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The purpose of this research was to study the effects of cerebral palsy on the ability to plan and execute a gross motor movement, as measured by the fractionation of Simple Reaction Time (SRT) into its premotor (central) and motor (peripheral) components. The experimental task required subjects (N = 10 cerebral palsied, and N = 10 non-handicapped) to grasp and move a stylus with the right hand as quickly and accurately as possible to depress an endpoint target immediately following the onset of a green light. Two target sizes were used to study the effect of accuracy demands on the planning and execution of a gross motor movement.

A 2 x 2 (group x target size) split-plot factorial design was used to analyze the dependent measures of premotor time, motor time, SRT, and movement time.

One-factor repeated measures ANOVA were conducted for each of the dependent measures.

A significant main effect for premotor time was found between groups providing empirical support for the hypothesis that spastic hemiplegic cerebral palsied youth require increased time to plan a gross motor response when compared to non-handicapped youth. Non-significant findings for motor time between groups further indicate that these differences were confined to central processing. A significant difference for movement time provided empirical support for the hypothesis that spastic hemiplegic cerebral palsied youth require increased time to execute a gross motor response when compared to non-handicapped youth.

The main effect of target size was significant for the dependent measure of movement time only. A major conclusion drawn from this experimental finding was that neither cerebral palsied nor non-handicapped subjects incorporated the parameter of accuracy within the motor program but rather shifted to a closed-loop mode of operation as the accuracy demands of the task increased.

COMPARISON OF FRACTIONATED REACTION TIME
BETWEEN CEREBRAL PALSIED AND NON-HANDICAPPED
YOUTH

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CHAPTER I

INTRODUCTION

Public Law 94-142, provides assurances that handicapped children will receive a free, appropriate public education. The Law defines special education to include classroom instruction, instruction in physical education, home instruction, and instruction in hospitals and institutions (Department of Health, Education, and Welfare [HEW], 1976).

The federal rules and regulations for Public Law 94-142, stress that whenever possible handicapped children are to be educated with those who are non-handicapped (HEW, 1976). Though the word "mainstream" does not appear in the law, many school administrators and educators interpret Public Law 94-142 to mean that handicapped youth are to be placed in the regular classroom setting with non-handicapped students. Teachers, therefore, are frequently expected to construct a learning environment to optimize the learning of both handicapped and non-handicapped students. Unfortunately, many teachers, including physical educators, lack the knowledge and training necessary to teach handicapped youth. To aid teachers, the rules and regulations provide for preservice, inservice, and consultations with experts in the field to prepare teachers to design and implement the appropriate instructional programs.

Materials have been designed and published explaining the various handicapping conditions and outlining teaching techniques appropriate for each specific condition. The teaching techniques for physical education appear to be adapted from those used in the special education self-contained classroom. Little information is known regarding the effectiveness of these techniques as they are applied in the gymnasium.

Educators strive continually to understand how individual students learn and the effect a handicapping condition has on the process of learning. Since physical education instruction is an essential component of special education, physical educators should be aware of how handicapped students process information and acquire motor skills.

Woodworth and Schlosberg (1954) define the learning process in terms of information-processing. The process begins when the stimulus organ is aroused. The information is then carried to the motor areas of the brain via the nervous system. The brain, in turn, sends messages to the muscles which produce an observable reaction. Since a finite amount of measurable time elapses prior to the initiation of movement, reaction time measures become an important research tool to quantify information-processing stages. Woodworth and Schlosberg suggested that reaction time could be used to determine the time required to process incoming stimulus information and the efficiency of a movement.

Woodworth and Schlosberg's (1954) definition of information-processing and its importance in furthering an understanding of the learning of a motor skill has been substantiated through research in the fields of experimental psychology and motor behavior. Both the Simple Reaction Time (SRT) paradigm (Henry and Rogers, 1960; Sternberg, Monsell, Knoll, and Wright, 1978; Christina, Fischman, Vercruyssen, and Anson, 1982; Fischman, 1984) and the Choice Reaction Time (CRT) paradigm (Donders, 1868; Hick, 1952; Klapp, Wyatt, and Lingo, 1974) have been used for the purpose of describing the underlying neurological processes involved in the planning and execution of motor actions. Despite the multitude of literature describing information-processing abilities of the non-handicapped, little attention has been focused on understanding how special populations, specifically cerebral palsied youth, process incoming information for the purpose of executing motor actions. Given the paucity of empirical evidence, it is difficult to know if the teaching techniques utilized by the practitioner are always the most appropriate. The purpose of this study is to provide information about the effects of spastic hemiplegic cerebral palsy on the underlying information-processing abilities. Likewise, this research will study the effect of increasing the accuracy demands of a gross motor task upon the information-processing abilities of cerebral palsied youth to determine whether these youth are differentially affected when compared to non-handicapped youth.

Purpose of Study

The purpose of the current research is to study the effects of cerebral palsy on the ability to plan and execute a gross motor movement, as measured by the fractionation of SRT. Specifically, answers to two questions are sought; (a) whether differences exist with respect to information-processing abilities between spastic hemiplegic cerebral palsied youth and non-handicapped youth and, (b) whether increasing the accuracy demands of a gross motor task differentially affect the cerebral palsied youth when compared to non-handicapped youth.

