus of attention or the scan of attention. They agree with the classical association of the focus of attention narrowing under stress but refer to the subjective lability of scan of attention under such conditions. That is, the attention seems to flit from point to point in the field (either external or internal). At the same time, the focus of attention narrows thus making it all the more difficult to assimilate all these separate points of information into a coherent whole.

Although emphasis for ability 8 has so far tended to be placed more on the focus of attention, it may be that it in fact concerns the scan of attention either instead of or as well as the focus. If this is the case then the association between Abilities 2 and 8 may be due to the scan element; i.e. the more relaxed a person is when participating the better able they are to reduce the attentional scan to the elements of the field that are of importance.

Nideffer has worked with various world-class professional sports people, his emphasis being on teaching them to be able to control the width and direction of their attention in order to use it optimally during the different phases of their game (Nideffer, 1976b). The basis behind much of the width control is the relaxation of the athlete during the game for which he advocates certain breathing techniques. These are similar to the deepening and slowing of breathing associated with most relaxation and meditation techniques. What Nideffer is suggesting, therefore, is that by controlling one's breathing one can reduce the flitting of one's attentional scan to and fro across perceptions that are not only unnecessary but potentially harmful to one's game (e.g. movements in the crowd or one's opponent's antics).

Abilities 6 and 7 both share Test 8diii (R.P.E.accuracy) with Ability 8. It is likely, therefore, that the perceptual clarity being tested by Test 8diii is enhanced by the ability to change to or maintain a narrow focus or scan of attention.

The correlations of ability scores 6 and 8 with the other ability scores is indicative of a high level of shared variance with them (by definition). In the factor extraction, however, the percentage variance ascribed to these two factors was not particularly high (8% and 7% respectively). Although these percentages are approximate since the composition of the factors was changed slightly from the original extraction, they still do not appear to justify the number of highly significant correlations that these two ability scores made with the others. The reason for this, however, is quite straightforward and is to do with the nature of the factor extraction. When the first factor is extracted, it takes with it all the variance that it shared with any of the other factors. If, then, a factor that correlates highly with another is extracted early on in the analysis, for example as factor 2, the variance that the remaining factor would have accounted for is suddenly reduced (since two or more factors can not account for the same variance or more than 100% of the variance would be finally accounted for; an impossible situation). Thus, although the highly correlated factor would have accounted for a large proportion of the data variance had it been extracted first, it is progressively reduced by the preceding extraction of other factors until there is little variance left in the data for it to explain.

It is possible, however, to arrive at an estimate of the variance the factor would have explained by summing the "bits" of variance that it had shared with the preceding factors in the extraction. Each "bit" is calculated from the product of the square of the mutual correlation coefficient with the percentage of variance ascribed to the earliest extracted factor. In illustration, to calculate the true percentage of variance accounted for by Factor 6 one would take its given percentage variance (8%) and add it to its "bit" of Factor 1 (0.6501^2 X 28%), its "bit" of Factor 2 (0.2848^2 X 17%) and so on up to and including Factor 5. This indicates that had factor 6 been extracted first then it would have accounted for approximately 25% of the common data variance. This figure matches more closely, perhaps, the number of correlations that this ability has with the others.

When similar calculations are made for all the factors the following table is arrived at:

Factor number	% variance
1	28.8
2	18.8
3	13.9
4	11.0
5	15.5
6	25.3
7	19.9
8	16.3

Table 2.4.i: "Approximate percentage variance of factors when obliqueness of extraction allowed for."

The new estimations of the amount of variance accounted for by each factor give a better indication of the importance of each ability they represent in perceptual-motor functioning. The perceptual Abilities 5, 6 and 7, for example, can now be seen to be much more influential in the performance of movement tasks than the motor smoothness of Factor 4. The combination of these various abilities and their relative importance will be considered below in terms of a model of skilled physical activity.

2.4.5 Factor scores in relation to physical parameters.

Pearson correlations of these parameters with the factor scores were given in Table 2.3.vi. The only factor scores demonstrating significant relationships with any of these parameters were those of Abilities 1, 3, 5 and 8; these are dealt with separately.

Ability 1 :

Pearson correlations showed statistically significant ($p < 0.01$) relationships with both weight and P.I.. Partial correlation, however, indicated that the variable weight both caused the P.I. relationship and hid a further relationship of Factor 1 scores with sex. Thus the true relationships were with weight and sex with both lighter people and male subjects scoring more highly ($p < 0.005$, two-tailed, for both). It may be that the lack of movement-requirement awareness itself is associated with heavier people. Although unlikely as a direct link, it could be postulated that such a lack of awareness results in inefficient and ineffective movement. This results in low self-efficacy and self-esteem (Bandura, 1977; Harter, 1978) which results in less participation in activities requiring overt movements (Head, Wesson & Doust, 1987). Such a lack of participation could result in the gaining of weight. Alternatively, it is possible that this tendency for the heavier subjects to score more poorly than did the lighter subjects, involves the timing of their movements. Greater limb segment inertia, due to the greater weight, would tend to slow movement down and may result in a loss of effective co-ordination. If this were the reason then one would expect it to have less effect as the movement is rehearsed since practice would allow the earlier initiation of movement in anticipation of the greater limb inertia. It could further be suggested that the reason for the male subjects demonstrating higher scores (once weight had been allowed for) is similarly to do with their higher participation rates in physical activities (Sports Council, 1981). This higher degree of participation would result in more practice at either translating perceptions into a model, using that model to plan motor output or both.

Ability 3 :

Pearson correlations indicated that weight, P.I. and sex were associated with Factor 3 scores. Partial correlation, however, showed that the association of both weight and P.I. with this factor score was due to their shared correlation with sex and that neither had any direct relationship.

The positive correlation between sex and the Factor 3 score indicates that the women scored more highly on this factor than did the men; i.e. they are better able to use kinaesthetic cues in maintaining a particular body shape or orientation. [When the four dancers are removed from the female group there is still a significant difference ($p < 0.05$, two-tailed) between the scores of the two sexes, thus the difference between them is not due merely to the presence of an extreme sub-group within the female subjects.] It is possible that the reason for this is related to the type of activities "classically" undertaken by men and women. It was felt, however, that something more intrinsic than mere training is involved.

It was noted in the first part of the study that women tended to have higher body barrier scores than had the men [Section 1.3.3.(b)]. Fisher & Cleveland (1958) interpret a high B.B.S. as being indicative of not only a greater awareness of the body as a separate entity but also of a greater awareness of the outside of the body (which would include information from the joints and muscles) compared to awareness of the inside (i.e. perception of the cardiovascular system). The fact that women score more highly on factor 3 could well be connected to this generally more heightened awareness of the movement-indicative perceptual cues. Although this sounds very similar to a measure of field-dependence/independence in which women are commonly held to be more field-dependent, it must be remembered that that dimension is measured using tests of visual discrimination and it is consequently assumed that any other perceptual mode will function in a like manner. These data, however, suggest that women would be more field-independent than men were the dimension to be measured using tests of kinaesthetic discrimination instead.

This difference in style across different perceptual modes may account for the lack of "logical" association in the female subjects between B.B.S. and E.F.T. scores demonstrated in part one of the study. Perhaps it should also be noted that Ability 6 which was interpreted as being a measure of the articulated perceptual style, contained tests both of visual and kinaesthetic discrimination; no differences in scores between the sexes were demonstrated.

Ability 5:

Pearson correlation indicated a negative association of Ability 5 with age; i.e. there is a lessening of visual discrimination with age. It is unlikely, given the relatively small age range in this sample, that the differences in visual perception are due to age-related physiological deterioration of the perceptual mechanisms. Although seemingly clichéd, it may be that changes in willingness to accept what is seen, both actually and metaphorically, create this age-related difference. That is, an increased familiarisation with what "should" be perceived in the environment could lead to an inability to accept what is actually perceived. Such cognitive changes were thought by Witkin to create parallel changes in perceptual style.

Ability 8:

Pearson correlation indicated that this too had a negative correlation with age. That is, as one gets older so it becomes more difficult to use a narrow perceptual focus. This at first sounds contradictory to the previous relationship since one might expect a metaphorical and perhaps actual narrowing of focus to accompany age. What it in fact suggests, however, is a similar lessening of ability to adapt to the environmental requirements.

Up until this point, it had been impossible to say whether ability 8 was the ability to change to a narrow attentional width or to maintain a narrow attentional width. This association of age with both ability 5 and ability 8 tends to indicate that the ability to adapt to circumstances lessens with age and therefore suggests that ability 8 is in fact the ability to change to a narrow attentional width when necessary.

2.4.6 Factor scores and the Attitude-Preference Questionnaire (A.P.Q.).

Only questions 2 and 3 showed any significant relationships with the ability scores.

2.4.6.1 Question 2: skill level of preferred activities.

Significant differences were found only between people preferring activity groups 1 and 3. Group 1 activities were "team, ball interception, tool/non-tool". Group 3 activities were "person orientated versus self/with or versus other, tool/non-tool". In terms of the perceptual skills required for the activities, these two groups were perhaps the most different; group 1 relying predominantly on visual skills whilst group 3 could be regarded as relying predominantly on kinaesthetic skills. Whilst there is no reason why these two skills can not exist together, it may be that the existence of strengths in one or the other perceptual modes would influence the type of activity a person attempts or finds, perhaps by accident, that they are good at.

Differences occurred in ability scores 3, 4 and 6.

Ability 3:

People preferring group 3 activities scored more highly on this ability than did those preferring group 1 activities. Ability 3 was the translation of body awareness into a movement pattern designed to fit a specified set of requirements. It would seem appropriate, therefore, that those people who are better able to make such an interpretation of body shape/orientation feedback tend to prefer activities that accentuate such an ability. It is equally plausible to suggest of course that due to their participation in group 3 type activities, their body shape/orientation ability has improved. The direction of causality is impossible to ascertain.

Ability 4:

People preferring group 3 activities scored more highly than those preferring group 1 activities.

Ability 4 was the ability to maintain fine motor voluntary movements without tremor. Although not as clear-cut as the previous result, it seems probable that group 1 activities (e.g. football, rugby, hockey) do not require, on the whole, the finesse of control that is required by the group 3 activities (e.g. gymnastics, fencing, dance). Further, group 1 activities tend to accentuate visual skills and group 3, kinaesthetic. The control of muscular tremor during voluntary movements would logically be more closely associated with proprioceptive skills than with visual ones.

Ability 6:

Participants of group 3 activities scored more highly than did those of group 1 activities.

Ability 6 was the measure of articulated perceptual style. Once again the requirements of the type of activity and the strength of ability appear to be well matched. Sports such as football, shinty or lacrosse tend to require movements that use the torso and limbs in relatively limited combinations. The martial arts, dance or diving, however, all promote the ability to isolate the separate limbs and body segments in order to diversify the range of movements as much as possible. Such diversification apparently benefits from a more articulated perceptual style, one that allows the perception of all the individual parts within the framework of a unified movement pattern.

2.4.6.2 Question 3: positive attitude toward sport.

Ability scores 1 and 2 showed associations with question 3. Both of these were such that those subjects indicating a more positive attitude scored more highly.

Ability 1.

This was the ability to perceive adequately the structure of one's environment in order, it was suggested, to plan and execute an appropriate motor-output pattern. Whether people develop a positive attitude toward sport because they find they can do it or whether people participate in sport (and therefore improve) because they have a positive attitude toward it, is impossible to ascertain.

Ability 2.

This was the ability to be at ease in activity situations. It was suggested when interpreting this factor that it may well be partially involved with personality (such as state or trait anxiety) and certain other attributes. It would follow that a person who feels anxiety or who tenses up when engaged in physical activity is likely to not have a particularly positive attitude toward it. Alternatively, a person who has a low opinion of sports participation presumably would be less involved in physical activities and may consequently feel tense or "out of place" when finding himself caught or on show in such.

2.4.6.3 General comments on the A.P.Q.

That the questions on the A.P.Q. showed few associations with the ability scores was, perhaps, not all that surprising.

Question 1: this asked for a favourite pastime which was then classified as either passive or active. It was thought possible that less "able" people would tend to prefer activities that did not require overt perceptual-motor skills and therefore enjoy passive pastimes over active ones. In retrospect, however, it would seem more than a little naive to equate ability and enjoyment in such a simple fashion. Although self-efficacy is regarded as an important motivational factor with regard to the continued participation in activities through which this perception is enhanced (Bandura, 1976), neither self-efficacy nor its associate, self-esteem, constitute "enjoyment". It could also be argued that people serious about their sport do not regard it as a mere pastime at all and may well put down a passive pastime in response to question 1 instead.

Question 2: the assignment of a subject's preferred sport or activity into a particular skill category has already been discussed.

The fact that none of the comparisons other than that between categories 1 and 3 showed any relationships with the ability scores could be attributable to a number of causes. The first is that the classification is artificial and that there are not, in fact, any real differences in the skill requirements between the sports of each category. The combining of several of the original groups of activities together would tend to "water down" any differences still further. It is suggested, however, that the reason for the lack of association lies not in the classification of the sports but in the performers of the sports.

The classification was based upon the skill requirements of each sport "were it to be played optimally" and a player exemplifying such standards would neccesarily be of international class. The majority of subjects used in this study could not be said to be able to play their chosen sport "optimally". Many took part relatively infrequently with only the odd one or two subjects achieving University team standards. In other words, although the sports required particular skills, the players did not neccesarily have them. If level of attainment can be used as an indication of skill level then it is something of a surprise to find any association at all between ability scores and preferred sport category with this particular group of subjects. Only the testing of elite athletes could really provide an answer to whether the problem lay in the subjects or in the classification technique. Presumably, the reason for differences being found between those subjects participating in group 1 and group 3 sports is due to the fact that these groups require skills from different sensory modalities rather than just differences in level on the same perceptual-motor dimension.

Question 3: this score referred to one of four categories concerning a subject's attitude toward participation in sport. The majority (64%) opted for category 1, the most positive attitude, which would again indicate that participation in sport is not dependent merely on the ability to do it but on more intrinsic factors such as, for example, sheer enjoyment of the game or health related value judgements.

Question 4: the lack of association between the ability scores and question 4 (whether or not a subject regarded themself as clumsy) was to be expected in the light of the poor shared understanding of just what constitutes clumsy behaviour.

2.4.7 Dancers Profile.

It can immediately be seen from the dancers P.M.A.P. (Figure 2.3.ii) that they tended to have higher scores than average on Abilities 1, 3 and 7. They would also appear to have marginally higher scores on Abilities 2 and 6.

Abilities 1 and 3 both concerned the awareness and control of the body such that it could be "fitted" into a particular movement pattern requirement. Ability 1 also concerned the creation of this movement template from "raw" perceptions of the environment. A dancer learns from visual demonstration. From watching the movements of the teacher, the dancer has to try and make his own body conform, within its physical limitations, to match the teacher's shapes and movement patterns. It should hardly be surprising, then, to find that the dancer group showed higher ability scores in these areas. Unsurprising, that is, until the level of performance of these particular subjects is considered. Whilst termed "dancers", it would not be unfair to say that though each gave dance as their preferred activity, the level at which they danced was not particularly high. If an equivalent could be drawn between dance and competitive sports then three of the four would have been in a University level team but would not expect any higher selection. One can only speculate, however, on what the P.M.A.P. would have looked like had professional dancers constituted the "dancer" group.

Video recordings of the subjects undergoing test 7b revealed some interesting qualitative differences. Test 7b loaded significantly on Factor 1 and also loaded highly on Factor 3. It was noted that in adopting the body shape shown on the slide, most people took it in distinct stages. First they took up the general orientation; this was followed by the "legs pattern", the "arms pattern", the trunk inclination or twist and finally the head position. The dancers and one or two others, however, moved everything at once thus adopting the shape as a whole unit rather than having to create it from its parts.

Ability 7 was interpreted as including the awareness of kinaesthetic cues. The whole purpose behind dance technique training is to learn to be able to move the limbs and segments of the body independently and in a controlled fashion. It should therefore be expected that dancers would score above average on an ability concerning positional information about the body.

Ability 6 was interpreted as representing the articulated perceptual style. The slightly higher score on this ability indicates that the dancers tend to be more field-independent than average; that is, they are more likely to be able to understand patterns of perception in terms of their constituent parts and to be able to recognise these parts.

In order to learn choreographed sequences of movements one must be able to recognise the constituent building blocks that go to make up a continuous sequence. It is noticeable when teaching beginner dancers that they are often unable to "see" what is actually being done in terms of discrete body movements when presented with a short movement sequence. It is then the teacher's task to break the sequence down into recognisable segments, quite often of virtually single movements. The above would imply that dance training causes an increase in field-independence. Whilst it is obvious to anyone involved in teaching dance that the ability to break sequences down into their component moves does undergo marked improvement with training, this does not necessarily mean that the learner's whole perceptual style is being changed. Though this might be the case (this possibility is more fully discussed below), it is also possible that an already articulated perceptual style would facilitate the learning of movement sequences. Since the learning of such sequences tends to be a major part of any dance class, it may well be that those people who regard themselves as unable to learn the sequences tend to drop off in attendance at the classes leaving only those who already had a predisposition toward an articulated perceptual style. This is not to say that more globally orientated people could not learn, only that the rate of learning would be slower.

