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Motor Skill Acquisition and Control

in Mentally Retarded Children

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Where there is honesty
    there is understanding
Where there is fairness
    there is peace
Where there is sharing
    there is friendship
Where there is love
    there is fulfillment

(Author Unknown)

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Abstract

Motor Skill Acquisition in Mentally Retarded Children

The control of motor skills, that is, decisions of where, when, how far and how fast to move, is a cognitive ability. The ability of Down Syndrome and other mentally retarded children to perform complex motor skills may provide valuable information about their organizational skills. This is possible because the formulation, monitoring and correction of a series of movements requires a considerable amount of information processing. Consequently, when and how the task breaks down may reflect the various strategies employed. The basic purpose of this study was to assess the motor control ability of mentally retarded (D.S. and M.R.) children within a pursuit tracking task when compared to groups of intellectually normal children matched for functional and chronological age. A total of 42 male subjects performed eight trials on a subject-paced pursuit tracking task (the N.R.C. stressalyser). The measures used were total response time, total response time by quarters, correct reaction time, non-overshoot movement time, overshoot movement time, error rate and overshoot rate (Buck, 1982). The main finding was that Down Syndrome boys did not respond to directional probability in the same manner shown by the mentally retarded or the non-retarded matches for chronological and/or functional age. This difference in strategy was also reflected in their greater emphasis on accuracy rather than speed. Finally, these effects were consistent across the Down Syndrome children despite the large intersubject variability seen in their performance.

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Chapter 1

Introduction

Mental retardation is a comparative concept based upon the distribution of intelligence in the total population. It is estimated that the mentally retarded ordinarily include those persons in the lowest three or four percent of this distribution (Waite, 1972). Intuitively, any discussion of the performance of mentally retarded children would imply a lower level of performance. Indeed, it is well established that on standardized tests of motor performance, mentally retarded children perform well below the average of intellectually normal children of the same age and sex (Rarick, 1973; Francis & Rarick, 1959; McGown, Dobbins & Rarick, 1973).

To date, only a few types of retardation can be accurately diagnosed. These can be divided into two groups; prenatal factors and mental retardation due to trauma or disease (Zigler, 1966). Of the various etiological factors Down syndrome is not only the most prevalent of the prenatal factors for mental retardation but also involves chromosomal anomalies not found in other disorders (Coleman, 1964). However, it is not yet known if there are differences between Down syndrome children and mentally retarded children (due to trauma or disease) in the cognitive processes used to attain knowledge. A confounding problem has been that the majority of mentally retarded (D.S. and M.R.) children are non-verbal or of low verbal skills. In order to obtain a better understanding of the manner in which the mentally retarded attain knowledge there is a need for tests that are not dependent upon verbal skills.

The control of motor skills, that is, decisions of where, when, how far and how fast to move, is a cognitive ability. The ability of Down syndrome and other mentally retarded children to perform complex motor skills may provide valuable information about their organizational skills. This is possible because the formulation, monitoring and correction of a series of movements requires a considerable amount of information processing. Consequently, when and how the task breaks down may reflect the various strategies employed.

Statement of the Problem

The basic purpose of this study was to assess the motor control ability of mentally retarded (D.S. and M.R.) children within a pursuit tracking task when compared to groups of intellectually normal children matched for functional and chronological age. A total of forty-two male subjects performed eight trials on a subject-paced pursuit tracking task. The N.R.C. stressalyser was used to measure the psychomotor performance of the children. The measures used were total response time, total response time by quarters, correct reaction time, non-overshoot movement time, overshoot movement time, error rate and overshoot rate (Buck, 1982).

Hypotheses

The hypotheses investigated in this study were: 1) there were no significant differences in the motor control parameters involved in a self-paced pursuit tracking task, between both groups of mentally retarded children and intellectually normal children matched for functional age and chronological age, and 2) there were no significant differences in performance in the motor control parameters between Down syndrome and other mentally retarded children.

Note, the motor control parameters refer to only those parameters measurable by the N.R.C. stressalyser (Buck, 1982).

Scope of the Study

A total of forty-two male subjects were tested. Differences and similarities were assessed in three separate analyses. The first analysis consisted of twenty subjects divided into four groups. One group of five Down syndrome boys were matched with five mentally retarded boys of equal functional age and within 180 days of their chronological age from the date of testing. The third group consisted of five elementary school males matched with the Down syndrome group for functional age. The fourth group was five male high school students matched with the Down syndrome males within 180 days of their chronological age from the date of testing.

The second analysis consisted of three groups of seven subjects each (N=21). The Down syndrome, the mentally retarded and elementary school males were matched for functional age only. An additional requirement for the elementary school children was that they not be within three months of their birthday at the date of testing.

The third experimental analysis consisted of three groups of eight subjects each (N=24). The Down syndrome, mentally retarded and high school boys were matched within 180 days of the chronological age of the Down syndrome match at the date of testing.

All forty-two subjects performed eight trials on the stressalyser in one 30 to 45 minute session. Each trial involved 100 movements, giving a total of 800 movements per subject.

Chapter II

Review of Literature

Motor control is the sum of the related decisions involved in producing an accurate movement. It includes general concepts and principles (schemes) and provides the information for the integration of different aspects of human experience into a response graded on prior learning and quality of perceptual information.

According to Posner and Keele (1972) some of the separate mental operations involved in the control of a motor skill are:

preparation phase → decision phase → movement phase → storage phase

The focus of this review will be to outline the components that have, in the past, been manipulated in the pursuit of an understanding of the overall process of motor control. The chapter will be broken down into four sections: section one will outline the special population being studied, sections two to four will deal with the first three phases involved in the acquisition and control of a task (Posner & Keele, 1972). The storage phase or memory component, although an important aspect of motor control, will not be dealt with in this paper.

Mental Retardation

This section of the review of literature will outline the relationship of task performance to variables such as chronological age (CA), mental age (MA) and functional age (FA) in order to provide a framework for an understanding of the concept of mental retardation in terms of motor skill acquisition.

The two major classifications of mental retardation, based on IQ scores, are the medical and educational classifications. These two classifications are outlined as follows:

Medical	IQ Range	Educational
Borderline	80 to 90	Slow learner
Mild	50 to 79	Educable
Moderate	30 to 55	Trainable
Profound	< 30	Totally dependent

(Grossman, 1973)

As yet there remains considerable disagreement as to what IQ (intelligence quotient) actually is. The scientific approach considers intelligence in terms of two categories: operational and theoretical. Maloney and Ward (1979) define the operational approach as any attempt to define intelligence by describing related behaviours and the theoretical approach as attempting to explain how or why intelligent behaviour occurs.

Within the operational approach educators use the term the 'capacity to learn', philosophers and mathematicians tend toward the ability to think in abstract terms, and comparative psychologists talk about adaptability to new situations. In recent years much attention has been directed to the idea of general problem-solving ability.

In the theoretical approach there are four schools of thought: learning theory, neurological-biological, developmental and psychometric. The concept of mental retardation (lower intelligence) is a reflection of the psychometric approach.

What then, is the meaning of IQ? The IQ summarizes a person's performance, or level of general intellectual functioning on a given test (Maloney & Ward, 1979). In the early 1900's Binet developed an age-graded scale and used the concept of mental age (MA) as an index of mental functioning. The MA was defined as the general mental ability of the average child of a particular chronological age (CA). Stern (1912) proposed the IQ concept. He suggested that since the absolute difference between MA and CA meant different things at different CA levels, that the ratio of MA to CA (MA÷CA) be adopted. Terman (1916) employed Stern's IQ index and thus established the formula as:

$$IQ = MA/CA \times 100$$

In this way, IQ was thought to indicate the rate of mental development.

The ratio method of computing IQ was the only method available until 1939 when the Wechsler-Bellevue Scales appeared. Wechsler abandoned the MA concept. Since data indicated that mean MA scores increased with advancing CA up to approximately 13 or 14 years and that beyond that age the MA levelled off, Wechsler felt that mental development had peaked; so the Wechsler Intelligence Scale for Children (WISC) was developed. In the WISC, Wechsler replaced the ratio IQ with the deviation IQ in order to deal with this levelling off of mental age. Both methods of IQ computation will be seen in the review of literature to follow so it is important to note that the two methods of computation yield similar results but the deviation method is more scientifically valid and precise (Maloney & Ward, 1979). Therefore, IQ is merely a measure of relative performance in terms of the rank - order of the individuals involved.

However, the system was originally developed for practical use in the school system and as such is concerned with performance. An important point about the utility of current intelligence tests in the diagnosis of mental retardation should be noted. In general, the greater the intellectual deficit, the more useful the tests. At lower levels of intellectual functioning, intelligence is crucial in determining behavioural adequacy and adjustment. This is because a minimum level of intellectual competency is necessary for daily living. Consequently, a more global approach has been adopted by the regional school boards in assessing the performance of the special population, i.e. functional age (FA). Functional age (FA), of which assessed IQ is only a component, attempts to look at the individual as a whole. Although functional age is a subjective measure with several objective measures (e.g. Basic Education Skills Inventory, Behavioural Characteristics Progression, Bender Visual-Motor Gestalt Tests) as components, it is used to determine the child's placement in the school system. This is contrasted to the nonretarded children whose behavioural performance and outcome is determined by such additional factors as motivation, interests, and personality variables (Maloney & Ward, 1979).

One component of functional age, which has been examined by several authors is the relationship between intelligence and motor performance. Rabin (1957) and Francis and Rarick (1959) found little or no relationship between intelligence and motor proficiency. However, Sloan (1951) and Malpass (1960) found moderate relationships while Black and Davis (1966) and Knights, Atkinson and Hyman (1967) reported positive correlations.

Groden (1969) points out that there are at least two difficulties found with much of the prior research relating motor proficiency to intelligence. One is that the motor proficiency score is often obtained from the combination of a number of different motor behaviours. As motor skill is by no means a unitary factor, it is often difficult to determine which motor behaviours are responsible and which are of little consequence in accounting for an overall relationship of motor proficiency with intelligence when one is found. A second difficulty, pointed out by Groden (1969), is that retarded children are more likely to be afflicted by specific motor disabilities.

The underlying assumption of these experiments in which motor proficiency is being related to intelligence is that when motor skills are produced information is processed and, the more effective the information processing skills the better the performance and therefore, the higher the IQ score. Although the correlation of low skill level to low IQ levels holds true only for the retarded population (Schmidt, 1982), the assumption is questioned when no relationship is found between IQ and motor skills such as hand grip strength and balancing tasks in the retarded as well as the non-retarded population. It should be noted that many of the tasks used are simple motor tasks which involve very little processing of information. Schmidt (1982) and Henderson, Morris and Ray (1981) suggested that the reason for the occasional positive relationship between IQ and motor skills may be due to the fact that retarded people are generally less active physically so that decrements in motor performance are perhaps due more to a lack of movement experiences in childhood than to any deficiency in mental functioning.

Therefore, not only should such factors as the rate of development of the individual, as outlined by chronological and mental or functional age, be taken into consideration, but also the task presented should indeed require the processing of information as is characteristic of a complex motor task.

Preparation Phase

During the preparation phase, also known as the anticipatory phase, the performer's expectations of what will occur and how these expectations can be used during performance will be examined. The literature describing the preparation phase of mentally retarded populations will be divided into three subsections: anticipation, sensory set and motor set.

Anticipation: The main role of anticipation is to eliminate or reduce feedback delays so that the performer will have made the adjustments to his movement before a further response must be made. Thus, the performer could shorten his reaction time delays and make the movement seem smoother and more efficient.

Poulton (1952, 1957) outlined three types of anticipation, each one building on the other. They are: effector anticipation, receptor anticipation, and perceptual anticipation. The third type, perceptual anticipation, involves situations where the performer is given no preview but where the stimuli is presented in some regular way and can be learned by the subject. There are two classes of perceptual anticipation: spatial and temporal (Adams, 1966; Poulton, 1957). Spatial anticipation involves the prediction of where a stimulus will occur, whereas temporal anticipation involves the prediction of the time of occurrence of the stimuli or 'when'. Cross (1966; cited in Schmidt, 1968) found that spatial and temporal anticipation could be manipulated independently under experimental conditions, but the interaction of the two determined the response proficiency in a given task. Not only does perceptual anticipation build upon effector and receptor anticipation, but it is also the most difficult of the three in terms of information processing demands.

The first class of perceptual anticipation mentioned was that of spatial anticipation. As previously seen, the performer has no direct receptor information of the upcoming event although he knows it will occur with some regularity. Stimulus probability can be defined as the relative frequency with which a particular stimulus is presented. Miller and Pachella (1973) have shown stimulus probability to be a variable capable of influencing the encoding process. The use of stimulus-probability information during the encoding process increases the efficiency of encoding. Klatzky and Smith (1972) explained the increase in speed to highly probable stimuli by an 'expectancy hypothesis'. That is, subjects expect stimuli that have occurred with a high degree of frequency and encode them more rapidly.

Maisto and Sipe (1980) examined the effect of stimulus probability on encoding in retarded individuals. Two groups of nine children each matched for chronological age were tested. The mean IQ of the nonretarded group was 107.28 (S.D. = 9.30) on the Peabody Picture Vocabulary Test. The retarded subject's IQ was assessed on the Stanford-Binet Intelligence Scale and found to have a mean of 62.15 (S.D. = 6.18). In other words the two groups were not assessed on the same scale. No mention was made of the type of retardation of the seven retarded children who finished the study. The subjects were matched for chronological age: the mean age for the control group was 13.40 years (S.D. = .74) and the mean age for the retarded group was 14.13 years (S.D. = 1.62) which gives a mean difference of approximately 9 months.

Their results showed that the effect of stimulus probability was more pronounced for the nonretarded subjects than for the retarded subjects, with highly probable stimuli being responded to fastest for both groups. The findings for the nonretarded group was similar to that of Miller and Pachella (1973). However, they reported that, although sensitive to manipulations in stimulus probability, the retarded group did not use this information during the encoding process. They reported that retarded individuals responded to low-probability information to a greater degree of "relative" efficiency (i.e., showed less decrease at higher levels of difficulty) as compared to nonretarded individuals; although within the retarded group they responded to highly probable stimuli faster than low probable stimuli.

The second aspect of perceptual anticipation was that of time. As previously seen, temporal anticipation involves the prediction of when an event will occur. A mere reaction to stimuli could cause intolerable lags in response initiation and control, especially in open skills. Klemmer (1956, 1957) demonstrated that adults can learn to anticipate the arrival of a stimulus in a simple reaction time situation, and Baumeister and Hawkins (1966) have provided evidence showing that retarded persons can anticipate the arrival of a signal.

Gosling and Jenness (1974) examined the differences in simple reaction time between retarded and nonretarded subjects with respect to three temporal variables. Their findings seemed to lend support to the idea that it was not that the mentally retarded subjects were unprepared to respond but that it was difficult to reorganize their responses. It was not clear whether this difficulty was basically a reluctance to abandon the expectancy or from confusion at having two contradictory sets of response determinants. There was evidence for a failure to respond promptly when expectancy was not fulfilled.

The above studies have all presented evidence that retarded people can anticipate the arrival of a signal. However, the tasks used in these experiments were all simple key presses where little or no precision was required. In two experiments, Newell, Wade and Kelly (1979) examined the extent to which retarded persons could temporally anticipate and preprogram a motor response that required a reasonable degree of speed and precision.

In the first experiment they looked at whether severely retarded adults (mean age = 30.9 years) could spontaneously reduce response latency as a result of switching from a variable to a fixed foreperiod and whether practice would facilitate anticipation. Included in this was the extent to which anticipation interacted with the index of difficulty of the movement and/or the length of the foreperiod. However, as noted above, the subjects were 10 severely retarded males, six of whom had a mean IQ of 44.7, two of which were below 30 and one whose IQ was unknown.

Three dependent measures were recorded: reaction time, movement time and error rate. The subjects were presented with nine target (width-amplitude) combinations on all 5 test days. The order in which the nine conditions were tested was randomized for each subject on each day.

The results of the reaction time data showed neither distance nor target width significantly altered the latency over the random foreperiod. Changing the nature of the foreperiod did not interact with the index of difficulty. The reaction time frequency distributions and means showed no differential response-initiation time to a fixed vs. a random warning interval. The movement time data showed that response amplitude and precision variables influenced retarded persons' movement time as described by Fitt's Law. The error rate data indicated some degree of speed-accuracy trade-off within the index of difficulty as found in nonretarded samples.

The second experiment was a result of their failure to demonstrate temporal anticipation in experiment one as was reported in earlier literature. They hypothesized that the temporal-anticipation ability of retarded adults may be a direct function of the complexity of the response. Experiment two replicated the essential features of experiment one, but with a simple release response as the task. The subjects were 14 male adults (mean age = 32 years) whose mean IQ was 36.08.

The reaction times were considerably lower which was considered as a direct reflection of the reduction of response difficulty. In general, the data suggested that when response complexity was minimal, retarded persons could take advantage of a short 1-second fixed interval warning condition and preprogram their responses to some degree.

The results posed another question: why did perceptual anticipation interact with the complexity of the response? Short-term memory is believed to take some part in the programming of a response. This holding of the program is most likely when the response is known in advance, such as a simple reaction time paradigm (Klapp, Wyatt &

MacLingo, 1974). The findings of Newell, Wade and Kelly (1979) suggested that the time over which the response had to be held and the complexity of the response may have interacted with this program-holding process, i.e. short-term memory. The authors suggested that a contributing factor to the subjects' failure to anticipate temporally the arrival of a warning signal may be their poor attentional capacity. Thus the difficulty retarded persons experience with focusing and/or maintaining their attention toward a stimulus may hinder their ability to timekeep and predict temporal intervals. It was also suggested that the attentional deficit may only magnify their basic inability to timekeep and preprogram responses.

Sensory Set: The second subsection of the preparation phase is that of the sensory set. Kerr (1982) defines sensory set as a change in the level of alertness such that the subject increases the rate at which target signals can be processed.

The first question is the understanding of how different levels of arousal can retard or facilitate information processing. From this point of view, Welford (1968) has formulated a concept that explains the poor operation of the channel at both low and high levels of arousal.

He reasoned that at low levels the channel was "inert" and the input was lost somewhere in the many information processing steps that were required to transform it into an output. At the other extreme, when activation was too high, this introduced "noise" into the channel so the input was interfered with and confusion arose.

According to Posner and Boies (1971) the key is that aspect of alertness that allows an individual to sustain attention on a task over an extended period of time. An optimal degree of alertness must be maintained so that performance can be maintained at maximum. Posner and Boies (1971) have shown this sensory set to be a general effect in that the normal or facilitated reaction time to an auditory cue suggested that there was a central alertness that was not specific for one sensory modality.

Marteniuk (1976) listed a number of determinants of activation. The first was stimulus intensity, that is, with an increasing intensity associated with increasing activation levels. A second variable or set of variables were postulated by Fiske and Maddi (1961) and are considered as the cognitive variables in that they require information processing by the CNS before they can influence arousal. These are stimulus complexity, uncertainty, meaningfulness and variation. A third set of variables that can affect arousal, especially when a movement task is required, are induced muscular tension and physical exertion.

Measures of activation levels have been considered as including various psychological indices such as changes in muscular tension, respiration, and heart rate.

Welford (1968) added a fourth variable that could determine level of activation, that of the introversion-extraversion traits. It would seem that introverts are by nature more highly aroused than extraverts. Therefore, introverts, because of their higher arousal level, would be expected to perform better on a number of tasks as compared to extraverts.

For the mentally retarded it has been hypothesized that they have below average levels of arousal (Baumeister & Ellis, 1963; Baumeister, Hawkins & Kellas, 1965; Belmont & Ellis, 1968). This reason, rather than an information-processing deficit, has often been associated with their lower performance levels. In the literature, there seems to be no indication of research which examines both as possible explanations. For this reason, the following section will present an overview of the literature concerned with attention and arousal, and the information processing aspects will be seen in the decision phase.

The first determinant of activation was that of stimulus intensity. The improvement in reaction time due to increases in the intensity of the reaction stimulus is a function of the distance from threshold, and therefore, a relatively intense signal would be expected to be more helpful to the retarded individual (Baumeister, Hawkins & Kellas, 1965).

The second determinant of activation was that of the cognitive variables. These include complexity, uncertainty, meaningfulness and variation.

Nettlebeck and Brewer (1976) used an 8-choice reaction time task to compare non-retarded and mildly retarded adults. They concluded that in a complex task the slower reaction times among retarded subjects may have been the result of a slower rate of accumulating information.

It seemed likely that when stimuli were at a distance, the retarded subjects made additional inspections before responding except when the signals were very discriminable, i.e., the two end lights.

The second cognitive variable, that of uncertainty, was indirectly looked at by Mosley (1980) in the form of familiarity of stimuli. He found that when confronted with unfamiliar stimuli, low mental age subjects failed to hold onto the potentially salient features of the stimulus event that could serve as cues for the recognition task. However, when the subjects were not time-limited in their processing of the unfamiliar stimuli their performance improved. In other words, when faced with a new task which consists of a degree of uncertainty the retarded subjects are at a disadvantage in the recognition-task situation.

Meaningfulness and variation will not be discussed here, however, the role of attention is an important point.

Krupski (1977) examined the role of attention in the reaction-time performance of mentally retarded adolescents. Her assumption was that good reaction time performance required attention during the preparatory interval of a trial and that observation of subjects during that time would provide descriptive information on whether retarded individuals exhibited behaviour reflecting the most basic evidence of attention. Ten retarded and ten nonretarded subjects were matched for chronological age (CA = 15.6 and 15.4, respectively). The reaction time scores for the retarded subjects were found to be significantly slower and more variable than for the nonretarded participants. In addition to performing more slowly on the reaction time task, the retarded subjects were also noted to glance off-task to a greater extent than their nonretarded counterparts. Krupski (1977) concluded that it was premature to infer that frequent off-task glancing in retarded subjects was solely responsible for their poor performance but that it was a contributing factor.

As mentioned previously measures of activation levels have been considered as including various psychological indices such as changes in muscular tension, heart rate and respiration. Bower and Tate (1976) studied cardiovascular and skin conductance correlates of a fixed-foreperiod reaction time task in retarded and nonretarded youths matched for both chronological and mental age. In all their measures the values for the mental age group fell between those of the chronological age and the retarded groups, with few of the differences reaching statistical significance. The mental age group was, however, significantly superior to the retarded group in mean reaction time and skin conductance response magnitude. On the other hand, the chronological age group manifested significantly more heart rate acceleration and cephalic pulse amplitude constriction than the mental age group. They concluded that these findings reflected a marginally lower integration of central, autonomic, and motor processes of the younger mental age group as compared to the older chronological age group.

This study presented consistent information of the retarded subjects as debilitated in comparison to their chronological age peers both physiologically and behaviourally during a reaction time task.

They hypothesized that the deficit might be due to an inability to achieve and maintain an instructed set and/or impairment in arousal functions.

<u>Motor Set</u>: The final subsection of the preparation phase is that of the motor set. Kerr (1982) defines motor set as the time when the most probable movement from among all the possible movements that could be made in any situation is selected. Weiss (1965) fractionated reaction time into motor and premotor components. Motor time was defined as the interval between the arrival of this neural signal at the muscle and the actual contraction of the muscle that initiates the response of the first observable movement (Kerr, 1982). The premotor time represents the interval between the presentation of the stimulus and the onset of the action potential in the responding muscle (Kerr, 1982).

A study by Ando, Wakabayashi and Yabe (1978) used a fractionated reaction time paradigm to look at mentally retarded children. They chose 43 mentally retarded male subjects (IQ = 49 to 50.3) and 107 non-intellectually handicapped males matched for chronological age only. A vertical jump task was fractionated. The premotor time was defined as the speed of conduction in the nervous system and the motor time as the speed of contraction. The results showed a significantly faster reaction time with age, a significant correlation between premotor time and age and no significant correlation between motor time and age. The faster response in reaction time in the retarded children in relation to age was due to the faster response in premotor time and not due to the motor component. For the normal children, there was significant increase in reaction time, premotor time and motor time with age. The two-way analysis of variance between response speed (RT = PMT - MT) and IQ showed no significant difference but there was a significant difference among these response speeds. They concluded that the slower premotor time accounted better for slower reaction times in the mentally retarded subjects than did motor time but that intelligence was not related to body reaction time.

To summarize this section on the preparatory phase, the need for a standardized task or system of research would seem obvious. To date, it has been shown that mentally retarded people can anticipate spatially but do not seem to use stimulus-probability information efficiently. Temporal anticipation seems to be less of a problem for the intellectually handicapped although the evidence has no systematic pattern. There seems to be support for both the information processing deficit and/or activation level deficit in sensory set.

The one commonality in all of these studies of mentally retarded functioning is the use of reaction time as a valuable tool for the study of individual differences in relation to adaptability.

Decision Phase

The actual time it takes to complete the decisional phase is usually referred to as reaction time (Kerr, 1982). Reaction time may be fractionated into its premotor and motor components. Premotor time is usually related to central processing, that is, the time taken to select the response. Motor time is usually related to peripheral delays in the musculature. The time from the firing of the efferent signal centrally to the onset of muscular contraction peripherally is relatively constant for any given response (Kerr, 1982; Andro, Wakabayashi & Yabe, 1978).

In the preparation phase it was shown that the speed of selection could be influenced by the factor of probability and the number of items, or possible responses held in memory. The preparation phase dealt mainly with the information that would be needed to make a decision and to hold it in memory. In the decision phase the main task is the retrieval of this stored information from memory and the choosing between a number of alternatives and then selecting a sequence of responses. Kerr (1982) states that the performer uses information to reduce uncertainty, e.g., the greater the number of alternatives, the greater the amount of information needed to make a correct decision. As the probability of an event or sequence of events increases, so the level of uncertainty decreases, but so does the amount of information provided by that event.

Can mentally retarded individuals retrieve information from memory in order to formulate a decision and if they can, can they do so efficiently? Once the information is retrieved from memory can they make the necessary choice between the number of alternatives and if so, is it as efficient as possible? The answers to these questions may be answered in part by looking at both input organization and inspection time.