Significance of Study

A review of the literature revealed that reaction time has been extensively used to measure information-processing abilities. In the field of motor behavior, theorists have utilized simple and choice reaction time paradigms to study the effects of variables such as attention, age, and task complexity upon information-processing abilities. The major proportion the research has been directed toward non-handicapped populations however, and not toward handicapped populations, specifically those with cerebral palsy. The proposed research will provide theoreticians and practitioners alike with valuable information concerning the effects of spastic hemiplegic cerebral palsy on the underlying information-processing abilities of cerebral palsied youth.

Research Hypotheses

The following hypotheses will be analyzed in this study.

1. Spastic hemiplegic cerebral palsied youth require increased time to plan a gross motor response when compared to non-handicapped youth.
2. The time required to plan a gross motor movement increases as the accuracy demands increase among both spastic hemiplegic cerebral palsied and non-handicapped youth.
3. Spastic hemiplegic cerebral palsied youth require increased time to initiate a gross motor response when compared to non-handicapped youth.
4. Spastic hemiplegic cerebral palsied youth require increased time to execute a gross motor response when compared to non-handicapped youth.

Statistical Hypotheses

The following statistical hypotheses correspond to the research hypotheses.

1. Ho_1 : $\mu\,CP > \mu\,NH$

   $H1_1$: $\mu\,CP \leq \mu\,NH$

2. Ho_2 : $(\mu CP/S - \mu CP/L) = (\mu NH/S - \mu NH/L)$

   $H1_2$: $\mu\,CP\,s \leq \mu\,NH$

3. Ho_3 : μ CP > μ NH

$H1_3$: μ CP $\leq$ μ NH

4. Ho_4 : μ CP > μ NH

$H1_4$: μ CP $\leq$ μ NH

CP = Cerebral Palsy S = Small target

NH = Non-Handicapped L = Large target

Assumptions

The following assumptions apply to this study.

1. Each subject performed the motor task to the best of his or her ability.
2. The intelligence level among participating subjects was homogeneous.
3. Premotor time measured the time from the onset of the visual stimulus to the first change in the electromygraphical (EMG) activity at the prime-moving muscle.
4. Motor time reflected the time from the first change in electromygraphical activity in the prime-moving muscle to the initiation of the movement.
5. Simple reaction time reflected the time required to initiate a movement response following the presentation of a single visual stimulus.

Limitations

The following limitations apply to this study.

1. The results of this study cannot be inferred to other special populations.
2. Not all testing was performed at the same site, resulting in fluctuations of a controlled laboratory environment.

Delimitations

The 20 subjects, 10 spastic hemiplegic cerebral palsied and 10 non-handicapped youth, ranged in age from 12 to 16 years. Each subject performed two blocks of 30 trials. The premotor, motor, SRT, and movement time measurements for each trial were obtained. The first five trials in each block were designated as warm-up trials, with the remaining 25 trials designated as test trials. The subject's starting position for each trial was standardized, ensuring that the biceps brachii was the major muscle involved in the initiation of the movement. Following the onset of the stimulus, the subject raised a stylus held in the right hand, vertically over a wooden barrier and then laterally to the right to contact either a large or small rounded target. The smaller target was 5.1 cm in diameter and the larger target was 10.2 cm in diameter. The subjects performed one block of 30 trials with each target. The subjects were all right-hand dominant.

Definitions

Catch Trial. A trial in which the visual stimulus does not follow the warning signal.

Cerebral Palsy. A nonprogressive disorder affecting movement and posture. The onset due to disease or neurological damage to the brain.

Closed-loop. A mode of operation which employs the use of visual feedback to achieve the movement's endpoint.

Correct Trial. A trial in which the response was initiated after the onset of the visual stimulus and was completed with the depression of the endpoint target and before a predetermined time limit.

Foreperiod. The time interval between a warning signal and the onset of a stimulus.

Fractionation of Reaction Time. The division of reaction time into its premotor (central) and motor (peripheral) components.

Motor Program. An abstract representation of an overt motor action.

Motor Time. The time interval from the first change in electrical activity in the prime-moving muscle to the first perceptible movement.

Movement Time. The time interval from the initiation of a movement to its completion.

Premotor Time. The time interval from the onset of a stimulus to the appearance of a muscle action potential in the prime-moving muscle.

Response Time. The time interval from the onset of the stimulus to the completion of the movement.

Simple Reaction Time. The time from the onset of a single visual stimulus to the initiation of a movement response.

Spastic Hemiplegia. A common form of a cerebral palsy affecting both limbs on the same side the body.

Speed-Accuracy Trade-Off. As the accuracy demand increases, time increases, and as the accuracy demand decreases, movement time decreases.

CHAPTER II

REVIEW OF LITERATURE

In order for practitioners and theoreticians to understand and evaluate the proficiency of movement, the body of knowledge concerning the variables which affect the learning and performance of movement must be examined. The early research in movement and learning is found in the areas of psychology and neurophysiology. The common interests shared by both fields became evident through increased open communication in the latter part of the 1970s.