This association of speed of learning of a novel perceptual-motor task with field-dependence/independence has been demonstrated previously (Jorgensen, 1972 in MacGillivary,

1979) with field-independent people showing a greater amount and rate of learning than the field-dependent subjects. It should be noted, however, that Jorgensen put some of this increased learning down to the stratagies adopted by the field-independents and not simply to their way of perceiving the task.

Ability 2 was thought to be the degree of arousal accompanying a person's engagement in physical activity. It is generally held that one needs to be at a certain level of arousal for optimum performance. Over-arousal due, perhaps, to the anxiety felt when attempting a certain task, tends to be counter-productive with one's performance at the task becoming worse. In dance, such anxiety is usually expressed as a tenseness in the muscles, very often to be seen in raised shoulders and claw-like hands. Such unintentional tenseness both restricts joint range and the flow of movement. It is consequently very common to hear in a dance class someone being told to relax, specifically to allow a better quality of movement. The above average score on this ability, though marginal, possibly reflects this need for physical ease whilst moving; it is not so high, however, as to suggest under-arousal. It would also follow that the reaction-time of dancers is not particularly fast but then, it very seldom needs to be.

Abilities 4, 5 and 8 are virtually the same as for the rest of the female subjects. Factor 4 was lack of tremor on fine motor voluntary movements; Factor 5 was visual discrimination and Factor 8, the ability to narrow the attention. There is no particular requirement that dance has with respect to these abilities that would be different from many other sports or activities. This would account for the dancers average scores.

The likelihood of any ability score occurring within a normal population can be determined almost directly from the Z-score since the percentage of a normal distribution falling between defined limits, measured in units of standard deviation, is known. Thus an ability Z-score of greater than 1, for example, would only be achieved by 16% of the population. Although such a score would not satisfy the usual cut-off points used in statistical data analysis, it must be remembered that statistical criteria are dependent upon the purpose for which the data are to be used. The potential uses of the ability measures are discussed more fully below but a major use could be as an indicator of potential sports aptitude. This form of diagnostic usage, as a basis for offering advice on future training, would not necessitate the level of statistical criteria usually associated with the analysis of data for more exploratory purposes.

3 PART THREE.

This last section considers the perceptual-motor abilities in the light of the previous two studies. Specifically, it considers the intrinsic structure and the interactions of the abilities. These have been used both to create an integrated model of perceptual-motor behaviour and to predict the future use and development of the measurement of perceptual-motor abilities in sports science.

3.1 The Nature Of Perceptual-Motor Abilities.

Study Two began by considering the aetiology of clumsiness or minimal cerebral dysfunction. Gubbay (1975) suggested that any treatment for this condition should preferably begin before the child was six years old and certainly before ten years of age since after this time the maleability of the central nervous system (C.N.S.) was so reduced as to render change of morphological function virtually impossible. This bodes ill for clumsy adults. Gubbay also stated that clumsiness only really created practical problems between the ages of six to twelve years old. This is the period during which peer group values tend to favour the physically gifted and are apt to hurt deeply those who are seen to be lacking. After this age, he suggested, the child has learnt to compensate in some way.
The only compensations available, however, are psychological ones. These usually involve the placing of value onto other acts or pursuits that tend to be met with more success. Other defence strategies may involve trying to turn failure into an

act worthy of some sort of peer esteem by "fooling about" during games periods and actually trying to "fail" in the most spectacular or humorous fashion that could be devised.

As the child gets older, so their degree of choice over their participation in games at school also increases: the clumsy ones drop out. Merely growing older does not improve their abilities, it simply allows them greater leeway in avoiding any activity in which they may be seen to be inadequate. Thus, although Gubbay's implication is that the older child and the adult find ways around these perceptual-motor inabilities, it is more probable, especially in the light of Gubbay's own comments regarding C.N.S. plasticity, that they simply hide from them. Estimates of clumsiness for children range from 5% to 20% of the normal school population (Clements, 1966) and if no improvement in ability can exist then there must be similar proportions of clumsy adults within the population to those of clumsy children.

The potential uses of the P.M.A.P. revolve around the metamorphic nature of these perceptual-motor abilities; i.e. whether or not they can be changed. Gubbay's work would suggest that the answer is "no". It would seem that the principal neurological pathways and interconnections upon which the abilities are determined are virtually unchangeable after about the age of ten. This is not to say that the plasticity required for the laying down of new memories, for example, no longer exists. It does imply, however, that if something as major as the complete formation of the sensory integration circuits has not occurred by this age then it never will. Despite this, improvement in skilled behaviour is seen to accompany practice. There are a number of possible explanations for such improvement.

One is that there is no ability limit and that anybody can achieve any level they desire given sufficient motivation and practice. Another possible explanation could be that abilities are indeed fixed in terms of the plasticity of the C.N.S. but that some areas or systems of the brain that are otherwise dormant are able to take on the extra load required thus allowing improvement. Either of these explanations implies that practice always leads to improvement.

A third possibility is that, despite no absolute changes being made in the underlying abilities, practice leads to an improvement in certain skills due to better strategies being used in the task and to the better prediction of events.

A final explanation is that the neurological underpinning of the abilities is fixed but may yet be maximised; i.e. the "circuitry" aquired by the age of six or so allows for a certain potential ability, a potential that may not be attained without specialized training. To clarify this position it may be helpful to draw an analogy with a more concrete example. An untrained person may be found to have, through muscle biopsy, 95% slow twitch fibres in their vastus lateralis muscle. This will not automatically make them a great long distance runner but will indicate that, on this parameter at least, they have the potential to be one. Whereas muscle biopsy may indicate a person's potential ability, an estimation of $\dot{V}O_2max.$, together with an anaerobic threshold assessment on this untrained subject, would probably have indicated a much lower current performance. The tests used to obtain the factor scores are analogous to the aerobic and anaerobic assessments. They are extrinsic and can only imply the nature of the intrinsic conditions. This fourth explanation may well incorporate changes in strategy and prediction but would ultimately go beyond these too. There is, as yet, no evidence for such an explanation nor is it easy to see what could constitute such evidence without a direct physiological correlate of an upper ability limit. [Just how, physiologically, these abilities could be maximised is also unknown. With the type I fibres in the muscle, fulfilling the maximum potential comes through such training effects as increased concentrations of oxidative enzymes and mitochondria and increased capillarisation of the muscle. Perhaps an equivalent would be changes in local concentrations of certain neuro-transmitters or catalytic enzymes.]

The principal contention concerning the nature of the plasticity of perceptual-motor abilities has been whether or not they can be changed and, if so, is this change limited or unlimited. Gubbay's clinical evidence would suggest they can not be changed yet experimental evidence shows that improvement usually accompanies practice (Whiting, 1976). It has been proposed, therefore, that improvement does follow practice up to a neurologically imposed maximum. This potential can not change and in most people is not reached due to lack of involvement in physical activities. The clumsy person would have lower potential and therefore would maximize their ability at a relatively low performance level. Further practice would not result in further improvement. Gifted people would have higher potential which in most cases would be unrealized. Such people, with the motivation to train in a physical activity, would find significant improvements in their abilities and related skills.

In appendix E are three "case histories" that go some way toward supporting the contention that perceptual-motor abilities do reach maxima beyond which they can not be improved regardless of intensity of training.

3.1.1 The structural organisation of perceptual-motor functioning.

"Movement is an adaptive mechanism for the achievement of ends and, as characteristics of living systems, these mechanisms might succeed or fail." [Higgins (nee Arend), 1985]. Her contention is that movement is an emergent form created from the interaction of the human system with the structure of the environment and subject to the limitations placed on these. Thus all movement has its boundaries defined by the limits of the performance environment, the biomechanical/morphological limitations of the performer and the physical principles operating on the external world (Arend, 1980). Each of these can be further broken down into more and more detailed observations to create increasingly specific interaction effects. The essence of these interactions, however, is relatively simple.

> "For a functional integration to occur, it seems apparent that performers must have intimate knowledge of the nature and state of their own physical system; the nature and state of the external surround in which they move; a responsive and well-tuned body; and a storehouse of cognitive plans or strategies that enable them to effectively utilize past experiences and current information in the planning, execution and evaluation of perceptual-motor behaviour in a variety of situations." (Arend, 1980).

The perceptual-motor system model below is, in essence, the same four-part model described in the foreword. It is, however, rather more elaborate with the findings for this study being used as the basis of its expansion. Higgins' theoretically based system of movement prerequisites has also been incorporated into the model since it appears to complement the structure indicated by the major components of perceptual-motor functioning as found in the above studies. The independent arrival at the same model of perceptual-motor requirements for the genesis of effective human movement from both a theoretical and an experimental standpoint, tends to suggest that the model has some basis, at least, for validity.

Figure 3.1.i:

"A Model of Perceptual-Motor Behaviour:

the functional integration of the eight perceptual-motor

abilities."

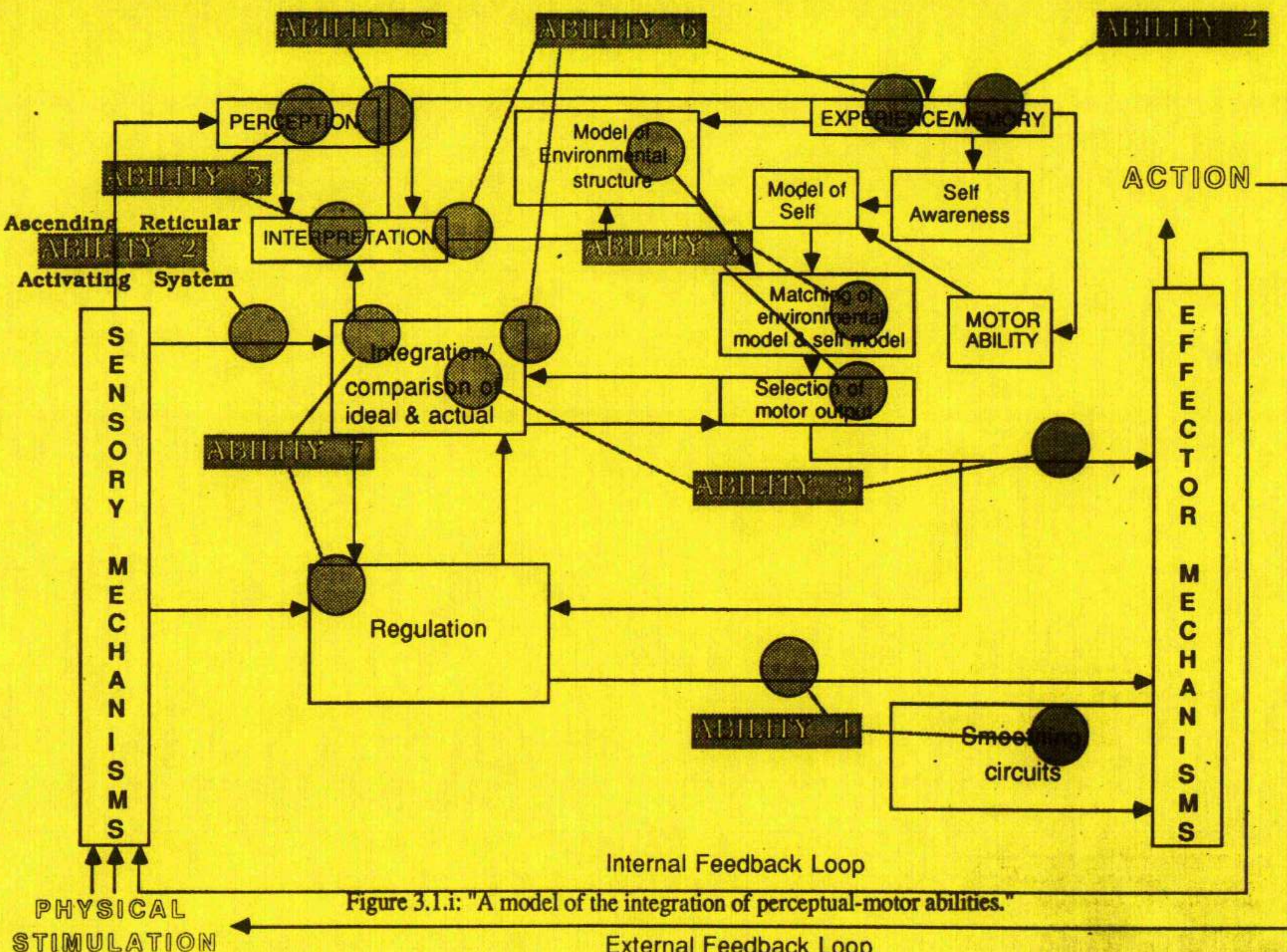
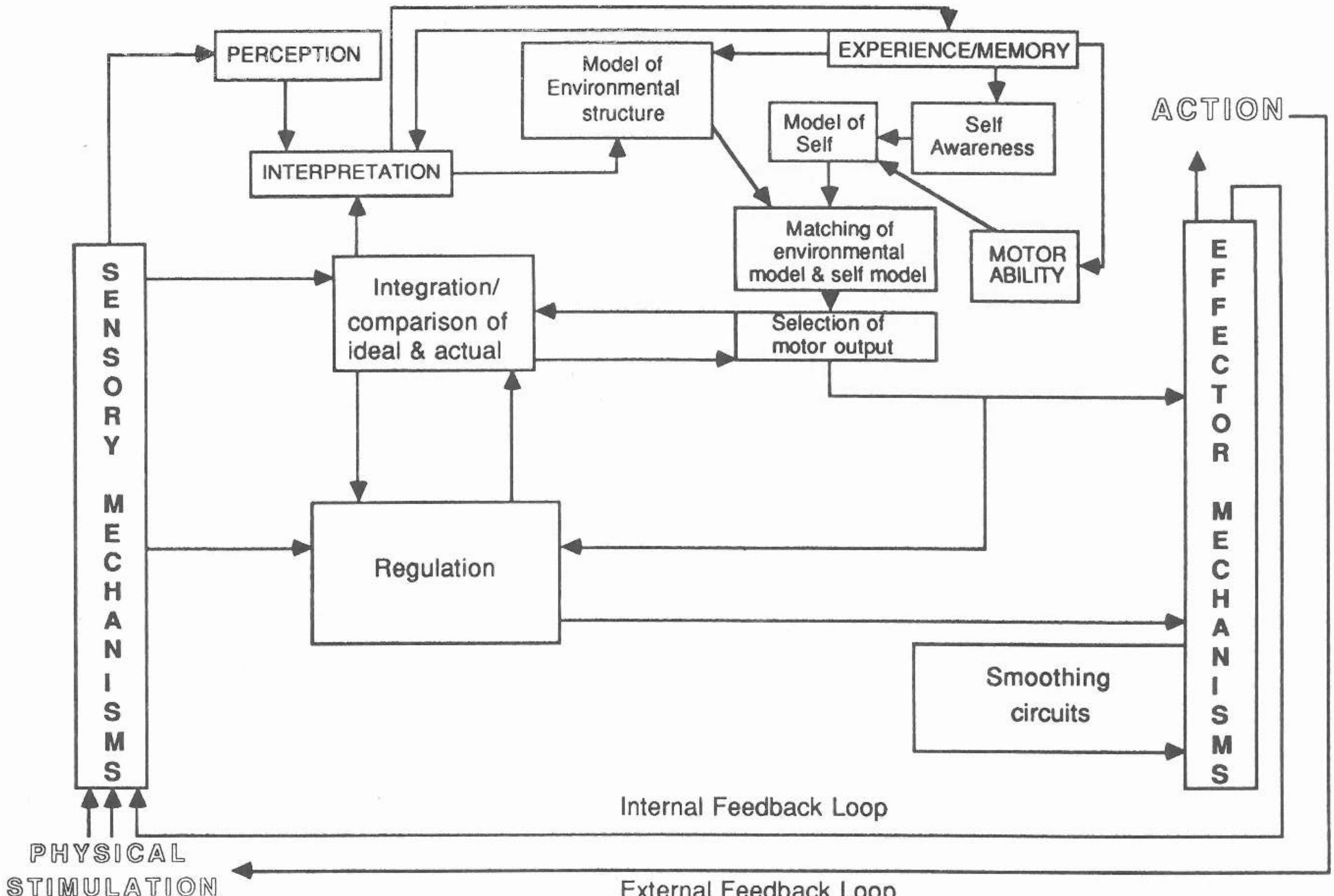


Figure 3.1.i: "A model of the integration of perceptual-motor abilities."


PERCEPTION
INTERPRETATION
Model of Environmental structure
EXPERIENCE/MEMORY
Model of Self
Self Awareness
Matching of environmental model & self model
MOTOR ABILITY
Selection of motor output
Integration/ comparison of ideal & actual
Regulation
Smoothing circuits
SENSORY MECHANISMS
EFFECTOR MECHANISMS
ACTION
Internal Feedback Loop
PHYSICAL STIMULATION
External Feedback Loop

The above diagrams showing the possible sites of influence of the eight abilities are not supposed to be exhaustive. For example, an ability shown as affecting the formation of the "model of self" could be expected to do so by affecting any of its input channels or the constructs from which those inputs come; i.e. "self awareness" or "motor ability". Since the whole system is interconnected via a number of internal and external feedback loops it could be argued that any of the constructs depicted may be the root cause of changes to the "model of self", thus the ability in question could operate anywhere. The groupings of variables within each factor, however, weigh against this argument and tend to restrict each factor's area of operation, if not just to those constructs indicated then certainly to within their close proximity.