August (1980) examined input organization as a mediating factor in memory. Campione and Brown (1977) had suggested that mentally retarded people's memory deficiency was attributed to a failure to spontaneously employ organizational strategies in preparation for recall, rather than an inability to organize per se. From this August (1980) reasoned that although mentally retarded individuals may possess, in some degree, prerequisite category information in permanent memory, they apparently fail to realize that certain mnemonic situations call for a deliberate strategic effort to utilize this information. In other words, if the use of organization strategies determined at least in part, the level of recall, and if the retarded subjects were unaware of the need for such strategic intervention, then techniques that directed their attention to organizing principles may also have facilitated recall. Glidden (1977) has shown that when stimuli are clusterable, improvements in recall noted for differing presentation methods were associated with improvements in measures of recall organization. For unrelated items, there was no direct relationship observed between measures of organization and recall. Apparently, for individuals of a low IQ level, different task conditions may result in either the production or nonproduction of a particular strategy.

August (1980), however, compared mentally retarded and non-retarded children of the same mental age to see if her findings would suggest the possibility that IQ related increases that had been typically reported for free recall might result primarily from an increase in the higher-IQ child's use of semantic relationships to organize weakly related items.

The results supported the hypothesis that improvements in recall were dependent on the specific nature of the task conditions and did not occur on an all-or-none basis. Improvements in clustering and subjective organization closely corresponded to improvements in recall. Indeed, Worden, Mandler and Chang (1978) had found that in order for subjects to benefit from a sorting input procedure, they had to be involved in generalizing their own personal organizations.

In sum, the findings of August's research suggested that the often reported memory deficit of mentally retarded individuals could not be entirely attributed to a product deficiency involving a failure to use spontaneously mnemonic strategies that were consistent with semantic organization. In addition to an accessibility deficit involving the development and monitoring of a plan to organize in anticipation for recall, mentally retarded individuals also may differ from the norm in the knowledge they possess about the meanings of words to be recalled (semantic knowledge) and in their ability to relate these words to the meanings of other words.

Although August's 1980 study was not a motor task it did provide some evidence that mentally retarded people have problems organizing information. As movements are not stored 'semantically', this may be the reason why the mentally retarded do not show as great a deficit in motor tasks as they often do in verbal tasks.

Once information is retrieved from memory can retarded individuals make selections between choices? Brewer and Nettlebeck (1977) worked upon Welford's (1971, 1973, 1974) assumption that people generally divided the stimulus array into two classes, inspected each class in turn to locate the one containing the signal, and then continued with successive inspections of progressively smaller classes until the specific location of the stimulus was identified. From their 1976 study, Nettlebeck and Brewer found that compared with nonretarded subjects, retarded subjects were more reliant upon the ends of the display and upon repetitions of the preceding stimulus in order to respond quickly. It was not clear, however, to what extent such reaction times were dependent upon the presence of this line as an explicit reference point or cue. Thus, there was a need to examine the extent to which retarded subjects were dependent upon this cue in order to direct their inspections of the stimulus display in an economical manner.

Their subjects were matched for chronological age (17 to 28 years) but the mentally retarded group were considered borderline or slow learners. In other words their mean IQ was 65 to 73, slightly above that of all previous studies seen. The results showed that when the centre line was absent, retarded subjects were still able to respond correctly to the stimuli in the middle of the display. However, while the patterns of reaction times suggested that the nonretarded subjects were using a conceptualized midline as a reference point this was not the case for the retarded subjects.

Thus, it appeared that even in a task in which the stimulus-response relationships were quite direct, the performance of the mildly retarded persons was greatly influenced by the presence of certain cues in the stimulus situation. In the absence of such cues, the responses of the retarded persons were slowed to a greater degree than were those of the nonretarded individuals. It appeared that retarded persons generally required more inspections in order to locate the stimulus and its response.

When a vibrotactile key was used to stimulate the responding finger directly, thereby greatly simplifying the processes of stimulus discrimination and S-R translation, the differences between retarded and nonretarded subjects in median reaction time and variability of reaction time between fingers in the 8-choice situation virtually disappeared. Thus, if the reaction time task can bypass effectively the discrimination and translation processes, then much of the difference between the retarded and nonretarded subjects disappeared (Brewer, 1978).

Lally and Nettlebeck (1980) used the term inspection time (λ) for the measure of information processing speed. This measure was derived from a discrimination model proposed by Vickers, Nettlebeck and Wilson (1972). The model assumes that when individuals are required to discriminate between alternatives, they make a series of inspections of the sensory data, storing information obtained in memory until the evidence favouring one alternative reaches a predetermined criterion. Inspection time is defined as the duration required to make one inspection of the sensory data.

Lally and Nettlebeck (1980) investigated the effect on estimates of varying the type of response required. The hypothesis was that longer estimates of λ obtained from retarded subjects could be due to difficulties in having to organize a response rapidly rather than to slower perceptual speed. Twenty retarded male subjects ranged in age from 17 to 25 years while their IQ ranged from 51 to 83 ($\bar{IQ}$ = 69, SD = 8). They were matched for chronological age only. Their results suggested that non-retarded individuals adopted different strategies for responding in the two tasks used. In the more difficult task requiring selection between two fingers of the one hand, nonretarded subjects responded more cautiously, so reaction time was increased. Error rates did not increase, so estimates of λ remained virtually unchanged; however, results obtained from retarded subjects were less clear. When these subjects were required to organize a more complex response, estimates of λ appeared to have been influenced by response-selection factors. Thus, estimates of inspection time of retarded subjects were not found to be independent from the manner in which the response was made. On the whole, retarded subjects responded at about the same speed in both tasks, irrespective of the number of errors made. Since reaction times remained relatively constant for both tasks, decision processes must have been made more rapidly and on the basis of less evidence in the task where response organization was more difficult, assuming that increases in response complexity take longer to organize. This strategy resulted in more errors and, therefore, longer estimates of λ.

While nonretarded subjects tended to trade speed for accuracy in the more difficult task, those in the retarded group traded accuracy for speed. Thus, it seems that the higher estimates of λ obtained in the more complex task for the retarded subjects were a consequence of making decisions on the basis of even lower overall levels of caution, rather than confusion in response organization. This would suggest that in a situation involving relatively high stimulus uncertainty, retarded and nonretarded persons may adopt qualitatively different strategies when attempting to cope with the same experimental constraints.

An additional problem that may be associated with response organization is that of reflection-impulsivity. Messer (1976) noted that reflective persons consistently perform better than do impulsive persons on problem-solving tasks involving response uncertainty. He also reported research indicating that the scanning strategies of impulsive individuals on the Matching Familiar Figures Test were less systematic and more global than those of reflective individuals.

Haskins and McKinney (1976) found significant correlations between the Matching Familiar Figure Test errors and problem-solving performance and suggested that the accurate children may have acquired more competence in information-processing skills. Borys and Spitz (1978) argued that one reason why the retarded groups performed poorly on problem-solving tasks was that they responded too quickly, failing to consider the problem carefully in order to reach a solution. They proceeded to test educable mentally retarded adolescents and nonretarded children of equal mental age using the Matching Familiar Figures Test to assess reflection-impulsivity.

They found no significant difference between error scores for retarded and fourth grade subjects. The only significant difference in latency was on the preschool test where retarded subjects took longer to respond. Thus, there were no reliable differences between the two subject groups in the proportion of impulsive-reflective, fast/accurate, or slow/inaccurate responders. Further analysis on the retarded group also indicated that there were no significant correlations between IQ and errors on IQ and latency. In sum, the results indicated that the retarded adolescents did not respond more quickly or less accurately on the Matching Familiar Figures Test than did their nonretarded mental age counterparts. In fact, the response times of the retarded adolescents were slightly longer than those of the fourth graders. It was thought to be unlikely, therefore, that impulsivity in retarded individuals was responsible for their marked inferiority to nonretarded children on certain problem-solving tasks.

The above studies have shown that mentally retarded individuals can retrieve information from memory in order to formulate a decision but research indicates that it is less efficient. Once this information is retrieved from memory they are capable of making a choice between a number of alternatives depending upon the complexity of the stimuli and/or the response. The major obstacle in drawing definite conclusions is the sample matching of chronological and mental age and the differences in the type of tasks used to reach these conclusions. None of the motor tasks were matched for mental age. The non-motor tasks matched for mental age (Mosley, 1980; August, 1980; Borys & Spitz, 1978) tended to show less of a discrepancy between the two groups.

Movement Phase

Having decided when and where to move, the next phase involves the question of how to move. A very large part of this phase concerns the effectiveness with which the various operations involved in a plan of action can be organized. Once these operations have been organized the effector mechanism must send commands to the muscles, a complex process in that some movements demand high amounts of information be sent at a fast rate to the muscles in order that rapid movements can be made.

The first problem that can occur is in the rate that commands can be organized and sent to the muscles; the second, is the way in which the motor commands are organized in light of an action plan (Marteniuk, 1976). Each will be reviewed in turn.

The first factor that could limit information processing in the movement phase is the amount of information being handled. Fitts (1954) studied the problem and found that the length of time it took to complete a movement was a function of both its length and required terminal accuracy. From the formula he derived, the difficulty of the task could be determined from knowledge of the bits of information. The results of his research have shown the capacity with which the motor system can process information. In support, Marteniuk (1976) pointed out that if there was no fixed capacity, movement speed would have been the same for each level of difficulty, but since movements became slower with increasing difficulty this indicated that only so much information per unit of time could be processed. Therefore, the more information available, the longer it took to process it. Marteniuk (1976) also added that the maximum rate with which the motor system could transmit information was about 12 bits per second.

Pew's 1974 work centered on the compensatory display where the subject sees only the error signal, i.e., he must move his control stick so as to return a cursor to the centre of the display and thereby correct for any deviations introduced by the input signal; the output is literally subtracted from the input before it is presented to the subject. Pew assumed that the subject operated on a discrete time base, executing one movement every 200 msec. In addition, Pew (1974) added the output of a short-term prediction on what has since become known as a short-term memory. This was a signal that comprised the weighted sum of position plus velocity of the error signal. The assumption was that the subject did not execute error corrections on the basis of position errors alone, but rather took account of trends and rates of change of the error signal in making his decision about what size correction to make. As mentioned in the preparatory phase, Poulton (1952) had defined this as perceptual anticipation. Therefore, the value of the desired error correction is held in memory for 200 msec (one sample period) and then released for execution in the form of a movement. Thus movements are always being executed 200 msec after the errors to which they are responsive have been sensed.

Combining the above with the evidence that predictability or perceptual anticipation can enhance performance, Poulton (1966) has produced reliably better tracking performance for just about all conditions that have been studied by providing the subject with a pursuit display, instead of the compensatory one. In other words, the compensatory tracking display was a useful tool to examine a simple tracking task in which very little processing was involved. However, many sports activities and video games of skill would not be possible if the human 'processor' could not take advantage of the predictability in the environment to better his performance. According to Poulton (1966) the pursuit display provided input and output information separately as well as permitting inferences about the error signal. It is generally assumed that it permits the subject to formulate commands on the basis of the pattern and predictabilities of the input signal unconfounded by the output signal.

From this discussion it can be assumed that the rate at which commands can be organized and sent to the muscles depends on the amount of information being handled. Also, commands can be organized into action plans. Accounting for residual motor 'noise', one sample period consisted of the 200 msec period of execution and that in order to take full advantage of the information perceptual anticipation was used when possible.

However, as indicated above, the 200 msec period also takes into account the monitoring of the movement. Monitoring of a movement includes a comparison of the current position with the desired outcome and the associated corrections. Before discussing movement monitoring a brief definition of the concept of a ballistic movement would seem in order.

Rasch and Burke (1978) describe a ballistic movement as a compound movement. The first of the three phases is a sustained force movement where the agonists contract concentrically, because the antagonists do not contract the body part(s) involved accelerate. The second phase is marked by no muscular contraction and so the body parts coast. In the final phase the antagonists contract eccentrically resulting in a deceleration. The three phases overlap at the transition stages, where one kind of movement blends smoothly into the next.

Welford, Norris and Shock (1969) deduced two separate controlling processes: 1) a faster one concerned with distance covering and 2) a slower one for 'homing in' on the target.

The first controlling process is concerned with distance covering. This is the only factor which is actually varied in the stressalyser. The distance required to travel to the target can be viewed in terms of overshooting. Buck (1978) found that the rate of overshooting a target in a manual positioning task dependended on the distance of the target from the boundary of the task, such that targets closer to the boundary were overshot less frequently. He also suggested that the task boundary is a cognitive construct rather than a perceived constraint, conceived by the subject as a frame of reference for his movements on the basis of changing requirements. Boundary distance was defined as the distance between the target and the boundary of the display in the direction of movement (Buck, 1976).

The second controlling process of movement monitoring involved the homing-in on the target. Where this part of the movement begins is difficult to discover unless there are obvious error corrections made. It may be that the homing-in period begins in the first phase of the basslistic movement when the decision to coast is made. A final factor which often augments the differences between the retarded and normal population in this area is that of variability. Variable error reflects the extent to which the person is inconsistent or how the person's performance varies about his own mean performance. This intra-subject variability seems to be higher for mentally retarded subjects than for their normal counterparts.

McGown, Dobbins and Rarick (1973) explored the intraindividual variability of retarded and nonretarded children on a coincidence timing task. The hypothesis that the lower performance level of the retarded children was a function of greater than normal within subject variability was not substantiated. Although there was large within subject variability in motor performance, which is characteristic of retarded children, the correlation between constant error and intraindividual variability was low. Therefore, the lower level of performance of the retarded was not, in this case, a reflection of their greater than normal within subject variability. Although consistency is an important aspect of skill, the mentally retarded children, when matched for chronological only, performed less well on this motor task. However, this consistency was apparently independent of constant error.

On the other hand Caffrey, Jones and Hinkle (1971) examined the differences and variabilities in reaction times of normal and educable mentally retarded children with respect to intersubject variability. The retarded children, matched for chronological age only, were significantly more variable than the normals. This inter-subject variability was also consistent with the findings of Berkson and Baumeister (1967). A final statement by Caffrey, Jones and Hinkle (1971) was that further study should allow for other physical abnormalities of the retarded child to be considered. As seen from this review this may be in the form of comparisons of groups on the basis of mental age (Kappauf, 1973) or of the different types of mental retardation (M.R. vs D.S.).

Chapter III

Method

Subjects

Ten trainable mentally retarded and twelve Down syndrome males were selected from the Ottawa Board of Education schools. Five children from each group were matched for both chronological age and functional age, seven children from each group were matched for functional age only, and eight children from each group were matched for chronological age only. Two groups of normal children, nine elementary school and eleven high school males were also selected from the area schools. The elementary school children provided the functional age matches with the Down syndrome group and the high school males provided the chronological age matches. The means and S.D.'s for chronological and functional age are presented in Table 1. All subjects were free from motor impairment. See Appendix A for the list of subjects for each analysis.

Functional age, as implied by the name, is the level at which an individual functions. The basic assumption is that functional age is equal to chronological age in normal children.

Table 1

Mean Chronological and Functional Age for Each Group in Years

Groups	N	Chronological Age Mean	Chronological Age S.D.	Functional Age Mean	Functional Age S.D.
Down Syndrome	12	18.19	1.66	7.08	1.22
Mentally Retarded	10	17.78	1.97	8.20	1.72
Elementary matched for FA	9	7.88	1.29		
High School matched for CA	11	18.16	1.75		

Apparatus

The apparatus used to measure psychomotor performance was the N.R.C. stressalyser. The system consists of a tracking unit and a control unit.

The tracking unit (figure 1) features a display within which five targets, 2.4 mm in diameter are set 41 mm apart in a semicircular fashion. A control steering wheel drives a pursuit pointer that has been set up at a 1:1 ratio. The manually controlled wheel requires an applied torque of 14.2 g m to initiate movement and has an inertia of 9.56 g m^2 (Buck, Leonardo, & Hyde, 1977). When a target is illuminated the subject must align the pursuit pointer within the target area for an uninterrupted period of 200 msec.

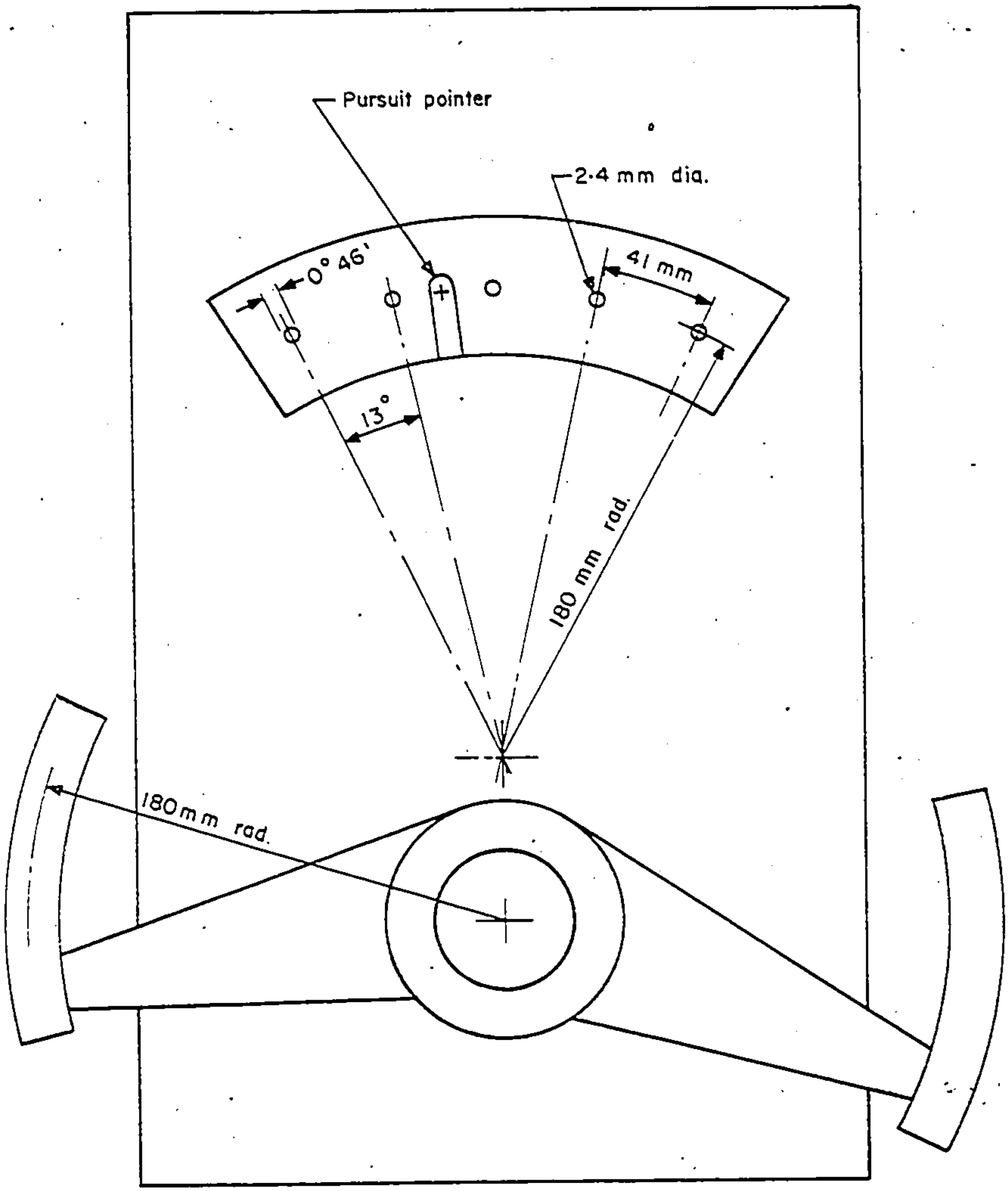

FIGURE 1

Front Plan of Tracking Unit
Direct Method

The control unit excites a potentiometer that is driven by the pursuit pointer and reads its output. This output is in the form of an amplified analogue measure of wheel and pointer position and movement. As the control unit monitors the potentiometer output it compares it with reference voltages corresponding to the starting and target positions for each step. As alignment conditions are met by the subject on the tracking unit the control unit selects the reference voltages, and illuminates the next target. The subject's task is to make 100 successive alignments of the pursuit element with one of the five illuminated targets. As the subject pursues the targets the information is written onto magnetic tapes for future decoding.

Procedure

All subjects completed a single test session. Each session consisted of eight trials performed successively with intertrial pauses of approximately one minute. Each session lasted between 20 and 30 minutes. Of the ten patterns of target movements that were available for use, numbers one to four were used. That is, the session began with pattern one and continued with a change of pattern at each run until the fifth run. On the fifth run pattern four was repeated and on subsequent runs the pattern was set in descending order so that the final trial was on pattern one.

The tracking unit was positioned on a table such that the center of the unit coincided with the center of the chair. Thus, the subject's body midline was directly in front of the tracking unit's centre light. The chair was adjusted for each subject in order that the target display of the tracking unit was below the line of sight. Indirect ambient lighting was used whenever possible. For each subject the cassetté number and side used was recorded on Stressalyser Test Record sheets. All details of the testing session were recorded on the record sheets.

On entry into the room the subject was seated at a comfortable distance from the tracking unit. He was then instructed to hold the wheel of the tracking unit so that the pointer was between targets 4 and 5 (counting the targets from left to right) until the appearance of the first target light. At this time, the subjects were shown the correct hand position that was to be maintained throughout the session. That is, both hands must grasp the vertical hand grips firmly but not too tightly, as in driving a car. The arms should be at a 45° angle at the elbow. The subject was told that 100 targets would be presented for each trial and that this would be done 8 times. During the explanation of the procedure, the wording varied according to the child's ability, the emphasis was placed on speed and accuracy of performance. The subjects received knowledge of results in the form of total number of seconds to complete the run at the end of each trial. The instructions were repeated as often as needed.

The task as a whole was explained as being a game. The children were asked if they had seen Star Wars and if they had, the target lights were treated as enemy star fighters and his task was to shoot the enemy down as fast as possible to make direct hits.

In the case they had not seen the movie, the task was treated as if they were driving the family car and in order to avoid hitting other cars or pedestrians, they had to drive towards the lights and not hit the lights. They were asked to get from school to home again as fast as they could without being in an accident.

The high school males did not require the 'game situation'. If he asked about accuracy they were told to track accurately in order to reduce speed. In other words, the subject had the final choice of strategy. The task itself gave knowledge of alignment accuracy.

Design and Analysis

The overall analysis was divided into three separate parts. In the first analysis (N = 20) five Down syndrome and five mentally retarded children were matched for functional age and chronological age to within 180 days from the date of testing. One control group of five males was matched for functional age only; the only stipulation being that at the date of testing, they not be within 90 days of their date of birth. A second control group was matched with the Down syndrome group to within 180 days of their birth date on the day of testing; i.e., for chronological age.

The second analysis (N = 21) compared seven mentally retarded and seven Down syndrome boys matched for functional age only. A control group of seven elementary school boys was matched with the Down syndrome group. The elementary school males could not be within 90 days of their birthday at the date of testing to ensure that they were in the middle of their functional age.

The third analysis was performed on three groups of eight subjects (N = 24). The Down syndrome group was matched for chronological age with the mentally retarded group. The control group of high school boys was matched with the Down syndrome group for chronological age to within 180 days at the date of testing.

In each of the three analyses the data was analyzed in terms of 1) total response time, 2) total response time in quarters, 3) correct reaction time at four levels of probability, 4) non-overshoot movement time for three distances, 5) overshoot movement time for four distances, 6) error score at four levels of probability, and 7) overshoot score for four distances.

A preliminary manipulation of the data was performed in order to remove atypical scores. Buck (1981) established error criterions for the very low atypical values of the distribution of data. An error criterion of 11 msec was set for error time which are mostly 1 msec in value. This error criterion of 11 msec presumably represents limits in the resolution of error movement detection (Buck, 1981). For overshoot times the low values lie between 6 and 15 msec and are associated with misalignments on the nearside of the target as distinct from true farside overshoots.

In addition to the error criterion, inclusion criteria were established for the high value atypical data. High values were defined as any break in performance over 10 seconds in duration; presumably caused by breaks in attention. The distributions for the atypical data are shown in Appendices B, C. and D. Therefore, inclusion criterions were set for both reaction time and movement time data. The intention being to give more support to the null hypothesis (Ho) being tested. The data within the inclusion criteria were then submitted to statistical analyses.

Total response time was analyzed using a groups x subjects x trials analysis of variance with repeated measures. Correct reaction time, non-overshoot movement time, overshoot movement time and total response time in quarters were analyzed separately using a groups x subjects x probabilities (or distances or quarters) x trials analysis of variance with repeated measures. Finally, error score and overshoot score were analyzed using the Chi-Square Test. Performance scores for all analyses were averaged over all trials, and simple main effects were used to describe the significant main effects.

Chapter IV

Results

The three separate analyses were examined together in terms of the seven specific measurements provided by the stressalyser. As the number of subjects varied for each analysis a summary of the analyses performed were presented in Table 2. The data were averaged within trials, however, in cases where data was missing due to mechanical failure, only those trials with complete data were used. Each specific measurement is presented in turn.

Total response time

The distribution of scores of total response time was normal. The data were submitted to a groups x subjects x trials analysis of variance with repeated measures (see Appendix H).

Table 2

Summary of Analyses Performed[1]

Measures	Functional and Chronological Age	Functional Age Only.	Chronological Age Only
Total response time	4 x 5 x 6[2]	3 x 7 x 7	3 x 8 x 5
Total response time in quarters	4 x 5 x 4 x 4[3]	3 x 7 x 4 x 7	3 x 8 x 4 x 5
Correct reaction time for 4 levels of probability	4 x 5 x 4 x 6	3 x 7 x 4 x 7	3 x 8 x 4 x 4
Non-overshoot movement time for 3 distances	4 x 5 x 3 x 6	3 x 7 x 3 x 7	3 x 8 x 3 x 3
Overshoot movement time for 4 distances	4 x 5 x 4 x 4	3 x 6 x 4 x 3	3 x 6 x 4 x 5
Error rate	X^2-test	X^2-test	X^2-test
Overshoot rate	X^2-test	X^2-test	X^2-test
Correction reaction time for Down Syndrome group only	12 x 4 x 7[4]		

1. Except where otherwise indicated Analyses of Variance with repeated measures were performed.
2. Groups x subjects x trials
3. Groups x subjects x levels x trials
4. Subjects x levels x trials

A summary of the analyses of variance is presented in Table 3.