Woodworth and Schlosberg (1954) suggested that reaction time could be used to determine the time required to process incoming stimulus information, and the efficiency of a movement. Investigators are continuing to examine and research the theories related to information-processing to better understand the learning of a motor skill. This chapter is divided into the following sections: (a) current theory of motor behavior, (b) reaction time paradigm, (c) Simple Reaction Time compared to Choice Reaction Time paradigm controversy, (d) fractionation of Simple Reaction Time, and (e) spastic hemiplegic cerebral palsy.

Current Theory of Motor Behavior

Psychologists and, more recently, motor behaviorists have studied the processes by which motor skills are developed. An increasing amount of research has been designed to investigate the learning of motor skills within a neurological framework. Questions have been addressed pertaining to the way in which incoming sensory information is stored and retrieved from memory and finally organized prior to translation into the appropriate efferent motor commands.

Early theorists forwarded the idea that every plan for a motor skill was stored as a neural structure. There were two major problems with this line of reasoning. First, given the many thousands of motor skills one learns throughout the course of a life span, the amount of space required in memory for storage would be extensive. The second problem related to the ability of individuals to perform movements never before seen. If individual motor programs were stored in memory based upon past experiences, how could a novel skill be performed?

Schmidt (1982) proposed the generalized motor program as a solution to the problems of storage and novelty. This schema concept, with the generalized motor program as its central operating component, stated that prior to movement a decision is made concerning the most appropriate motor program to run. The program is then retrieved from memory and stored in a buffer where the program is readied. Decisions are made concerning the movement parameters of overall duration, force, spatial aspects, and movement extent. These modifications are then applied to the retrieved general motor program, making it specific to the situation and the movement to be performed.

The ability to perform a variety of motor skills is accomplished by supplying a new set of initial conditions (i.e., force, direction, extent) to the program according to the environmental context in which the skill is to be performed. For example, an individual using an overhand throw who wanted to hit a target with a baseball would retrieve from memory a generalized motor program of throwing. To make the program specific to the situation, an appropriate set of initial conditions would be supplied (e.g., stance of the person relative to the target) in conjunction with the appropriate movement parameters, such as the force which must be applied to the ball, the direction of the flight of the ball, and the extent of the arm movement. In addition, environmental factors such as wind, which might compromise successful performance of the motor skill, would be supplied to the generalized motor program.

The schema concept proposed by Schmidt (1982) further states that once the response has been executed four types of information are briefly stored. The types specified are (1) the parameters of the response (i.e., force, direction, and extent); (2) movement outcome, or what happened in the environment, which is obtained through feedback or knowledge of the results of the response; (3) sensory consequences which describe the sensory feedback produced by the response; and (4) initial conditions which are determined by the initial state of the body and environment. A relationship between the newly stored information is "abstracted" to generate or update a rule which describes the relationship. As experience in performing the same and/or similar movement increases, the rule or schema is strengthened because of the updating taking place after performance of the particular skill. Moreover, Schmidt concluded that the more variety introduced to the skill environment (e.g., throwing a ball at a target from various distances), the stronger the schema.

Reaction Time Paradigm

Historically, the reaction time paradigm has served as the primary means of both quantifying and describing the underlying neurological mechanism involved in the formulation of motor programs. As early as 1868, Donders sought to isolate information-processing into discrete and well defined stages. Sternberg (1969) later refined Donders' subtraction method by manipulating the amount and level of information processed. Using Simple Reaction Time (SRT), Henry and Rogers (1960) tested the effect of task complexity upon information-processing operations. Sternberg, Monsell, Knoll and Wright (1978) studied the effects of task complexity on information-processing, using verbal and fine motor skills rather than the gross motor tasks studied by Henry and Rogers. Conversely, another group of researchers (Klapp, Anderson & Berrian, 1973; Klapp, 1974; Klapp, Wyatt, & Lingo, 1974; Klapp, 1977) employed a Choice Reaction Time (CRT) paradigm to study the nature of programming operations. These researchers believed that the SRT paradigm was severely limited as a means of explaining the way in which motor programs were formulated and subsequently executed.

Pre-1900 Research

Perhaps the first attempt to empirically define the information-processing operations or stages involved in planning movement responses was offered by Donders in 1868. Donders designed a series of experiments to evaluate "The Speed of Mental Processes." The first of three tasks used by Donders involved a SRT task. The second task involved CRT where the movement response was determined by the stimulus. Following the onset of one of two possible lights, the subject was to execute the movement paired to the triggered light. The third task measured Disjunctive Reaction Time (DRT), which required the subject to discriminate between relevant and irrelevant stimuli and then make a decision to respond if the stimulus was that originally matched to the correct movement response. In this task, light A and light B were the stimuli. Light A required a response, whereas light B required no response.

Donders believed the measurement of SRT, which required the subject to recognize and respond to a single stimulus, represented the first stage in the processing of information. Choice reaction time, which represented the second stage in the processing of information, involved stimulus categorization in which the subject had to decide which stimulus had been presented. The third stage of information-processing, which encompassed each of the components of the SRT and CRT tasks, was reflected by the DRT task which involved (a) the simple reaction or initial response to the stimulus, (b) stimulus-categorization, and (c) response selection, reflecting the time required to select the appropriate movement.