Though explaining only 29% of the data variance, Ability 1 comes closest to being an overall perceptual-motor ability. Accordingly it concerns both an understanding of movement needs and the selection of the movement output to meet those needs. The matching of perceived abilities with movement requirements dictates the possible patterns of motor output available. Ability 1 correlated with Ability 6, defined as perceptual style. This is the second most important ability in terms of explaining data variance (when the obliqueness of factors is allowed for). It includes the interpretation of sensory input which, as well as influencing the determination of the "model of environmental structure" of Factor 1, influences many of the other subsequent structures. A number of these structures are associated with Factors 5 (visual discrimination) and 7 (kinaesthetic awareness) thus giving rise to their correlations with Factor 6 (Section 2.3.4).

Factor 6 is also depicted as being a product of "experience/memory" since it is felt that it is this link that determines the individual interpretation of perceptual cues. The results of such interpretation, in terms of effectiveness of "action" in dealing with the environment will, presumably, feedback into "experience/memory" so that the "interpretation" may be modified if necessary for future occasions.

The significance of kinaesthetic awareness (Factor 7) is emphasized by the high amount of data variance it explains (20% when factor inter-correlations are allowed for). Perhaps because of the volume of experimental work that has been performed on visual perception, the importance of the awareness of body position and movement in the execution of skilled activities has tended to have been overlooked.

The association of Factor 6 with Factor 8 could be explained in two ways. A person with the ability to narrow their focus of attention on to parts of a sensory array should accordingly be in a better position to separate those parts from the rest of that array. Alternatively, a person with the ability to perceive those parts as separate already would have a more "concrete" item to narrow the focus upon. In the diagram, Factor 8 is shown to be influencing the system before Factor 6, this can not be interpreted too directly however. The separation of "perception" and "interpretation" is increasingly being regarded as suspect (Gibson in Bruce & Green, 1985; Lee, 1976; Hofsten & Lee, 1982; Solomon, Carello & Turvey, 1984), thus Factors 6 and 8 may well function in parallel rather than in series.

Factor 8, despite only being depicted as being associated with "perception", had a number of correlations with other factors. Again, this may be because differences in perception will alter all subsequent behaviour, however, its correlation with Factor 7 may simply be an indication of the concentration required to focus upon kinaesthetic cues given the common preference for using visual information. The association of Factor 8 with Factor 2 has already been discussed.

Factor 2 has been depicted as acting at two separate sites. The first is as part of the general arousal of the C.N.S., usually attributed to the Ascending Reticular Activating System. Feeding in to the higher areas of the brain via the "integration" centre, this provides a general stimulation of the cortex (Barr, 1974). The ability to reduce unnecessary arousal must influence all aspects of perceptual-motor functioning and may account for the high percentage (19%) of data variance that Factor 2 explains when considered separately from the other abilities. It has also been shown hovering over "experience/memory"; this is to indicate the effect of past successes and failures in movement behaviour on the arousal/anxiety that accompanies each successive attempt.

Ability 3 concerns both the integration of proprioceptive information (which is then available for use by other parts of the model) and its direct translation into movement output. This last facet is vital for all movement since it provides the automatic corrections required for the maintenance of balance and posture.

Ability 4 would appear to be almost entirely motor, being concerned with the smoothing of the motor output. Accordingly, it has no overt associations with the other abilities.

The model above is not meant to represent rigidly defined areas of operation for the eight abilities but to indicate the ways in which these abilities combine together to produce perceptual-motor behaviour.

3.2 Perceptual-motor Abilities And Uses For The P.M.A.P.

The principal application envisaged for the P.M.A.P. is not just the mapping of prominent abilities for different sports events or physical activities but the use of such maps to help predict whether hopeful individuals showed an aptitude for their desired activity. To do this, for a given sport a number of "elite exponents" would need to be tested on all of the above perceptual-motor tests to ascertain which of the eight abilities were accentuated and to what degree. Comparison of the novice's P.M.A.P. with that "required" would indicate which abilities would need to be improved or even whether continuing in that particular sport was ultimately pointless, in terms of performance level. An assumption being made here is, of course, that any of the heightened abilities observed were causatively related to the elite exponents' performance capabilities. Another assumption, being implied in the phrase "which abilities would need to be improved", is that these abilities could be changed. The dividing line between whether to give up the sport or to practise all the harder is ultimately dependent upon the nature of the abilities themselves.

The two ends of the "ability" spectrum have been brought into consideration; the athlete looking to improve and the drop-out looking not to be seen. Even should it be proven that these perceptual-motor abilities can be changed, the "drop-out" would presumably have little inclination to put his self-esteem at risk once again by attempting any form of voluntary movement therapy. Movement problems would arise only when faced with situations that could not be avoided such as conditions at the workplace or when driving a car in busy traffic. In times of stress particularly, the latent perceptual-motor deficit could manifest itself as an inability to cope and an accident occur: it may well be that "accident prone" people are the lost clumsy adults. If this is the case then a possible use of the P.M.A.P. outside the sports-science field could be to highlight those people who would be more prone to industrial accidents in particularly hazardous workplaces. It could be that the lack of particular abilities may even correspond to the type of accident that happens; e.g. a person with a very poor sense of temporal pattern recognition may tend to trap hands and/or fingers in hammering or mould-pressing type machinery that works on an automatic timing mechanism. This is, of course, only speculation and both refinement of the tests used to measure the abilities and a large amount of background data would be required before such predictive uses could be made.

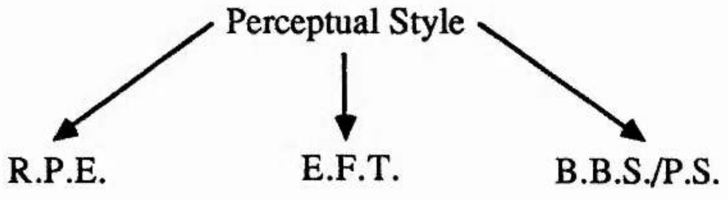
Not being able to measure these latent perceptual-motor abilities directly is no argument against using the P.M.A.P as an aptitude test for particular sports. To return to the analogy with the test of aerobic fitness; if a person scores poorly but has done no recent, relevant training then it is likely that there is room for improvement but not, perhaps, enough to become an international class runner. If the individual performs very well on the test yet still has not done any recent, relevant training then it is likely that not only is there room for improvement but that such improvement would take him into the realms of physiological fitness required by an international standard athlete.

This balance of present fitness with past training to predict future performance could be similarly achieved with the perceptual-motor abilities. The difference is that, whereas the effects of training on aerobic fitness indices are very well documented and can be utilized in order to make the predictions, the relative effects of different (or any) training regimes on the ability scores is totally unknown, thus there is no way of telling what range of improvement could be expected.

Even if it were proven that there were no limits to improvement, the P.M.A.P. could still be used to indicate in which areas training was needed and how far an individual had to go to achieve a desired standard. If, as is proposed here, a limited potential only may be achieved through practice then the P.M.A.P. would have a further use in predicting the maximum performance level possible should sufficient practice be maintained. It is felt that this use of the P.M.A.P. as an aptitude test would, ultimately, be more useful.

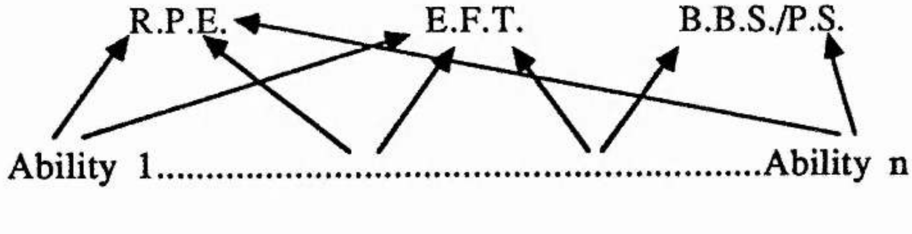
3.3 Overall Conclusion.

This study began with a search for a perceptual-motor "g-factor". The first step along the path was to compare three tests of perceptual functioning for their degree of overlap. It was proposed that if they did exhibit such functional redundancy then it would be because of their subservience to this overall style of perceptual and possibly cognitive functioning. That is, the following arrangement would exist:



They did not concur, at least not in a particularly consistent fashion.

The varying relationships between the three tests suggested that they were related, not by a super-ordinate general perceptual factor but by a number of subordinate perceptual or perceptual-motor abilities. Different combinations of these abilities, for example between men and women, would create different relationships between the dependent perceptual tests. Thus the arrangement to be tested had become:



The search for these underlying perceptual-motor abilities eventually uncovered eight factors. The factor definitions were made using the common elements of their constituent tests and, as such, are regarded as still being open to the modification of their interpretation should new evidence suggest it. For the moment, they appear to hold some agreement at least with theoretically derived perceptual-motor constructs. A model of perceptual-motor functioning intended to draw these separate abilities into a coherent whole has been put forward.

It is interesting to see that the abilities tend to cut across classically defined skill categories such as static and dynamic balance, fine and gross motor patterns or visual discrimination and rhythmic sense. Instead the awareness of patterns of stimuli, almost regardless of sensory modality, has been shown to be more fundamental.

The three perceptual tests used in Study 1 were included amongst the original 76 measures of skilled perceptual-motor performance for two reasons. The first was because the principal intention behind the study was to find out what the underlying abilities connecting these three tests in particular were. The second was to weight the factor extraction in order to emphasize the perceptual elements of creating and maintaining efficient movement since deficits in the perception of one's environment or in the planning of movement output are more likely to be the causes behind most "clumsy" behaviour than inabilities to control the neuromuscular output patterns.

While the study has revealed eight interlocking perceptual-motor abilities, it is not yet clear how valuable, practically, this identification will be. Depending upon the maleability of the abilities, potential uses could be in the identification of sports participation aptitude and the prescription of training both of people who wish to generally improve their performance levels in a number of physical activities and of those wishing to train for specialized sports events at a high level. It is not enough to train the appropriate energy systems of the body and simply hope that the abilities required for the skilled performance of the activity will just emerge of their own accord. It may be that the required abilities can never be achieved and that the aspiring athlete would be better advised to change to an activity in which his or her ability potential would be sufficient to take them to a higher performance level.

Having come full circle it appears that the true causes of the relationships between E.F.T., R.P.E. and B.B.S./P.S. are a combination of the above arrangements. That is, cognitive style or, at least, perceptual style is responsible in part for their association. It does not act, however, as a super-ordinate construct but as one of eight inter-related perceptual-motor abilities. Differences in the relationships between the three tests demonstrated by male and female subjects for example, are due to the varying weightings of interaction of perceptual style with the other seven abilities. Witkin's perceptual style, though important as a basic "ability", is not the all-encompassing dimension which he advocated. It does indeed have strong associations with many of the other abilities but not, it is felt, in the role of the causative factor.

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APPENDIX A

Ai)

	V_E/R.P.E.c (Z)	V_E/R.P.E.o (Z)	V_E/R.P.E.1 (Z)	Wk.Ld./R.P.E.c (Z)	Wk.Ld./R.P.E.o (Z)
V_E/R.P.R.c (Z)	1.0000	.8369**	.5978**	.3587	.2218
V_E/R.P.R.o (Z)	.8369**	1.0000	.6993**	.3027	.3238
V_E/R.P.R.1 (Z)	.5978**	.6993**	1.0000	.1249	.2229
Wk.Ld./R.P.E.c (Z)	.3587	.3027	.1249	1.0000	.6523**
Wk.Ld./R.P.E.o (Z)	.2218	.3238	.2229	.6523**	1.0000
Wk.Ld./R.P.E.1 (Z)	-.1053	-.1040	.2890	.0421	.1908
$\dot{V}O_2$/R.P.E.c (Z)	.8434**	.8371**	.5206**	.3221	.1410
$\dot{V}O_2$/R.P.E.o (Z)	.6437**	.8661**	.5096**	.2749	.1875
$\dot{V}O_2$/R.P.E.1 (Z)	.4274*	.6001**	.7825**	.0812	.0955
H.R./R.P.E.c (Z)	.3117	.3790	.1737	.1602	.2323
H.R./R.P.E.o (Z)	.4468*	.4900**	.4069*	.1785	.1301
H.R./R.P.E.1 (Z)	.2295	.3591	.5027**	.0126	-.0883
B.B.S.	-.3959*	-.2175	-.2284	-.2698	-.1421
P.S.	.0164	.0387	.0778	-.1357	-.0337
E.F.T.	.0842	.1687	.2883	.3105	.2588
Height	.2345	.0326	.0388	.0579	-.1242
Weight	.2113	.0344	.0582	-.0247	-.1878
P.I.	-.0401	-.0094	-.0322	.1403	.1529
Sex	.2546	-.0118	-.0696	.2085	.1010
Age	.2182	.2892	.4121*	.0438	.0130

	Wk.Ld./R.P.E.1 (Z)	$\dot{V}O_2$/R.P.E.c (Z)	$\dot{V}O_2$/R.P.E.o (Z)	$\dot{V}O_2$/R.P.E.1 (Z)	H.R./R.P.E.c (Z)
V_E/R.P.R.c (Z)	-.1053	.8434**	.6437**	.4274*	.3117
V_E/R.P.R.o (Z)	-.1040	.8371**	.8661**	.6001**	.3790
V_E/R.P.R.1 (Z)	.2890	.5206**	.5096**	.7825**	.1737
Wk.Ld./R.P.E.c (Z)	.0421	.3221	.2749	.0812	.1602
Wk.Ld./R.P.E.o (Z)	.1908	.1410	.1875	.0955	.2323
Wk.Ld./R.P.E.1 (Z)	1.0000	-.1219	-.1439	.2677	-.1083
$\dot{V}O_2$/R.P.E.c (Z)	-.1219	1.0000	.8809**	.6540**	.2699
$\dot{V}O_2$/R.P.E.o (Z)	-.1439	.8809**	1.0000	.6982**	.3545
$\dot{V}O_2$/R.P.E.1 (Z)	.2677	.6540**	.6982**	1.0000	.1566
H.R./R.P.E.c (Z)	-.1083	.2699	.3545	.1566	1.0000
H.R./R.P.E.o (Z)	-.0678	.5082**	.4137*	.3531	-.0709
H.R./R.P.E.1 (Z)	.2081	.3639	.3773	.4762*	-.2239
B.B.S.	-.1025	-.2638	-.0503	-.0668	-.0131
P.S.	-.1628	.0314	.0516	.1589	-.0544
E.F.T.	.0970	.0336	.0751	.1660	.0844
Height	.0822	.3112	.1272	.1894	-.0826
Weight	.1450	.2837	.1020	.1654	-.1068
P.I.	-.1284	-.0330	.0325	.0183	.0814
Sex	.1541	.2847	.0793	.1220	.0148
Age	.0653	.2681	.2635	.4579*	.0945

* - SIGNIF. LE .01   ** - SIGNIF. LE .001   2-TAILED

"Pearson Correlation Matrix of Perceptual Tests and Physiological Parameters (All subjects)."

Ai) continued.