Table 3

Summary of ANOVAs for the Total Response Time for Each Analysis

Effects	Functional and Chronological Match	Functional Match Only	Chronological Match Only
Groups	$p < .05$	n.s.[1]	$p < .01$
Trials	$p < .01$	$p < .01$	$p < .05$
Groups x Trials	$p < .01$	n.s.	n.s.

1. No significant difference

The main effects of groups shows that when Down syndrome children and mentally retarded children were matched for functional age only with elementary school boys there was no significant difference between the groups. However, there was a significant difference between the groups when the Down syndrome and mentally retarded children were matched with the high school males for chronological age only. This was supported by the significant difference between groups in the functional and chronological age analysis.

The main effects for trials was significantly different in all three analyses. This practice effect indicated that as the number of trials increased the total response time decreased (see Figure 2).

Since there were significant differences between groups a simple main effects was performed. A summary of this is provided in Table 4.

Table 4

Summary of Simple Main Effects Between Groups for Total Response Time

Comparisons	Functional and Chronological Age Match	Functional Age Only Match	Chronological Age Only Match
D.S.[1] vs M.R.[2]	n.s.	n.s.	$p < .05$
D.S. vs E.S.[3]	n.s.	n.s.	-
D.S. vs H.S.[4]	$p < .05$	-	$p < .01$
M.R. vs E.S.	n.s.	n.s.	-
M.R. vs H.S.	$p < .01$	-	$p < .01$
E.S. vs H.S.	$p < .01$	-	-

1. Down syndrome group (D.S.)
2. Mentally retarded group (M.R.)
3. Elementary school group (E.S.)
4. High school group (H.S.)

The simple main effects of each separate analysis for groups supports the results of the main effects of the three separate analyses. That is when Down syndrome boys were matched with mentally

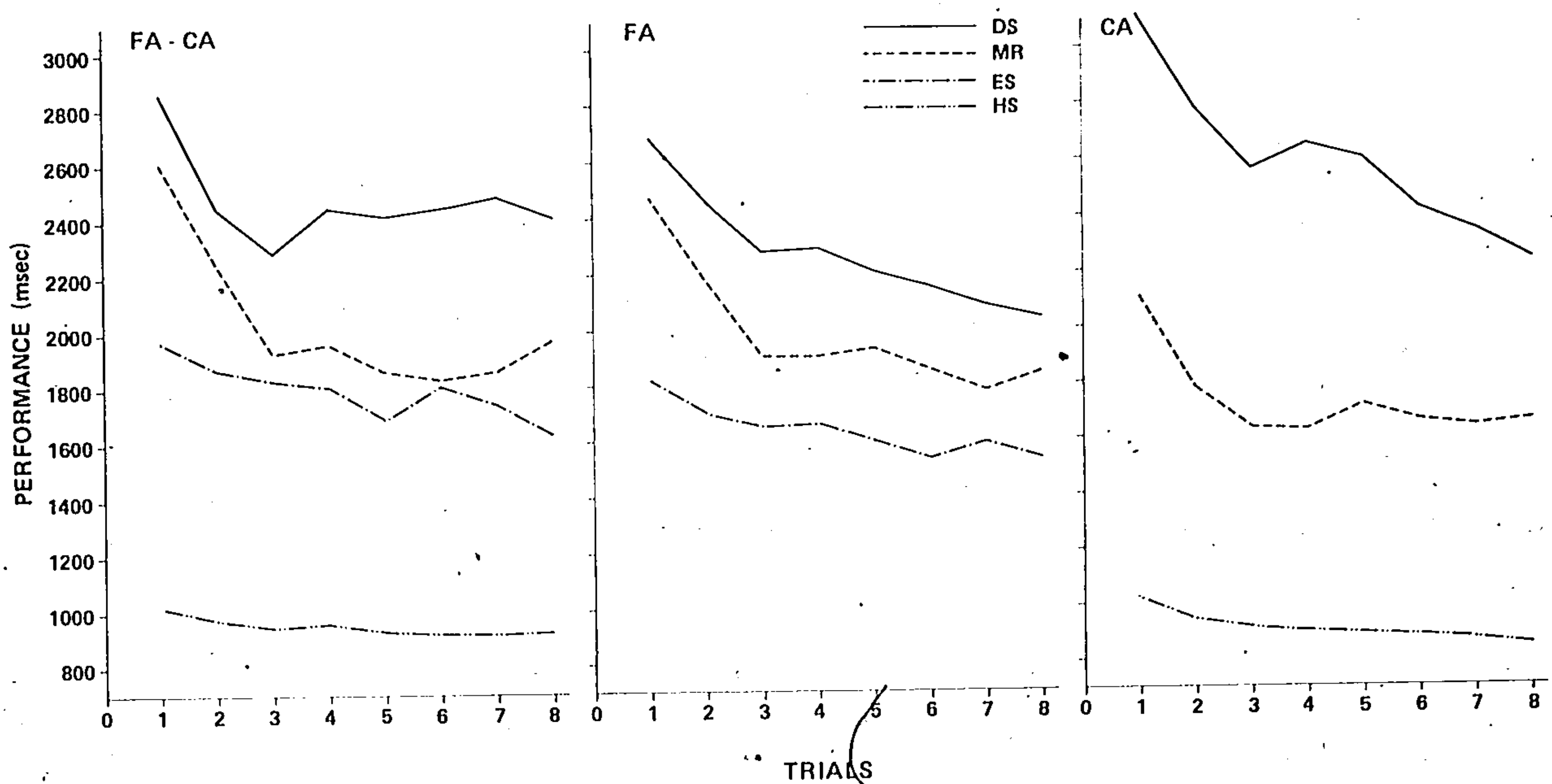

Figure 2 Total Response Time.

retarded boys for functional age only there was no significant difference in total response time. When the Down syndrome group was matched with the mentally retarded group for chronological age only there was a significant difference in total response time.

The simple main effects also showed that neither the Down syndrome group nor the mentally retarded group were significantly different from the elementary school children when matched for functional age only. However, both the Down syndrome group and the mentally retarded group showed a significant difference from the high school boys when matched for chronological age only.

From the simple main effects for the functional and chronological age matches it was seen that there was a significant difference between the elementary school boys (mean chronological age of 7.88 years, S.D. = 1.29) and the high school boys (mean chronological age of 18.16 years, S.D. = 1.75).

Examination of the graphs for the analyses (see Figure 2) showed that the high school males performed consistently faster than the other groups. The elementary school boys performed faster than the mentally retarded group, who in turn performed faster than the Down syndome group, although there were no significant differences between the groups.

<u>Total response time in quarters</u>

The distribution of scores of total response time in quarters was normal. The data were submitted to a groups x subjects x quarters x trials analysis of variance with repeated measures (see Table 2).

A summary of the analyses of variance is presented in Table 5.

Table 5

Summary of ANOVAs for the Total Response Time in Quarters for Each Comparison

Effects	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Groups	$p < .05$	n.s.	$p < .01$
Quarters	n.s.	$p < .01$	$p < .01$
Trials	$p < .01$	$p < .01$	$p < .01$
Groups x Quarters	n.s.	n.s.	$p < .05$
Groups x Trials	$p < .01$	n.s.	n.s.
Quarters x Trials	n.s.	n.s.	n.s.
Groups x Quarters x Trials	n.s.	n.s.	n.s.

The main effects for total response time in quarters for groups and trials were identical with those discussed previously for total response time (see Appendix H).

The main effects for quarters showed no significant difference in the functional and chronological age match analysis but did show significance in the functional age match only and in the chronological age match only. The results for the simple main effects for the analyses are shown in Table 6.

Table 6

Summary of Simple Main Effects for Quarters for Total Response Time in Quarters[1]

Comparisons	Functional Age Only Match			Chronological Age Only Match		
	D.S.	M.R.	E.S.	D.S.	M.R.	H.S.
Quarters 1 vs 2	$p<.05$	n.s.	$p<.01$	$p<.01$	$p<.05$	$p<.01$
Quarters 1 vs 3	$p<.01$	$p<.05$	$p<.01$	$p<.01$	$p<.05$	n.s.
Quarters 1 vs 4	$p<.01$	n.s.	$p<.01$	$p<.01$	$p<.05$	$p<.01$
Quarters 2 vs 3	n.s.	n.s.	n.s.	n.s.	n.s.	$p<.05$
Quarters 2 vs 4	$p<.05$	n.s.	n.s.	n.s.	n.s.	n.s.
Quarters 3 vs 4	n.s.	n.s.	$p<.05$	n.s.	n.s.	n.s.

1. Quarter 1 = Lights 1 through 25
   Quarter 2 = Lights 26 through 50
   Quarter 3 = Lights 51 through 75
   Quarter 4 = Lights 76 through 100

By combining the results from Table 6 with the results from Figure 3 it was observed that all groups performed significantly better during their first quarter (i.e., the first twenty-five targets) except

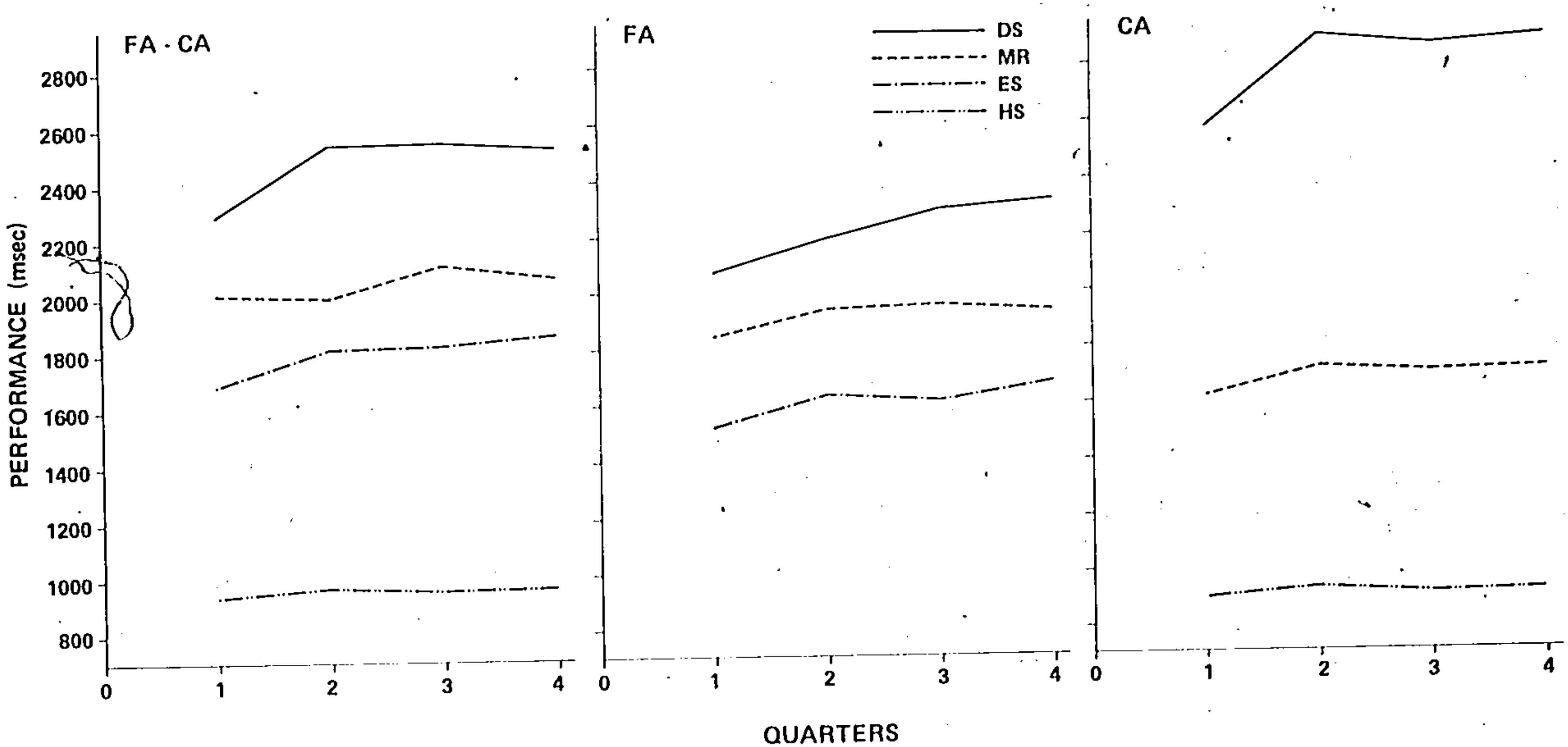

Figure 3 Total Response Time in Quarters.

for the mentally retarded group in the functional age only match. The elementary school groups showed significant difference between the third and fourth quarters (i.e., they slowed down) and the high school group showed a significant difference between the second and third quarters (i.e., they went faster). The Down syndrome and mentally retarded groups showed no further significant change in performance from quarter to quarter after the first quarter.

When comparing the first quarter with the fourth quarter, the mentally retarded group in the analysis of functional age matches only showed no significant change in performance although they seem to be performing slower. However, when comparing the first and last quarters for the other three groups (Down syndrome, elementary school and high school), their performance was significantly slower in the last quarter.

Reaction Time

The reaction time data was examined in terms of reaction times for correct responses and reaction times for error responses. Reaction time data for correct responses is affected by directional probability. It is therefore possible to combine the data to produce mean correct reaction times for four probability levels (.25, .50, .75, and 1.00). Reaction times for error responses show the same effect to the extent that those for movements starting from targets 1 and 5 are lower than all others, but otherwise the effect is absent (Buck, 1981). Since some subjects make no errors and few make errors in all probability categories the error reaction times differ from the correct reaction times (Buck, 1981).

In both conditions (reaction times for correct and incorrect responses) an inclusion criterion of 51 to 1600 msec was imposed. Examination of the atypical data (i.e., data not within the 51 to 1600 msec criteria) for both types of reaction time revealed that neither was not affected by directional probability.

The atypical data for reaction times for correct responses was examined. Table 7 shows how each group was affected by the inclusion criterion of 51 to 1600. From the functional and chronological age match a total of 3.5% of the data was considered atypical, while 2.5% of the data from the functional age only match and 3.9% of the chronological age only match were dropped (see Appendix B for histograms).

Table 7

Percentages of Atypical Data Excluded:
Reaction Times for Correct Responses[1]

Group	Function and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Down Syndrome	7.71%	3.89%	7.19
Mentally Retarded	2.19%	2.16%	2.12
Elementary	1.94%	1.48%	-
High School	2.04%	-	2.40

1. Inclusion criterion of 51 to 1600 msec

Although the atypical scores were eliminated from the total data, the majority of atypical scores were from the Down syndrome group.

Correct Reaction Time

The distribution of scores for correct reaction times was normal and the data were submitted to a groups x subjects x probabilities x trials analysis of variance with repeated measures (see Table 2).

A summary of the analyses of variance is presented in Table 8.

Table 8

Summary of ANOVAs for Correct Reaction Times for Each Analysis

Effect	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Groups	$p<.01$	$p<.05$	$p<.01$
Probability	$p<.01$	$p<.01$	$p<.01$
Trials	$p<.01$	$p<.01$	$p<.01$
Group x Probability	$p<.01$	$p<.01$	$p<.01$
Group x Trial	n.s.	$p<.05$	n.s.
Probability x Trial	n.s.	n.s.	n.s.
Group x Probability x Trial	n.s.	n.s.	n.s.

1. Inclusion criterion of 51 to 1600 msec

The main effects all showed significant differences. Of particular interest was the group x probability interaction that showed significant differences in all three analyses (see Appendix H).

Simple main effects for groups showed that when Down syndrome subjects were matched for functional age only with the mentally retarded subjects there was no significant difference. However, when they were matched for chronological age only a significant difference did exist (see Table 9). When the Down syndrome children were matched with high school boys for chronological age there was a significant difference in performance. When the Down syndrome children were matched with the elementary school males for functional age only there was a significant difference.

The mentally retarded boys, matched for functional age only with the elementary school boys showed no significant differences but when the mentally retarded boys were matched with their high school counterparts there were significant differences in performance.

Consistent with total response time and total response time in quarters, the high school males performed significantly better than the elementary school males.

Although there was no significant difference between the Down syndrome group and the elementary school group when matched for functional and chronological age, there was a significant difference between these two groups when they were matched for functional age only. On examination of the two analyses it was observed that the standard

Table 9

Summary of Simple Main Effects Between
Groups for Correct Reaction Time

Comparison	Functional and Chronological Age Match	Functional Age Only Match	Chronological Age Only Match
D.S. vs M.R.	n.s.	n.s.	$p < .001$
D.S. vs E.S.	n.s.	$p < .025$	-
D.S. vs H.S.	$p < .01$	-	$p < .001$
M.R. vs E.S.	n.s.	n.s.	-
M.R. vs H.S.	$p < .01$	-	$p < .001$
E.S. vs H.S.	$p < .001$	-	-

deviation of the Down syndrome group in the functional and chronological age match analysis differed markedly from the functional age only match (see Table 10).

The standard deviations for the twelve Down syndrome boys combined was calculated, the results of which are shown in Table 10. The results of the functional age match only were considered in Table 9. In other words, when Down syndrome males were matched for functional age only with elementary school males there was a significant difference in performance. The variability in performance shown by the Down syndrome group did not appear in the mentally retarded in either the

Table 10

Comparison of S.D.s for Correct Reaction Time

		Level of Probability 1.00	.75	.50	.25
FA-CA Analysis	D.S.	40.6	40.3	40.5	37.2
	M.R.	20.2	22.1	24.7	27.8
	E.S.	14.0	14.5	15.7	19.0
	H.S.	7.1	8.2	8.0	8.8
FA Analysis	D.S.	25.8	24.2	25.8	24.7
	M.R.	12.9	16.7	15.9	18.0
	E.S.	9.6	9.1	11.6	14.6
CA Analysis	D.S.	31.0	24.6	27.4	27.3
	M.R.	14.1	17.3	16.0	20.7
	H.S.	4.1	4.1	3.6	5.8
DS Only Analysis		21.4	19.0	18.8	17.4

functional age match only analysis and the chronological age only match analysis. In fact, the variability between the mentally retarded and the elementary school boys did not differ greatly (see Table 10). The high school boys were the least variable.

The simple main effects for probability are presented in Table 11. The Down syndrome children showed no significant difference in performance for correct reaction time between probabilities 1.00 and .50 when matched for functional age only. The mentally retarded group

Table 11

Summary of Simple Main Effects for Probability Levels for Correct Reaction Time

Comparison	Functional Age Only Match			Chronological Age Only Match		
	D.S.	M.R.	E.S.	D.S.	M.R.	H.S.
Prob 1.00 vs .75	$p<.001$	$p<.001$	$p<.001$	n.s.	$p<.001$	$p<.001$
Prob 1.00 vs .50	n.s.	$p<.001$	$p<.001$	$p<.05$	$p<.01$	$p<.001$
Prob 1.00 vs .25	$p<.025$	$p<.001$	$p<.001$	$p<.001$	$p<.01$	$p<.001$
Prob .75 vs .50	$p<.01$	n.s.	$p<.01$	$p<.001$	n.s.	$p<.001$
Prob .75 vs .25	$p<.001$	n.s.	$p<.05$	$p<.001$	n.s.	$p<.05$
Prob .50 vs .25	$p<.01$	n.s.	n.s.	$p<.001$	n.s.	n.s.

showed no significant improvement in performance for correct reaction time except when reacting to the easiest probability level (1.00). Only the Down syndrome boys showed any significant difference in correct reaction time between the two most difficult probability levels (prob .50 vs .25). The elementary school boys seemed to react to probability levels in a similar fashion to the high school boys, albeit more slowly.

Figure 4 partly explains the interaction between groups and probability levels. On examination of the probability factor in the simple main effects between groups for correct reaction time, it seemed that when the probability between groups was not significant there was a significant group x probability interaction (see Table 12). When there was a significant difference in probability between groups, there was no interaction effect.

Table 12

Summary of Probability and Group x Probability Interaction Effects Between Groups for Correct Reaction Time

Comparison	Probability			Group x Probability		
	A[1]	B[2]	C[3]	A	B	C
D.S. vs M.R.	n.s.	$p<.01$	n.s.	$p<.01$	$p<.01$	$p<.01$
D.S. vs E.S.	n.s.	n.s.	-	$p<.01$	$p<.01$	-
D.S. vs H.S.	n.s.	-	$p<.01$	$p<.01$	-	$p<.01$
M.R. vs E.S.	$p<.01$	$p<.01$	-	n.s.	n.s.	-
M.R. vs H.S.	$p<.01$	-	$p<.01$	n.s.	-	n.s.
E.S. vs H.S.	$p<.01$	-	-	n.s.	-	-

1. Functional and chronological age match analysis
2. Functional age match only analysis
3. Chronological age match only analysis

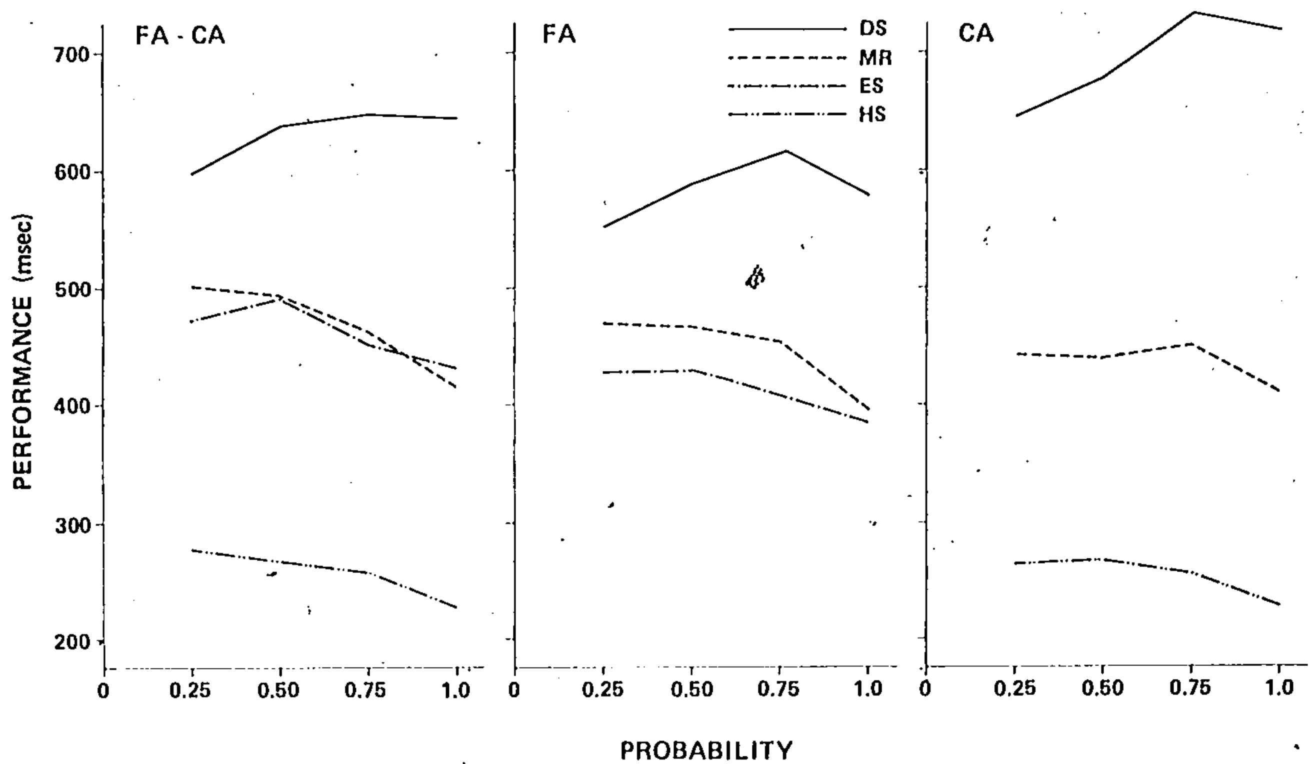

Figure 4 Correct Reaction Time.

Figure 4 and Table 12 show that whereas the mentally retarded, the elementary school and high school boys react faster for highly probable targets and more slowly for the less probable targets; the Down syndrome boys performed better at the most difficult levels.

In order to confirm that the Down syndrome boys were not reacting to directional probability a separate analysis of variance with repeated measures was performed with the twelve Down syndrome boys. The results for the larger sample supported the results of the functional age match only (see Table 11).

Non-overshoot Movement Time

Movement times for responses made without an overshoot are generally faster than movement time where an overshoot has been made (Buck, 1981). As with the previous measurements (total response time, total response time in quarters and correct reaction time) the data were normally distributed and were submitted to a groups x subjects x distances x trials analysis of variance with repeated measures (see Table 2). However, the analyses available to handle this data required complete data sets (i.e., would not accept missing data). Consequently for this analysis, one distance level was dropped. Also, an inclusion criterion of between 1 to 3000 msec was imposed in order to exclude atypical data. The histograms in Appendix C show the pattern of the atypical data.

Table 13

Percentages of Atypical Data Excluded:
Non-overshoot Movement Time[1]

Group	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Down syndrome	4.5%	7.3%	9.1%
Mentally retarded	2.9%	3.8%	1.9%
Elementary school	1.0%	.3%	-
High School	0%	-	.04%
Total data	2.8%	3.8%	3.7%

1. The inclusion criterion of 1 to 3000 msec

Table 13 demonstrates to what extent the Down syndrome group affect the total data with their atypical scores.

A summary of the results of the ANOVAs is presented in Table 14. The main effects for groups was significant for two of the three analyses, i.e., there was no significant difference between groups when the groups were matched for functional age only. The distance main effects were significant for all three analyses, however, the main effects for trials was significant in the functional and chronological age match analysis and the functional age match only analysis. When

Table 14

Summary of ANOVAs for Non-overshoot Movement Time for Three Distances

Effect	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Groups	$p<.001$	n.s.	$p<.001$
Distance	$p<.001$	$p<.01$	$p<.001$
Trials	$p<.01$	$p<.01$	n.s.
Group x Distance	$p<.01$	$p<.01$	$p<.01$
Group x Trials	$p<.01$	n.s.	n.s.
Distance x Trials	n.s.	n.s.	n.s.
Group x Distance x Trial	n.s.	n.s.	n.s.

the groups were matched for chronological age only there was no significant difference between trials. Each main effect will be examined in turn (see Appendix H).