Using the three stages, Donders developed the subtraction method of reaction time which attempted to isolate each time segment involved in the processing of information. Donders believed each stage was an independent unit which could be subtracted from one or both of the remaining two stages to provide chronometric information concerning the speed of specific information-processing operations.

Post 1900 Research

Sternberg (1969) extended Donders' work, shifting the research emphasis from quantifying the speed of the information-processing to describing the nature of the processes involved. To accomplish this task, Sternberg manipulated several variables thought to affect specific information-processing stages. For example, degrading the integrity of a stimulus was believed to affect the stimulus-categorization stage. Subsequent experimentation revealed this to be the case, with SRT increasing significantly as the stimulus was further degraded.

Contrary to Donders' results, Sternberg (1969) found that by adding or deleting stages, other stages were affected. According to Donders' subtraction method, the duration of recognition is equal to CRT - SRT. Sternberg proposed that to subtract a SRT measurement from a CRT measurement does not address variables that affect the recognition time, such as the integrity of a stimulus. The experimental findings showed that manipulation of certain variables yielded additive effects and were, therefore, acting upon different stages of processing while others did not. Sternberg concluded that the stages proposed by Donders were not discrete, but, overlapped, so that a second stage might begin as the preceding one was ending.

Sternberg (1969) proposed the additive factor method to explain how incoming information is processed and translated into overt motor action. Despite contrasting theoretical interpretations of the experimental results, both Donders and Sternberg remained convinced that the processing of information occurred in relatively distinct stages.

Henry and Rogers (1960) studied information-processing through the manipulation of task complexity. The memory drum theory, a product of Henry and Rogers' research, was based on the assumption that there is a store of unconscious motor memory which can be thought of as a memory storage drum. An unconscious mechanism uses the stored information to channel afferent impulses and stimuli to neuromotor coordination centers. Commands are sent from the centers via efferent neural pathways to produce the desired overt motor response. Henry and Rogers proposed that reaction time increased as a function of increasing task complexity (i.e., accuracy demands and number of connected movement parts comprising the task). Using a SRT paradigm, Henry and Rogers measured information-processing abilities through preprogrammed movements. Comparison of the SRTs obtained for each of the three complexity levels provided support for the memory drum theory. Increasing the number of connected movement parts from one to three resulted in significant increases in the time required to initiate the movement. Additional support for the notion that increasing the number of connected movement parts leads to increases in reaction time was confirmed in experiments conducted by Christina, Fischman, Vercruyssen, and Anson (1982), and Fischman (1984). The results also suggested that the time to initiate a movement was significantly affected by manipulating the accuracy demands of the tasks (Christina et al., 1982). Conversely, no effect upon SRT was found as a consequence of manipulating the number of directional changes required throughout the course of the movement. Such a finding suggests that the movement component of direction is not included in the motor program controlling the motor skill.

Sternberg, Monsell, Knoll, and Wright (1978) manipulated task complexity in both the verbal and motor domains. Sternberg et al., proposed that a motor program, representing the movement response to be performed, is constructed after the onset of the stimulus and prior to the execution of the response. The retrieved program consists of a randomly organized set of subprograms which are placed in a motor program buffer believed to be distinct from short-term memory. Following the onset of the stimulus, a search through the set of unordered subprograms begins for the purpose of serially ordering them prior to execution. Such a theoretical construct was proposed on the basis of experimental results which showed SRT to increase linearly as a consequence of increasing the number of subprograms comprising the total motor program. In terms of the experimental task used, increasing the number of syllables comprising a word, or number of keystrokes comprising a movement sequence, increased the time required to initiate the first response.

Based upon a different definition of programming from that used by Henry and Rogers (1960), Klapp, Wyatt, and Lingo (1974) chose to utilize the CRT paradigm. According to Klapp et al., programming time included the time required to select and assemble the subprograms in a motor program, retrieve each of the assembled subprograms, and, finally, execute the whole motor program. Using SRT as a control condition for the purpose of comparing the non-programming effects upon reaction time, Klapp et al., employed short and long duration key presses in a choice situation to test the effects of task complexity on the time required to initiate the chosen movement response.

Simple Reaction Time Versus Choice Reaction Time Paradigm

The controversy concerning which of the two reaction time paradigms is the most appropriate to use in the study of motor programming did not arise until Klapp, Wyatt, and Lingo (1974) questioned Henry and Rogers' (1960) use of the SRT paradigm when testing the effects of movement complexity on reaction time. Klapp et al., hypothesized that if an effect was found, by changing the parameters of a movement, it would be robust only for CRT. Whereas with SRT the effect would be unreliable and disappear with practice and instruction. Klapp (1977) continued the debate in a review paper in which he stated that CRT would more accurately reflect the time to program, and subsequently execute, a movement response, since in a CRT task the subject does not know the response to be performed until the onset of the stimulus.

Henry and Rogers (1960) considered using the CRT paradigm but ultimately rejected it on the grounds that if a longer reaction time was found, the cause could be the complexity of the task and/or the effect of the response selection in the CRT paradigm. Another concern addressed by Henry and Rogers was based on their definition of programming, which encompassed only the retrieval, read-out and translation of a stored neuromotor program into efferent commands. The initial selection of the motor program was not a component of their definition.