	H.R./R.P.E.o (Z)	H.R./R. P.E.1 (Z)	B.B.S.	P.S.	E.F.T.
V_E/R.P.R.c (Z)	.4468*	.2295	-.3959*	.0164	.0842
V_E/R.P.R.o (Z)	.4900**	.3591	-.2175	.0387	.1687
V_E/R.P.R.1 (Z)	.4069*	.5027**	-.2284	.0778	.2883
Wk.Ld./R.P.E.c (Z)	.1785	.0126	-.2698	-.1357	.3105
Wk.Ld./R.P.E.o (Z)	.1301	-.0883	-.1421	-.0337	.2588
Wk.Ld./R.P.E.1 (Z)	-.0678	.2081	-.1025	-.1628	.0970
$\dot{V}O_2$/R.P.E.c (Z)	.5082**	.3639	-.2638	.0314	.0336
$\dot{V}O_2$/R.P.E.o (Z)	.4137*	.3773	-.0503	.0516	.0751
$\dot{V}O_2$/R.P.E.1 (Z)	.3531	.4762*	-.0668	.1589	.1660
H.R./R.P.E.c (Z)	-.0709	-.2239	-.0131	-.0544	.0844
H.R./R.P.E.o (Z)	1.0000	.7508**	-.0133	.0011	.0920
H.R./R.P.E.1 (Z)	.7508**	1.0000	.0325	-.0170	.2143
B.B.S.	-.0133	.0325	1.0000	.0788	-.2393
P.S.	.0011	-.0170	.0788	1.0000	-.2470
E.F.T.	.0920	.2143	-.2393	-.2470	1.0000
Height	.0810	.0360	-.1362	-.0536	-.1580
Weight	.0778	.0826	-.2141	-.1824	-.1736
P.I.	-.0414	-.0996	.2201	.2222	.0658
Sex	.0301	-.0617	-.2418	-.1505	-.0306
Age	.1656	.2898	-.2555	.1088	.2894

	Height	Weight	P.I.	Sex	Age
V_E/R.P.R.c (Z)	.2345	.2113	-.0401	.2546	.2182
V_E/R.P.R.o (Z)	.0326	.0344	-.0094	-.0118	.2892
V_E/R.P.R.1 (Z)	.0388	.0582	-.0322	-.0696	.4121*
Wk.Ld./R.P.E.c (Z)	.0579	-.0247	.1403	.2085	.0438
Wk.Ld./R.P.E.o (Z)	-.1242	-.1878	.1529	.1010	.0130
Wk.Ld./R.P.E.1 (Z)	.0822	.1450	-.1284	.1541	.0653
$\dot{V}O_2$/R.P.E.c (Z)	.3112	.2837	-.0330	.2847	.2681
$\dot{V}O_2$/R.P.E.o (Z)	.1272	.1020	.0325	.0793	.2635
$\dot{V}O_2$/R.P.E.1 (Z)	.1894	.1654	.0183	.1220	.4579*
H.R./R.P.E.c (Z)	-.0826	-.1068	.0814	.0148	.0945
H.R./R.P.E.o (Z)	.0810	.0778	-.0414	.0301	.1656
H.R./R.P.E.1 (Z)	.0360	.0826	-.0996	-.0617	.2898
B.B.S.	-.1362	-.2141	.2201	-.2418	-.2555
P.S.	-.0536	-.1824	.2222	-.1505	.1088
E.F.T.	-.1580	-.1736	.0658	-.0306	.2894
Height	1.0000	.8392**	.0432	.6879**	-.0979
Weight	.8392**	1.0000	-.5013**	.6164**	-.1184
P.I.	.0432	-.5013**	1.0000	-.0743	.0518
Sex	.6879**	.6164**	-.0743	1.0000	-.1329
Age	-.0979	-.1184	.0518	-.1329	1.0000

* - SIGNIF. LE .01   ** - SIGNIF. LE .001   2-TAILED

Aii)

	V_E/R.P.E.c (Z)	V_E/R.P.E.o (Z)	V_E/R.P.E.1 (Z)	Wk.Ld./R.P.E.c (Z)	Wk.Ld./R.P.E.o (Z)
V_E/R.P.R.c (Z)	1.0000	.8225**	.0622	.4380	.3739
V_E/R.P.R.o (Z)	.8225**	1.0000	.2145	.4396	.5799*
V_E/R.P.R.1 (Z)	.0622	.2145	1.0000	.2895	.3084
Wk.Ld./R.P.E.c (Z)	.4380	.4396	.2895	1.0000	.7233**
Wk.Ld./R.P.E.o (Z)	.3739	.5799*	.3084	.7233**	1.0000
Wk.Ld./R.P.E.1 (Z)	-.3180	-.2259	.4618	-.0161	.1563
$\dot{V}O_2$/R.P.E.c (Z)	.7663**	.7454**	.0883	.2623	.2919
$\dot{V}O_2$/R.P.E.o (Z)	.6781**	.8637**	.2187	.2859	.4312
$\dot{V}O_2$/R.P.E.1 (Z)	-.0187	.2081	.8283**	.0678	.1707
H.R./R.P.E.c (Z)	.5884*	.3298	-.0733	.3866	.2521
H.R./R.P.E.o (Z)	.1264	.4149	.2605	.4626	.5343*
H.R./R.P.E.1 (Z)	-.2831	-.0362	.5182*	.3020	.2146
B.B.S.	.0115	-.0168	-.1119	-.1516	-.1799
P.S.	.0889	.1959	.0881	-.2456	-.1279
E.F.T.	.0942	.1136	.3123	.3978	.2018
Height	-.0865	-.2158	.0706	-.1921	-.2955
Weight	-.1199	-.2696	.1596	-.0626	-.2138
P.I.	.0276	.0311	-.0972	-.2050	-.1474
Age	.2492	.3189	.4869	.1351	.1332

	Wk.Ld./R.P.E.1 (Z)	$\dot{V}O_2$/R.P.E.c (Z)	$\dot{V}O_2$/R.P.E.o (Z)	$\dot{V}O_2$/R.P.E.1 (Z)	H.R./R.P.E.c (Z)
V_E/R.P.R.c (Z)	-.3180	.7663**	.6781**	-.0187	.5884*
V_E/R.P.R.o (Z)	-.2259	.7454**	.8637**	.2081	.3298
V_E/R.P.R.1 (Z)	.4618	.0883	.2187	.8283**	-.0733
Wk.Ld./R.P.E.c (Z)	-.0161	.2623	.2859	.0678	.3866
Wk.Ld./R.P.E.o (Z)	.1563	.2919	.4312	.1707	.2521
Wk.Ld./R.P.E.1 (Z)	1.0000	-.2789	-.2081	.4532	-.0770
$\dot{V}O_2$/R.P.E.c (Z)	-.2789	1.0000	.8683**	.2965	.2438
$\dot{V}O_2$/R.P.E.o (Z)	-.2081	.8683**	1.0000	.4417	.1849
$\dot{V}O_2$/R.P.E.1 (Z)	.4532	.2965	.4417	1.0000	-.2134
H.R./R.P.E.c (Z)	-.0770	.2438	.1849	-.2134	1.0000
H.R./R.P.E.o (Z)	-.0798	.2282	.3140	.1701	-.1795
H.R./R.P.E.1 (Z)	.3341	-.0761	.0116	.4539	-.3239
B.B.S.	-.0352	.0086	.0404	.0166	-.2234
P.S.	-.2777	.0953	.2415	.1751	-.1665
E.F.T.	.0680	-.0829	-.0409	.0536	.0862
Height	-.0504	.0439	-.0030	.1560	-.2091
Weight	.1480	-.0701	-.1718	.1377	-.1402
P.I.	-.2732	.1510	.2159	.0570	-.1440
Age	.0995	.3265	.3784	.5562*	.2530

* - SIGNIF. LE .01 ** - SIGNIF. LE .001 2-TAILED

"Pearson Correlation Matrix of Perceptual Tests and Physiological Parameters (Male subjects)."

Aii) continued.

	H.R./R.P.E.o (Z)	H.R./R. P.E.1 (Z)	B.B.S.	P.S.	E.F.T.
V_E/R.P.R.c (Z)	.1264	-.2831	.0115	.0889	.0942
V_E/R.P.R.o (Z)	.4149	-.0362	-.0168	.1959	.1136
V_E/R.P.R.1 (Z)	.2605	.5182*	-.1119	.0881	.3123
Wk.Ld./R.P.E.c (Z)	.4626	.3020	-.1516	-.2456	.3978
Wk.Ld./R.P.E.o (Z)	.5343*	.2146	-.1799	-.1279	.2018
Wk.Ld./R.P.E.1 (Z)	-.0798	.3341	-.0352	-.2777	.0680
$\dot{V}O_2$/R.P.E.c (Z)	.2282	-.0761	.0086	.0953	-.0829
$\dot{V}O_2$/R.P.E.o (Z)	.3140	.0116	.0404	.2415	-.0409
$\dot{V}O_2$/R.P.E.1 (Z)	.1701	.4539	.0166	.1751	.0536
H.R./R.P.E.c (Z)	-.1795	-.3239	-.2234	-.1665	.0862
H.R./R.P.E.o (Z)	1.0000	.7173**	.1872	.0920	.1593
H.R./R.P.E.1 (Z)	.7173**	1.0000	.0757	.0650	.2886
B.B.S.	.1872	.0757	1.0000	.2666	-.4314
P.S.	.0920	.0650	.2666	1.0000	-.3081
E.F.T.	.1593	.2886	-.4314	-.3081	1.0000
Height	-.1750	-.0647	.1015	.0787	-.3296
Weight	-.3246	-.1608	.0655	-.2747	-.2390
P.I.	.1813	.1267	.0535	.5266*	-.1732
Age	-.0184	.1692	-.4025	.2677	.2408

	Height	Weight	P.I.	Age
V_E/R.P.R.c (Z)	-.0865	-.1199	.0276	.2492
V_E/R.P.R.o (Z)	-.2158	-.2696	.0311	.3189
V_E/R.P.R.1 (Z)	.0706	.1596	-.0972	.4869
Wk.Ld./R.P.E.c (Z)	-.1921	-.0626	-.2050	.1351
Wk.Ld./R.P.E.o (Z)	-.2955	-.2138	-.1474	.1332
Wk.Ld./R.P.E.1 (Z)	-.0504	.1480	-.2732	.0995
$\dot{V}O_2$/R.P.E.c (Z)	.0439	-.0701	.1510	.3265
$\dot{V}O_2$/R.P.E.o (Z)	-.0030	-.1718	.2159	.3784
$\dot{V}O_2$/R.P.E.1 (Z)	.1560	.1377	.0570	.5562*
H.R./R.P.E.c (Z)	-.2091	-.1402	-.1440	.2530
H.R./R.P.E.o (Z)	-.1750	-.3246	.1813	-.0184
H.R./R.P.E.1 (Z)	-.0647	-.1608	.1267	.1692
B.B.S.	.1015	.0655	.0535	-.4025
P.S.	.0787	-.2747	.5266*	.2677
E.F.T.	-.3296	-.2390	-.1732	.2408
Height	1.0000	.7794**	.4655	-.0823
Weight	.7794**	1.0000	-.1895	-.1625
P.I.	.4655	-.1895	1.0000	.1178
Age	-.0823	-.1625	.1178	1.0000

* - SIGNIF. LE .01   ** - SIGNIF. LE .001   2-TAILED

Aiii)

	V_E/R.P.E.c (Z)	V_E/R.P.E.o (Z)	V_E/R.P.E.1 (Z)	Wk.Ld./R.P.E.c (Z)	Wk.Ld./R.P.E.o (Z)
V_E/R.P.R.c (Z)	1.0000	.8835**	.8486**	.2589	.0901
V_E/R.P.R.o (Z)	.8835**	1.0000	.8591**	.2228	.1540
V_E/R.P.R.1 (Z)	.8486**	.8591**	1.0000	.0365	.1732
Wk.Ld./R.P.E.c (Z)	.2589	.2228	.0365	1.0000	.5840
Wk.Ld./R.P.E.o (Z)	.0901	.1540	.1732	.5840	1.0000
Wk.Ld./R.P.E.1 (Z)	-.0549	-.0485	.1689	.0478	.2218
$\dot{V}O_2$/R.P.E.c (Z)	.8530**	.9165**	.7409**	.2756	-.0366
$\dot{V}O_2$/R.P.E.o (Z)	.6379*	.8718**	.6206*	.2232	-.0347
$\dot{V}O_2$/R.P.E.1 (Z)	.5996*	.7654**	.7879**	.0287	-.0116
H.R./R.P.E.c (Z)	.1938	.4187	.3159	-.0055	.2162
H.R./R.P.E.o (Z)	.6342*	.5488	.5024	-.0587	-.3350
H.R./R.P.E.1 (Z)	.5349	.5522	.5006	-.2508	-.4727
B.B.S.	-.5940*	-.3543	-.3570	-.3346	-.0511
P.S.	.0420	-.0582	.0599	.0551	.1717
E.F.T.	.1324	.2945	.3507	.2425	.4240
Height	.2463	.2695	.1865	-.0527	-.2669
Weight	.1674	.1929	.1139	-.3596	-.5127
P.I.	-.0422	-.0251	-.0108	.3961	.4599
Age	.3711	.3862	.4398	-.0241	-.2352

	Wk.Ld./R.P.E.1 (Z)	$\dot{V}O_2$/R.P.E.c (Z)	$\dot{V}O_2$/R.P.E.o (Z)	$\dot{V}O_2$/R.P.E.1 (Z)	H.R./R.P.E.c (Z)
V_E/R.P.R.c (Z)	-.0549	.8530**	.6379*	.5996*	.1938
V_E/R.P.R.o (Z)	-.0485	.9165**	.8718**	.7654**	.4187
V_E/R.P.R.1 (Z)	.1689	.7409**	.6206*	.7879**	.3159
Wk.Ld./R.P.E.c (Z)	.0478	.2756	.2232	.0287	-.0055
Wk.Ld./R.P.E.o (Z)	.2218	-.0366	-.0347	-.0116	.2162
Wk.Ld./R.P.E.1 (Z)	1.0000	-.1535	-.1878	.0165	-.1712
$\dot{V}O_2$/R.P.E.c (Z)	-.1535	1.0000	.9081**	.8082**	.3019
$\dot{V}O_2$/R.P.E.o (Z)	-.1878	.9081**	1.0000	.8063**	.4461
$\dot{V}O_2$/R.P.E.1 (Z)	.0165	.8082**	.8063**	1.0000	.3946
H.R./R.P.E.c (Z)	-.1712	.3019	.4461	.3946	1.0000
H.R./R.P.E.o (Z)	-.0830	.6867*	.4764	.4734	.0117
H.R./R.P.E.1 (Z)	.0288	.6543*	.5750	.5142	-.1460
B.B.S.	-.1264	-.3514	-.0738	-.0816	.1803
P.S.	.1444	.0771	-.0459	.2004	.0740
E.F.T.	.1942	.1985	.2276	.3791	.0987
Height	-.0160	.3037	.2045	.1542	-.0336
Weight	-.0765	.2530	.1785	.1018	-.1525
P.I.	.0464	-.0790	-.0267	.0122	.2229
Age	.0368	.4310	.2898	.4969	-.1337

* - SIGNIF. LE .01 ** - SIGNIF. LE .001 (2-TAILED

"Pearson Correlation Matrix of Perceptual Tests and Physiological Parameters (Female subjects)."

Aiii) continued.

	H.R./R.P.E.o (Z)	H.R./R. P.E.1 (Z)	B.B.S.	P.S.	E.F.T.
V_E/R.P.R.c (Z)	.6342*	.5349	-.5940*	.0420	.1324
V_E/R.P.R.o (Z)	.5488	.5522	-.3543	-.0582	.2945
V_E/R.P.R.1 (Z)	.5024	.5006	-.3570	.0599	.3507
Wk.Ld./R.P.E.c (Z)	-.0587	-.2508	-.3346	.0551	.2425
Wk.Ld./R.P.E.o (Z)	-.3350	-.4727	-.0511	.1717	.4240
Wk.Ld./R.P.E.1 (Z)	-.0830	.0288	-.1264	.1444	.1942
$\dot{V}O_2$/R.P.E.c (Z)	.6867*	.6543*	-.3514	.0771	.1985
$\dot{V}O_2$/R.P.E.o (Z)	.4764	.5750	-.0738	-.0459	.2276
$\dot{V}O_2$/R.P.E.1 (Z)	.4734	.5142	-.0816	.2004	.3791
H.R./R.P.E.c (Z)	.0117	-.1460	.1803	.0740	.0987
H.R./R.P.E.o (Z)	1.0000	.7836**	-.1811	-.0937	-.0001
H.R./R.P.E.1 (Z)	.7836**	1.0000	-.0341	-.1340	.1245
B.B.S.	-.1811	-.0341	1.0000	-.2525	.0556
P.S.	-.0937	-.1340	-.2525	1.0000	-.1352
E.F.T.	-.0001	.1245	.0556	-.1352	1.0000
Height	.4257	.3429	-.0441	.0525	.1977
Weight	.3791	.3937	-.2185	.0586	-.1658
P.I.	-.1774	-.2511	.3276	-.0550	.3968
Age	.5062	.5193	-.1382	-.3288	.4506

	Height	Weight	P.I.	Age
V_E/R.P.R.c (Z)	.2463	.1674	-.0422	.3711
V_E/R.P.R.o (Z)	.2695	.1929	-.0251	.3862
V_E/R.P.R.1 (Z)	.1865	.1139	-.0108	.4398
Wk.Ld./R.P.E.c (Z)	-.0527	-.3596	.3961	-.0241
Wk.Ld./R.P.E.o (Z)	-.2669	-.5127	.4599	-.2352
Wk.Ld./R.P.E.1 (Z)	-.0160	-.0765	.0464	.0368
$\dot{V}O_2$/R.P.E.c (Z)	.3037	.2530	-.0790	.4310
$\dot{V}O_2$/R.P.E.o (Z)	.2045	.1785	-.0267	.2898
$\dot{V}O_2$/R.P.E.1 (Z)	.1542	.1018	.0122	.4969
H.R./R.P.E.c (Z)	-.0336	-.1525	.2229	-.1337
H.R./R.P.E.o (Z)	.4257	.3791	-.1774	.5062
H.R./R.P.E.1 (Z)	.3429	.3937	-.2511	.5193
B.B.S.	-.0441	-.2185	.3276	-.1382
P.S.	.0525	.0586	-.0550	-.3288
E.F.T.	.1977	-.1658	.3968	.4506
Height	1.0000	.7187**	-.2011	.1887
Weight	.7187**	1.0000	-.8221**	.1271
P.I.	-.2011	-.8221**	1.0000	-.0442
Age	.1887	.1271	-.0442	1.0000

* - SIGNIF. LE .01 ** - SIGNIF. LE .001 (2-TAILED

Aiv)