Simple main effects for groups were analysed; a summary of which is presented in Table 15. There was no significant difference between the Down syndrome and the mentally retarded group whether they were matched for functional age only, chronological age only or for

Table 15

Summary of Results of Simple Main Effects for Groups for Non-overshoot Movement Time

Comparison	Functional and Chronological Age Match	Functional Age Match	Chronological Age Match
D.S. vs M.R.	n.s.	n.s.	n.s.
D.S. vs E.S.	n.s.	n.s.	-
D.S. vs H.S.	$p<.001$	-	$p<.001$
M.R. vs E.S.	n.s.	n.s.	-
M.R. vs H.S.	$p<.001$	-	$p<.001$
E.S. vs H.S.	$p<.025$	-	-

both. There was, as well, no significant difference between the Down syndrome, the mentally retarded and the elementary school groups in the first two analyses (i.e., functional and chronological age match analysis and the functional age only analysis). For movement times without overshoots only the high school subjects performed significantly different from the other groups (see Figure 5).

The simple main effects for distance (see Table 16) revealed that each group had a significant increase in movement time with each change in distance.

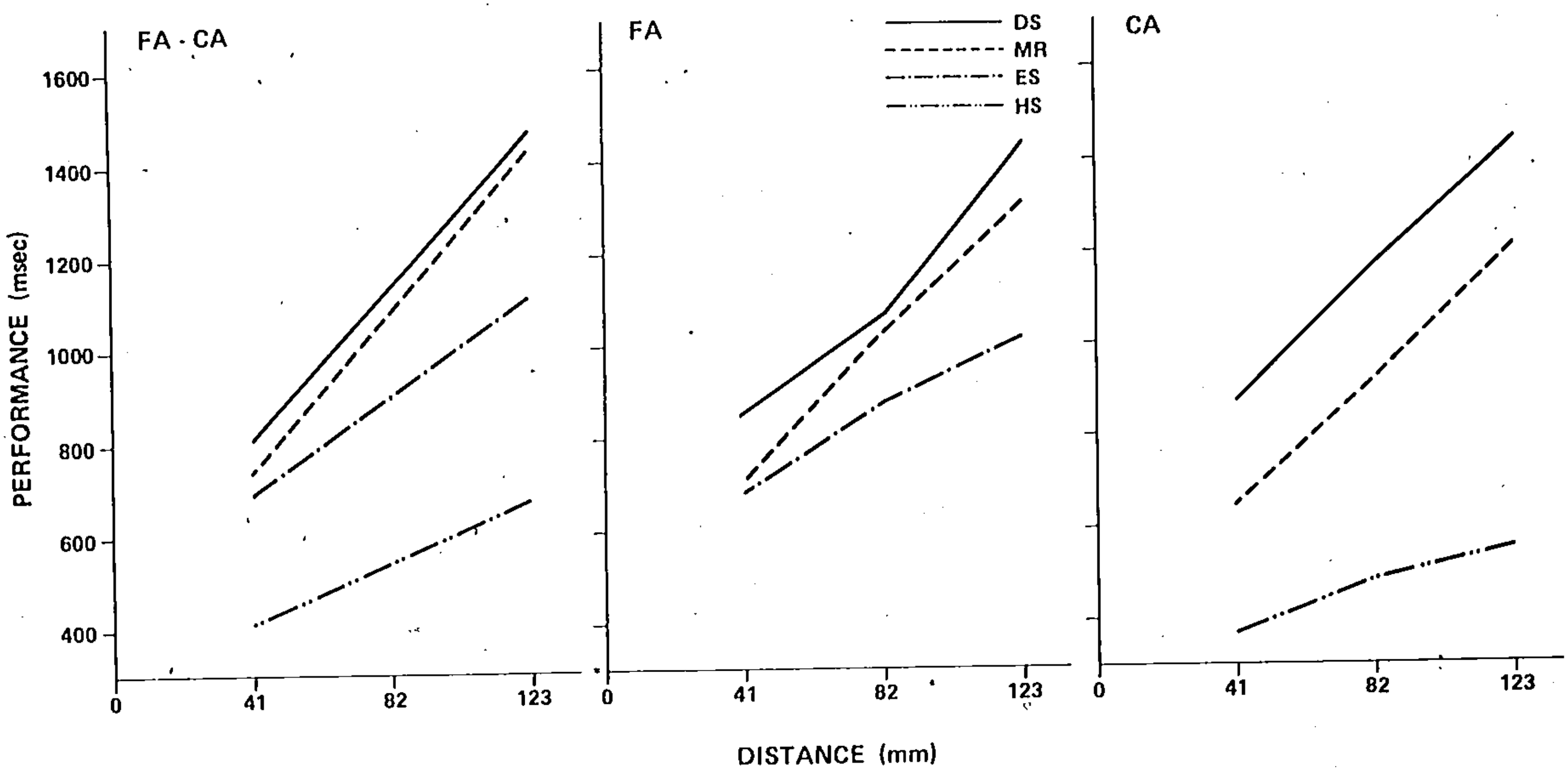

Figure 5 Non - Overshoot Movement Time.

Table 16

Summary of Results of Simple Main Effects for Distance for Non-overshoot Movement Time

Comparison	Functional and Chronological Age Match				Functional Age Match Only			Chronological Age Match Only		
	D.S.	M.R.	E.S.	H.S.	D.S.	M.R.	E.S.	D.S.	M.R.	H.S.
Distance 41 mm vs 80 mm	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$
Distance 41 mm vs 123 mm	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$
Distance 82 mm vs 123 mm	$p<.001$	$p<.001$	$p<.01$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.001$	$p<.01$

Although there was no significant difference between the Down syndrome group, the mentally retarded group and the elementary school group their performance curves differed (see Figure 5). Although the high school boys moved through all distances faster than the other groups, the difference in performance between different distances was less than for the other three groups, i.e., the slope of the line was not steep. For the functional age only analysis the sighificant group x distance interaction was a consequence of significant differences between the Down's and mentally retarded groups when compared to the elementary school group at the longest distance.

Overshoot Movement Time

The overshoot movement times with their accompanying error corrections were slower. An inclusion criterion of 1 to 5000 msec was applied to this measurement in order to exclude atypical data (see Appendix D for distributions of data). The amount of atypical data that was dropped from the analyses was for the most part that of the Down syndrome group (see Table 17). One set of subjects was dropped because on trials 1 to 5 one of the Down syndrome subjects did not produce any movement times with overshoots. As a result the analysis available would not accept this set of subjects.

Table 17

Percentages of Atypical Data Excluded: Overshoot Movement Time[1]

Group	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Down syndrome	5.8%	3.1%	4.5
Mentally retarded	3.6%	3.1%	1.1
Elementary school	1.0%	.6%	--
High School	0%	-	0
Total data	2.6%	2.2%	1.8%

1. Inclusion criterion of 1 to 5000 msec

A summary of the results of the ANOVAs is presented in Table 18. When groups were matched for functional age only there was no significant difference between the groups. However, when the groups were matched for chronological age only there was a significant difference between groups. Whereas there was a significant difference between distance main effect for all groups, the trials main effect was significant for all but the functional age only match. The interactions of group x distance and group x trial were not significantly different for the functional age only group (see Appendix H).

Table 18

Summary of Results of ANOVAs for Overshoot Movement Time for Four Distances

Effect	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Groups	$p < .001$	n.s.	$p < .001$
Distance	$p < .001$	$p < .001$	$p < .001$
Trials	$p < .001$	n.s.	$p < .01$
Group x Distance	$p < .01$	n.s.	$p < .01$
Group x Trial	$p < .01$	n.s.	$p < .01$
Distance x Trial	$p < .01$	n.s.	n.s.
Group x Distance x Trial	n.s.	n.s.	n.s.

A simple main effects for groups demonstrated that the significant differences were between the high school group and the other three groups. That is, when the Down syndrome group and the mentally retarded group were matched with elementary school children there was no significant difference. However, there was a significant difference in performance between the Down syndrome and the mentally retarded groups when they were matched for chronological age only (see Figure 6 and Table 19).

Table 19

Simple Main Effects for Overshoot Movement Time for Each Analysis for Four Distances

Comparison	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
D.S. vs M.R.	n.s.	n.s.	$p < .025$
D.S. vs E.S.	n.s.	n.s.	-
D.S. vs H.S.	$p < .01$	-	$p < .001$
M.R. vs E.S.	n.s.	n.s.	$p < .001$
M.R. vs H.S.	$p < .001$	-	-
E.S. vs H.S.	$p < .01$	-	-

The simple main effects for distance were significant except for the mentally retarded group and the elementary school group for the comparison between distances 3 and 4 (123mm vs 164mm) in the functional and chronological age match analysis. This can be seen in Figure 6. In the functional age only analysis the Down syndrome group showed no significant difference in performance between targets 2 and 3 (82 vs 123mm) and targets 3 and 4 (123 vs 164mm).

A simple main effects for trials was not performed. However, from the Table of Means (see Appendix E) for the overshoot movement time scores for trials, the groups generally showed faster times on trial 8 than on the first trial.

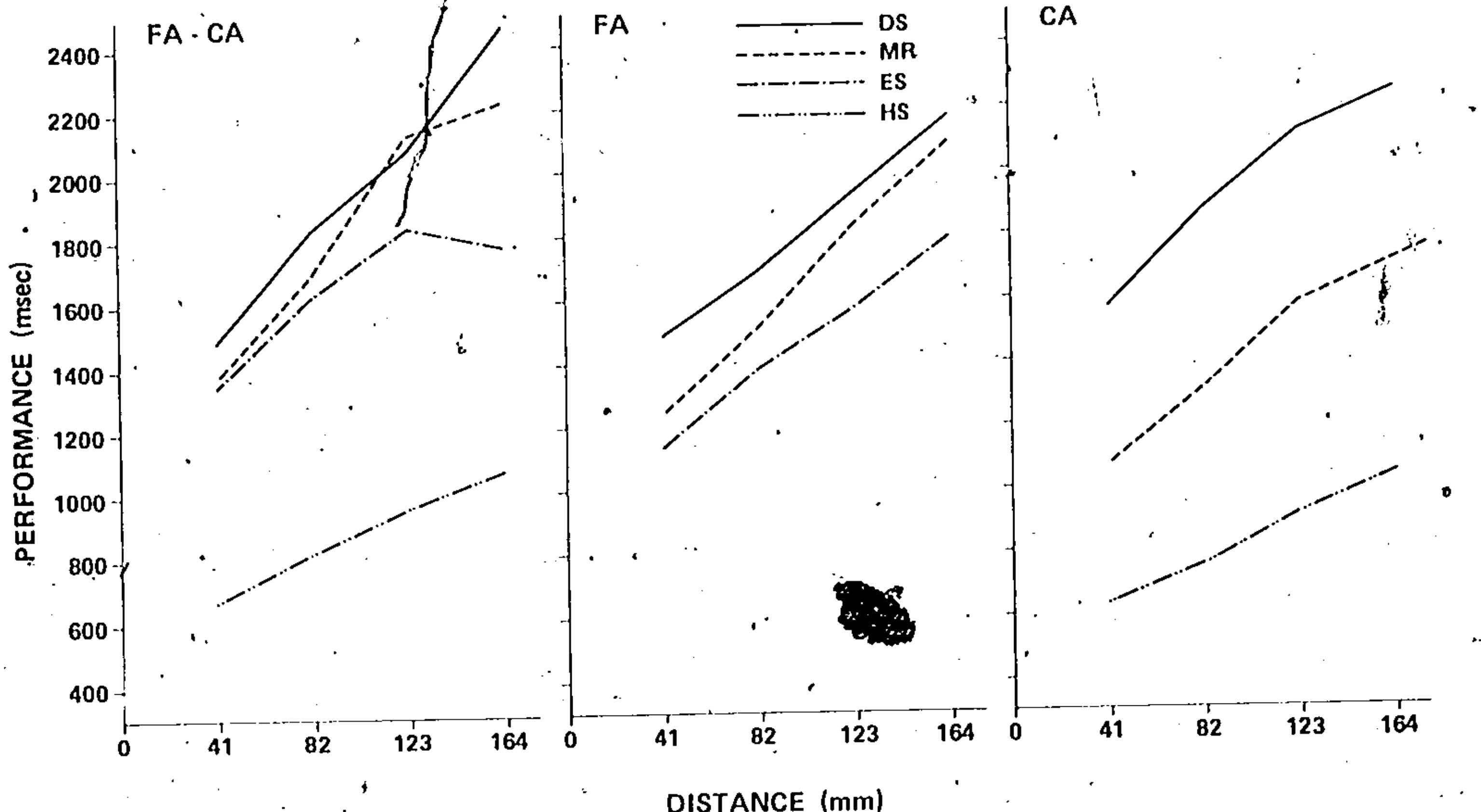

Figure 6 Overshoot Movement Time.

Error Rate

For previous measurements the data were normally distributed and in each of these distributions the variable (performance in msec) was measured on an interval scale. However, when discussing error rate the observations were measured on a nominal scale. In order to use the Chi-Square Distribution the data was further manipulated in order that all observations be independent. Percentages are not independent, and, consequently, their use could result in improper conclusions. The data was, therefore, transformed to nominal values and collapsed across trials and difficulty levels (see Appendix F for raw data). From this data the mean was determined. In the functional and chronological age match it was calculated to be 85.94, for the functional age only match the mean was 100.74 and for the chronological age match only the mean was 67.02. In each analysis any score less than their respective mean was considered a low score. Alternatively, any score more than the mean was considered a high score. Table 20 shows the results of the three Chi-Square tests. In the chronological age match only the Down syndrome group performed significantly better than both the mentally retarded and high school groups. Figure 7 indicates that the Down syndrome children made fewer errors on the most difficult probability level (.25) than any other group. However, at the level of highest probability (1.00) they performed as well as the other groups. The Down syndrome group showed no significant difference in error rates between probability levels .5 and .75, i.e., almost a plateau. The

Table 20

Results of Chi-Square Test for Error Rate
at Four Levels of Probability

Comparisons	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Groups (all)	n.s.	n.s.	$p < .05$
Between D.S. & M.R.	-	-	$p < .05$
D.S. & H.S.	-	-	$p < .05$
M.R. & H.S.	-	-	n.s.

high school and elementary school children made the most errors at the .25 probability level and the least at the 1.00 probability level. That is, both the elementary and high school children were making use of directional probability. The mentally retarded children seemed to respond in a pattern that more closely resembled the elementary school children.

Overshoot Rate

Overshoot rate differs from error rate in that an overshoot was detected when the pointer crossed the far side of the target position before alignment time on the new target (see Figure 8). Error rate, on the other hand, occurred after the alignment had been accomplished

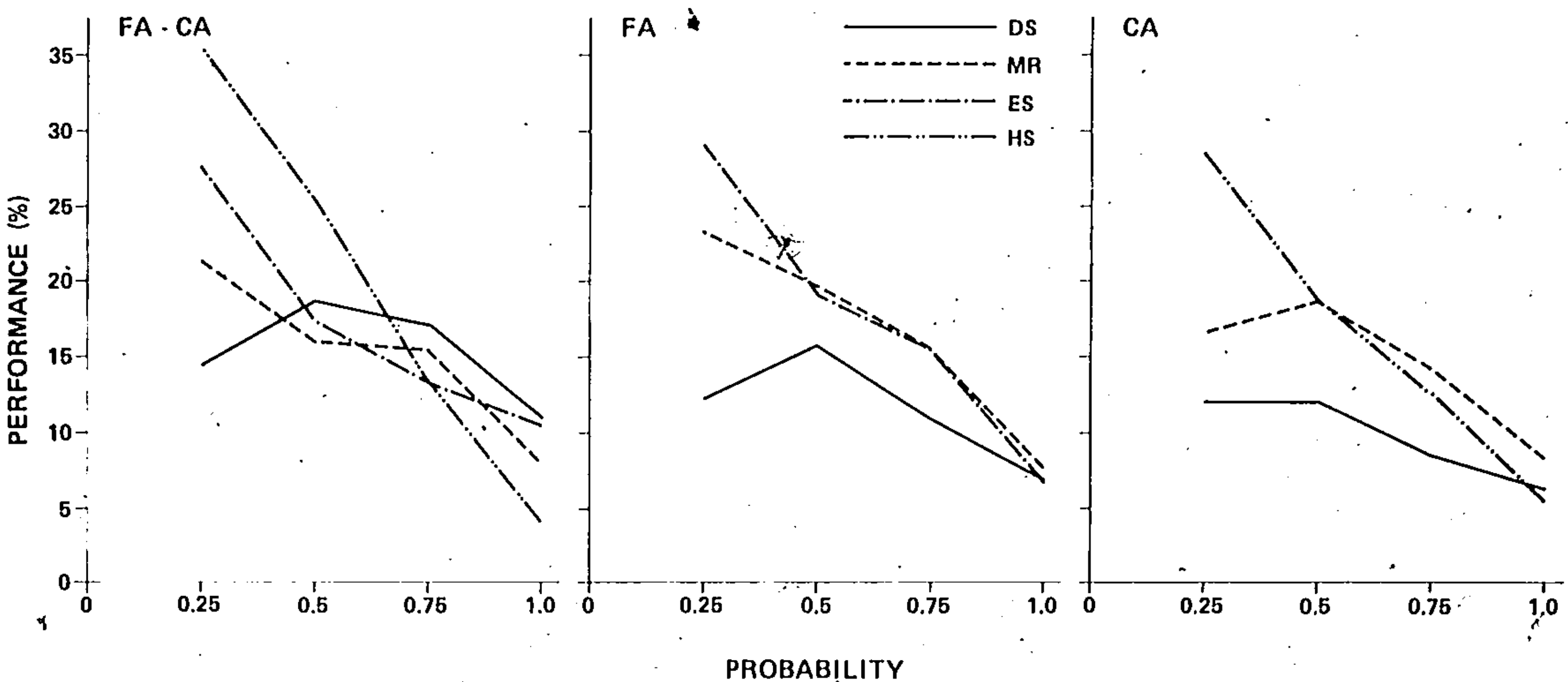

Figure 7 Error Rate.

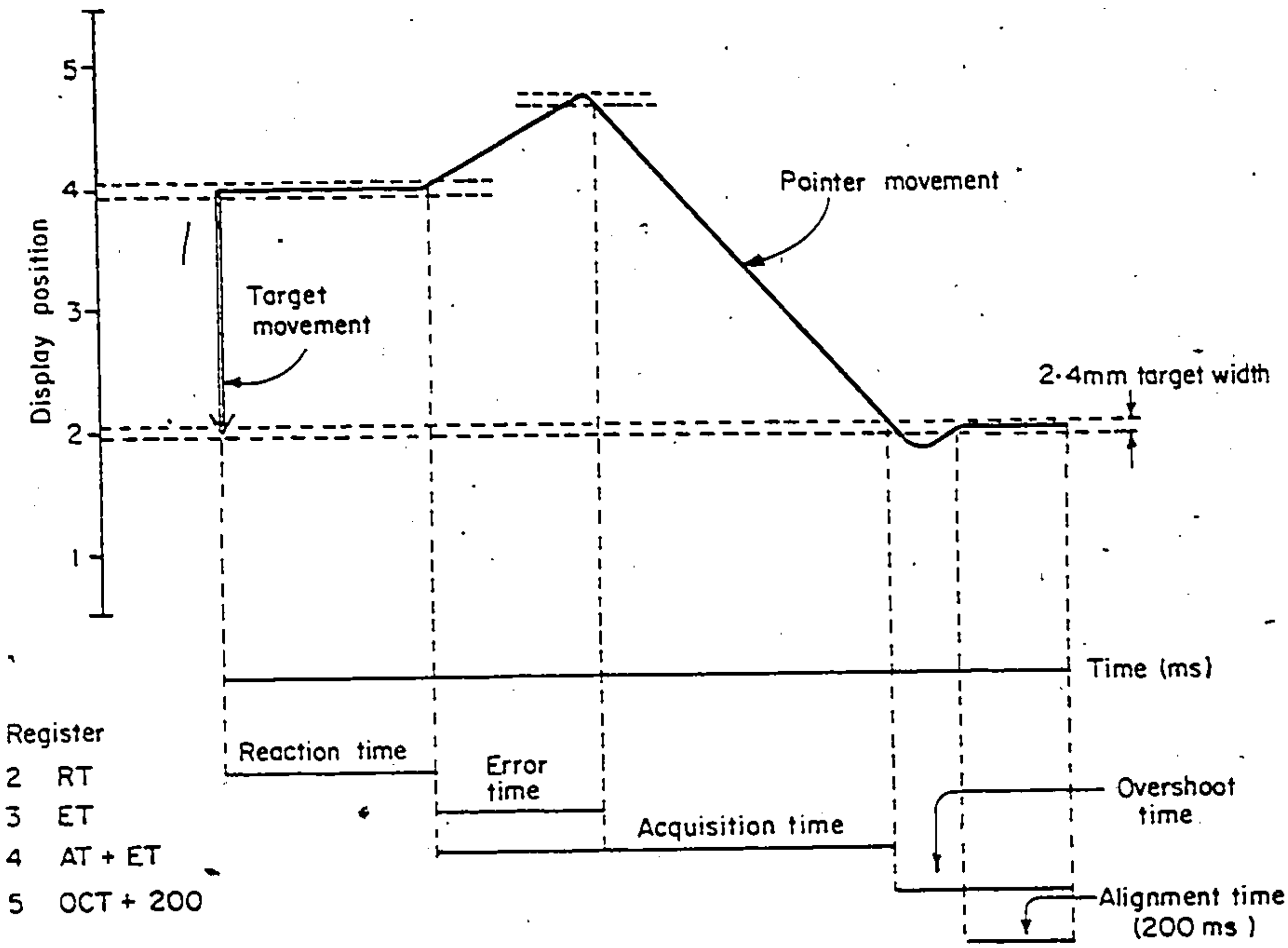

FIGURE 8

Schematic Trajectory of Two Pursuit:

on the actual target and the subject was preparing to move to the next target. As such neither can be discussed in terms of decisional processes. The number of overshoots can be determined but the point in time when the decision was made to make the correction cannot be determined.

Overshoot rate, however, depends upon a within-task variable which Buck (1981) has called boundary distance. It is defined as the relative location of the target with respect to the boundary of the task in the direction of movement (see Table 21). Each of the twenty possible movements within a run occurred five times. Therefore, boundary

Table 21

Table of Directional Probability (P), Target Distance (D), and Boundary Distance (B)

STARTING POSITION		TARGET POSITION 1	2	3	4	5
1	P	-	1.00	1.00	1.00	1.00
	D		1	2	3	4
	B		4	3	2	1
2	P	.25	-	.75	.75	.75
	D	1		1	2	3
	B	1		3	2	1
3	P	.50	.50	-	.50	.50
	D	2	1		1	2
	B	1	2		2	1
4	P	.75	.75	.75	-	.25
	D	3	2	1		1
	B	1	2	3		1
5	P	1.00	1.00	1.00	1.00	-
	D	4	3	2	1	
	B	1	2	3	4	

distance 1 occurred 40 times within a run, boundary distance 2 30 times, boundary distance 3 20 times and boundary distance 4 only 10 times within a run.

The overshoot data for each subject was collapsed across trials and boundary distances and submitted to a Chi-Square Test (see Appendix G for raw data). The results of the Chi-Square Test, see Table 22, showed no significant differences between groups for overshoot rate. However, as outlined in the graphs in Figure 9, the Down syndrome group, when moving to the boundary of the task committed less overshoots than any other group. When moving to the targets, other than targets 1 or 5, they overshot as often as the other groups. The elementary school children made the most overshoots.

The variability between groups, as in error rate, was not significantly different.

Table 22

Results of Chi-Square Test for Overshoot Rate
for Four Boundary Distances

Comparisons	Functional and Chronological Age Match	Functional Age Match Only	Chronological Age Match Only
Groups	n.s.	n.s.	n.s.

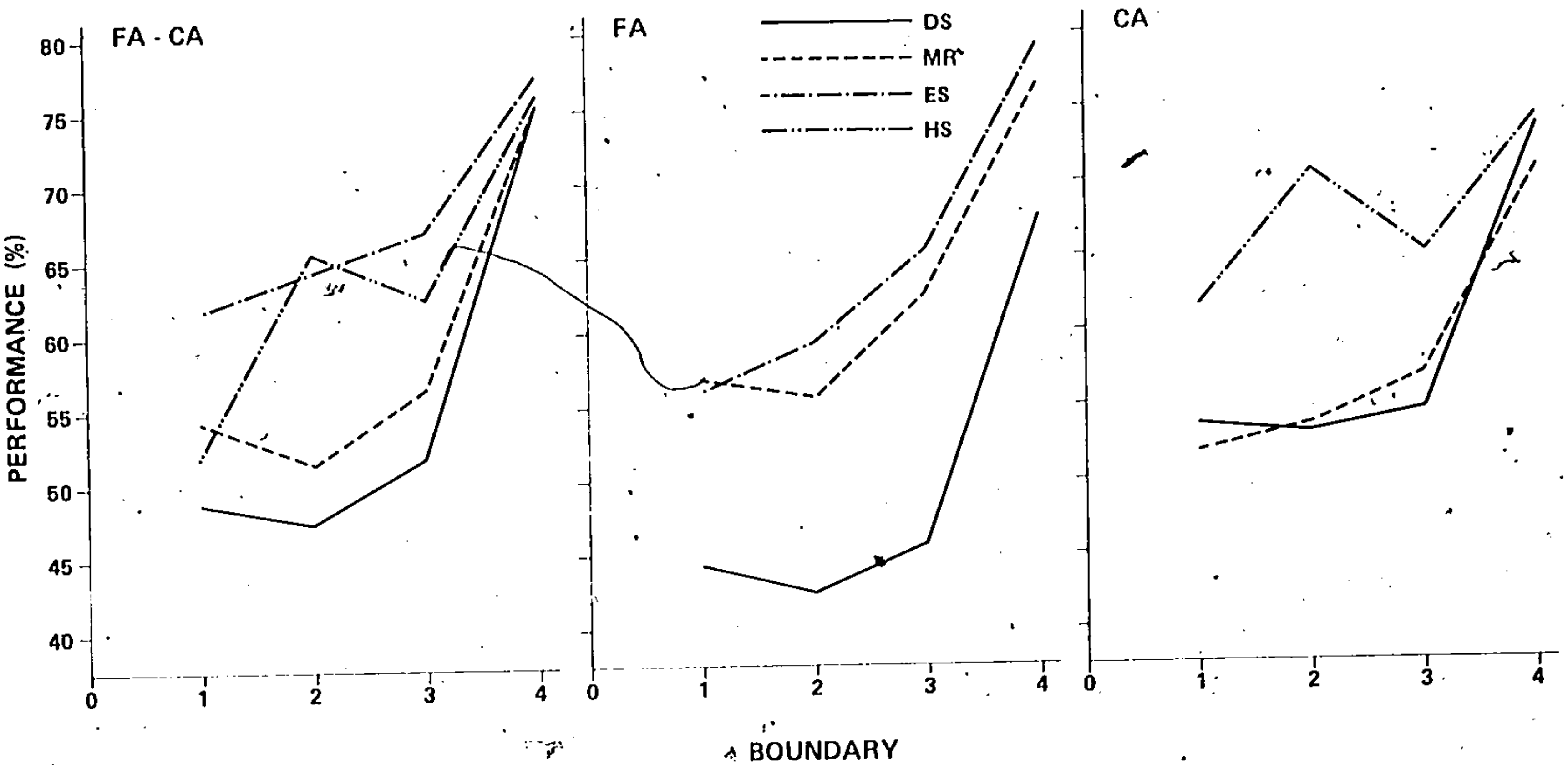

Figure 9 Overshoot Rate.