Sternberg, Monsell, Knoll, and Wright (1978) also employed the SRT paradigm in their research. The reasons for such a choice were guided by a desire to eliminate the possible effects of previous stimulus-response mappings where the same stimulus produced a different response. Sternberg et al., indicated that the possibility of the effects of response-response compatibility, meaning other possible responses influence the required response because of their similarities, would influence the results in a CRT paradigm. Growing evidence was reported by Sternberg et al., of the influence of the number and kind of possible responses on reaction time. For example, in a binary choice study Berlyne (1957) found the latency of a response was shorter when it was paired with another response performed at the same time. Kornblum (1965) suggested a shorter latency of a response was evident when a finger on the opposite hand also performed the response, whereas Megaw (1972) found that the shorter latency of a response was a result of the binary response movement being performed in the same direction. Sternberg et al., (1978) concluded that the SRT paradigm better controlled for response influences, thus producing results more representative of the time required for planning the execution of a motor program.

Concerning the SRT - CRT paradigm controversy, the point of disagreement appears to be based upon the different definitions of programming proposed by various investigators. Henry and Rogers (1960) and Sternberg, Monsell, Knoll, and Wright (1978) employed the SRT paradigm to study the effect of task complexity on reaction time using very different tasks. Both studies produced robust results which were replicated in later research by Christina, Fischman, Vercruyssen, and Anson (1982), and Fischman (1984).

Both CRT and SRT paradigms have proven successful in motor behavior research. The research question to be studied is the major factor in deciding which paradigm to use. The SRT paradigm appears to be the most appropriate choice when measuring the effect of task complexity upon the programming of a response as originally defined by Henry and Rogers (1960).

Fractionation of Simple Reaction Time

The increasing use of electromyography (EMG) has provided researchers with the opportunity to more precisely fractionate reaction time into a central (premotor) and peripheral (motor) component. Empirically, the first measured component, premotor time, measures the time from the onset of the stimulus to the first sign of heightened electrical activity in the prime-moving muscle displayed in the form of an EMG waveform. The second component, motor time, measures the time from the first change in EMG activity in the prime-moving muscle to the first observable movement of the involved limb. Motor time is quantified by the subtraction of premotor time from simple reaction time.

Behaviorally, the premotor time component is hypothesized to reflect the information-processing or motor programming operations occurring within the central nervous system. These operations primarily involve the retrieval of a randomly organized motor program from long-term memory appropriate for the intended movement and its subsequent organization and translation into efferent motor commands. In contrast, the motor time component reflects peripheral processes more related to biomechanical constraints and/or physiological processes occurring at the site of the prime-moving muscle. Such processes are not believed to be related to the motor programming process. Weiss (1965) fractionated SRT to study the variables of age, foreperiod, and motivation and their effects upon the time required to initiate a movement response. Weiss found that changes in reaction time were evident in the premotor time component due to manipulating variables of motivation and foreperiod. The premotor time increased as a function of decreasing the level of subject motivation and length of the foreperiod. The increase in this central component was reported to be greater in the older age group (65 to 80 years) than the younger age group (18 to 30 years). This study was unique because it was the first known attempt to fractionate reaction time using surface EMG recordings and it employed, as subjects, a section of the population not previously studied, the older adult.

Schmidt and Stull (1970) tested the effect of increasing muscular pre-tension on premotor and motor time of a SRT task. Subjects were required to apply muscular tension by squeezing a hand grip device, modified from a hand dynamometer, prior to the onset of a stimulus, and increasing the force applied following its onset. The data indicated significant changes in the central and peripheral components as a function of increasing pretension, but in opposing directions. As the amounts of muscular pretension to be applied increased, the motor time component increased but the central premotor component decreased. Employing Henry and Rogers' (1960) definition of programming, Schmidt and Stull hypothesized that the partial muscular contraction was the same as partially initiating a motor program to contract. By further increasing the tension, less programming time was required which Schmidt and Stull hypothesized would be reflected in a shorter premotor time. This hypothesis was supported by the empirical findings.

A second study employing older adults as subjects was conducted by Clarkson and Kroll (1978). Fractionated reaction time measures were obtained to study the effects of age and level of physical activity on the time to initiate a knee-extension task. Four groups of male subjects, partitioned according to age (older versus younger) and activity level (physically active versus inactive), were tested in both SRT and CRT conditions. The premotor and motor times revealed that both physically active groups were faster to initiate the required movement than the physically inactive groups. The physically active groups remained significantly faster, despite the physically inactive groups improving significantly more with practice. Simple reaction time for the two older groups yielded statistically significant practice effects, as demonstrated by the shorter premotor and motor times over the blocks and days of testing. Furthermore, overall CRT measures decreased significantly for both younger adult groups and older physically inactive adult groups. Lowered CRT resulted due to significant decreases in both the premotor and motor time components. Only the movement times for SRT and CRT showed significant improvement among the two physically inactive groups. On the measure of movement time, the older active adult groups was more similar to the young inactive group than to the old inactive group in both the SRT and CRT tasks. The authors concluded, with respect to the reaction time measures, that regular physical activity may lessen the effects of aging on reaction time and movement time as well as reduced interindividual variability.