Male subjects

	B.B.S.
V_E/R.P.E. difference (1 - c)	-.0917
$\dot{V}O_2$/R.P.E. difference (1 - c)	.0061
Wk.Ld/R.P.E. difference (1 - c)	.0747
H.R./R.P.E. difference (1 - c)	.1875

Female subjects

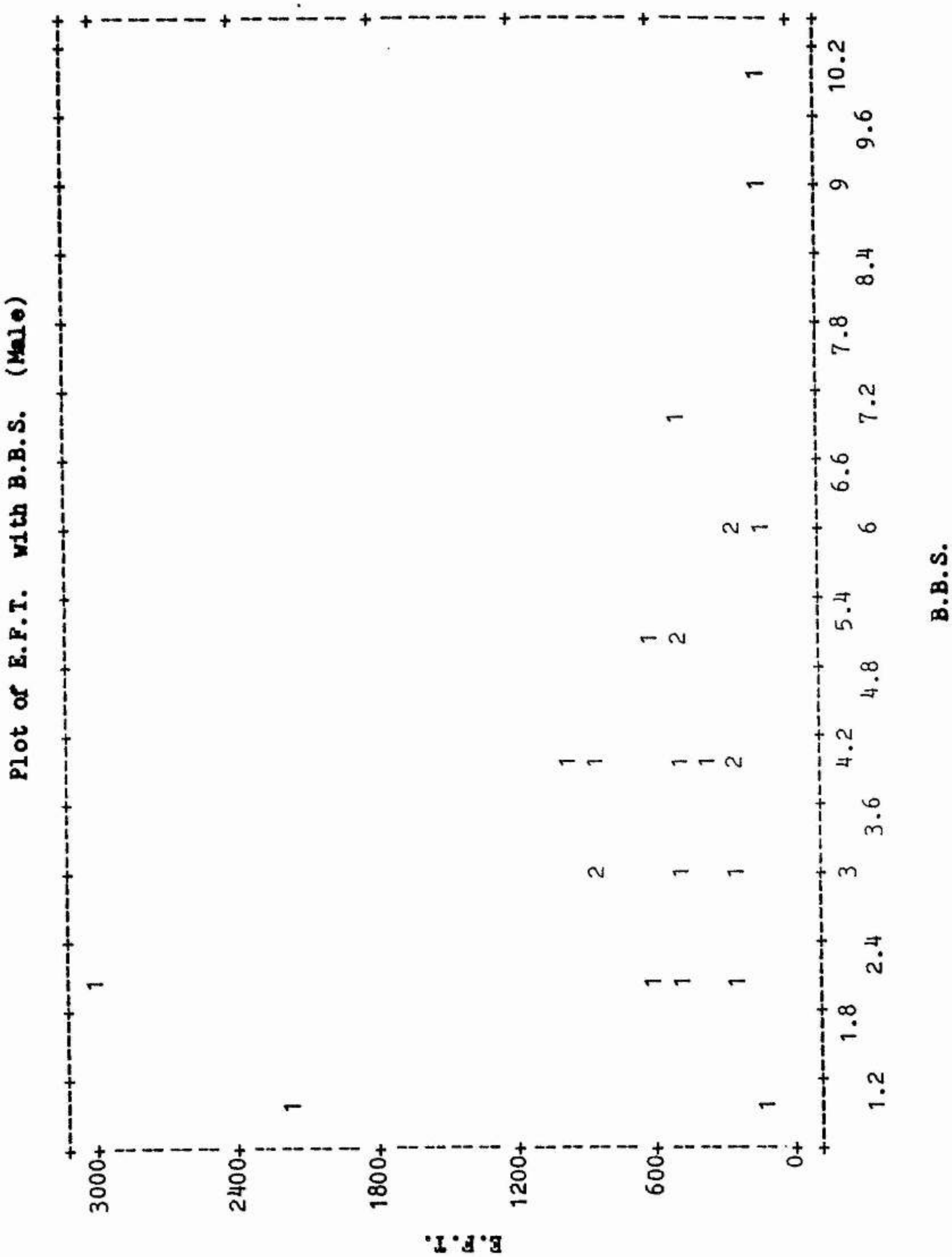
	B.B.S.
V_E/R.P.E. difference (1 - c)	.4838
$\dot{V}O_2$/R.P.E. difference (1 - c)	.4911
Wk.Ld/R.P.E. difference (1 - c)	.2154
H.R./R.P.E. difference (1 - c)	-.1465

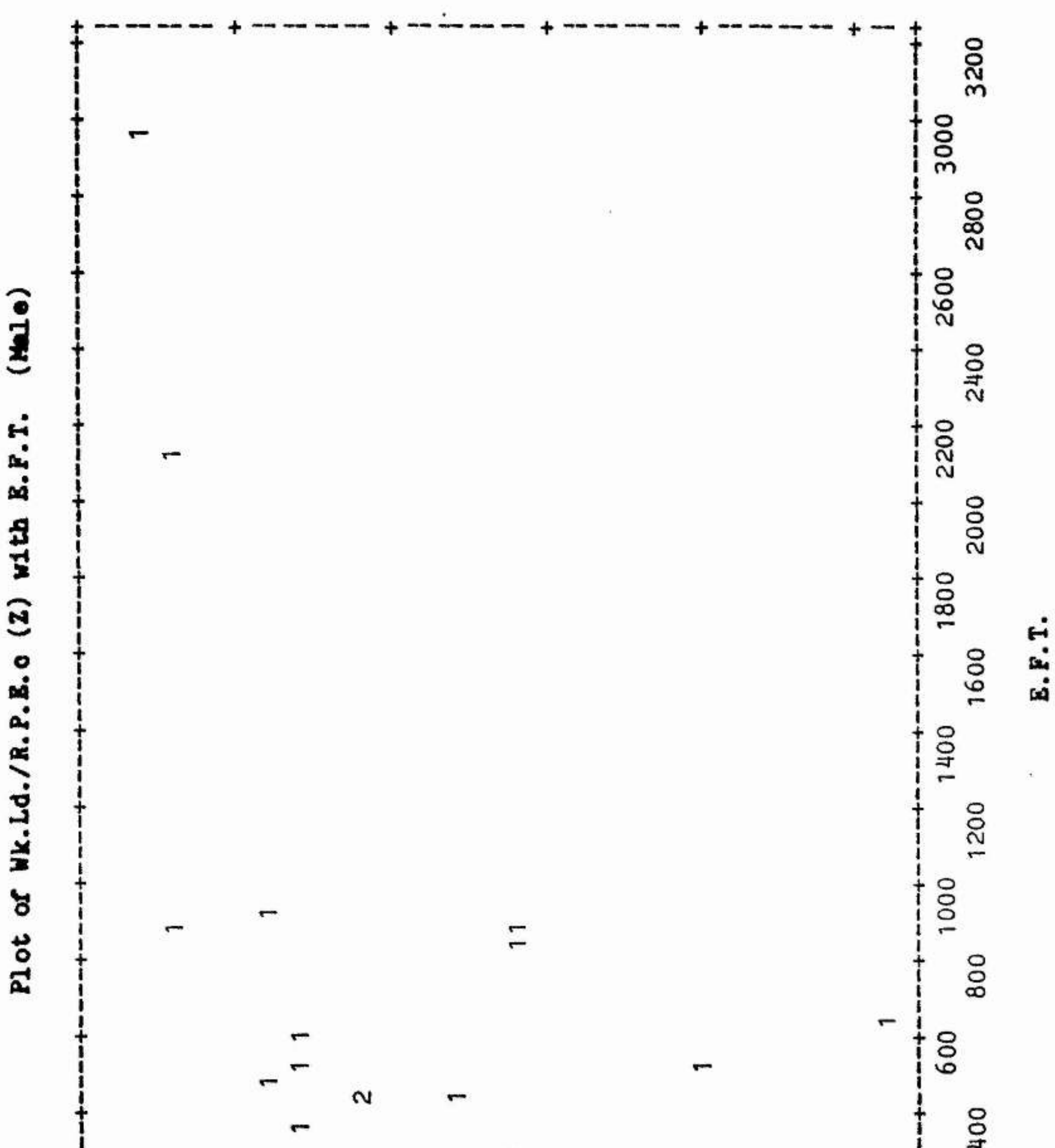
Combined sexes

	B.B.S.
V_E/R.P.E. difference (1 - c)	.2094
$\dot{V}O_2$/R.P.E. difference (1 - c)	.2783
Wk.Ld/R.P.E. difference (1 - c)	.1449
H.R./R.P.E. difference (1 - c)	.0286

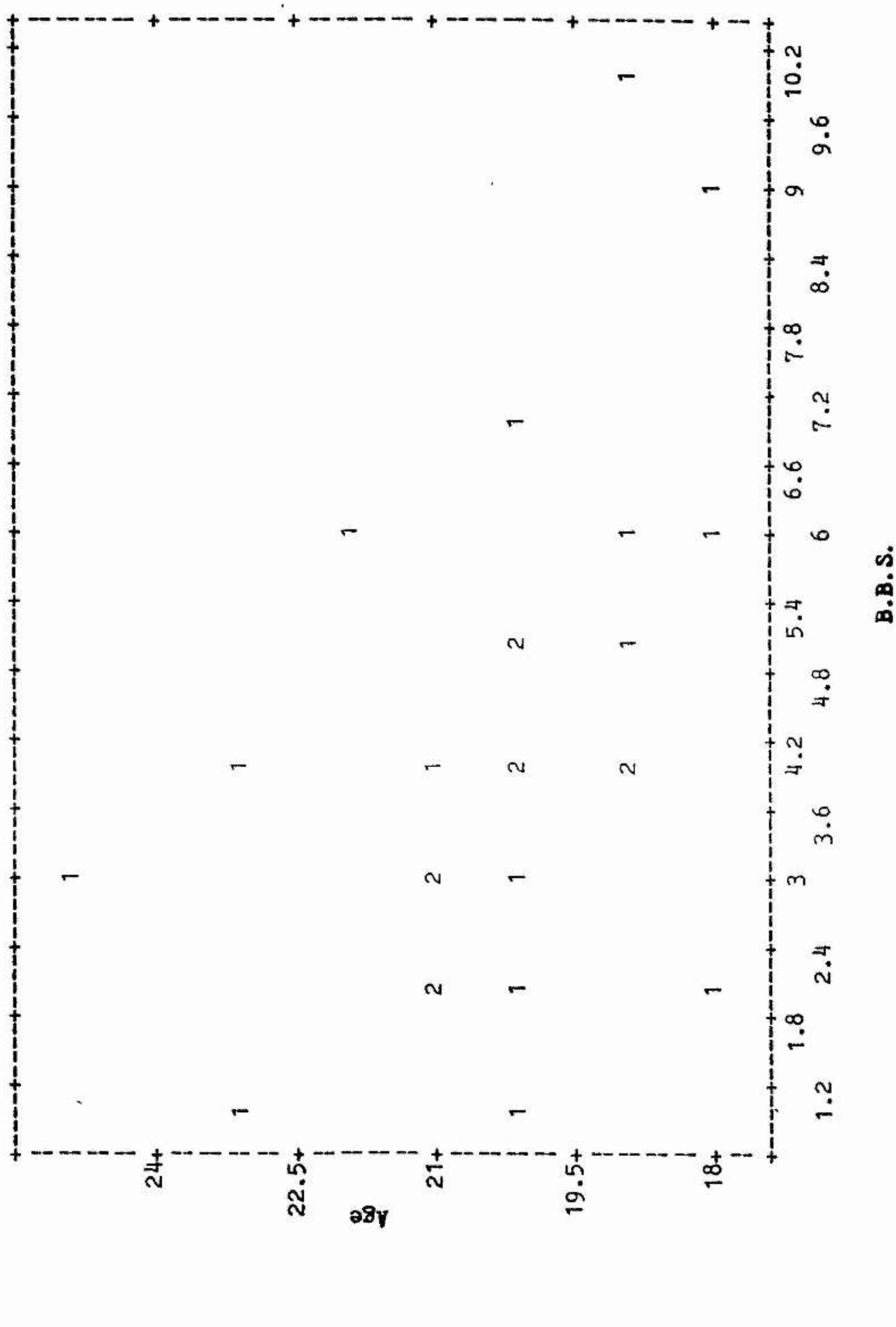
"Pearson Correlation Matrices of R.P.E.1 - R.P.E.c differences with B.B.S."

Av)

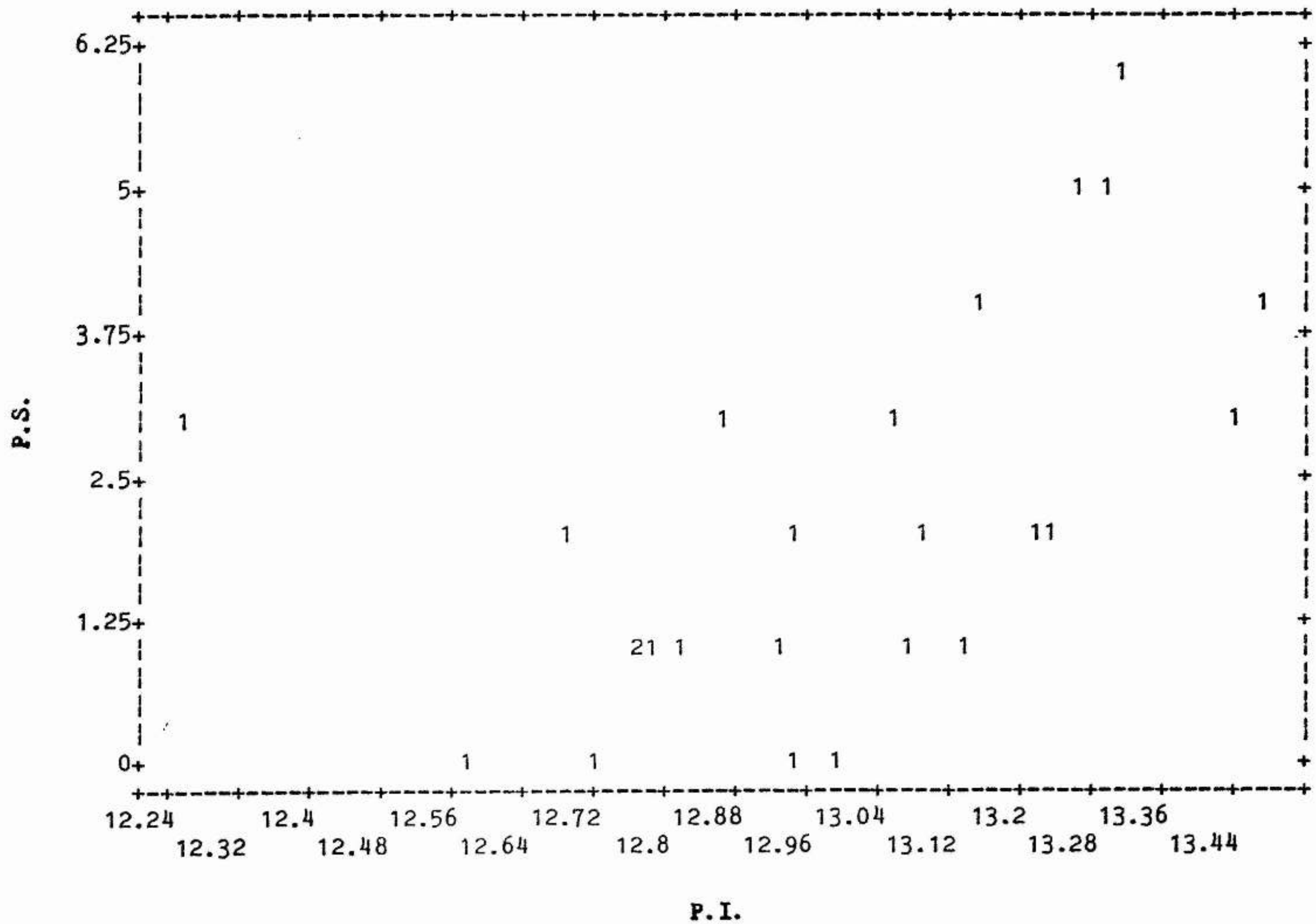

Plot of E.F.T. with B.B.S. (Male)
E.F.T.
3000
2400
1800
1200
600
0
1.2
1.8
2.4
3
3.6
4.2
4.8
5.4
6
6.6
7.2
7.8
8.4
9
9.6
10.2
B.B.S.


Plot of Wk.Ld./R.P.E.c (Z) with E.F.T. (Male)
Wk.Ld./R.P.E.c (Z)
1.8
1.5
1.2
.9
.6
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
E.F.T.