Chapter V

Discussion

This study differs from previous studies in that in previous studies usually one, sometimes two, parameters were employed to investigate this special population. The N.R.C. stressalyser allowed the conclusions of this study to be drawn from measurements on seven different parameters based on over 130,000 pieces of data.

The hypotheses investigated in this study were:

1) There were no significant differences in the motor control parameters involved in a self-paced pursuit tracking task between Down syndrome and mentally retarded children and intellectually normal children matched for functional age and chronological age.

2) There were no significant differences in performance in the motor control parameters between Down syndrome children and other mentally retarded children.

The data from the three analyses demonstrated that there were significant differences between the performance of mentally retarded (D.S. and M.R.) children and their intellectually normal matches, and between Down syndrome and mentally retarded children (see Table 23). As the findings vary according to the measure being analyzed it is more appropriate to consider the hypotheses in relation to each measure individually.

Table 23

Acceptance or Rejection
of Null Hypotheses

Main Findings

Matching Conditions	Total Response Time	Total Response Time in Quarters	Correct Reaction Time	Non-Overshoot Movement Time	Overshoot Movement Time	Error Rate	Overshoot Rate
MR-DS vs ES-HS							
FA-CA	Reject	Reject	Reject	Reject	Reject	Accept	Accept
FA	Accept	Accept	Reject	Accept	Accept	Accept	Accept
CA	Reject	Reject	Reject	Reject	Reject	Reject	Accept
DS vs MR							
FA-CA	Accept	Accept	Accept	Accept	Accept	Accept	Accept
FA	Accept	Accept	Accept	Accept	Accept	Accept	Accept
CA	Reject	Reject	Reject	Accept	Reject	Reject	Accept

For total response time, both hypotheses were supported for the functional age only matches. That is, there were no significant differences in total response time between any of the groups, Down syndrome, mentally retarded and elementary school, when matched for functional age only. Both hypotheses were rejected, however, when the Down syndrome group, the mentally retarded group and the high school group were matched for chronological age as all three groups responded significantly different from one another.

On the basis of total response time Down syndrome and mentally retarded children performed at a level that more closely resembled their functional age matches rather than their chronological age matches. The learning curve over trials showed evidence of more initial learning in the retarded groups than in the nonretarded groups. This invites an additional question. Since the retarded children demonstrated the ability to learn the task, could they, with more learning trials, match the performance of either the elementary school or high school children?

The results of correct reaction time showed that Down syndrome children reacted to stimuli in a very different fashion from both the mentally retarded and nonretarded children. Although there was no significant difference between the Down syndrome and mentally retarded children when matched for functional age, the effect of stimulus probability was more pronounced for the nonretarded groups and mentally retarded group than for the Down syndrome group. In general, the mentally retarded group and the nonretarded groups responded to highly probable stimuli faster than to lower probable stimuli. The Down syndrome group showed the reverse relationship.

The mentally retarded group did respond to highly probable stimuli faster than low probability stimuli in the same fashion as their functional age nonretarded match. In this sense the findings of the present study agree with Maisto and Sipe (1980). In their study, where subjects were matched for chronological age only, they reported that the mentally retarded group was sensitive to manipulations in stimulus probability.

Nettlebeck and Brewer (1976) have shown that when stimuli were at a distance, the retarded subjects made additional inspections before responding except when the signals were very discriminable; as are the lights at the end of the display. The results of the present study support the results of Nettlebeck and Brewer (1976) with a few additions. When the Down's children were moving to targets immediately adjacent to their starting position they responded quickly (see Appendix I). In addition, when the adjacent target was also an end light of the task, they produced their fastest reaction times: these fast reaction times were for the most difficult level of probability (.25).

The slight difference in total response time of the functional age only match between the mentally retarded and elementary school children seemed to indicate that it took the retarded children a little longer to process the information but that they were able to do this effectively. The Down syndrome children, on the other hand, did not seem to use stimulus probability and, therefore, may have responded to the task by making additional inspections in order to locate the stimulus. These additional inspections may explain, at least in part, their higher total response time, as in the Nettlebeck and Brewer (1976) study.

Therefore, the responses of the Down syndrome children did not follow the predictions of the Hick-Hyman law, whereas those of the mentally retarded children did.

The movement time data, for both overshoot and non-overshoot movement time, showed no significant differences between groups when they were matched for functional age only. Response amplitude did not influence the retarded groups' movement time any differently than for the normal children. For the movement time parameters the performance of all the groups conformed to the expectations of Fitt's Law.

The error rate and overshoot rate indicated that some degree of speed-accuracy trade-off was made. The Down syndrome children made fewer errors and fewer overshoots thus indicating a speed for accuracy trade. The mentally retarded and elementary school children tended to trade accuracy for speed although to a lesser extent than the high school boys.

An additional point to be made concerning movement time is that since there were no significant differences between the Down syndrome, the mentally retarded and the elementary school groups, the differences noted in total response time were most likely due to differences in the response selection phase.

The results for error rate showed that errors were independent of probability levels for Down syndrome, i.e., although the Down's children had more difficulty in the selection of a response, once they moved to the target they made fewer errors. This agrees with the findings of Borys and Spitz (1978) in that impulsivity was not responsible for slower performance times among M.R.

When total response time for each trial was divided into quarters, the hypotheses were accepted. It seemed that all groups performed significantly different from the first to the last quarter, i.e., performance deteriorated within the groups.

The hypotheses for functional and chronological age match were rejected for all parameters except overshoot and error rates (see Table 23). A complex motor task, in which response selection is dependent upon information being processed cannot be investigated in terms of chronological age matching with control groups. The majority of studies have used chronological age as their matching criterion and have, as in this study, found many significant differences between non-retarded and retarded groups. The system, as suggested by Kappauf (1973), of using both comparison, functional and chronological age, control groups in identifying the areas of difficulty (e.g., use of stimulus-probability) experienced by these children has been supported by this present study.

Variability has been cited as a problem in many studies of special populations. As a group the Down syndrome group was more variable than both the mentally retarded and elementary school children;

the latter two groups were very similar. The high school boys showed the least variability. The pattern of variability seen in the present study concurs in part (there was no Down syndrome comparison group) with the studies of Caffrey, Jones and Hinkle (1971) and Berkson and Baumeister (1967).

The main finding was that Down syndrome boys did not respond to directional probability in the same manner shown by the mentally retarded or the non-retarded matches for chronological and/or functional age. This difference in strategy was also reflected in their greater emphasis on accuracy rather than speed. Finally, these effects were consistent across the Down syndrome children despite the large intersubject variability in their performance.

Chapter VI

Summary, Conclusions and Recommendations

Summary

The basic purpose of the present study was to assess the motor control ability of mentally retarded (D.S. and M.R.) children within a pursuit tracking task when compared to groups of intellectually normal children matched for functional and chronological age. The NRC stressalyser was used to measure the psychomotor performance of the children.

The hypotheses tested in this study were as follows:

1) There were no significant differences in the motor control parameters involved in a self-paced pursuit tracking task between Down syndrome and mentally retarded children and intellectually normal children matched for functional age and chronological age.

2) There were no significant differences in performance in the motor control parameters between Down syndrome children and other mentally retarded children.

A total of forty-two male subjects were tested. Differences and similarities were assessed in three separate analyses. The first analysis consisted of twenty subjects divided into four groups. One group of five Down syndrome boys were matched with five mentally retarded boys of equal functional age and within 180 days of their chronological age from the date of testing. The third group consisted of five elementary school males matched with the Down syndrome group for functional age. The fourth group was five male high school students matched with the Down syndrome males within 180 days of their chronological age from the date of testing.

The second analysis consisted of three groups of seven subjects each (N=21). The Down syndrome, the mentally retarded and elementary school males were matched for functional age only. An additional requirement for the elementary school children was that they not be within three months of their birthday at the date of testing. This was to ensure that they were in the middle of their functional age.

The third experimental analysis consisted of three groups of eight subjects each (N=24). The Down syndrome, mentally retarded and high school boys were matched within 180 days of the chronological age of the Down syndrome match at the date of testing.

All forty-two subjects performed eight trials on the stress-alyser in one 30 to 45 minute session. Each trial involved 100 movements, giving a total of 800 movements per subject.

Conclusions

A summary of the main findings in relation to the hypotheses are shown in Table 23.

Within the limitations of this study, the following conclusions could be made with respect to performance across test trials:

1. Practice resulted in an improvement in performance in total response time for the Down syndrome, the mentally retarded and elementary school children.
2. All groups performed significantly different from the first to the last quarter of the trials, i.e., slowed down.
3. Down syndrome do not seem to use probability information for correct reaction time.
4. Mentally retarded children and elementary school children matched for functional age seem to perform similarly.
5. Down syndrome children did not follow the predictions of the Hick-Hyman law whereas mentally retarded children did.
6. For movement time all groups conformed to the expectations of Fitt's Law.
7. The Down's group showed a lower error and overshoot rate than all other groups.
8. Matching groups for functional age provides a more accurate representation of the retarded child's (D.S. and M.R.) performance level than chronological age.
9. Down syndrome children clearly emphasize accuracy rather than speed.

Recommendations

The review of literature indicated the diversity of research related to exceptional children. The primary thrust of current research should be involved with using homogeneous groups of retarded children and using both functional and chronological age control group matches.

Some evidence has been presented that indicates that Down syndrome children may not use the same strategies as other mentally retarded children. Further research directed at the Down syndrome group differences as opposed to mentally retarded group (D.S. & M.R.) differences may build a clearer picture of the exceptional child's true performance level.

More specifically, the results of this study provide further support that Down syndrome children lack the necessary strategies required to perform certain tasks. The teaching of strategies may further improve their performance. Although this may mean further isolation of groups (i.e., D.S. vs M.R.) during teaching sessions, it may, in the long run, help to close the gap between the two groups.

REFERENCES

Adams, J.A. Some mechanisms of motor responding: An examination of attention. In E.A. Bilodeau (Ed.) Acquisition of Skill. Academic Press: New York, 1966.

Ando, H., Wakabayashi, S., & Yabe, K. Cross-sectional study on reaction time of mentally retarded children. Journal of Mental Deficiency Research, 1978, 22, 11-17.

Appleton, L.E. A Comparative Study of the Play Activities of Adult Savages and Civilized Children. Chicago: The University of Chicago Press, 1910.

August, G.J. Input organization as a mediating factor in memory: a comparison of educable mentally retarded and nonretarded individuals. Journal of Experimental Child Psychology, 1980, 30, 125-143.

Baumeister, A.A., & Ellis, N.R. Delayed response performance of retardates. American Journal of Mental Deficiency, 1963, 67, 714-722.

Baumeister, A., Hawkins, W.F., & Kellas, G. The interactive effects of stimulus intensity and intelligence upon reaction time. American Journal of Mental Deficiency, 1965, 69, 526-530.

Baumeister, A.A., & Hawkins, W.F. Variations of the preparatory interval in relation to the reaction times of mental defectives. American Journal of Mental Deficiency, 1966, 70, 689-694.

Baumeister, A.A. & Kellas, G. Reaction time and mental retardation. In Ellis, N. (Ed.) International Review of Research in Mental Retardation, Vol. 3, New York: Academic Press, 1968.

Berkson, G., & Baumeister, A. Reaction time variability of mental defectives and normals. American Journal of Mental Deficiency, 1967, 72, 262-266.

Black, A.H., & Davis, L.J. The relationship between intelligence and sensorimotor proficiency in retardates. American Journal of Mental Deficiency, 1966, 71, 55-59.

Borys, S.V., Spitz, H.H. Reflection-impulsivity in retarded adolescents and nonretarded children of equal MA. American Journal of Mental Deficiency, 1978, 82, 601-604.

Bower, A.C., & Tate, D.L. Cardiovascular and skin conductance correlates of a fixed foreperiod reaction time task in retarded and nonretarded youth. Psychophysiology, 1976, 13, 1-9.

Brewer, N. Motor components in the choice reaction time of mildly retarded adults. American Journal of Mental Deficiency, 1978, 82, 565-572.

Brewer, N., & Nettlebeck, T. Influence of contextual cues on the choice reaction time of mildly retarded adults. American Journal of Mental Deficiency, 1977, 82, 37-43.

Brewer, N., & Nettlebeck, T. Speed and accuracy in choice reaction time of mildly retarded adults. American Journal of Mental Deficiency, 1979, 84, 55-61.

Buck, L. Skilled performance on the NRC stressalyser. Mechanical Engineering Report LTR-CS-130, 1974. Ottawa: National Research Council.

Buck, L. Boundary distance effects on overshooting. Journal of Motor Behavior, 1976, 8, 35-41.

Buck, L. Defining the boundary in a position task. Acta Psychologica, 1978, 42, 7-19.

Buck, L. The sensory basis of target location. Quarterly Journal of Experimental Psychology, 1979, 31, 111-120.

Buck, L. Variability of aim as a cause of overshooting. Mechanical Engineering Report LTR-CS-210, 1980. Ottawa: National Research Council.

Buck, L., Hyde, F., Isnor, C.D., Leonardo, R., & Trembley, K. Operating Procedures for the NRC Stressalyser. Mechanical Engineering Report LTR-CS-230, Ottawa: National Research Council, June, 1982.

Buck, L., Leonardo, R., & Hyde, F. Measuring impaired performance with the NRC "stressalyser". Applied Ergonomics, 1981, 12, 231-236.

Caffrey, B., Jones, J.D., & Hinkle, B.R. Variability in reaction times of normal and educable mentally retarded children. Perceptual and Motor Skills, 1971, 32, 255-258.

Campione, J.C., & Brown, A.L. Memory and metamemory development in educable retarded children. In R.V. Krail, Jr. & J.W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N.J.: Erlbaum, 1977.

Coleman, J.C. Abnormal Psychology and Modern Life. New York: Scott, Foresman and Co., 1964, 523-535.

Connolly, J.A. Intelligence levels in Down's Syndrome children. American Journal of Mental Deficiency, 1978, 83, 193-196.

Fiske, D.W., & Maddi, S.R. Functions of Varied Experience. Homewood, Ill.: Dorsey Press, 1961.

Fitts, P.M. The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology, 1954, 47, 381-391.

Francis, R.J. & Rarick, G.L. Motor characteristics of the mentally retarded. American Journal of Mental Deficiency, 1959, 63, 792-811.

Glidden, L.M. Stimulus relations, blocking, and sorting in the free recall and organization of EMR adolescents. American Journal of Mental Deficiency, 1977, 82, 250-258.

Gosling, H., & Jenness, D. Temporal variables in simple reaction times of mentally retarded boys. American Journal of Mental Deficiency, 1974, 79, 214-224.

Groden, G. Relationships between intelligence, simple, and complex motor proficiency. American Journal of Mental Deficiency, 1969, 74, 373-375.

Grossman, H.J. Manual on Terminology and Classification in Mental Retardation. American Association on Mental Deficiency, 1973.

Haskins, R., & McKinney, J.D. Relative effects of response tempo and accuracy on problem solving and academic achievement. Child Development, 1976, 47, 690-696.

Henderson, S.E., Frith, U. The motor deficit in Down's Syndrome Children: a problem of timing? A paper presented to the North American Society for the Psychology of Sport and Physical Activity, Monterey, May 1981.

Henderson, S.E., Morris, J., & Ray, S. Performance of Down Syndrome and other retarded children on the Cratty Gross - Motor Test. American Journal of Mental Deficiency, 1981, 85, 416-424.

Holden, E.A., & Corrigan, J.G. Self-paced vs. externally paced motor tracking by retarded and nonretarded persons. American Journal of Mental Deficiency, 1980, 84, 387-392.

Kappauf, W.E. Studying the relationship of task performance to variables of chronological age, mental age, and IQ. In International Review of Research in Mental Retardation. Ellis, N.R. (Ed), vol. 6, New York: Academic Press, 1973.

Kelso, J.A.S., Goodman, D., Stamm, C.L., & Hayes, C. Movement coding and memory in retarded children. American Journal of Mental Deficiency, 1979, 83, 601-611.

Kerr, R. Psychomotor Learning. Philadelphia: Saunders College Publishing, 1982.

Klapp, S.T., Wyatt, E.P., & MacLingo, W. Response programming in simple and choice reactions. Journal of Motor Behavior, 1974, 6, 263-271.

Klatzky, R.L., & Smith, E.E. Stimulus expectancy and retrieval from short-term memory. Journal of Experimental Psychology, 1972, 94, 101-107.

Klemmer, E.T. Time uncertainty in simple reaction time. Journal of Experimental Psychology, 1956, 51, 179-184.

Klemmer, E.T. Simple reaction time as a function of time uncertainty. Journal of Experimental Psychology, 1957, 54, 195-200.

Knights, R.M., Atkinson, D.R., & Hyman, J.A. Tactual discrimination and motor skills in mongoloid and nonmongoloid retardates and normal children. American Journal of Mental Deficiency, 1967, 71, 894-900.

Krupski, A. Role of attention in the reaction-time performance of mentally retarded adolescents. American Journal of Mental Deficiency, 1977, 82, 79-83.

Lally, M., & Nettlebeck, T. Inspection time, intelligence, and response strategy. American Journal of Mental Deficiency, 1980, 84, 553-560.

Maista, A.A., & Sipe, S. Effects of stimulus probability on encoding by mentally retarded and nonretarded persons. American Journal of Mental Deficiency, 1980, 84, 577-581.

Maloney, M.P., & Ward, M.P. Mental Retardation and Modern Society. New York: Oxford University Press, 1979.

Malpass, L.F. Motor skills and mental deficiency. In N.R. Ellis (Ed.), Handbook of Mental Deficiency. New York: McGraw-Hill, 1963, 602-631.

Marteniuk, R.G. Information Processing in Motor Skills. New York: Holt, Rinehart and Winston, 1976.

Messer, S.B. Reflection-impulsivity: A review. Psychological Bulletin, 1976, 83, 1026-1052.

Miller, J.O., & Pachella, R.G. Locus of the stimulus probability effect. Journal of Experimental Psychology, 1973, 101, 227-231.

Morelan, S.J., Prehm, H.J., & Warrick, D.B. Performance of retarded and nonretarded adolescents when processing relevant and irrelevant information. Perceptual and Motor Skills, 1976, 42, 771-774.

Mosley, J.L. Selective attention of mildly mentally retarded and nonretarded individuals. American Journal of Mental Deficiency, 1980, 84, 568-576.

McGown, C.M., Dobbins, D.A., Rarick, G.L. Intra-individual variability of normal and educable mentally retarded children on a coincidence timing task. Journal of Motor Behavior, 1973, 5, 193-198.

Nettlebeck, T., & Brewer, N. Effects of stimulus-response variables on the choice reaction time of mildly retarded adults. American Journal of Mental Deficiency, 1976, 81, 85-92.

Newell, K.M., Wade, M.G., & Kelly, T.M. Temporal anticipation of response initiation by mentally retarded persons. American Journal of Mental Deficiency, 1979, 84, 289-295.

Pew, R.W. Human perceptual-motor performance. In B.H. Kantowitz (Ed.), Human Information Processing: Tutorials in Performance and Cognition. New York: Erlbaum, 1974.

Posner, M.I., & Boies, S.J. Components of attention. Psychological Review, 1971, 78, 391-408.

Posner, M.D., & Keele, S.W. Skill learning. In R.M.W. Travers (Ed.), Handbook of Research on Teaching. Washington, D.C.: American Educational Research Association, 1972.

Poulton, E.C. Perceptual anticipation in tracking with two-pointer and one-pointer displays. British Journal of Psychology, 1952, 43, 222-229.

Poulton, E.C. On prediction in skilled movements. Psychological Bulletin, 1957, 54, 467-478.

Poulton, E.C. Tracking behavior. In E.A. Bilodeau (Ed.), Acquisition of Skill. New York: Academic Press, 1966.

Rabin, H.M. The relationship of age, intelligence, and sex to motor proficiency in mental defectives. American Journal of Mental Deficiency, 1957, 62, 507-516.

Rarick, G.L. Motor performance of mentally retarded children. In Physical Activity Human Growth and Development. Rarick, G.L. (Ed.), New York: Academic Press, 1973.

Rasch, P.J., & Burke, R.K. Kinesiology and Applied Anatomy. Philadelphia: Lea and Febiger, 1978.

Schmidt, R.A. Anticipation and timing in human motor performance. Psychological Bulletin, 1968, 70, 631-646.

Schmidt, R.A. Motor Control and Learning. Champaign, Illinois: Human Kinetics Publishers, 1982.

Sinson, J.C., & Wetherick, N.E. Evidence for increased mental capacity with age in Down's Syndrome. Journal of Mental Deficiency Research, 1976, 20, 31-34.

Sloan, W. Motor proficiency and intelligence. American Journal of Mental Deficiency, 1951, 55, 394-406.

Vickers, D., Nettlebeck, T., & Wilson, R.J. Perceptual indices of performance: the measurement of 'inspection time' and 'noise' in the visual system. Perception, 1972, 1, 263-295.

Waite, K.B. The Trainable Mentally Retarded Child. Springfield, Illinois: Charles C. Thomas Publisher, 1972.

Weiss, A.D. The locus of reaction time change with set, motivation, and age. Journal of Gerontology, 1965, 20, 60-64.

Welford, A.T. Fundamentals of Skill. London: Methuen & Co. Ltd., 1968.

Welford, A.T., Norris, A.H., & Shock, N.W. Speed and accuracy of movement and their changes with age. Acta Psychologica, 1969, 30, 3-15.

Worden, P.E., Mandler, J.M., & Chang, F.R. Children's free recall: An explanation of sorts. Child Development, 1978, 49, 836-844.

Zigler, E. Mental retardation: current issues and approaches. In Hoffman, L.W. & Hoffman, M.L. (Eds.). Review of Child Development Research, Vol. 2, New York: Russell Sage Foundation, 1966.

APPENDIX A

List of Subjects for Each Separate Analysis

ANALYSIS I - Subjects matched for functional age and chronological age

DOWN SYNDROME	MENTALLY RETARDED
Jeffrey M.	John N.
Edward van B.	Wayne S.
Darren R.	Skender M.
Barry V.	John McL.
Richard R.	Vaughn B.

ELEMENTARY SCHOOL	HIGH SCHOOL
Thomas D.	Robert B.
Alistair H.	Rob F.
Colin H.	Craig B.
Wesley C.	Dave S.
Shawn C.	Morey A.

ANALYSIS II - Subjects matched for functional age only

DOWN SYNDROME

Mike C.
Paul Bu.
Alex D.
Barry V.
Richard R.
Randy E.
John S.

MENTALLY RETARDED

John N.
Wayne S.
Jimmy B.
John McL.
Louis A.
Skender M.
Harris D.

ELEMENTARY SCHOOL

Angelo K.
Thomas D.
Peter K.
Wesley C.
Shawn C.
Stephen T.
Brendan A.

ANALYSIS III - Subjects matched for chronological age only

DOWN SYNDROME	MENTALLY RETARDED
Mike C.	John McR.
Alex D.	Wayne S.
Darren R.	Harris D.
Barry V.	Piero V.
Paul C.	Vaughn B.
Paul Bu.	Paul Br.
John S.	Louis A.
Peter McM.	Jimmy B.

HIGH SCHOOL

Bill D.
Dave W.
Craig B.
Peter H.
Morey A.
Stuart D.
Kevin H.
Alec T.