Fractionated reaction time has subsequently been used by Anson (1982) to further test the conclusions forwarded earlier by Henry and Rogers (1960), concerning the effect of increasing task complexity upon the SRT measure. Alternative explanations for Henry and Rogers' findings were explored by Anson who manipulated peripheral factors such as target size, movement extent, and size of the unit used to perform the movement response (i.e., finger lift versus elbow flexion versus shoulder flexion). Fractionation of SRT into its premotor and motor time components enabled Anson to isolate central processing effects from the peripheral factors of interest. Anson found that by requiring subjects to perform the required movement using shoulder flexion as opposed to only finger or elbow flexion, the motor time component of the SRT measure increased significantly. Conversely, no significant increases in the premotor component were observed as a function of increasing the size of the anatomical unit performing the task. Anson concluded that biomechanical factors, such as size of anatomical unit, were unrelated to central programming operations and accounted for some of the increases in SRT previously observed by Henry and Rogers.

More recently, Christina and Rose (1985) used fractionated reaction time to study the effects of increasing individual movement parameters, such as the number of movement parts and accuracy demands in a gross motor task. The effect of the combinations of these same movement parameters was also analyzed. The experimental findings showed that premotor time increased as a function of increasing the number of movement parts comprising the movement response from one to two and increasing the accuracy demands involved in the task. No significant increases were found for the peripheral motor component. Of greater research interest was the finding that by combining both movement parts, the premotor time was increased more significantly than by increasing either of the movement parameters alone. The effects of an increase in task complexity were found in the premotor time. The authors attributed the increases in premotor time to a longer motor program comprised of more subprograms because the complexity of the task was increased. The disproportionate increase in premotor time, observed as a result of combining the movement parameters of movement accuracy and number of movement parts, was hypothesized to be due to a longer over all "unpacking" operation of each subprogram.

Spastic Hemiplegia Cerebral Palsy

Cerebral palsy, as described by Batshaw, Perret, & Harryman (1981), is any movement or posture disorder which is a result of a nonprogressive abnormality of the immature brain. The brain has been reported to mature around 16 years of age (Batshaw, Perret, & Harryman, 1981). Although cerebral palsy does not progress, the effects of the disorder may change as the individual physically matures.

Cerebral palsy is not a disease, but rather a group of disorders. It is diagnosed by three major factors: (1) the onset of the disorder occurs before the brain reaches maturity, (2) the damage to the brain is not progressive, and (3) at least one motor impairment is of cerebral origin (Low and Downey, 1982).

Hagberg (1979) reported that for approximately 60% of the cases of cerebral palsy the cause can be determined. The known causes include events which happened during the first trimester of pregnancy, such as exposure to radiation, intrauterine infection, and chromosonal abnormalities, which account for 7% of the cases. Abruptio placenta and fetal malformations which take place in the later stages of pregnancy contribute to 32% of the cases. Problems arising during labor and delivery account for 17%, and neonatal problems such as prematurity, and asphyxia are found in 39% of the cases. The final 5% of the cases are the product of meningitis, head trauma, lead intoxication, and other early childhood disorders (Hagberg, 1979). Low and Downey (1982) characterized low birth weight as the most frequent single common denominator in cerebral palsied individuals. These authors noted that 25% of children with cerebral palsy had a birth weight of less than 2,500 grams.

Cerebral palsy is classified according to the observable limitations of the disorder. The three major classifications are (1) pyramidal, (2) extrapyramidal, and (3) mixed. In this study, only the pyramidal classification will be addressed.

The classification "pyramidal" is represented by a spastic condition which is the result of damage to the motor cortex or to the pyramidal tract of the brain. Signals for voluntary movement are sent from the motor strip of the frontal lobe to the spinal cord by way of the pyramidal tract. Damage to any part of the pathway of nerve impulses going from the brain to the spinal cord leads to spasticity (Batshaw, Perret, & Harryman, 1981).

Different parts of the body are affected depending upon the location of the damaged area of the brain. The premature infant has a fragile area at the superior part of the motor strip. Although blood vessels are nearby, they lack deep roots to supply oxygen and nutrients to the strip. If a premature infant experiences hypoxia, this part of the brain is the first to be affected. The results is spastic diplegia, where all four limbs are affected, with the legs affected more than the arms. The hands may just appear to be clumsy in grasping (Nelson, Vaughn, McKay, & Behrman, 1970).

Damage to one side of the cerebral cortex results in paralysis of the opposite side of the body since nerve fibers cross over before they enter the spinal cord. This pyramidal cerebral palsy is termed spastic hemiplegia (Batshaw, Perret, & Harryman, 1981). Low and Downey (1982) explain that partial lobe damage may result in impairment of sensory-cortical function. This is manifested in the individual's absence of or reduction in the ability to recognize size, shape, and texture of objects when held in the affected hand. The involved arm in spastic hemiplegia is flexed with pronation of the forearm and flexion of the wrist. Nelson, Vaughn, McKay, & Behrman (1979) further characterized the results as a limp in the gait. The face is rarely involved. In right-sided hemiplegia of postnatal origin, speech may be affected, but if the right-sided hemiplegia is congenital in nature no speech defects are found (Jolly, 1981). Although intelligence varies in this group, severe mental retardation rarely appears. The level of intelligence is dependent upon whether the brain lesion was confined to one hemisphere of the brain (Nelson et al., 1979). Convulsions are commonly found in this category of the cerebral palsy.