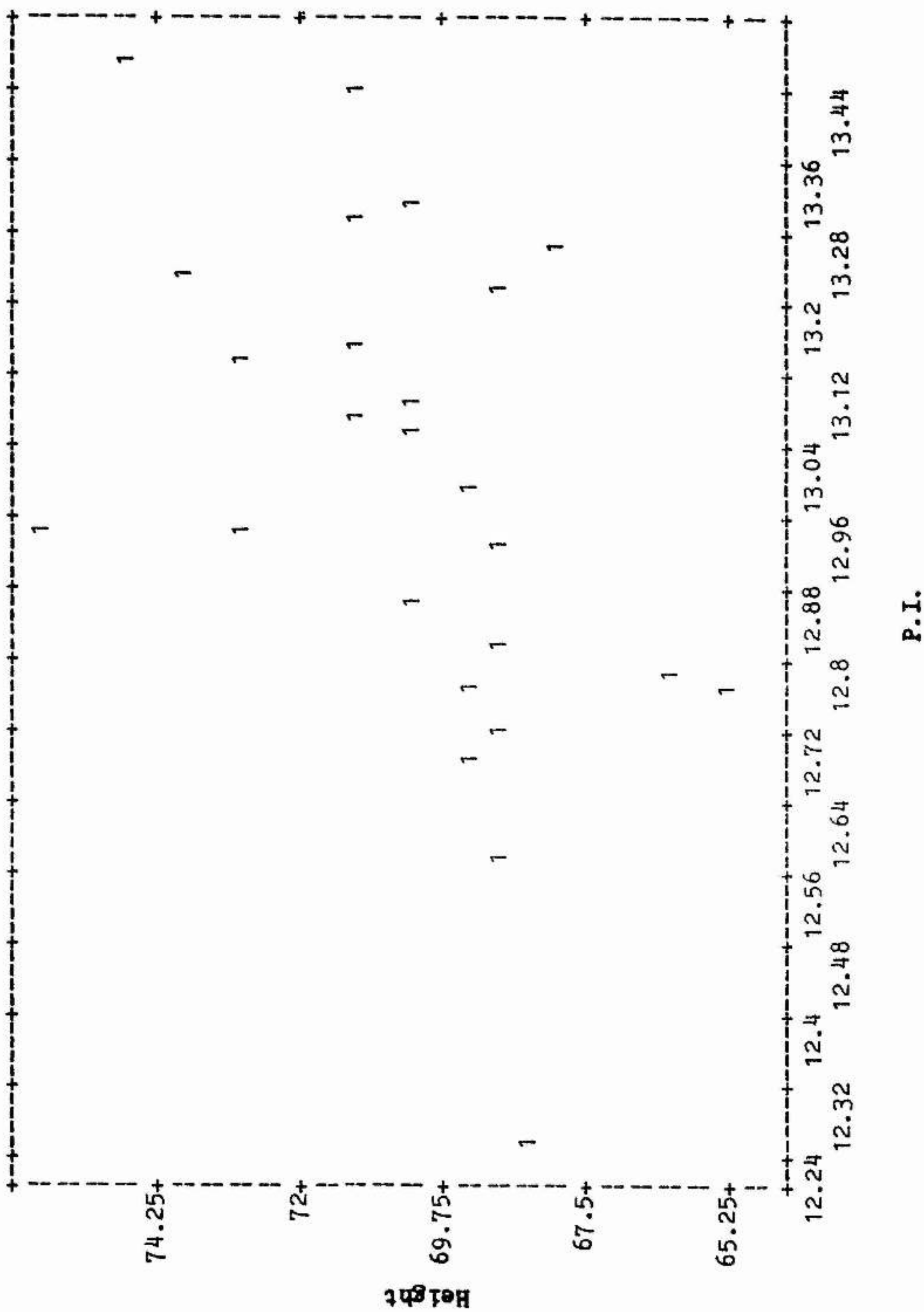
Plot of Age with B.B.S. (Male)



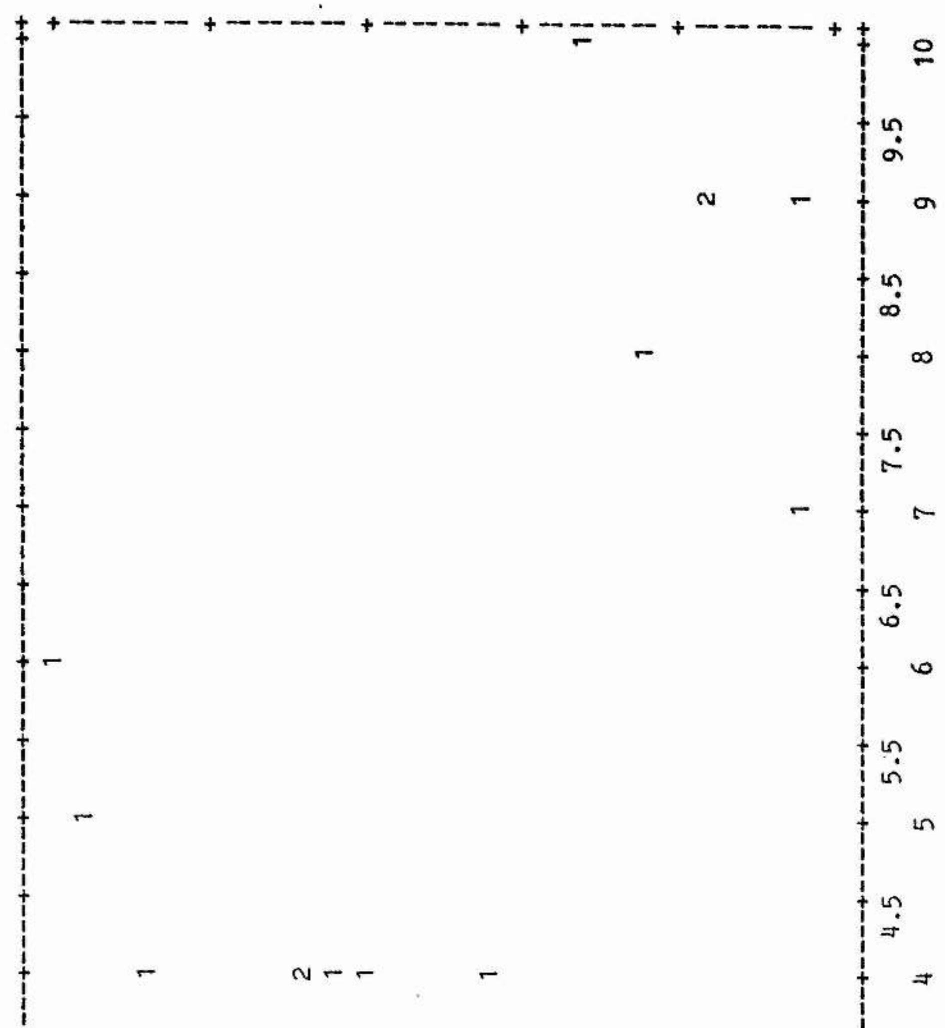
Plot of P.S. with P.I. (Male)



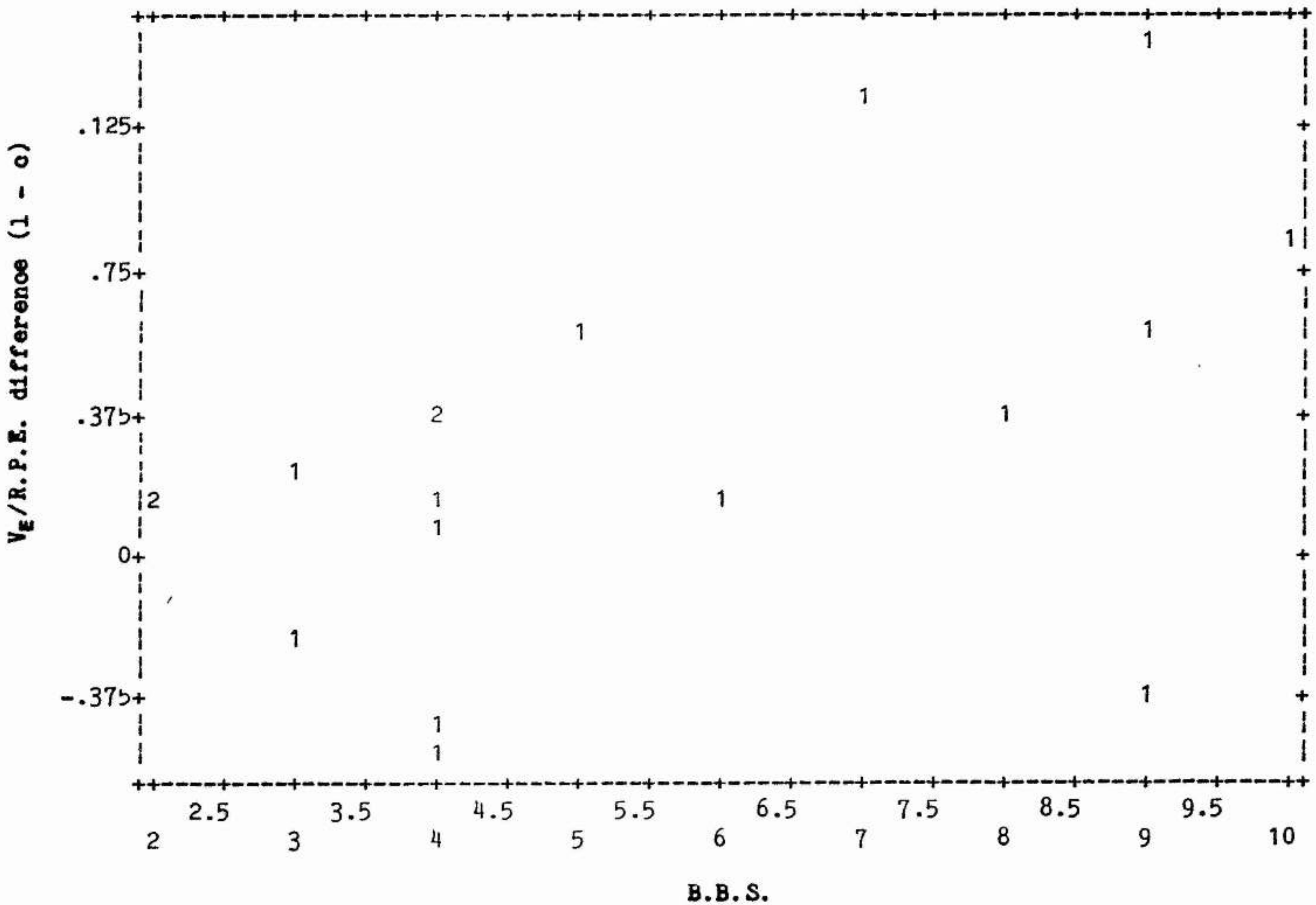
Plot of Height with P.I. (Male)



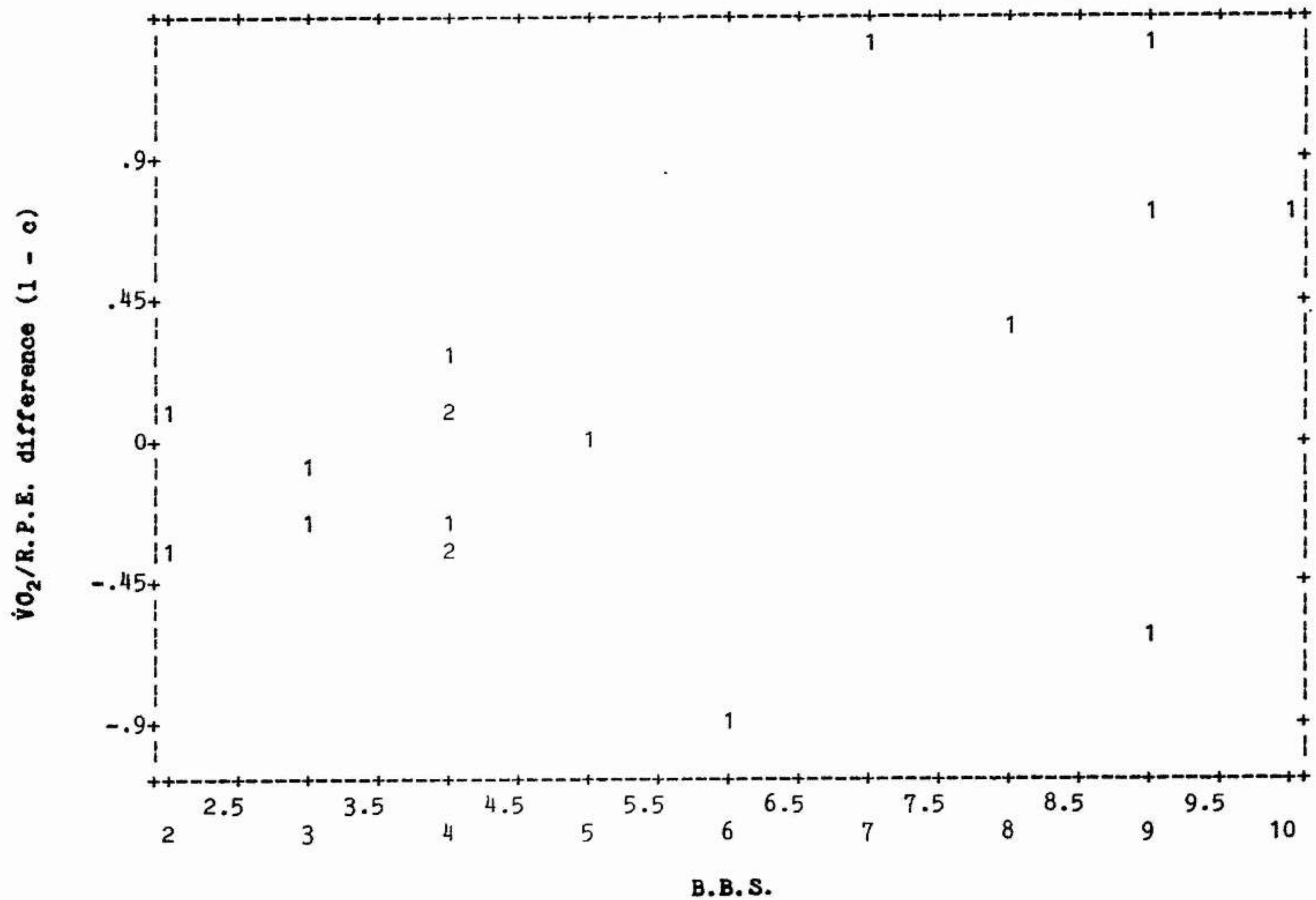
Plot of V_E/R.P.E.o (Z) with B.B.S. (Female)

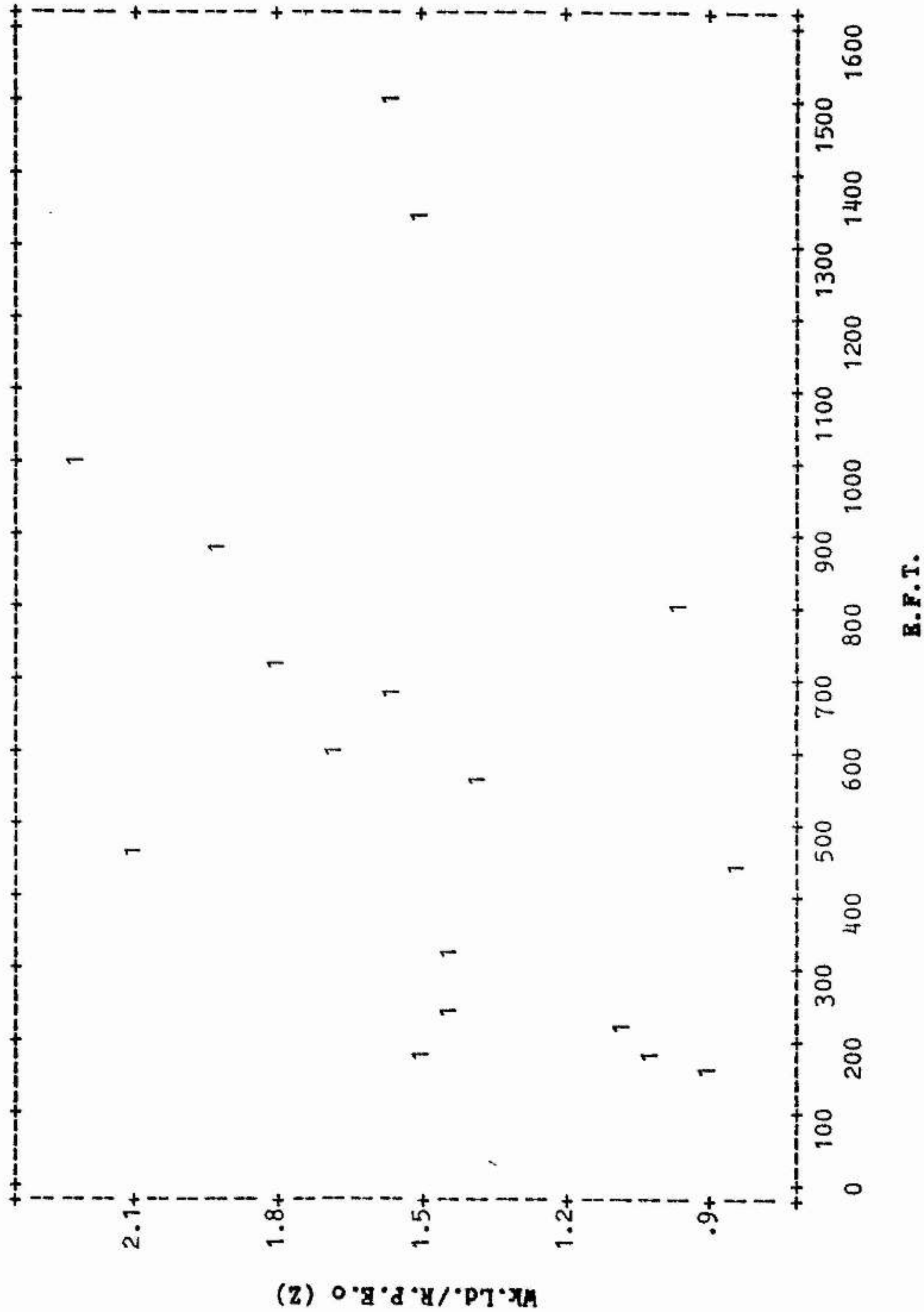


Plot of V_E/R.P.E. (Z) difference (local - central) with B.B.S. (Female)