APPENDIX B

Distributions for Reaction Time Data

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS ALL 4 LEVELS
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MILLISECS		N	
1	200	1596.	****************
201	400	5877.	***
401	600	3573.	************************************
601	800	1118.	************
801	1000	502.	******
1001	1200	260.	***
1201	1400	156.	**
1401	1600	119.	**
1601	1800	56.	*
1801	2000	32.	*
2001	2200	26.	*
2201	2400	18.	*
2401	2600	13.	*
2601	2800	8.	*
2801	3000	10.	*
3001	3200	6.	*
3201	3400	2.	*
3401	3600	9.	*
3601	3800	7.	*
3801	4000	1.	*
4001	4200	4.	*
4201	4400	2.	*
4401	4600	2.	*
4601	4800	1.	*
4801	5000	2.	*
5001	5200	2.	*
5201	5400	0.	
5401	5600	0.	
5601	5800	1.	*
5801	6000	1.	*
6001	6200	0.	
6201	6400	0.	
6401	6600	0.	
6601	6800	0.	
6801	7000	0.	
7001	7200	0.	
7201	7400	0.	
7401	7600	0.	
7601	7800	1.	*
7801	8000	1.	*
8001	UP	1.	*

TOTAL	13407.	MINIMUM	1.	STANDARD DEVIATION	383.88
MISSING DATA	13.	MAXIMUM	9349.	SKEWNESS	5.84
EXCLUDED DATA	0.	MEAN	455.	KURTOSIS	78.94
HISTOGRAM SCALE	100				

ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS ALL 4 LEVELS
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MILLISECS		N	
51	100	287.	******
101	150	399.	********
151	200	651.	**************
201	250	1293.	**************************
251	300	1413.	*****************************
301	350	1553.	********************************
351	400	1618.	*********************************
401	450	1337.	***************************
451	500	1027.	*********************
501	550	714.	***************
551	600	495.	**********
601	650	382.	********
651	700	314.	*******
701	750	247.	*****
751	800	175.	****
801	850	168.	****
851	900	132.	***
901	950	107.	***
951	1000	95.	**
1001	1050	78.	**
1051	1100	67.	**
1101	1150	58.	**
1151	1200	57.	**
1201	1250	41.	*
1251	1300	44.	*
1301	1350	33.	*
1351	1400	38.	*
1401	1450	29.	*
1451	1500	39.	*
1501	1550	23.	*
1551	1600	28.	*
1601	1650	0.	

TOTAL	12942.	MINIMUM	51.	STANDARD DEVIATION	247.62
MISSING DATA	13.	MAXIMUM	1597.	SKEWNESS	1.75
EXCLUDED DATA	465.	MEAN	431.	KURTOSIS	34.48
HISTOGRAM SCALE	50				

INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA   SPRING 1982

```
FACTOR 1   GROUPS      ALL   3 LEVELS
FACTOR 2   SUBJECTS    ALL   7 LEVELS
FACTOR 3   TRIALS      ALL   8 LEVELS
```

REACTION TIMES FOR CORRECT RESPONSES

```
      MILLISECS        N

      1   100        456.   **********
    101   200        485.   **********
    201   300       1160.   ************************
    301   400       4111.   **************************************************
    401   500       3462.   **************************************************
    501   600       1825.   *************************************
    601   700       1104.   ***********************
    701   800        596.   ************
    801   900        398.   ********
    901  1000        250.   *****
   1001  1100        174.   ****
   1101  1200        142.   ***
   1201  1300         88.   **
   1301  1400         59.   **
   1401  1500         68.   **
   1501  1600         40.   *
   1601  1700         27.   *
   1701  1800         16.   *
   1801  1900         11.   *
   1901  2000          9.   *
   2001  2100          8.   *
   2101  2200          6.   *
   2201  2300          6.   *
   2301  2400          3.   *
   2401  2500          4.   *
   2501  2600          6.   *
   2601  2700          2.   *
   2701  2800          2.   *
   2801  2900          3.   *
   2901  3000          3.   *
   3001  3100          2.   *
   3101  3200          2.   *
   3201  3300          0.
   3301  3400          3.   *
   3401  3500          1.   *
   3501  3600          1.   *
   3601  3700          1.   *
   3701  3800          0.
   3801  3900          0.
   3901  4000          1.   *
   4001    UP          2.   *

          TOTAL    14537.   MINIMUM          1.    STANDARD DEVIATION   293.05
   MISSING DATA       19.   MAXIMUM      10283.    SKEWNESS               5.29
  EXCLUDED DATA        0.   MEAN           488.    KURTOSIS             127.97
HISTOGRAM SCALE       50

      ERROR CRITERION      11
```

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MILLISECS		N	
51	100	208.	*****
101	150	219.	*****
151	200	266.	******
201	250	357.	********
251	300	803.	*****************
301	350	1753.	************************************
351	400	2358.	**
401	450	1975.	**
451	500	1487.	******************************
501	550	1083.	**********************
551	600	742.	***************
601	650	622.	*************
651	700	482.	**********
701	750	353.	********
751	800	243.	*****
801	850	218.	*****
851	900	180.	****
901	950	128.	***
951	1000	122.	***
1001	1050	95.	**
1051	1100	79.	**
1101	1150	70.	**
1151	1200	72.	**
1201	1250	42.	*
1251	1300	46.	*
1301	1350	29.	*
1351	1400	30.	*
1401	1450	38.	*
1451	1500	30.	*
1501	1550	21.	*
1551	1600	19.	*
1601	1650	0.	

TOTAL	14170.	MINIMUM	51.	STANDARD DEVIATION	227.40
MISSING DATA	19.	MAXIMUM	1592.	SKEWNESS	1.63
EXCLUDED DATA	367.	MEAN	481.	KURTOSIS	67.18
HISTOGRAM SCALE	50				

INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 8 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MILLISECS		N	
1	100	646.	*************
101	200	1087.	**********************
201	300	4294.	**
301	400	3237.	**
401	500	2220.	***
501	600	1352.	****************************
601	700	1001.	*********************
701	800	690.	**************
801	900	515.	***********
901	1000	356.	********
1001	1100	277.	******
1101	1200	220.	*****
1201	1300	147.	***
1301	1400	109.	***
1401	1500	98.	**
1501	1600	71.	**
1601	1700	59.	**
1701	1800	51.	**
1801	1900	29.	*
1901	2000	23.	*
2001	2100	29.	*
2101	2200	13.	*
2201	2300	15.	*
2301	2400	10.	*
2401	2500	10.	*
2501	2600	13.	*
2601	2700	1.	*
2701	2800	8.	*
2801	2900	7.	*
2901	3000	4.	*
3001	3100	4.	*
3101	3200	4.	*
3201	3300	1.	*
3301	3400	3.	*
3401	3500	6.	*
3501	3600	5.	*
3601	3700	2.	*
3701	3800	4.	*
3801	3900	1.	*
3901	4000	1.	*
4001	UP	21.	*

TOTAL	16644.	MINIMUM	1.	STANDARD DEVIATION	415.91
MISSING DATA	19.	MAXIMUM	10283.	SKEWNESS	5.70
EXCLUDED DATA	0.	MEAN	480.	KURTOSIS	85.08
HISTOGRAM SCALE	50				

ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 8 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MILLISECS		N	
51	100	312.	*******
101	150	405.	*********
151	200	682.	**************
201	250	1973.	**
251	300	2321.	***
301	350	1767.	************************************
351	400	1470.	******************************
401	450	1199.	************************
451	500	1021.	*********************
501	550	747.	***************
551	600	605.	*************
601	650	546.	***********
651	700	455.	**********
701	750	385.	********
751	800	305.	*******
801	850	271.	******
851	900	244.	*****
901	950	186.	****
951	1000	170.	****
1001	1050	146.	***
1051	1100	131.	***
1101	1150	102.	***
1151	1200	118.	***
1201	1250	73.	**
1251	1300	74.	**
1301	1350	56.	**
1351	1400	53.	**
1401	1450	47.	*
1451	1500	51.	**
1501	1550	38.	*
1551	1600	33.	*
1601	1650	0.	

TOTAL	15986.	MINIMUM	51.	STANDARD DEVIATION	274.38
MISSING DATA	19.	MAXIMUM	1598.	SKEWNESS	1.52
EXCLUDED DATA	658.	MEAN	451.	KURTOSIS	27.27
HISTOGRAM SCALE	50				

INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

APPENDIX C

Distribution of Data for Non-Overshoot Movement Time

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS ALL 4 LEVELS.
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITHOUT OVERSHOOT

MILLISECS		N	
1	250	96.	**
251	500	1151.	***********************
501	750	1703.	**********************************
751	1000	1330.	***************************
1001	1250	864.	******************
1251	1500	514.	***********
1501	1750	343.	*******
1751	2000	213.	*****
2001	2250	127.	***
2251	2500	97.	**
2501	2750	53.	**
2751	3000	39.	*
3001	3250	34.	*
3251	3500	30.	*
3501	3750	22.	*
3751	4000	13.	*
4001	4250	11.	*
4251	4500	5.	*
4501	4750	7.	*
4751	5000	4.	*
5001	5250	6.	*
5251	5500	2.	*
5501	5750	1.	*
5751	6000	2.	*
6001	6250	2.	*
6251	6500	0.	
6501	6750	4.	*
6751	7000	1.	*
7001	7250	0.	
7251	7500	0.	
7501	7750	1.	*
7751	8000	1.	*
8001	8250	1.	*
8251	8500	0.	
8501	8750	0.	
8751	9000	0.	
9001	9250	1.	*
9251	9500	0.	
9501	9750	0.	
9751	10000	1.	*
10001	UP	3.	*

TOTAL	6682.	MINIMUM	128.	STANDARD DEVIATION	757.02
MISSING DATA	0.	MAXIMUM	14357.	SKEWNESS	4.63
EXCLUDED DATA	0.	MEAN	1002.	KURTOSIS	60.04
HISTOGRAM SCALE	50				

OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS ALL 4 LEVELS
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITHOUT OVERSHOOT

MILLISECS		N	
1	125	0.	
126	250	96.	**
251	375	473.	**********
376	500	678.	**************
501	625	861.	******************
626	750	842.	*****************
751	875	724.	***************
876	1000	606.	*************
1001	1125	476.	**********
1126	1250	388.	********
1251	1375	303.	*******
1376	1500	211.	*****
1501	1625	172.	****
1626	1750	171.	****
1751	1875	132.	***
1876	2000	81.	**
2001	2125	71.	**
2126	2250	56.	**
2251	2375	60.	**
2376	2500	37.	*
2501	2625	29.	*
2626	2750	24.	*
2751	2875	22.	*
2876	3000	17.	*

TOTAL	6530.	MINIMUM	128.	STANDARD DEVIATION	514.12
MISSING DATA	0.	MAXIMUM	2998.	SKEWNESS	1.25
EXCLUDED DATA	152.	MEAN	927.	KURTOSIS	36.31
HISTOGRAM SCALE	50				

INCLUSION CRITERIA 1 AND 3000
OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITHOUT OVERSHOOT

MILLISECS	N	
1 300	119.	***
301 600	1326.	***************************
601 900	1951.	**
901 1200	1573.	********************************
1201 1500	915.	*******************
1501 1800	537.	***********
1801 2100	307.	*******
2101 2400	180.	****
2401 2700	124.	***
2701 3000	79.	**
3001 3300	65.	**
3301 3600	52.	**
3601 3900	48.	*
3901 4200	28.	*
4201 4500	24.	*
4501 4800	14.	*
4801 5100	13.	*
5101 5400	8.	*
5401 5700	9.	*
5701 6000	5.	*
6001 6300	3.	*
6301 6600	1.	*
6601 6900	2.	*
6901 7200	2.	*
7201 7500	1.	*
7501 7800	1.	*
7801 8100	1.	*
8101 8400	0.	
8401 8700	0.	
8701 9000	2.	*
9001 9300	0.	
9301 9600	1.	*
9601 9900	0.	
990110200	1.	*
1020110500	0.	
1050110800	0.	
1080111100	0.	
1110111400	0.	
1140111700	0.	
1170112000	0.	
12001 UP	3.	*

TOTAL	7395.	MINIMUM	191.	STANDARD DEVIATION	874.39
MISSING DATA	0.	MAXIMUM	21209.	SKEWNESS	5.09
EXCLUDED DATA	0.	MEAN	1163.	KURTOSIS	79.00
HISTOGRAM SCALE	50				

OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITHOUT OVERSHOOT

MILLISECS		N	
1	125	0.	
126	250	31.	**
251	375	307.	****************
376	500	537.	***************************
501	625	710.	************************************
626	750	801.	***
751	875	838.	**
876	1000	772.	***************************************
1001	1125	639.	********************************
1126	1250	530.	***************************
1251	1375	394.	********************
1376	1500	325.	*****************
1501	1625	251.	*************
1626	1750	210.	***********
1751	1875	174.	*********
1876	2000	120.	******
2001	2125	103.	******
2126	2250	80.	****
2251	2375	75.	****
2376	2500	62.	****
2501	2625	49.	***
2626	2750	42.	***
2751	2875	34.	**
2876	3000	27.	**

TOTAL	7111.	MINIMUM	191.	STANDARD DEVIATION	533.38
MISSING DATA	0.	MAXIMUM	2985.	SKEWNESS	1.11
EXCLUDED DATA	284.	MEAN	1041.	KURTOSIS	47.68
HISTOGRAM SCALE	20				

INCLUSION CRITERIA 1 AND 3000
OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 8 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITHOUT OVERSHOOT

MILLISECS		N	
1	150	1.	*
151	300	397.	********
301	450	1104.	***********************
451	600	1216.	*************************
601	750	1143.	***********************
751	900	820.	*****************
901	1050	620.	*************
1051	1200	455.	**********
1201	1350	341.	*******
1351	1500	303.	*******
1501	1650	219.	*****
1651	1800	191.	****
1801	1950	138.	***
1951	2100	116.	***
2101	2250	83.	**
2251	2400	70.	**
2401	2550	61.	**
2551	2700	48.	*
2701	2850	45.	*
2851	3000	32.	*
3001	3150	35.	*
3151	3300	33.	*
3301	3450	31.	*
3451	3600	22.	*
3601	3750	26.	*
3751	3900	23.	*
3901	4050	16.	*
4051	4200	12.	*
4201	4350	13.	*
4351	4500	10.	*
4501	4650	9.	*
4651	4800	8.	*
4801	4950	10.	*
4951	5100	2.	*
5101	5250	4.	*
5251	5400	5.	*
5401	5550	7.	*
5551	5700	4.	*
5701	5850	1.	*
5851	6000	4.	*
6001	UP	27.	*

TOTAL	7705.	MINIMUM	125.	STANDARD DEVIATION	944.21
MISSING DATA	0.	MAXIMUM	21209.	SKEWNESS	5.25
EXCLUDED DATA	0.	MEAN	1024.	KURTOSIS	68.57
HISTOGRAM SCALE	50				

OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 8 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITHOUT OVERSHOOT

MILLISECS		N	
1	125	1.	*
126	250	200.	****
251	375	689.	**************
376	500	1032.	*********************
501	625	997.	********************
626	750	942.	*******************
751	875	707.	***************
876	1000	546.	***********
1001	1125	413.	*********
1126	1250	377.	********
1251	1375	249.	*****
1376	1500	247.	*****
1501	1625	185.	****
1626	1750	164.	****
1751	1875	145.	***
1876	2000	92.	**
2001	2125	96.	**
2126	2250	65.	**
2251	2375	62.	**
2376	2500	50.	*
2501	2625	42.	*
2626	2750	42.	*
2751	2875	34.	*
2876	3000	26.	*

TOTAL	7403.	MINIMUM	125.	STANDARD DEVIATION	548.81
MISSING DATA	0.	MAXIMUM	2985.	SKEWNESS	1.36
EXCLUDED DATA	302.	MEAN	889.	KURTOSIS	25.28
HISTOGRAM SCALE	50				

INCLUSION CRITERIA 1 AND 3000
OVERSHOOT CRITERION 51

APPENDIX D

Distribution of Data for
Overshoot Movement Time

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1	GROUPS	ALL	4 LEVELS
FACTOR 2	SUBJECTS	ALL	5 LEVELS
FACTOR 3	TRIALS	ALL	8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITH OVERSHOOT

MILLISECS	N	
1 750	1990.	**
751 1500	3824.	**
1501 2250	1748.	***********************************
2251 3000	749.	***************
3001 3750	330.	*******
3751 4500	169.	****
4501 5250	117.	***
5251 6000	57.	**
6001 6750	36.	*
6751 7500	23.	*
7501 8250	20.	*
8251 9000	8.	*
9001 9750	8.	*
975110500	10.	*
1050111250	3.	*
1125112000	6.	*
1200112750	4.	*
1275113500	1.	*
1350114250	4.	*
1425115000	0.	
1500115750	1.	*
1575116500	1.	*
1650117250	0.	
1725118000	0.	
1800118750	0.	
1875119500	1.	*
1950120250	1.	*
2025121000	1.	*
2100121750	0.	
2175122500	1.	*
2250123250	0.	
2325124000	0.	
2400124750	0.	
2475125500	0.	
2550126250	0.	
2625127000	0.	
2700127750	0.	
2775128500	0.	
2850129250	0.	
2925130000	1.	*

TOTAL	9114.	MINIMUM	208.	STANDARD DEVIATION	1364.43
MISSING DATA	0.	MAXIMUM	29979.	SKEWNESS	4.95
EXCLUDED DATA	0.	MEAN	1564.	KURTOSIS	59.29
HISTOGRAM SCALE	50				

OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS ALL 4 LEVELS
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITH OVERSHOOT

MILLISECS		N	
1	125	0.	
126	250	8.	*
251	375	141.	***
376	500	400.	********
501	625	698.	**************
626	750	743.	***************
751	875	762.	****************
876	1000	719.	***************
1001	1125	683.	**************
1126	1250	657.	**************
1251	1375	527.	***********
1376	1500	476.	**********
1501	1625	385.	********
1626	1750	327.	*******
1751	1875	341.	*******
1876	2000	291.	******
2001	2125	226.	*****
2126	2250	178.	****
2251	2375	175.	****
2376	2500	156.	****
2501	2625	117.	***
2626	2750	118.	***
2751	2875	96.	**
2876	3000	87.	**
3001	3125	69.	**
3126	3250	59.	**
3251	3375	72.	**
3376	3500	39.	*
3501	3625	48.	*
3626	3750	43.	*
3751	3875	36.	*
3876	4000	26.	*
4001	4125	35.	*
4126	4250	26.	*
4251	4375	19.	*
4376	4500	27.	*
4501	4625	21.	*
4626	4750	24.	*
4751	4875	19.	*
4876	5000	18.	*

TOTAL	8892.	MINIMUM	208.	STANDARD DEVIATION	873.96
MISSING DATA	0.	MAXIMUM	4993.	SKEWNESS	1.46
EXCLUDED DATA	222.	MEAN	1417.	KURTOSIS	25.94
HISTOGRAM SCALE	50				

INCLUSION CRITERIA 1 AND 5000
OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITH OVERSHOOT

MILLISECS	N	
1 750	1160.	************************
751 1500	4077.	**-
1501 2250	2302.	***
2251 3000	922.	*******************
3001 3750	374.	********
3751 4500	199.	****
4501 5250	91.	**
5251 6000	56.	**
6001 6750	38.	*
6751 7500	21.	*
7501 8250	18.	*
8251 9000	6.	*
9001 9750	7.	*
975110500	8.	*
1050111250	1.	*
1125112000	4.	*
1200112750	3.	*
1275113500	1.	*
1350114250	2.	*
1425115000	0.	
1500115750	0.	
1575116500	2.	*
1650117250	0.	
1725118000	0.	
1800118750	0.	
1875119500	0.	
1950120250	1.	*
2025121000	0.	
2100121750	0.	
2175122500	1.	*
2250123250	0.	
2325124000	0.	
2400124750	0.	
2475125500	1.	*
2550126250	1.	*
2625127000	1.	*
2700127750	0.	
2775128500	0.	
2850129250	0.	
2925130000	2.	*

TOTAL	9299.	MINIMUM	251.	STANDARD DEVIATION	1346.65
MISSING DATA	0.	MAXIMUM	29979.	SKEWNESS	6.62
EXCLUDED DATA	1.	MEAN	1688.	KURTOSIS	103.16
HISTOGRAM SCALE	50				

OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITH OVERSHOOT

MILLISECS		N	
1	125	0.	
126	250	0.	
251	375	42.	***
376	500	188.	**********
501	625	383.	********************
626	750	547.	****************************
751	875	624.	********************************
876	1000	722.	*************************************
1001	1125	719.	************************************
1126	1250	760.	**************************************
1251	1375	673.	**********************************
1376	1500	579.	*****************************
1501	1625	537.	***************************
1626	1750	479.	************************
1751	1875	414.	*********************
1876	2000	343.	******************
2001	2125	292.	***************
2126	2250	237.	************
2251	2375	215.	***********
2376	2500	192.	**********
2501	2625	167.	*********
2626	2750	130.	*******
2751	2875	113.	******
2876	3000	105.	******
3001	3125	87.	*****
3126	3250	67.	****
3251	3375	77.	****
3376	3500	40.	**
3501	3625	59.	***
3626	3750	44.	***
3751	3875	47.	***
3876	4000	30.	**
4001	4125	46.	***
4126	4250	26.	**
4251	4375	20.	*
4376	4500	30.	**
4501	4625	16.	*
4626	4750	18.	*
4751	4875	16.	*
4876	5000	12.	*

TOTAL	9096.	MINIMUM	251.	STANDARD DEVIATION	836.37
MISSING DATA	0.	MAXIMUM	4970.	SKEWNESS	1.32
EXCLUDED DATA	204.	MEAN	1556.	KURTOSIS	40.81
HISTOGRAM SCALE	20				

INCLUSION CRITERIA 1 AND 5000
OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 8 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

MOVEMENT TIMES FOR RESPONSES WITH OVERSHOOT

MILLISECS	N	
1 750	3423.	**
751 1500	4491.	**
1501 2250	1737.	***********************************
2251 3000	735.	***************
3001 3750	347.	*******
3751 4500	188.	****
4501 5250	96.	**
5251 6000	52.	**
6001 6750	38.	*
6751 7500	22.	*
7501 8250	22.	*
8251 9000	12.	*
9001 9750	5.	*
975110500	2.	*
1050111250	1.	*
1125112000	4.	*
1200112750	3.	*
1275113500	2.	*
1350114250	4.	*
1425115000	0.	
1500115750	0.	
1575116500	1.	*
1650117250	0.	
1725118000	0.	
1800118750	0.	
1875119500	0.	
1950120250	0.	
2025121000	1.	*
2100121750	0.	
2175122500	1.	*
2250123250	0.	
2325124000	0.	
2400124750	0.	
2475125500	1.	*
2550126250	1.	*
2625127000	1.	*
2700127750	0.	
2775128500	0.	
2850129250	0.	
2925130000	1.	*

TOTAL	11191.	MINIMUM	179.	STANDARD DEVIATION	1278.73
MISSING DATA	0.	MAXIMUM	29411.	SKEWNESS	6.05
EXCLUDED DATA	1.	MEAN	1384.	KURTOSIS	86.70
HISTOGRAM SCALE	50				

OVERSHOOT CRITERION 51

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA   SPRING 1982

```
FACTOR 1   GROUPS      ALL   3 LEVELS
FACTOR 2   SUBJECTS    ALL   8 LEVELS
FACTOR 3   TRIALS      ALL   8 LEVELS
```

MOVEMENT TIMES FOR RESPONSES WITH OVERSHOOT

```
   MILLISECS         N

     1  125         0.
   126  250         9.   *
   251  375       258.   *********
   376  500       701.   ************************
   501  625      1229.   *****************************************
   626  750      1226.   *****************************************
   751  875      1082.   *************************************
   876 1000       970.   *********************************
  1001 1125       791.   ***************************
  1126 1250       686.   ***********************
  1251 1375       525.   ******************
  1376 1500       437.   ***************
  1501 1625       407.   **************
  1626 1750       350.   ************
  1751 1875       317.   ***********
  1876 2000       266.   *********
  2001 2125       222.   ********
  2126 2250       175.   ******
  2251 2375       176.   ******
  2376 2500       143.   *****
  2501 2625       119.   ****
  2626 2750       115.   ****
  2751 2875        94.   ****
  2876 3000        88.   ***
  3001 3125        80.   ***
  3126 3250        65.   ***
  3251 3375        70.   ***
  3376 3500        44.   **
  3501 3625        41.   **
  3626 3750        47.   **
  3751 3875        51.   **
  3876 4000        24.   *
  4001 4125        41.   **
  4126 4250        27.   *
  4251 4375        18.   *
  4376 4500        27.   *
  4501 4625        14.   *
  4626 4750        27.   *
  4751 4875        21.   *
  4876 5000         8.   *

          TOTAL   10991.   MINIMUM      179.   STANDARD DEVIATION  844.03
   MISSING DATA       0.   MAXIMUM     4964.   SKEWNESS              1.65
  EXCLUDED DATA     201.   MEAN        1272.   KURTOSIS             21.32
HISTOGRAM SCALE      30

      INCLUSION CRITERIA       1 AND  5000
     OVERSHOOT CRITERION      51
```

APPENDIX E

Table of Means for Overshoot and Non-Overshoot Movement Time

14:42:10 25-AUG-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51).

FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 2 GROUPS ALL 4 LEVELS
FACTOR 4 TRIALS ALL 8 LEVELS

SCORES AVERAGED FOR FOLLOWING FACTORS
FACTOR 3 SUBJECTS ALL 5 LEVELS

DISTANCE 1

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1702.	1433.	1438.	1376.	1368.	1431.	1633.	1620.
	247.1	133.6	157.6	170.5	174.7	232.0	223.8	308.4
	5	5	5	5	5	5	5	5
2	1555.	1301.	1310.	1341.	1271.	1332.	1191.	1291.
	150.9	112.9	98.0	108.6	104.5	77.5	99.5	85.4
	5	5	5	5	5	5	4	4
3	1450.	1352.	1353.	1356.	1255.	1325.	1275.	1180.
	244.1	168.9	162.3	145.7	147.6	145.7	115.4	75.9
	5	5	5	5	5	5	5	5
4	689.	691.	653.	702.	675.	641.	667.	690.
	52.0	71.8	44.5	53.6	51.2	35.4	40.1	29.0
	5	5	5	5	5	5	5	5

DISTANCE 2

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1939.	1861.	1675.	1745.	1762.	1792.	1991.	2029.
	255.5	246.5	199.4	164.8	233.5	179.4	349.6	439.0
	5	5	5	5	5	5	5	5
2	2008.	1548.	1582.	1575.	1672.	1567.	1476.	1671.
	142.4	115.8	101.9	120.9	207.2	66.6	107.8	160.1
	5	5	5	5	5	5	4	4
3	1847.	1558.	1538.	1410.	1634.	1476.	1523.	1499.
	276.5	202.2	188.1	133.7	161.7	233.5	142.1	180.0
	5	5	5	5	5	5	5	5
4	811.	796.	803.	821.	860.	824.	835.	763.
	75.4	91.0	72.0	55.6	50.1	82.3	65.7	40.6
	5	5	5	5	5	5	5	5

DISTANCE 3

GROUPS TRIALS

GROUPS	1	2	3	4	5	6	7	8
1	2657.	1984.	2186.	2063.	1805.	1867.	2151.	2139.
	264.4	188.7	138.0	310.8	229.4	184.2	293.3	456.4
	5	5	5	4	5	5	5	5
2	2525.	2315.	1953.	1867.	1719.	1943.	2083.	1718.
	306.3	206.4	187.3	168.7	137.4	101.3	173.3	77.5
	5	5	5	5	5	5	4	4
3	1899.	1985.	1801.	1677.	1605.	1784.	1689.	1462.
	308.8	263.9	241.3	183.1	117.1	241.1	264.1	212.5
	5	5	5	5	5	5	5	5
4	999.	882.	990.	956.	1028.	929.	982.	929.
	83.2	79.9	68.5	94.0	63.9	89.3	98.6	101.5
	5	5	5	5	5	5	5	5

DISTANCE 4

GROUPS TRIALS

GROUPS	1	2	3	4	5	6	7	8
1	2762.	2822.	2547.	2139.	2438.	1849.	2023.	2462.
	352.3	300.6	288.9	258.2	266.1	129.8	335.3	547.0
	5	5	4	4	5	5	5	5
2	2847.	2381.	2223.	2397.	1808.	1835.	2450.	1980.
	344.8	219.5	244.9	269.7	172.8	187.7	107.7	234.0
	5	5	5	5	5	5	4	3
3	2029.	1938.	1854.	2107.	1483.	1656.	1890.	1754.
	311.0	245.5	312.8	247.2	173.1	171.5	280.6	251.6
	5	5	5	5	5	5	5	5
4	1102.	1011.	1148.	1112.	1045.	1112.	975.	1123.
	102.0	86.4	125.3	115.5	87.9	56.3	90.6	127.6
	5	5	5	5	5	5	5	5

14:50:26 25-AUG-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 4 TRIALS ALL 8 LEVELS

SCORES AVERAGED FOR FOLLOWING FACTORS
FACTOR 3 SUBJECTS ALL 7 LEVELS

DISTANCE 1

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1615.	1690.	1640.	1708.	1725.	1472.	1597.	1409.
	165.8	269.1	247.8	322.1	284.3	247.7	240.7	180.4
	6	7	7	7	7	7	7	7
2	1513.	1282.	1284.	1238.	1258.	1305.	1154.	1257.
	137.5	90.8	88.3	116.6	94.4	81.8	99.5	126.4
	7	7	7	7	7	7	7	7
3	1275.	1221.	1234.	1250.	1164.	1097.	1155.	1101.
	94.1	98.7	110.8	112.8	111.8	103.0	92.9	47.6
	7	7	7	7	7	7	7	7

DISTANCE 2

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	2046.	1792.	1956.	1854.	1951.	1919.	1714.	1649.
	172.2	238.6	284.9	196.8	276.5	341.1	195.6	211.1
	6	7	7	7	7	7	7	7
2	1859.	1611.	1525.	1543.	1696.	1579.	1456.	1565.
	144.6	129.0	112.0	113.6	140.2	104.5	119.2	111.1
	7	7	7	7	7	7	7	7
3	1553.	1497.	1429.	1388.	1357.	1291.	1381.	1354.
	109.6	123.2	129.7	93.1	129.6	170.3	103.3	145.6
	7	7	7	7	7	7	7	7

DISTANCE 3

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	2150.	1987.	2319.	1944.	2139.	2007.	2025.	1983.
	170.5	159.1	221.1	213.6	211.3	207.9	263.0	282.2
	6	7	7	6	7	7	7	7

	231.7	195.3	161.7	177.4	186.4	130.2	176.3	95.2
	7	7	7	7	7	7	7	7
3	1864.	1688.	1455.	1540.	1445.	1612.	1551.	1409.
	249.8	134.3	113.4	117.5	90.7	138.7	186.5	155.9
	7	7	7	7	7	7	7	7

DISTANCE 4

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	2682.	2145.	2136.	2217.	2629.	2246.	1994.	2242.
	287.2	214.1	159.8	238.2	436.9	423.3	219.6	442.8
	5	6	6	6	6	7	7	7
2	2732.	2318.	2077.	2150.	1998.	1952.	2251.	2159.
	293.7	181.2	192.3	214.8	60.5	109.5	201.5	375.1
	7	7	7	7	7	7	7	6
3	2010.	1892.	1901.	1789.	1506.	1748.	1708.	1756.
	242.4	166.2	225.3	98.4	113.5	101.4	215.1	184.2
	6	7	7	7	7	7	7	7

14:53:58 25-AUG-82
MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 4 TRIALS ALL 8 LEVELS

SCORES AVERAGED FOR FOLLOWING FACTORS
FACTOR 3 SUBJECTS ALL 8 LEVELS

DISTANCE 1

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1763.	1660.	1681.	1697.	1749.	1558.	1579.	1405.
	159.6	235.4	202.8	280.0	237.1	231.0	226.8	170.8
	7	8	8	8	8	8	8	8
2	1346.	1144.	1130.	1084.	1193.	1155.	1042.	1109.
	106.7	93.4	69.4	78.5	112.8	91.3	105.0	137.6
	8	8	8	8	8	8	7	7
3	689.	693.	646.	616.	612.	635.	621.	605.
	34.8	36.9	33.8	19.3	25.3	29.0	21.4	19.2
	8	8	8	8	8	8	8	8

DISTANCE 2

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	2146.	1878.	2019.	1831.	2035.	1917.	1793.	1714.
	142.9	212.5	238.3	207.5	228.5	308.6	167.6	178.5
	7	8	8	8	8	8	8	8
2	1661.	1497.	1357.	1317.	1399.	1444.	1347.	1387.
	127.2	139.4	114.5	107.9	107.8	98.9	142.0	138.7
	8	8	8	8	8	8	7	7
3	799.	732.	722.	727.	779.	698.	728.	692.
	40.8	30.6	26.4	27.1	40.6	34.8	27.3	18.2
	8	8	8	8	8	8	8	8

DISTANCE 3

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	2334.	2005.	2262.	1974.	2231.	1968.	2156.	1996.
	160.2	140.3	228.6	234.7	192.2	208.9	195.0	232.1
	7	8	8	7	8	8	8	8

	201.4	166.6	121.9	183.1	201.4	156.9	216.2	134.2
	8	8	8	8	8	8	7	7
3	973.	839.	895.	888.	922.	850.	800.	856.
	48.2	43.5	47.7	47.7	57.2	44.3	41.9	35.6
	8	8	8	8	8	8	8	8

DISTANCE 4

GROUPS	TRIALS							
	1	2	3	4	5	6	7	8
1	2435.	2174.	2196.	2239.	2651.	2173.	2021.	2354.
	167.8	245.7	247.8	226.0	328.6	370.0	185.3	346.7
	6	7	7	7	8	8	8	8
2	2691.	1960.	1701.	1894.	1873.	1754.	2033.	1999.
	280.1	172.7	115.0	157.1	165.2	133.2	224.4	400.1
	8	8	8	8	8	8	7	6
3	1064.	1017.	986.	1070.	1029.	979.	1000.	926.
	66.8	74.0	39.8	58.2	80.6	44.8	72.4	42.9
	8	8	8	8	8	8	8	8

14:46:01 25-AUG-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

NON-OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 2 GROUPS ALL 4 LEVELS
FACTOR 4 TRIALS ALL 8 LEVELS

SCORES AVERAGED FOR FOLLOWING FACTORS
FACTOR 3 SUBJECTS ALL 5 LEVELS

DISTANCE 1

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	954.	893.	677.	763.	832.	796.	912.	835.
	152.3	137.9	61.0	91.7	126.9	105.3	135.2	131.4
	5	5	5	5	5	5	5	5
2	907.	787.	673.	683.	643.	745.	779.	881.
	120.2	68.6	65.3	45.4	64.2	27.9	42.0	125.1
	5	5	5	5	5	5	4	4
3	751.	728.	709.	591.	725.	688.	699.	644.
	85.1	51.3	64.8	55.4	84.4	58.8	64.3	37.2
	5	5	5	5	5	5	5	4
4	415.	401.	412.	428.	429.	400.	428.	441.
	51.8	47.2	35.7	24.2	13.6	27.9	27.7	38.6
	5	5	5	5	5	5	5	5

DISTANCE 2

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1302.	1035.	1030.	1099.	1259.	1108.	1217.	1222.
	146.3	181.8	90.0	98.5	163.5	143.4	177.7	144.7
	5	5	5	5	5	5	5	5
2	1228.	1234.	992.	1108.	969.	994.	1069.	1059.
	195.0	129.6	105.1	88.9	56.0	75.0	109.2	135.9
	5	5	5	5	5	5	4	4
3	1003.	1008.	897.	841.	878.	846.	880.	878.
	168.0	108.7	133.6	56.0	72.4	54.6	89.4	147.5
	5	5	5	5	5	5	5	5
4	528.	567.	525.	582.	541.	561.	521.	547.
	63.5	80.9	37.9	61.3	44.2	45.9	53.8	64.5
	5	5	5	5	5	5	5	5

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1551.	1502.	1362.	1309.	1524.	1596.	1451.	1485.
	63.4	175.5	84.8	98.1	174.2	197.1	152.9	230.9
	5	5	5	5	5	5	5	5
2	1724.	1563.	1214.	1537.	1308.	1252.	1279.	1316.
	146.9	212.7	163.4	202.3	77.4	98.4	142.1	144.4
	5	5	5	5	5	5	4	4
3	1267.	1120.	1124.	1192.	1019.	968.	942.	862.
	228.3	159.2	189.5	333.6	99.9	91.5	112.1	117.9
	5	5	5	5	5	5	5	5
4	642.	704.	636.	695.	711.	615.	674.	685.
	71.9	86.4	47.8	60.2	50.8	55.8	65.8	62.1
	5	5	5	5	5	5	5	5

DISTANCE 4

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1747.	1567.	1594.	1524.	1225.	1711.	1611.	1761.
	168.1	126.8	132.9	155.7	128.8	199.5	223.8	283.3
	4	5	5	4	5	4	4	4
2	1915.	1927.	1320.	1678.	1471.	1306.	1473.	1740.
	203.7	174.4	208.8	169.9	125.9	116.3	70.0	184.0
	5	5	5	5	5	5	4	4
3	1368.	1310.	1120.	1274.	1122.	1064.	1044.	1064.
	293.4	185.7	207.7	113.2	176.9	105.3	269.8	134.0
	5	4	5	3	4	5	5	5
4	766.	737.	731.	833.	790.	801.	709.	812.
	82.7	80.2	78.3	115.4	64.2	86.2	63.7	85.2
	5	5	5	5	5	5	5	5

14:48:47 25-AUG-82
MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

NON-OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 4 TRIALS ALL 8 LEVELS

SCORES AVERAGED FOR FOLLOWING FACTORS
FACTOR 3 SUBJECTS ALL 7 LEVELS

DISTANCE 1

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	905.	942.	868.	841.	853.	890.	889.	732.
	130.5	147.2	136.7	161.8	128.2	140.5	110.2	100.8
	6	7	7	7	7	7	7	7
2	862.	753.	672.	673.	688.	689.	691.	769.
	92.4	54.2	51.6	46.9	80.4	51.3	64.1	101.5
	7	7	7	7	7	7	7	7
3	748.	729.	685.	669.	708.	671.	658.	669.
	43.2	39.5	55.2	62.4	60.7	34.5	40.0	41.2
	7	7	7	7	7	7	7	7

DISTANCE 2

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1170.	1269.	1164.	1183.	1206.	1164.	1134.	1015.
	77.5	137.5	173.5	211.2	156.1	199.3	148.5	101.1
	6	7	7	7	7	7	7	7
2	1159.	1160.	958.	1064.	1001.	979.	1063.	986.
	141.0	106.5	78.1	91.0	72.3	88.8	133.6	92.5
	7	7	7	7	7	7	7	7
3	912.	975.	892.	876.	867.	831.	846.	816.
	65.0	71.9	75.5	53.1	46.3	38.8	66.3	107.5
	7	7	7	7	7	7	7	7

DISTANCE 3

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1686.	1539.	1455.	1355.	1491.	1497.	1368.	1222.
	84.6	196.2	150.8	133.3	172.9	162.7	170.5	174.4
	6	7	7	7	7	7	7	7

	151.1	175.3	139.8	160.1	89.0	108.8	93.7	107.5
	7	7	7	7	7	7	7	7
3	1136.	1096.	1092.	988.	1038.	977.	938.	1007.
	117.4	108.4	99.6	109.9	82.4	73.5	87.7	67.2
	7	7	7	7	7	7	7	7

DISTANCE 4

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1682.	1775.	1744.	1644.	1583.	1588.	1513.	1385.
	168.3	78.0	141.9	172.3	200.7	186.3	163.1	177.6
	6	7	7	6	7	7	7	6
2	1827.	1827.	1317.	1638.	1496.	1357.	1404.	1533.
	156.4	159.4	156.3	147.0	110.3	159.0	102.1	157.8
	7	7	7	7	7	7	7	7
3	1264.	1168.	1060.	1297.	1134.	1055.	1166.	1038.
	142.1	106.5	108.8	88.0	99.9	89.0	172.4	75.4
	7	6	7	6	7	7	7	7

14:52:30 25-AUG-82
SPRING 1982

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA

NON-OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 4 TRIALS ALL 8 LEVELS

SCORES AVERAGED FOR FOLLOWING FACTORS
FACTOR 3 SUBJECTS ALL 8 LEVELS

DISTANCE 1

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	972.	972.	837.	840.	897.	869.	893.	789.
	134.7	133.6	124.8	147.7	116.6	144.1	107.8	79.7
	7	8	8	8	8	8	8	8
2	798.	651.	622.	658.	676.	636.	636.	704.
	91.2	47.5	49.0	46.7	71.1	58.2	73.1	116.9
	8	8	8	8	8	8	7	7
3	393.	347.	345.	371.	382.	383.	364.	397.
	21.2	12.4	34.7	34.3	23.3	16.9	19.7	15.0
	8	8	8	8	8	8	8	8

DISTANCE 2

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1180.	1084.	1094.	1165.	1247.	1153.	1177.	1008.
	90.3	169.2	161.9	192.8	133.1	196.1	129.7	122.4
	7	8	8	8	8	8	8	8
2	1115.	951.	904.	933.	921.	926.	971.	955.
	129.5	108.5	89.4	86.8	81.5	93.7	163.5	110.0
	8	8	8	8	8	8	7	7
3	497.	445.	476.	502.	497.	481.	472.	474.
	43.5	36.6	29.6	33.5	22.2	29.3	15.3	16.8
	7	8	8	8	8	8	8	8

DISTANCE 3

GROUPS	TRIALS 1	2	3	4	5	6	7	8
1	1566.	1500.	1382.	1292.	1492.	1441.	1312.	1313.
	120.1	205.4	147.0	126.2	183.2	157.4	174.4	172.9
	7	8	8	8	8	8	8	8

	145.9	121.8	126.8	131.7	103.3	117.0	123.0	150.1
	8	8	8	8	8	8	7	7
3	603.	583.	525.	605.	555.	563.	572.	582.
	51.3	43.6	37.3	42.5	51.6	35.7	27.0	32.3
	7	7	8	7	8	8	8	8

DISTANCE 4

GROUPS	TRIALS							
	1	2	3	4	5	6	7	8
1	1610.	1534.	1557.	1338.	1380.	1503.	1442.	1496.
	129.2	158.0	168.8	249.7	226.6	227.4	198.7	189.1
	6	8	8	6	8	8	7	7
2	1699.	1500.	1302.	1441.	1392.	1310.	1245.	1366.
	166.5	195.0	142.9	186.3	112.2	147.2	138.8	179.9
	8	8	8	8	8	8	7	7
3	712.	706.	660.	638.	700.	661.	588.	633.
	54.2	49.3	71.0	55.7	40.0	32.0	27.3	47.2
	7	7	7	8	7	8	8	8

APPENDIX F

Raw Data for Error Rate

Raw Data for Error Rate

Group	Subject Number	Score: Functional and Chronological Age Analysis	Score: Functional Age Match Only Analysis	Score: Chronological Age Match Only Analysis
D.S.	1	17.7	65.84	45.90
	2	115.74	71.04	32.76
	3	125.64	43.52	125.64
	4	67.98	94.08	67.98
	5	125.10	189.20	44.88
	6	-	89.04	42.78
	7	-	33.81	20.90
	8	-	-	20.76
M.R.	1	53.64	70.64	74.10
	2	88.02	119.04	88.02
	3	96.06	127.12	83.82
	4	74.10	92.96	63.90
	5	84.06	78.72	84.06
	6	-	127.84	79.02
	7	-	113.68	52.86
	8	-	-	88.02
E.S.	1	105.72	82.96	
	2	136.56	135.36	
	3	72.90	100.88	
	4	65.76	90.88	
	5	65.04	91.04	
	6	-	126.16	
	7	-	171.84	
	8	-	-	
H.S.	1	94.68		99.96
	2	96.90		94.92
	3	81.96		81.96
	4	98.64		85.86
	5	52.68		52.68
	6	-		57.66
	7	-		70.26
	8	-		49.86
Means		85.94	100.74	67.02

APPENDIX G

Raw Data for Overshoot Rate

Raw Data for Overshoot Rate

Group	Subject Number	Score		
		Functional and Chronological Age Match Analysis	Functional Age Match Only Analysis	Chronological Age Match Only Analysis
D.S.	1	133.68	171.60	128.88
	2	315.60	412.88	372.84
	3	468.78	505.60	468.78
	4	348.18	477.28	348.18
	5	245.88	310.56	436.92
	6	-	308.56	315.00
	7	-	382.69	246.95
	8	-	-	322.92
M.R.	1	400.68	521.68	235.02
	2	390.66	535.84	390.66
	3	454.74	545.28	371.58
	4	235.02	294.34	321.72
	5	238.68	270.72	238.68
	6	-	592.72	419.76
	7	-	527.84	196.74
	8	-	-	415.38
E.S.	1	389.76	490.48	
	2	412.80	505.52	
	3	267.96	411.84	
	4	411.48	540.32	
	5	489.84	632.64	
	6	-	454.00	
	7	-	403.76	
	8	-	-	
H.S.	1	320.82		549.84
	2	261.78		454.92
	3	414.78		414.78
	4	485.76		452.88
	5	299.70		299.70
	6	-		240.60
	7	-		422.88
	8	-		377.70
Means		349.32	442.67	351.80

APPENDIX H

Analyses of Variance with Repeated Measures

14:01:36   04-OCT-82
MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA   SPRING 1982

TOTAL RESPONSE TIME SCORE

FACTOR 1 GROUPS ALL 4 LEVELS
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS 6 SELECTED LEVELS:
1 2 3 4 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	37159888.00	3	12386629.00	4.50
RESIDUAL	44090284.00	16	2755642.75	
WITHIN-SUBJECTS				
TRIALS	2228399.00	5	445679.81	13.71
GROU TRIA	1242250.62	15	82816.71	2.55
RESIDUAL	2600185.75	80	32502.32	
TOTAL	87321000.00	119		

14:09:00 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

TOTAL RESPONSE TIME SCORE

FACTOR 2 GROUPS ALL 4 LEVELS
FACTOR 3 SUBJECTS ALL 5 LEVELS
FACTOR 1 QUARTER ALL 4 LEVELS
FACTOR 4 TRIALS 4 SELECTED LEVELS:
1 2 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	107095232.00	3	35698412.00	4.56
RESIDUAL	125187280.00	16	7824205.00	
WITHIN-SUBJECTS				
QUARTER	506847.69	3	168949.23	1.66
TRIALS	7877163.50	3	2625721.25	25.77
GROU QUAR	838911.31	9	93212.37	0.91
GROU TRIA	4004396.50	9	444932.94	4.37
QUAR TRIA	1622348.62	9	180260.95	1.77
GROU QUAR TRIA	1929086.37	27	71447.64	0.70
RESIDUAL	24449400.00	240	101872.50	
TOTAL	273510688.00	319		

14:13:05 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

CORRECT REACTION TIME SCORE
(ERROR CRITERION = 11)

FACTOR 2 GROUPS ALL 4 LEVELS
FACTOR 3 SUBJECTS ALL 5 LEVELS
FACTOR 1 PROBALTY ALL 4 LEVELS
FACTOR 4 TRIALS 6 SELECTED LEVELS:
1 2 3 4 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	8491444.00	3	2830481.25	7.10
RESIDUAL	6377225.50	16	398576.59	
WITHIN-SUBJECTS				
PROBALTY	118371.01	3	39457.00	9.24
TRIALS	382556.91	5	76511.38	17.91
GROU PROB	159825.84	9	17758.43	4.16
GROU TRIA	91374.52	15	6091.63	1.43
PROB TRIA	44233.81	15	2948.92	0.69
GROU PROB TRIA	103377.84	45	2297.29	0.54
RESIDUAL	1572070.87	368	4271.93	
TOTAL	17340480.00	479		

14:21:49 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

NON-OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 2 GROUPS ALL 4 LEVELS
FACTOR 3 SUBJECTS ALL 5 LEVELS
FACTOR 1 DISTANCE 3 SELECTED LEVELS:
1 2 3
FACTOR 4 TRIALS 6 SELECTED LEVELS:
1 2 3 4 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	19766076.00	3	6588692.00	9.96
RESIDUAL	10586551.00	16	661659.44	
WITHIN-SUBJECTS				
DISTANCE	15263502.00	2	7631751.00	231.95
TRIALS	1125475.62	5	225095.13	6.84
GROU DIST	1941748.25	6	323624.72	9.84
GROU TRIA	1163685.00	15	77579.00	2.36
DIST TRIA	108119.39	10	10811.94	0.33
GROU DIST TRIA	721906.81	30	24063.56	0.73
RESIDUAL	8949668.00	272	32903.19	
TOTAL	59626712.00	359		

14:31:03   04-OCT-82
MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA   SPRING 1982

OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 2 GROUPS   ALL 4 LEVELS
FACTOR 3 SUBJECTS ALL 5 LEVELS
FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 4 TRIALS   SELECTED LEVELS:
1 2 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	57276324.00	3	19092108.00	10.89
RESIDUAL	28062238.00	16	1753889.87	
WITHIN-SUBJECTS				
DISTANCE	20582276.00	3	6860758.50	94.64
TRIALS	6235918.00	3	2078639.37	28.67
GROU DIST	3554261.50	9	394917.94	5.45
GROU TRIA	2945392.00	9	327265.78	4.51
DIST TRIA	2082646.00	9	231405.11	3.19
GROU DIST TRIA	3003816.00	27	111252.45	1.53
RESIDUAL	17399016.00	240	72495.90	
TOTAL	141141904.00	319		

14:49:19 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

TOTAL RESPONSE TIME SCORE

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS 7 SELECTED LEVELS:
2 3 4 5 6 7 8

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	9103096.00	2	4551548.00	2.07
RESIDUAL*	39521164.00	18	2195620.25	
WITHIN-SUBJECTS				
TRIALS	1448608.75	6	241434.80	4.49
GROU TRIA	288922.94	12	24076.91	0.45
RESIDUAL	5804993.50	108	53749.94	
TOTAL	56166784.00	146		

14:51:40 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

TOTAL RESPONSE TIME SCORE

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS ALL 7 LEVELS
FACTOR 1 QUARTER ALL 4 LEVELS
FACTOR 4 TRIALS 7 SELECTED LEVELS:
2 3 4 5 6 7 8

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	36404524.00	2	18202262.00	2.07
RESIDUAL	157987200.00	18	8777067.00	
WITHIN-SUBJECTS				
QUARTER	2273333.00	3	757777.69	8.74
TRIALS	5768410.50	6	961401.75	11.09
GROU QUAR	514862.56	6	85810.43	0.99
GROU TRIA	1155628.87	12	96302.41	1.11
QUAR TRIA	1714940.37	18	95274.47	1.10
GROU QUAR TRIA	1645944.50	36	45720.68	0.53
RESIDUAL	42148328.00	486	86724.95	
TOTAL	249613200.00	587		

14:57:10 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

CORRECT REACTION TIME SCORE
(ERROR CRITERION = 11)

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS ALL 7 LEVELS
FACTOR 1 PROBALTY ALL 4 LEVELS
FACTOR 4 TRIALS 7 SELECTED LEVELS:
2 3 4 5 6 7 8

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	3254778.75	2	1627389.37	4.40
RESIDUAL	6655195.50	18	369733.09	
WITHIN-SUBJECTS				
PROBALTY	161417.38	3	53805.79	11.53
TRIALS	407077.47	6	67846.24	14.54
GROU PROB	181767.69	6	30294.62	6.49
GROU TRIA	111360.45	12	9280.04	1.99
PROB TRIA	60894.84	18	3383.05	0.72
GROU PROB TRIA	73008.35	36	2028.01	0.43
RESIDUAL	2268177.00	486	4667.03	
TOTAL	13173677.00	587		

15:03:40 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

NON-OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS ALL 7 LEVELS
FACTOR 1 DISTANCE 3 SELECTED LEVELS:
1 2 3
FACTOR 4 TRIALS 7 SELECTED LEVELS:
2 3 4 5 6 7 8

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	6121140.00	2	3060570.00	2.28
RESIDUAL	24133354.00	18	1340741.87	
WITHIN-SUBJECTS				
DISTANCE	18572178.00	2	9286089.00	311.10
TRIALS	845082.56	6	140847.09	4.72
GROU DIST	1056742.12	4	264185.53	8.85
GROU TRIA	521665.41	12	43472.12	1.46
DIST TRIA	215151.50	12	17929.29	0.60
GROU DIST TRIA	209804.66	24	8741.86	0.29
RESIDUAL	10745772.00	360	29849.37	
TOTAL	62420892.00	440		

15:10:17 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS 6 SELECTED LEVELS:
1 2 3 5 6 7

FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 4 TRIALS 3 SELECTED LEVELS:
6 7 8