Summary of the Literature

The use of reaction time, whether it be CRT or SRT, appears frequently in the literature and has constituted the most popular method for the study of information-processing. The advent of electromyographic techniques has enabled researchers to fractionate reaction time into its premotor, or central processing component, and motor, or peripheral component. The purpose of this dissertation was to quantify, using EMG, the underlying information-processing operations used by spastic hemiplegic cerebral palsied youth in the execution of a gross motor task.

Previous research concerning information-processing has not been conducted with spastic hemiplegic cerebral palsied youth. As a result of the lack of empirical data, it remains unknown whether cerebral palsied youth process information in a similar manner of non-handicapped youth. Perhaps the size of a motor program for the cerebral palsied might vary from one employed by the non-handicapped. The program may be longer as a consequence of a greater number of subprograms and, therefore, would subsequently require a greater length of time to execute. If this is the case, would one expect to find cerebral palsied youth significantly slower in initiating the movement? How might increasing the accuracy demands of a task affect the time required to initiate a movement?

An alternative account of the findings might suggest that information-processing is similar for the cerebral palsied and non-handicapped youth and any differences observed in the time to initiate a movement response and the increased reaction times are wholly attributed to peripheral deficiencies (i.e., diminished muscular strength, and decrease in motor unit recruitment). The deficiencies experienced by cerebral palsied youth may be unrelated to the time required to program the intended movement.

The fractionated reaction time paradigm provides the opportunity to more precisely determine the locus of changes in SRT which may or may not be observed among spastic hemiplegic cerebral palsied youth, when compared to non-handicapped youth. The empirical findings of such a study may, indeed, provide important implications for the teacher of the cerebral palsied child.

CHAPTER III

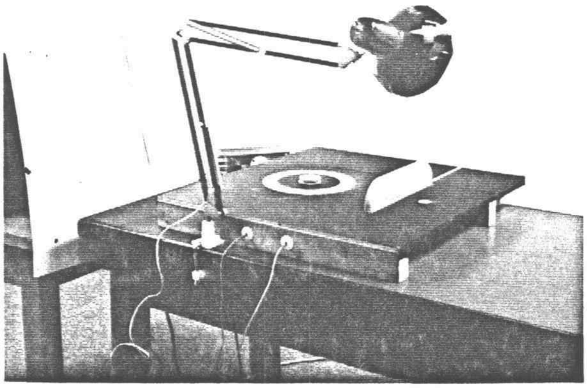
METHODS AND PROCEDURES

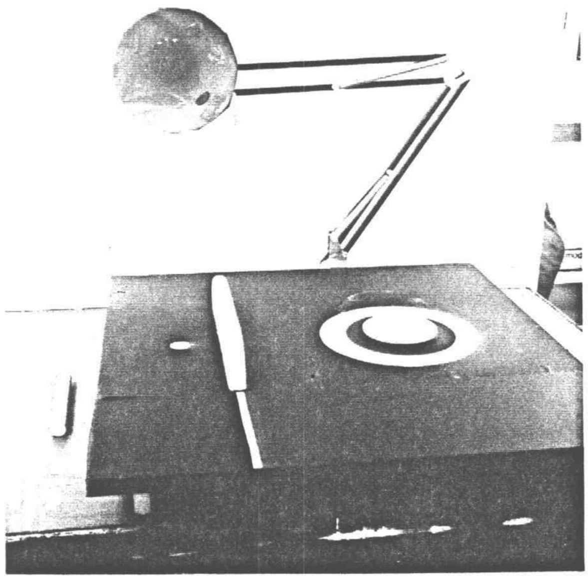
The purpose of this research was to study the effects of cerebral palsy on the ability to plan and execute a gross motor movement, as measured by the fractionation of Simple Reaction Time (SRT). Specifically, answers to two questions were sought: (a) whether differences exist with respect to information-processing abilities between spastic hemiplegic cerebral palsied youth and non-handicapped youth, and (b) whether increasing the accuracy demands of a gross motor task differentially affects the cerebral palsied youth when compared to non-handicapped youth. This chapter is divided into the following sections: (a) apparatus, (b) subjects, (c) task, (d) trial-to-trial procedures, and (d) treatment of data.

Apparatus

The test apparatus used is illustrated in Figure 1. The apparatus consisted of a 52.0 cm x 61.0 cm plywood platform raised 7.0 cm above a standard laboratory table (73.0 cm in height). The starting position consisted of a white circle (1.6 cm in diameter) surrounding a centrally located microswitch. A wooden stylus (15.0 cm

Figure 1. Experimental Apparatus.