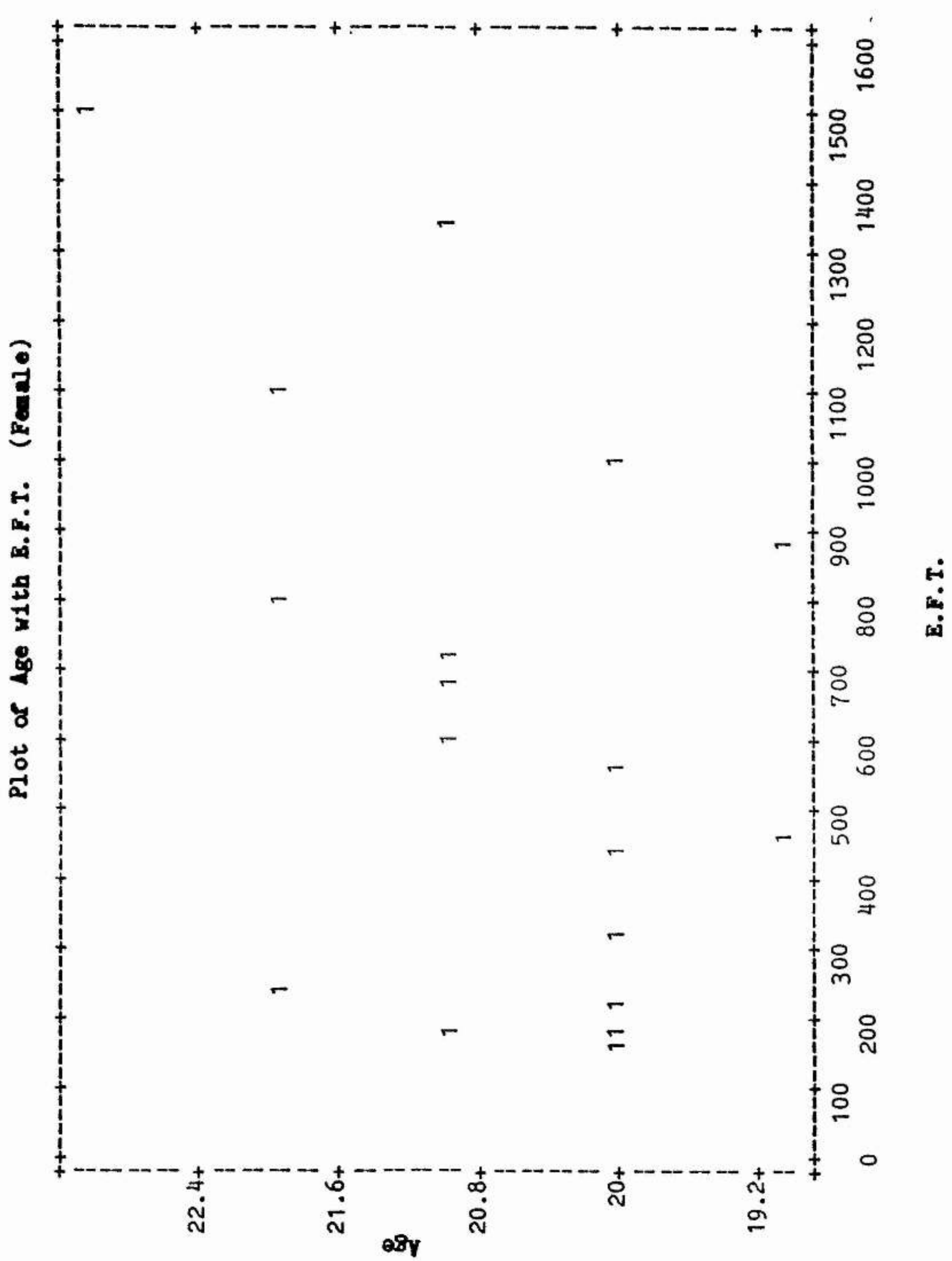


Plot of $\dot{V}O_2$/R.P.E. (Z) difference (local - central) with B.B.S. (Female)





Plot of Wk.Ld./R.P.E.o (Z) with E.F.T. (Female)


Plot of Age with E.F.T. (Female)
Age
22.4
21.6
20.8
20
19.2
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
E.F.T.

APPENDIX B

List of original tests for perceptual-motor assessment.

1: Static Balance

(a) Standing with eyes closed.

(bi) Standing on right leg; eyes open.

(bii) Standing on right leg; eyes closed.

(ci) Standing on left leg; eyes open.

(cii) Standing on left leg; eyes closed.

(d) Sitting balanced between lower pelvic bones and cocyx bone; legs straight, forward and off the floor. Arms straight and to the side.

(e) Standing in 2nd. position (feet apart) on demi-point (on balls of feet with the heels raised as high as possible). Legs straight.

i. arch the back and look at the ceiling.

ii. arch forward and look at the floor.

iii. look to the right-centre-left-centre etc.

All the standing tests were carried out against parallel vertical bars so that any movement could be more easily detected. Each position had to be held for 10 seconds. All the tests were videod and the subsequent scoring made on a 1 to 9 scale (see appendix E) and was made on the basis of the degree and duration of imbalance during the test period.

Test 1d was later discarded since many people were unable to achieve the starting position let alone maintain it for ten seconds.

2: Dynamic Balance

(a) The blindfolded subject was turned slowly on a rotating platform (too slowly to cause dizziness) and, once aimed in the right direction by the experimenter, asked to walk in a straight line for ten yards. The score was the deviation of the subject from the straight line, measured from the ten yard mark on the straight line and perpendicular to it.

(b) Balancing on a small rectangular board which rested on (but was not attached to) a solid cylindrical pivot. Due to difficulties in scoring this test, however, it was decided very early on in the study to omit it.

(c) Running a zig-zag course between 6 bollards, each 4 feet apart, around the end bollard and back. The score was the sum of the penalty points which were given as follows:

1 for knocking a bollard over; 1/2 for touching a bollard; 1/2 for missing a bollard out or for jumping over it to avoid it; 1/2 for each "awkward" motion change. Again, this provided a

score of inability.

(d) Walking along a 3 inch by 7 feet beam:

i; forwards.

ii; backwards.

with a 360 degree turn half way along.

These were scored on the nine-point scale for the ability to remain in balance whilst in motion.

Both 2c and 2d were video'd to aid the assessment. All the balance tests were performed in the gymnasium.

3: Posture

(a) Walking in a straight line (approximately 20 yards).

(b) Running in a straight line (approximately 20 yards).

It was very quickly realized with the first "pilot" subjects that to objectively measure a person's posture and style of movement would require far too many measurements and would constitute a separate study within its own right. It was also felt that to give a score based on such "criteria" as verticality, leading body part (i.e. head, chest, pelvis), rigidity or motion of arms and legs superfluous to forward propulsion had no theoretical background and, though subjectively appealing, could not meaningfully be used. The assessment of posture was consequently dropped from the study.

4: Rhythm

(a) A 4-beat clapping task in which a pause was introduced in a logical sequence as follows (C = clap, P = pause):

C C C P

C C P C

C P C C

P C C C

The pattern was demonstrated to the subject until he was certain he knew what the pattern was supposed to be. The sequence was attempted four times, each time to completion, and the total number of mistakes was used as the score.

(b) Skipping with a skipping rope to an imposed regular rhythm (72 beats per minute) from a metronome. Each session was one minute.

i. Jumping, two feet together.

ii. Stepping over, right foot first.

iii. Stepping over, left foot first.

Both the number of stoppages (a score) and the adherence to the imposed rhythm (b score) were used to score this test.

(c) Ball-bouncing with no auditory feedback. The subject was taught a simple rhythm and, whilst listening to white noise on a set of headphones, was asked to bounce a light sponge-rubber ball (approximately 8 inches in diameter) to that rhythm.

This test was eventually omitted when it became apparent that the actual control of the ball proved so difficult as to negate the ability or inability to move to an imposed rhythm.

All the rhythm tests were carried out in the laboratory.

5: Motor Dexterity

(a) Fine-manual; finger drumming under a 3 X dual-condition matrix. The conditions were: an even or a quick (natural) drumming; right or left hand; starting the drumming from either the right or the left (i.e. from the little finger or from the index finger). In the even condition the purpose was to try and maintain as even an interval between each finger strike as possible, regardless of the speed of movement. In the quick condition the fingers had to be drummed as quickly as possible.

Thus the eight (2*) resulting tests were:

ia; quick, left, little finger.

ib; even, left, little finger.

iia; quick, left, index finger.

iib; even, left, index finger.

iiia; quick, right, little finger.

iiib; even, right, little finger.

iva; quick, right, index finger.

ivb; even, right, index finger.

The tests were performed on touch sensitive keys, one for each finger, thus enabling the time interval between adjacent fingers to be measured. For each drumming of the fingers one obtained three interval measurements. The variance for these was calculated and used as the test measure. Other measures were consequently derived from combinations of these test scores as follows:

va; sum of the quick, left hand scores.

vb; sum of the even, left hand scores.

via; sum of the quick, right hand scores.

vib; sum of the even, right hand scores.

viia; sum of all quick scores.

viib; sum of all even scores.

viii; sum of all scores.

(b) Manual dexterity; the subject was required to place wooden blocks of various shapes into appropriately shaped holes whilst blindfolded. The test was scored as the time taken to fit all the blocks. Despite the blindfold, however, most people found the task very easy. This resulted in a skewed distribution of scores and so the test was left out of the final analysis.

(c) Belinda Neave test for Motor Dexterity; this test was taken from a dance exercise and required the subject to move the body in a nimble fashion in a previously explained pattern: step forward on the right foot, bring the left foot up to join it; step to the right on the right foot, bring up the left foot; step backward on the left foot, bring the right foot back to join it; step left on the left foot, bring the right foot to join it; step forward on the left foot, bring the right up to join it; step left on the left foot, bring the right up; step back on the right foot, bring the left foot to join it; step right on the right foot, bring the left across to join it. This sequence creates a floor pattern of two adjacent squares with the subject both starting and finishing at the same spot.

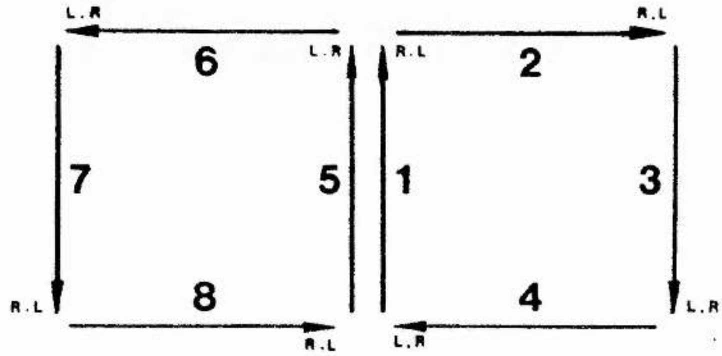


Figure X.B.i: "Movement pattern for the Belinda Neave test."

The pattern was demonstrated a number of times until the subject fully understood what was required; the speed of the movement was emphasized as being of importance and that every effort should be made to maintain the demonstrated speed. The test was scored as the number of mistakes made in completing the pattern three times. This test was performed in the gymnasium and was video'd to aid in the assessment.

6: Visual-motor co-ordination

(a) Hand Steadiness; the subject had to pass a small ring (diameter 1 cm.) on the end of a wire rod along a convuluted wire frame without touching it. Contact of the ring on the wire completed an electrical circuit causing a small bulb to light up. This illumination was detected by a light-sensitive cell connected to a timing device. Thus contact of the ring with the wire was timed. Three measures were obtained as follows:

i; total time to complete the circuit.

ii; contact time.

iii;contact time/total time.

(b) Rotary Pursuit; the subject was required to follow a moving light around a star-shaped pattern with a light-sensitive rod. As above, time in contact was measured. The light rotated at 10 rpm for a test duration of 20 seconds. The subject was given one trial run and then three test runs each separated by 20 seconds rest. The test measure was the total time in contact.

(c) Gross perceptual-motor (Stepping Stones); The subject was required to run,jump or hop in order to land either foot on a series of points marked on the floor (crosses were marked using 2" red tape with the diagonals approximately 6" long). The points were irregularly spaced so as to require changes of direction and stride length (see below).

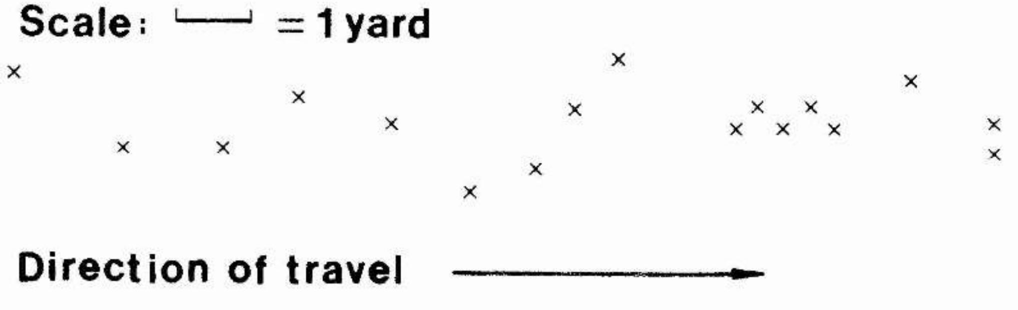


Figure X.B.ii: "Movement pattern for stepping-stone test."

The test was originally measured in four ways:

i; the number of stepping-stones missed.

ii; an assessment of number of points of loss of rhythm or hesitation.

iii;the number of extra steps taken in between the stones.

iv; time taken to run the course.

The subjects were instructed to run the course as fast as possible, that every cross must be stood upon and that there should be no extra steps on the bare floor.
The test was intended to assess the ability to translate the visual perception of the pattern into the gross body movements required to follow that pattern.

(d) A circuit was marked out using light bollards and the subject allowed to walk the circuit twice. He was then immediately blindfolded and asked to walk the circuit once again. The test provided two measures:

i; total number of mistakes (e.g. walking into bollards or turning the wrong direction).

ii; the time taken to complete the circuit.

Tests 6c and 6d were video'd to aid their assessment.

7: Knowledge of Body Position

(a) The subject was shown a slide of a person in a particular body position for 10 seconds. They were then shown a slide of four body positions of which one was exactly the same as the first slide and three were slightly different in various ways. The subject was shown this second slide for 10 seconds during which time they had to mark on a special answer sheet which of the four positions was the same as the original. Fifteen pairs of slides were shown

(b) The subject was shown a slide of a person in a particular body position for 10 seconds during which time they had to adopt the same position (the position had to be in an identical orientation to the picture on the screen; i.e. a mirror image was not regarded as being correct). Each position adopted was given an error score assessed as follows:

Placement; wrong limbs used = 1 mistake unless:

Mirror; if mirror image but otherwise correct = 1 mistake.

(n.b. any combination of mirrored error other than a perfect mirror image is counted as separate errors of placement.)

Limb angles; 1/2 mistake for each joint angle error.

Torso; Contraction instead of extension and visa versa

= 1/2 mistake.

contraction/extension instead of straight body and visa versa = 1 mistake.

Head; elevation error (up - horizontal - down) = 1 mistake.

direction error (side - front - back) = 1 mistake.

(maximum of 1 head mistake).

Direction; whole body at wrong angle to observer = 1 mistake.

There were a total of 15 slides and the final score was the sum of each error score.

These tests were adapted from Stone (1979) who used stick-figure drawings rather than photographs of a real person. Her work was consequently criticised on the grounds that many of the drawings were ambiguous since the juxtaposition of the limbs and trunk was not always apparent. The second test, 7b, was video'd and the stop-frame facilities that this offered were vital in its assessment.

8: Perceptual Tests

(a) Witkin's Embedded Figures Test (see study one for details).

(b) Self Awareness; a different test to the previously mentioned B.B.S. or P.S. was used.
The subject simply had to write down 20 things of which they were aware. The test score was the number of self-related items (e.g. feeling warm or worrying about a piece of work that had to be done). Non-self items might be noises outside the room or the room being warm (with no reference to themselves being warm) for example.

(c) The B.B.S./P.S. as measured in the first part of the study.