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	4463169.50	2	2231584.75	0.75
RESIDUAL	44685604.00	15	2979040.25	
WITHIN-SUBJECTS				
DISTANCE	16030874.00	3	5343624.50	62.16
TRIALS	175979.86	2	87989.93	1.02
GROU DIST	288343.16	6	48057.19	0.56
GROU TRIA	231042.31	4	57760.58	0.67
DIST TRIA	255825.92	6	42637.65	0.50
GROU DIST TRIA	866830.25	12	72235.85	0.84
RESIDUAL	14183227.00	165	85958.95	
TOTAL	81180904.00	215		

15:13:30 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

TOTAL RESPONSE TIME SCORE

FACTOR 1 GROUPS ALL 3 LEVELS
FACTOR 2 SUBJECTS ALL 8 LEVELS
FACTOR 3 TRIALS 5 SELECTED LEVELS:
2 3 4 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	56824824.00	2	28412412.00	14.56
RESIDUAL	40981320.00	21	1951491.37	
WITHIN-SUBJECTS				
TRIALS	415386.81	4	103846.70	3.17
GROU TRIA	287220.66	8	35902.54	1.09
RESIDUAL	2754964.25	84	32797.20	
TOTAL	101263720.00	119		

15:15:42 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

TOTAL RESPONSE TIME SCORE

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS ALL 8 LEVELS
FACTOR 1 QUARTER ALL 4 LEVELS
FACTOR 4 TRIALS 5 SELECTED LEVELS:
2 3 4 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	227285840.00	2	113642920.00	14.57
RESIDUAL	163820352.00	21	7800969.00	
WITHIN-SUBJECTS				
QUARTER	1757920.87	3	585973.62	7.38
TRIALS	1653223.62	4	413305.91	5.20
GROU QUAR	1289934.50	6	214989.42	2.71
GROU TRIA	1148166.12	8	143520.77	1.81
QUAR TRIA	859475.06	12	71623.17	0.90
GROU QUAR TRIA	1260464.38	24	52519.35	0.66
RESIDUAL	31699306.00	399	79446.88	
TOTAL	430774752.00	479		

15:24:04 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

CORRECT REACTION TIME SCORE
(ERROR CRITERION = 11)

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS ALL 8 LEVELS
FACTOR 1 PROBALTY ALL 4 LEVELS
FACTOR 4 TRIALS 4 SELECTED LEVELS:
2 3 4 5

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	12595509.00	2	6297754.50	32.68
RESIDUAL	4046590.75	21	192694.80	
WITHIN-SUBJECTS				
PROBALTY	52923.14	3	17641.05	4.35
TRIALS	189415.88	3	63138.63	15.57
GROU PROB	138492.63	6	23082.10	5.69
GROU TRIA	33119.96	6	5519.99	1.36
PROB TRIA	30714.61	9	3412.73	0.84
GROU PROB TRIA	45174.75	18	2509.71	0.62
RESIDUAL	1277198.62	315	4054.60	
TOTAL	18409140.00	383		

15:28:00 04-OCT-82

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

NON-OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS ALL 8 LEVELS
FACTOR 1 DISTANCE 3 SELECTED LEVELS:
1 2 3
FACTOR 4 TRIALS 3 SELECTED LEVELS:
3 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	17694924.00	2	8847462.00	14.20
RESIDUAL	13081172.00	21	622912.94	
WITHIN-SUBJECTS				
DISTANCE	6851872.50	2	3425936.25	163.13
TRIALS	118346.79	2	59173.39	2.82
GROU DIST	1215107.62	4	303776.91	14.46
GROU TRIA	48212.33	4	12053.09	0.57
DIST TRIA	1926.33	4	481.58	0.02
GROU DIST TRIA	25141.79	8	3142.72	0.15
RESIDUAL	3528159.75	168	21000.95	
TOTAL	42564860.00	215		

OVERSHOOT MOVEMENT TIME SCORE
(OVERSHOOT CRITERION = 51)

FACTOR 2 GROUPS ALL 3 LEVELS
FACTOR 3 SUBJECTS 6 SELECTED LEVELS:
2 3 4 5 6 7
FACTOR 1 DISTANCE ALL 4 LEVELS
FACTOR 4 TRIALS 5 SELECTED LEVELS:
2 3 4 5 6

SOURCE	DEVIANCE	DF	VARIANCE	F
BETWEEN-SUBJECTS				
GROUPS	74098848.00	2	37049424.00	25.17
RESIDUAL	22083146.00	15	1472209.75	
WITHIN-SUBJECTS				
DISTANCE	17781920.00	3	5927306.50	131.77
TRIALS	763975.37	4	190993.84	4.25
GROU DIST	1010809.00	6	168468.17	3.75
GROU TRIA	1117103.12	8	139637.89	3.10
DIST TRIA	673844.44	12	56153.70	1.25
GROU DIST TRIA	488548.91	24	20356.21	0.45
RESIDUAL	12819964.00	285	44982.33	
TOTAL	130838176.00	359		

APPENDIX I

Reaction Times for Correct Responses with Respect to Starting Position

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR MA AND CA SPRING 1982

FACTOR 1 GROUPS LEVELS 1
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	611	644	731	736	0	616	645	716	73[illegible]
	0.0	43.9	50.9	78.1	58.4	0.0	395.0	427.3	683.1	536.2
	0	40	40	40	40	0	165	166	167	181
2	750	0	655	676	732	701	0	651	693	721
	72.4	0.0	49.5	57.5	58.3	555.6	0.0	383.2	485.1	478.6
	40	0	40	40	40	154	0	175	153	159
3	1051	642	0	634	681	1052	644	0	761	68[illegible]
	163.4	55.4	0.0	103.9	59.8	1376.0	565.5	0.0	735.8	503.9
	40	40	0	40	40	158	177	0	146	161
4	880	739	711	0	543	880	755	703	0	55[illegible]
	85.4	81.6	70.8	0.0	33.0	829.5	820.9	571.4	0.0	274.2
	40	40	40	0	40	157	168	178	0	179
5	678	677	647	623	0	679	665	652	616	0
	46.8	52.6	44.3	48.5	0.0	438.6	445.5	375.6	405.9	0.0
	40	40	40	40	0	177	179	182	174	0

NUMBER OF MISSING DATA 4.
ERROR CRITERION 11

MOTOR CONTROL IN DS [illegible]D MR. SUBJECTS MATCHED FOR MA AND CA. SPRING 1982

FACTOR 1 GROUPS LEVELS 1
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 9 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MEAN SCORES — TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0 0.0 0	26 12.4 [illegible]	27 3.[illegible] 2	[illegible] [illegible].0 0	25 [illegible].[illegible] 4
2	[illegible] [illegible].7 4	[illegible] [illegible] [illegible]	4 [illegible] 1	25 [illegible] [illegible]	3[illegible] [illegible].2 3
3	25 3.9 [illegible]	20 5.[illegible] [illegible]	0 0.[illegible] [illegible]	19 11.[illegible] 3	12 7.[illegible] 3
4	29 [illegible].7 [illegible]	13 [illegible].5 3	14 13.0 2	0 [illegible].0 0	19 8.7 4
5	11 [illegible] 3	1[illegible] 4.[illegible] 5	28 14.[illegible] 2	27 4.9 3	0 [illegible] 0

MEAN DATA — TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0 0.0 0	26 21.5 3	27 4.2 2	0 0.0 0	25 18.7 6
2	30 17.4 4	0 0.0 0	4 0.[illegible] 1	25 9.1 6	30 15.9 3
3	25 14.2 7	22 13.3 7	0 0.0 0	19 20.1 3	12 12.1 3
4	27 15.6 5	13 6.1 3	14 18.4 2	0 0.0 0	19 17.3 4
5	11 10.4 3	18 9.0 5	28 19.8 2	27 8.5 3	0 0.0 0

NUMBER OF MISSING DATA 4.
NUMBER OF EXCLUDED DATA 5274.
INCLUSION CRITERIA 1 AND 50
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS, MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS LEVELS 1
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	591	624	668	688	0	584	597	650	659
	0.0	37.7	43.1	42.3	43.5	0.0	309.4	317.2	327.9	353.9
	0	40	40	40	40	0	157	157	153	155
2	643	0	615	673	701	595	0	598	666	672
	51.3	0.0	41.7	46.2	44.4	333.2	0.0	254.1	362.8	352.9
	40	0	40	40	40	139	0	166	142	150
3	658	591	0	626	632	635	583	0	592	619
	54.7	39.2	0.0	35.6	39.2	396.9	333.9	0.0	285.9	297.9
	40	40	0	39	40	127	162	0	129	153
4	654	615	605	0	539	642	604	587	0	541
	45.3	39.5	40.2	0.0	26.3	362.0	328.7	314.1	0.0	211.6
	40	40	40	0	40	132	155	164	0	172
5	636	649	626	601	0	629	623	630	582	0
	37.5	39.5	39.3	39.5	0.0	335.8	298.5	322.6	303.3	0.0
	40	40	40	40	0	166	167	176	166	0

NUMBER OF MISSING DATA 4.
NUMBER OF EXCLUDED DATA 258.
INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS LEVELS 1
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MEAN SCORES — TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0	1686	1757	1840	1856
	0.0	12.0	54.7	44.7	52.4
	0	2	3	3	5
2	1703	0	1744	1828	1677
	46.7	0.0	37.6	11[illegible].0	0.0
	5	0	6	2	1
3	1851	1720	0	1747	1692
	34.2	49.8	0.0	85.6	21.9
	6	3	0	4	3
4	1749	1685	1845	0	1787
	32.6	39.3	76.0	0.0	25.7
	5	4	3	0	2
5	1780	1669	1832	1869	0
	63.7	30.8	73.5	48.4	0.0
	4	2	2	3	0

MEAN DATA — TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0	1686	1769	1820	1856
	0.0	17.0	84.6	76.4	117.[illegible]
	0	2	4	4	5
2	1703	0	1742	1828	1677
	104.4	0.0	104.4	159.8	57.3
	5	0	7	2	2
3	1851	1732	0	1747	1692
	83.9	99.9	0.0	171.2	37.9
	6	4	0	4	3
4	1749	1685	1858	0	1779
	73.9	78.7	170.9	0.0	155.3
	5	4	4	0	3
5	1786	1659	1800	1869	0
	152.7	47.5	93.4	83.8	0.0
	5	3	3	3	0

NUMBER OF MISSING DATA 4.
NUMBER OF EXCLUDED DATA 3263.
INCLUSION CRITERIA 1601 AND 2000
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS LEVELS 2
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MEAN SCORES
TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0	379	395	392	410
	0.0	18.4	19.7	16.8	24.8
	0	38	38	38	38
2	509	0	400	494	406
	23.5	0.0	21.3	74.6	19.2
	38	0	38	38	38
3	565	489	0	472	448
	33.5	20.7	0.0	26.2	25.4
	37	38	0	38	38
4	548	489	458	0	487
	38.7	31.4	25.2	0.0	28.0
	38	38	38	0	38
5	422	41[illegible]	413	405	0
	29.9	24.6	15.7	15.4	0.0
	38	38	38	38	0

MEAN DATA
TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0	379	380	391	404
	0.0	157.0	163.1	164.8	201.6
	0	170	166	179	175
2	507	0	401	465	407
	213.3	0.0	174.1	321.4	209.7
	173	0	167	163	16[illegible]
3	571	486	0	472	451
	371.7	195.9	0.0	233.0	191.3
	132	155	0	154	177
4	538	488	460	0	487
	400.9	256.3	205.6	0.0	230.[illegible]
	160	159	164	0	156
5	423	420	411	403	0
	247.6	221.7	169.5	172.0	0.0
	183	171	183	184	0

NUMBER OF MISSING DATA 2.
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1	GROUPS	LEVELS 2	
FACTOR 2	SUBJECTS	ALL	5 LEVELS
FACTOR 3	TRIALS	ALL	8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0 0.0 0	20 8.5 3	18 3.3 6	22 3.6 6	8 0.0 1	0 0.0 0	20 14.7 3	19 14.5 7	22 8.9 6	8 4.2 2
2	0 0.0 0	0 0.0 0	29 5.0 6	36 9.2 4	25 8.1 6	0 0.0 0	0 0.0 0	29 12.2 6	36 18.3 4	25 19.8 6
3	12 0.0 1	0 0.0 0	0 0.0 0	22 7.0 2	34 2.5 2	12 0.0 1	0 0.0 0	0 0.0 0	22 9.9 2	34 3.5 2
4	0 0.0 0	12 4.0 2	37 11.5 2	0 0.0 0	29 5.5 2	0 0.0 0	14 7.0 4	37 16.3 2	0 0.0 0	29 7.8 2
5	29 9.3 3	12 0.0 1	23 10.8 3	13 10.6 4	0 0.0 0	29 16.0 3	12 0.0 1	23 18.7 3	13 21.2 4	0 0.0 0

NUMBER OF MISSING DATA 2.
NUMBER OF EXCLUDED DATA 3236.
INCLUSION CRITERIA 1 AND 50
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS LEVELS 2
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	386	402	404	414	0	385	396	404	410
	0.0	18.7	19.0	16.2	24.5	0.0	150.7	147.4	152.2	198.1
	0	38	38	38	38	0	167	159	173	173
2	578	0	413	490	421	507	0	415	480	414
	23.5	0.0	20.1	26.0	18.8	213.3	0.0	161.4	239.9	176.2
	38	0	38	38	38	133	0	161	158	156
3	549	489	0	468	454	547	486	0	467	456
	30.8	20.7	0.0	20.6	23.5	283.9	195.9	0.0	183.5	187.0
	37	38	0	38	38	129	155	0	151	175
4	493	492	462	0	486	482	492	465	0	485
	25.7	28.1	24.4	0.0	25.5	239.8	227.2	201.4	0.0	205.9
	38	38	38	0	38	155	154	162	0	153
5	415	420	419	414	0	413	422	418	411	0
	24.2	24.4	18.4	19.4	0.0	192.5	220.1	163.2	163.6	0.0
	38	38	38	38	0	178	170	180	180	0

NUMBER OF MISSING DATA 2.
NUMBER OF EXCLUDED DATA 72.
INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR MA AND CA SPRING 1982

FACTOR 1	GROUPS	LEVELS 2	
FACTOR 2	SUBJECTS	ALL	5 LEVELS
FACTOR 3	TRIALS	ALL	8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0
2	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	1605 0.0 1	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	1605 0.0 1
3	1847 0.0 1	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	1847 0.0 1	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0
4	1797 156.0 2	1745 0.0 1	0 0.0 0	0 0.0 0	1642 0.0 1	1797 220.6 2	1745 0.0 1	0 0.0 0	0 0.0 0	1642 0.0 1
5	1855 92.0 2	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0	1855 130.1 2	0 0.0 0	0 0.0 0	0 0.0 0	0 0.0 0

NUMBER OF MISSING DATA	2.
NUMBER OF EXCLUDED DATA	3286.
INCLUSION CRITERIA	1601 AND 2000
ERROR CRITERION	11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1	GROUPS	LEVELS 3	
FACTOR 2	SUBJECTS	ALL	5 LEVELS
FACTOR 3	TRIALS	ALL	8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION					MEAN DATA TARGET POSITION				
	1	2	3	4	5	1	2	3	4	5
1	0	417	425	418	406	0	418	411	418	399
	0.0	16.7	20.7	19.6	15.5	0.0	154.4	149.2	159.1	149.6
	0	40	40	40	40	0	173	167	175	174
2	462	0	413	438	412	471	0	410	440	406
	19.7	0.0	16.6	17.6	15.7	200.1	0.0	153.6	170.2	153.8
	40	0	40	40	40	130	0	172	157	153
3	523	451	0	493	435	525	454	0	487	435
	22.8	10.3	0.0	25.5	15.4	236.5	128.4	0.0	244.1	170.4
	40	40	0	40	40	144	169	0	148	171
4	483	438	420	0	456	485	435	420	0	456
	24.5	14.5	12.9	0.0	17.3	242.0	145.8	135.1	0.0	170.0
	40	40	40	0	40	166	167	174	0	150
5	438	413	442	412	0	437	410	441	411	0
	19.8	13.9	16.9	14.7	0.0	193.6	135.2	176.6	152.3	0.0
	40	40	40	40	0	164	180	174	176	0

NUMBER OF MISSING DATA	4.
NUMBER OF EXCLUDED DATA	65.
INCLUSION CRITERIA	51 AND 1600
ERROR CRITERION	11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA AND CA SPRING 1982

FACTOR 1 GROUPS LEVELS 4
FACTOR 2 SUBJECTS ALL 5 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	221	22[illegible]	222	217	0	218	227	224	216
	0.0	7.5	7.9	[illegible]	6.6	0.0	63.8	65.1	62.3	61.7
	0	40	40	40	40	0	189	181	187	192
2	261	0	254	244	247	261	0	249	242	245
	10.7	0.0	6.8	10.7	8.7	83.4	0.0	67.1	93.0	76.9
	39	0	40	40	40	103	0	159	169	172
3	264	258	0	272	260	264	256	0	279	263
	8.8	7.7	0.0	9.5	6.1	81.9	74.2	0.0	77.5	59.6
	40	40	0	40	40	141	168	0	125	152
4	257	257	249	0	261	25[illegible]	254	247	0	283
	8.5	6.7	6.4	0.0	8.2	74.3	63.8	61.7	0.0	68.1
	40	40	40	0	40	171	177	180	0	135
5	222	222	217	216	0	223	221	216	216	0
	7.4	7.7	6.9	6.1	0.0	65.1	72.8	66.1	56.9	0.0
	40	40	40	40	0	187	193	184	183	0

NUMBER OF MISSING DATA 2.
NUMBER OF EXCLUDED DATA 70.
INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

FACTOR 1 GROUPS LEVELS 1
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	508	574	653	636	0	508	569	649	631
	0.0	21.9	24.0	27.3	30.0	0.0	211.6	238.5	279.8	303.8
	0	55	55	55	55	0	238	250	232	234
2	608	0	530	655	625	593	0	528	663	632
	33.0	0.0	19.1	25.9	28.2	280.4	0.0	190.2	285.7	302.8
	55	0	55	55	55	220	0	244	222	230
3	670	561	0	590	569	688	563	0	593	566
	33.0	26.5	0.0	26.9	25.7	316.6	270.6	0.0	252.9	237.3
	55	55	0	55	55	201	236	0	209	222
4	701	622	569	0	515	707	631	570	0	514
	34.5	26.2	25.2	0.0	20.0	331.8	284.7	251.9	0.0	197.4
	55	55	55	0	55	234	236	245	0	242
5	645	601	558	518	0	639	595	558	520	0
	32.0	27.4	26.9	23.8	0.0	324.6	265.8	237.7	218.3	0.0
	55	55	55	55	0	250	256	253	254	0

NUMBER OF MISSING DATA 9.
NUMBER OF EXCLUDED DATA 191.
INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 1982

FACTOR 1	GROUPS	LEVELS 2	
FACTOR 2	SUBJECTS	ALL	7 LEVELS
FACTOR 3	TRIALS	ALL	8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	386	399	401	411	0	386	393	399	405
	0.0	13.8	14.5	14.7	20.3	0.0	140.9	139.3	163.7	186.6
	0	56	56	56	56	0	250	251	260	254
2	485	0	408	482	419	482	0	408	476	413
	15.4	0.0	14.6	21.6	14.3	198.1	0.0	148.5	246.9	159.9
	56	0	56	56	56	196	0	243	225	224
3	537	472	0	467	444	529	467	0	471	445
	28.2	17.2	0.0	16.3	17.1	292.5	196.4	0.0	177.8	169.6
	55	56	0	56	56	195	229	0	213	256
4	487	501	462	0	468	480	498	464	0	466
	24.2	25.7	17.5	0.0	18.3	259.9	245.9	176.6	0.0	181.6
	56	56	56	0	56	223	222	242	0	231
5	417	424	415	402	0	411	420	417	403	0
	22.7	20.7	16.1	15.3	0.0	203.7	211.5	164.7	156.4	0.0
	56	56	56	56	0	259	258	253	261	0

NUMBER OF MISSING DATA 4.
NUMBER OF EXCLUDED DATA 105.
INCLUSION CRITERIA 151 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR FA SPRING 19[illegible]

FACTOR 1 GROUPS LEVELS 3
FACTOR 2 SUBJECTS ALL 7 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5
1	0	395	375	400	382
	0.0	12.0	10.1	11.7	10.1
	0	56	56	56	56
2	449	0	402	406	393
	17.6	0.0	12.3	12.6	9.5
	56	0	56	56	56
3	485	430	0	445	400
	20.3	8.7	0.0	20.4	11.6
	56	56	0	56	56
4	455	417	401	0	429
	17.4	10.9	8.5	0.0	14.4
	56	56	56	0	55
5	412	375	403	384	0
	15.2	10.3	13.8	11.6	0.0
	56	56	56	56	0

STARTING POSITION	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	398	377	400	382
	0.0	140.3	116.9	123.9	130.[illegible]
	0	255	250	257	262
2	451	0	402	407	393
	205.0	0.0	130.6	141.4	128.1
	198	0	250	234	231
3	456	433	0	440	399
	206.0	117.0	0.0	191.1	140.7
	193	228	0	211	248
4	455	419	402	0	432
	202.5	126.4	116.5	0.0	163.7
	228	222	242	0	194
5	408	376	403	385	0
	184.0	119.8	154.4	139.5	0.0
	244	255	253	258	0

NUMBER OF MISSING DATA 5.
NUMBER OF EXCLUDED DATA 71.
INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA — SPRING 1982

FACTOR 1 GROUPS LEVELS 1
FACTOR 2 SUBJECTS ALL 8 LEVELS
FACTOR 3 TRIALS ALL 8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

STARTING POSITION	MEAN SCORES TARGET POSITION 1	2	3	4	5	MEAN DATA TARGET POSITION 1	2	3	4	5
1	0	595	690	787	785	0	582	665	770	763
	0.0	25.0	29.4	29.6	33.0	0.0	262.7	299.2	307.6	343.9
	0	63	63	63	63	0	279	280	253	261
2	699	0	611	798	748	670	0	594	777	732
	32.8	0.0	27.1	27.6	33.3	299.5	0.0	240.9	306.3	344.6
	63	0	[illegible]	63	63	245	0	276	262	255
3	774	627	0	658	660	755	614	0	643	642
	34.4	25.6	0.0	27.0	24.3	332.2	281.2	0.0	272.2	256.8
	63	63	0	62	63	228	271	0	236	260
4	820	719	634	0	559	807	712	615	0	555
	32.0	25.0	26.3	0.0	20.6	347.8	315.0	280.7	0.0	217.7
	63	63	63	0	63	256	265	277	0	278
5	758	732	662	629	0	746	714	654	613	0
	29.2	24.7	26.1	26.4	0.0	346.2	278.1	277.1	267.9	0.0
	63	63	63	63	0	247	276	294	294	0

NUMBER OF MISSING DATA 0.
NUMBER OF EXCLUDED DATA 431.
INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA SPRING 1982

FACTOR 1	GROUPS	LEVELS 2	
FACTOR 2	SUBJECTS	ALL	8 LEVELS
FACTOR 3	TRIALS	ALL	8 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MEAN SCORES

STARTING POSITION	TARGET POSITION 1	2	3	4	5
1	0 0.0 0	391 13.1 62	394 12.8 62	433 16.9 62	415 17.5 62
2	449 16.7 62	0 0.0 0	402 12.2 62	474 19.0 62	417 12.7 62
3	496 24.3 61	434 15.3 62	0 0.0 0	441 14.4 62	432 16.5 62
4	488 20.2 62	491 22.1 62	433 15.6 62	0 0.0 0	439 17.4 62
5	431 22.6 62	444 20.2 62	413 14.2 62	387 12.5 62	0 0.0 0

MEAN DATA

STARTING POSITION	TARGET POSITION 1	2	3	4	5
1	0 0.0 0	392 135.1 272	392 135.0 277	424 205.1 279	417 172.6 279
2	446 175.6 235	0 0.0 0	404 132.4 272	471 239.3 246	416 158.2 253
3	495 267.7 221	429 176.9 269	0 0.0 0	445 166.6 229	432 179.2 273
4	490 259.3 248	494 220.3 249	437 167.0 274	0 0.0 0	438 175.2 265
5	421 222.5 280	437 210.9 279	411 147.0 277	387 125.6 287	0 0.0 0

NUMBER OF MISSING DATA 4.
NUMBER OF EXCLUDED DATA 114.
INCLUSION CRITERIA 51 AND 1600
ERROR CRITERION 11

MOTOR CONTROL IN DS AND MR SUBJECTS MATCHED FOR CA   SPRING 1982

FACTOR 1   GROUPS   LEVELS 3
FACTOR 2   SUBJECTS   ALL   8 LEVELS
FACTOR 3   TRIALS   ALL   5 LEVELS

REACTION TIMES FOR CORRECT RESPONSES

MEAN SCORES — TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0 0.0 0	228 4.5 64	228 4.3 64	231 4.[illegible] 64	221 4.1 64
2	249 7.1 63	0 0.0 0	25[illegible] 4.3 64	254 4.2 64	250 4.5 64
3	271 4.9 64	262 3.8 64	0 0.0 0	274 5.1 64	26[illegible] 3.9 64
4	258 5.5 64	254 4.[illegible] 64	254 4.4 64	0 0.0 0	277 5.2 63
5	229 5.4 64	227 4.9 64	224 4.2 64	228 4.8 64	0 0.0 0

MEAN DATA — TARGET POSITION

STARTING POSITION	1	2	3	4	5
1	0 0.0 0	226 53.1 293	228 53.1 295	232 55.4 290	221 57.4 299
2	254 76.7 194	0 0.0 0	255 55.6 259	253 59.2 280	248 55.2 257
3	272 68.7 249	261 57.8 273	0 0.0 0	275 63.9 228	259 51.6 268
4	257 68.6 274	252 54.5 276	254 53.1 287	0 0.0 0	276 67.1 21[illegible]
5	228 60.5 297	226 61.3 294	223 56.2 293	227 54.5 295	0 0.0 0

NUMBER OF MISSING DATA   0.
NUMBER OF EXCLUDED DATA   133.
INCLUSION CRITERIA   51 AND 1600
ERROR CRITERION   11