Test 8b was taken from Fisher and Fisher (1964) and was regarded by them as testing a similar form of self awareness as Test 8c. It was finally decided to use this in preference to the B.B.S.

due to its relative brevity and ease of scoring.

(d) This was the R.P.E. accuracy score measured as the variance amongst ratings of effort for five equal workloads. There were three measures:

i; Central R.P.E.

ii; Local R.P.E.

iii; Overall R.P.E.

(e) This was the R.P.E. accuracy score measured as the correlation co-efficient between the rating of perceived effort and heart-rate on dis-similar workloads. There were three measures:

i; Central R.P.E.

ii; Local R.P.E.

iii; Overall R.P.E.

Correlations between the three R.P.E. measures for both test 8d and 8e were so high as to render the retention of all three a pointless exercise. Accordingly, only the overall R.P.E. measure was used. It was also decided that the variance accuracy score was superior to the correlation accuracy score since it did not depend on an assumed link between heart-rate and rating of perceived effort. Only measure 8diii was therefore used in the final data analysis.

9: Physical Parameters

(a) Electromyographic recordings were made with "homemade" electrodes (following Basmajan, 1967) over the frontalis muscle on the forehead. Despite the electrodes working adequately, it was later discovered that the signal amplifier was not and was introducing apparently random signals into the output. As a consequence, all E.M.G. data had to be discounted and was not used in any part of the analysis.

(b) The following body measurements were made:

i; Height.

ii; Weight.

iii; Ponderal Index ($Ht/Wt^{\frac{1}{3}}$) was calculated.

10: Reaction Time

Reaction times were measured on standard R.T. equipment to both visual and auditory stimuli as follows:

(a) Visual; reaction time to any one of a five lamp display. The average for three trials was calculated.

(b) Visual;

i; reaction time to a particular pairing of lamps. Two out of five trials were the correct pairing and their order of presentation was randomised. The average of the correct responses was calculated.

ii; the number of mistakes made in 9bi, i.e. reactions to the wrong pairings or, occasionally, no reaction to the required pairing.

(c) Auditory; reaction time to a given tone. The average for three trials was calculated.

(d) Visual choice time: 10bi - 10a.

(e) Whilst waiting for a visual cue to react to, the subject was given the auditory tone. If the subject reacted to this by mistake then an error score of 1 was awarded.

NAME: ....

Poor ——————————————————> Good

1.	a)	1	2	3	4	5	6	7
	bi)	1	2	3	4	5	6	7
	bii)	1	2	3	4	5	6	7
	ci)	1	2	3	4	5	6	7
	cii)	1	2	3	4	5	6	7
	d)	1	2	3	4	5	6	7
	ei)	1	2	3	4	5	6	7
	eii)	1	2	3	4	5	6	7
	eiii)	1	2	3	4	5	6	7

2. a) ________________ m.

b) No. of touches in session (30 secs.)

1. ______ 2. ______ 3. _______ 4. _______ 5. ________

c) Bollards touched : ________________ @ ½ each =

" missed : ________________ @ ½ each =

" knocked over: ________________ @ 1 each =

'Awkward' motion changes: ________________ @ ½ each = ________

TOTAL ________

di)	1	2	3	4	5	6	7
dii)	1	2	3	4	5	6	7
diii)	1	2	3	4	5	6	7
div)	1	2	3	4	5	6	7

3.

4. a) No. of mistakes: ______________

bi) No. of stoppages: __________

bii) " " " : __________

biii) " " " : __________

c)

5. a) i) ________ ________ ________ Variance: __________

ii) ________ ________ ________ __________

iii) ________ ________ ________ __________

iv) ________ ________ ________ __________

b) __________ mins. _______ secs.

c)/

5\. c) No. of mistakes : ____________

Poor ——————————————→ Good

		1	2	3	4	5	6	7
d)	i)	1	2	3	4	5	6	7
	ii)	1	2	3	4	5	6	7
e)	i)	1	2	3	4	5	6	7
	ii)	1	2	3	4	5	6	7

6\. a) i) Total time ; Trial 1) __min. __ sec. 2) __min. __sec.
3) __min. __ sec.

ii) Mistake time; 1) __min. __ sec. 2) __min. __sec.
3) __min. __sec.

b) Time; Trial 1) ____ secs. 2) ____secs. 3) ____ secs.
Average time 'on target': _____ secs.

c)(i) Missed marks: ____________ Time taken: __________secs.
(ii) Loss of rhythm: ____________
(iii) Extra steps ____________

d) Mistakes : ____________ Course finished? YES/NO
Time taken: ____________seconds

7\. a) Score: ____________________

b) Score: ____________________

8\. a) ____________mins. __________secs.

b) Self: ________________ Non-self: ______________

c) B.B.S. ________________ P.S. ______________

d) Variation: ____________________

9\. a) ________________ mV.

b) Ht: ________ inches. Wt.: ________ lbs. H/∛W: ________

APPENDIX C

Attitude-Preference Questionnaire

Question 2:

Initially, an attempt was made to classify sporting and activity skills in such a way as to rank them in order of difficulty. Though it is felt that this was achieved in many respects, direct comparison between activities requiring predominantly visual skills (e.g. cricket) and those requiring predominantly kinaesthetic cues (e.g. diving) can not be justified. The following general statements were used as the basis of classification.

A) For a given type of activity; "team" activities (interaction) require more skill than "individual" (non or limited interaction) ones.

B) For a given type of activity; "tool use" activities require more skill than "non-tool use" ones.

C) For a given type of activity; "interception" activities (object in motion) require more skill than "stationary" ones.

D) For a given type of activity; "with/versus other" activities (unpredictable) require more skill than "versus environment" (predictable) ones.

E) For a given type of activity; "self-orientated" (e.g. gymnastics) require more KINAESTHETIC skill than "with or versus other" (e.g. karate) ones.

F) For a given type of activity; activities incorporating "variables" require more skill than those incorporating "constants".

All the above statements refer to the activity being performed optimally and have been used to place a number of sports into categories of skill requirement (Table X.C.i).

The following 5 categories were subsequently defined for use in this study:

1) Team, ball interception, tool/non-tool (e.g. Hockey, Football).

2) Individual, ball interception, tool/non-tool (e.g. Cricket, Squash).

3) Person orientated versus self/with or versus other, tool/non-tool (e.g. Gymnastics, Fencing).

4) Team/individual, tool/non-tool, stationary ball (e.g. Golf) and object orientated, target (e.g. Archery).

5) Object orientated, projection (e.g. Shot, Javelin) and non-ball, versus environment, tool/non-tool (e.g. Cycling, Running).

Whilst these numbers can only be regarded as category level data, it is felt that some order does exist amongst categories 1, 2, 4 and 5 with category 1 sports generally requiring greater levels of skill than category 5 sports.

Figure X.C.i: "Sports skill categories".

TEAM (interaction) ACTIVITIES								
Ball (or similar object) Games				Non - ball Games				
Interception (Object in motion)		Non -Interception (Object stationary)		Person Orientated (versus other/environment)				Object Orientated
Tool	Non-tool	Tool	Non-tool	Versus Other		Versus Environment		Field-gun Races
				Tool	Non-tool	Tool	Non-tool	
HOCKEY LACROSSE SHINTY	FOOTBALL RUGBY BASKETBALL NETBALL	Corner/Free hit in Hockey	Corner/Free kick in Football					

INDIVIDUAL (or very limited interaction) ACTIVITIES										
Ball (or similar object) Games				Non - ball Games						
Interception (Object in motion)		Non-Interception (Object stationary)		Person Orientated (self versus self/other/environment)					Object Orientated	
Tool	Non-tool	Tool	Non-tool	Versus Self	With or versus Other		Versus Environment		Target	Projection
					Tool	Non-tool	Tool	Non-tool		
CRICKET (batting) BADMINTON SQUASH TENNIS	HANDBALL	GOLF SNOOKER BILLIARDS POOL	CRICKET (bowling) BOWLS Free shot in basketball Penalty in football Place kick or conversion in rugby	GYMNASTICS FIGURE SKATING DIVING DANCE (Ballet) (Contemporary) (Jazz)	KENDO FENCING	KUNG FU KARATE JUDO BOXING FOLK DANCING	SKIING SKATING SAILING CYCLING CLIMBING ROWING ORIENTEERING	SWIMMING RUNNING (all distances) AEROBICS	ARCHERY SHOOTING DARTS 10-PIN BOWLING	HAMMER SHOT JAVELIN CABER WEIGHT LIFTING

Attitude-Preference Questionnaire

NAME..

SEX : M/F

AGE..............

OCCUPATION..

1. What do you regard as your favourite past-time?........

   ....

2. What sport or physical activity do you like to do most

   of all?...

3. Which of the following phrases best sums up your attitude

   toward sport and physical activity?

☐ I always want to have a go at everything/can not get enough.

☐ I like to work hard at certain sports/activities.

☐ I usually feel that I have better things to do.

☐ I do as little as possible.

4. Would you describe yourself as a clumsy person? Y/N

APPENDIX D

(i) Loadings of variables on 8 factors after rotation.

Variable	F1	F2	F3	F4
1a	-0.1923	0.4221	0.3918	-0.1936
1bi	0.0005	-0.0361	0.5743	0.0925
1bii	-0.0227	0.0427	0.2792	-0.0006
1ci	0.0283	-0.1348	0.7164	0.1880
1cii	0.1655	0.1953	0.4888	0.2575
1eiii	0.2700	0.2220	-0.0082	-0.0596
2a	0.2880	0.0926	0.0451	0.0864
2c	-0.0287	0.2298	-0.2916	-0.3559
2di	0.5848	0.2725	0.1675	0.0014
2dii	0.1353	0.0089	0.6674	-0.2028
4a	-0.7778	-0.1014	0.0414	0.2354
4bib	0.4031	0.1559	0.3453	-0.1047
5a7a	-0.0908	0.0736	0.0053	0.2487
5a7b	-0.0148	-0.0881	0.0534	0.8186
5c	0.0079	0.1335	-0.7587	0.0408
6aiii	-0.1814	0.2564	0.0156	0.7758
6b	-0.0680	-0.1915	0.2061	-0.2500
6ciii	-0.9410	-0.1819	0.0002	-0.0278
7a	-0.4607	-0.0252	-0.1326	0.0407
7b	-0.5487	0.3506	-0.3580	0.0290
8a	-0.2489	0.0860	0.2847	-0.1431

8b	0.2101	0.0092	0.0964	0.1897
8diii	-0.1652	0.1427	0.0095	0.1679
10a	-0.1004	-0.7693	0.0531	0.0235
10bii	-0.5239	0.1899	0.0286	0.0209
10c	-0.0849	-0.6081	0.1557	-0.1114
10d	-0.1565	0.1382	0.2266	-0.2161
10e	0.1161	0.6067	-0.1047	0.1352

Variable	F5	F6	F7	F8
1a	0.0851	0.0694	0.6082	-0.0255
1bi	0.2705	0.0294	0.0140	0.1924
1bii	-0.0223	-0.6489	-0.0237	-0.0054
1ci	0.0328	-0.1217	-0.1448	0.1491
1cii	0.4315	-0.0227	-0.0373	-0.0118
1eiii	0.6114	-0.0878	-0.1029	0.2753
2a	0.0200	0.0294	-0.1010	-0.7481
2c	-0.0530	-0.2753	-0.1974	-0.5195
2di	0.1623	0.0058	-0.2848	0.1997
2dii	-0.1346	-0.2513	0.1328	0.0256
4a	-0.2484	0.0381	0.0573	0.1208
4bib	-0.2532	0.3308	-0.2458	0.1846
5a7a	-0.0364	-0.3209	0.0720	-0.6099
5a7b	0.0007	0.0513	-0.0888	-0.2471
5c	0.0552	0.0164	0.0020	0.1326
6aiii	-0.1689	-0.0915	0.0336	0.1932
6b	0.7073	-0.0363	-0.0526	-0.0588

6ciii	0.0583	0.1562	-0.2695	0.0701
7a	0.4700	-0.0471	0.0634	-0.3775
7b	-0.1162	-0.2563	-0.0610	0.1675
8a	-0.6094	-0.1964	-0.3370	-0.2595
8b	0.1358	-0.3719	-0.0398	0.6320
8diii	0.0235	-0.0139	-0.7730	-0.3411
10a	0.2440	-0.1784	-0.1640	0.0287
10bii	-0.0388	0.5857	0.0044	-0.0818
10c	-0.0186	0.1824	0.1017	0.1024
10d	0.0462	0.0584	-0.5986	0.1298
10e	0.4223	0.0727	-0.2097	-0.2100

APPENDIX D

(ii) Values of Diagonal of the Inverse Factor Correlation Matrix.

Factor 1	1.08870
Factor 2	1.03111
Factor 3	1.08322
Factor 4	1.02095
Factor 5	1.03122
Factor 6	1.02304
Factor 7	1.02563
Factor 8	1.08303

APPENDIX C

(iii) Triangular Pearson Correlation Matrix of Ability Scores.

Ability	A1	A2	A3	A4
A1	--			
A2	-0.2521	--		
A3	0.2347	0.1455	--	
A4	0.0814	0.2158	-0.0374	--
A5	0.4059	-0.1456	0.1519	0.1607
A6	0.6501**	0.2849	-0.0347	0.3065
A7	0.4305	0.0395	0.0833	0.3526
A8	-0.0830	0.4582*	0.1330	0.1045

Ability	A5	A6	A7	A8
A1				
A2				
A3				
A4				
A5	--			
A6	0.5597*	--		
A7	0.2874	0.7494**	--	
A8	0.2032	0.5307	0.5607*	--

(* = $p < 0.025$, ** = $p < 0.01$).

APPENDIX E

Three Case Histories.

The "evidence" given below against perceptual-motor abilities being unlimited is purely circumstantial and arises from the author's own subjective perceptions concerning various individuals undergoing prolonged practice. What is being suggested is that the following three people had particularly low maximum potentials in certain perceptual-motor abilities and that these potentials had already been reached at the onset of the periods to be discussed.

Circumstantial evidence - case histories.

The first case is that of a young man taking up contemporary dance. It was part of his personality to be somewhat "hyper", this general state of high arousal showing itself in his dance style via raised shoulders and twitching fingers; classic physical tenseness as defined by ability 2. Over the span of several years a number of dance teachers emphasized his need to relax during class. It was not until he undertook professional dance tuition over a three year period, however, that his dance style altered appreciably but even now, five years and many hundreds of classes later, he still demonstrates this lack of relaxation when he moves.
Given the amount of tuition this particular individual has

received and the minimal change in his ease of movement, the author would suggest that the concept of an upper limit to this ability would seem more likely.

Again in illustration, is the case of a young woman attending dance classes week after week who tried hard at class and appeared to be enjoying herself. Her sense of orientation, however, was virtually non-existent and although apparently cognisant of the movement requirements, did not seem to know how to go about making her body adjust to them. This same young woman also took up squash at about the same time showing similar problems in orientation and no ability to predict the motion of the ball. These did not improve with practice (she had in fact been playing squash some time before asking for coaching).
It should perhaps be noted that she enjoyed both her dancing and her squash and is a shining example of the fact that ability and enjoyment are not, of necessity, related.

Perhaps it is appropriate to point out here that the use of the P.M.A.P. could only be used to indicate "performance" limitations. By no means is a limited ability being equated with a limited enjoyment of sports participation, a phenomenon that itself appears to enjoy, thankfully, no rational explanation.

A final example is of another young woman wanting to participate in some form of physical activity who, perhaps because she recognised her own shortcomings, took up running; a sport categorised as requiring very little perceptual skill. It was observed at the time that her running style was extremely awkward with no real leg thrust, no use of the arms and a very upright posture. She always ran at the same pace, never attempting to sprint the final stages of a race. When asked to sprint she appeared not to be able to incorporate the forward lean of the body nor the higher leg lift required; she did not appear to be able to alter her style at all. At the same time, she began attending an aerobics-type class twice a week. It was immediately noticed that not only did she perform the exercises just out of synchrony but that the movements seemed to be exagerrated as though slightly out of control.

Four years later, she is a lot fitter physiologically but still runs with exactly the same gait, still appearing to be unable to alter her style for sprinting. She has continued to attend the aerobics classes regularly over the four years, sometimes going four times a week. It would not be unfair to suggest that her movement is equally anarchic. Whether this idiosynchratic mode of performance is due to a lack of awareness of just what her body is doing or whether it is due to poor motor control is difficult to say. The author is of the opinion, however, that it is the former since she does not appear to realize that she is doing anything different from the other people in the class. This ability, or lack of it, has not appreciably improved during all this time and with all this practice. One might well argue that her potential had been reached and was not open to change.

These case histories are intended to illustrate that practice does not always lead to improvement. It is proposed that the reason in these particular examples is because performance maxima had already been reached and could not be breached. The individuals described in these three cases are not unusual and they certainly would not stand out in the course of normal, everyday activities. Indeed, the first case described could be regarded being gifted in many of his other perceptual-motor abilities, as is implied by his acceptance by one of Britain's leading dance schools. It is felt, also, that they illustrate that performance maxima are subject to gross individual differences. These differences in potential, it is proposed, are neurologically set and are unalterable.