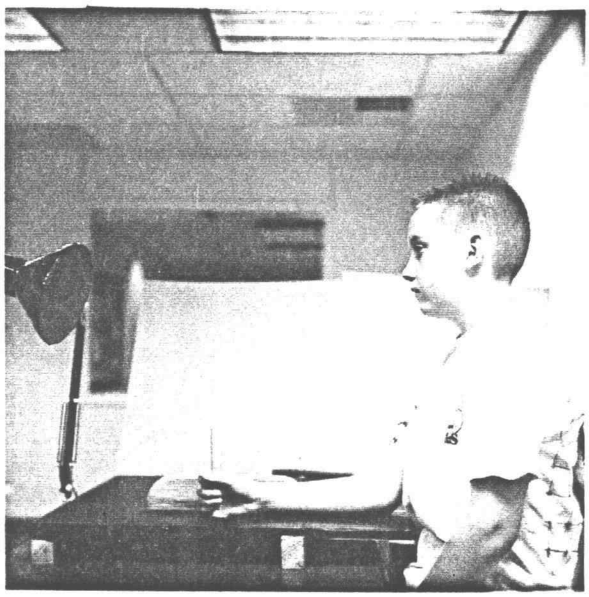




in length, 1.6 cm in diameter) was used in the execution of the movement response. The weight of the stylus when grasped by the subject resulted in the depression of an underlying microswitch. To ensure the subjects' use of the biceps brachii as the prime-moving muscle, a 1.9 cm x 29.6 cm x 6.4 cm wooden barrier was mounted on the platform 5.4 cm to the right of the center of the starting position. The use of the barrier also ensured that the initial segment of the movement was standardized for each trial. The subject's position with respect to the test apparatus is illustrated in Figure 2.

The center-to-center linear distance from the starting position to both the large and small targets was 30.0 cm. The interchangable targets were red discs with a diameter of 5.1 cm for the small target, and 10.2 cm for the large target. The target was surrounded by a concentric annular black region with an inner radius of 2.6 cm (small target) and 5.1 cm (large target), and an outer radius of 7.5 cm. The black annular region was in turn surrounded by a concentric white annular region with an inner radius of 7.5 cm and an outer radius of 10.9 cm. The white and black concentric circles were overlaid on the platform. The red target, raised 1.0 cm

Figure 2. Subject seated at experimental apparatus.



from the white and black concentric circles, was parallel to the platform. To reduce visual confusion, the platform of the apparatus was colored black and contrasted against the two red interchangable targets.

The starting position microswitch was activated by the raising of the stylus, while a second microswitch, placed under the end-point target, was activated when depressed by the hand-held stylus. Approximately 140 grams were necessary to depress the underlying target microswitch.

An Automatic Performance Analyzer (APA) (Dekan Model 741), interfaced with the apparatus, was used to record both the SRT and total movement time of each response. A push button switch, by means of a relay, was used to trigger the onset of the visual stimulus (green colored light) and APA, and the oscilloscope. The light stimulus was attached to the back of the apparatus on an adjustable arm to ensure the light was at eye level for each subject. A consistent foreperiod was ensured by using a light emitting diode, visible only to the experimenter, flashing at an interval of 2.0 seconds.

A Nicolet digital oscilloscope (Model 3091) was also interfaced with the apparatus and was automatically triggered with the onset of the green light. The electromyographical (EMG) trace, obtained from the oscilloscope, indicated the onset of heightened electrical activity from baseline at approximately the center of the biceps brachii muscle. Premotor time for each trial was obtained by lining the cursor up on the oscilloscope with the first change in electrical activity above baseline. Motor time was obtained by subtracting premotor time from SRT. A pair of silver chloride disk pellet biopotential surface electrodes was placed along the center of the biceps brachii of the right arm to obtain the EMG signal. The centers of the pair of electrodes were placed approximately 2 cm apart, and a ground electrode was placed 1 cm above the elbow. Adhesive collars were applied to the electrodes and the centers of the electrodes were filled with electrolyte gel. The raw EMG signal from the muscle was passed through a high-impedance differential AC microelectrode preamplifier (Grass Instruments, Model P15) powered by a 9-volt battery pack, to the oscilloscope (Nicolet, Model P15D). Based on a sweep trigger speed of 500 ms, the EMG signal was converted to a digital value by the oscilloscope. The input voltage range was set at $\pm$ 1 volt. The subject was seated directly in front of the apparatus on an adjustable stool so that the right shoulder was 1.0 cm to the left of the barrier. To ensure that the arm's starting position was identical on all trials, a line of tape (0.4 cm x 8.0 cm) was placed on the apparatus 1.0 cm to the left of the barrier as a guideline.

Subjects

All necessary forms were filed and approval was obtained from the Oregon State University Human Subjects Committee (Appendix A). Permission was granted by the parents of twenty youth to participate in the experiment. The subjects were subsequently assigned to one of two groups. Group I was comprised of randomly selected non-handicapped individuals attending public schools in Corvallis, Oregon. Group II consisted of spastic hemiplegic cerebral palsied youth who were identified with the assistance of the Oregon Health Sciences University and the Portland Motor Development Team. Each subject in Group II was classified spastic hemiplegic cerebral palsy, which impaired the left side, by the subject's physician according to accepted medical guidelines. The subjects were obtained from the areas of Portland, Salem and Eugene, Oregon. The subjects' ages ranged from 12 to 16 years. The number of males and females selected was not controlled. Participants in the non-handicapped group were selected because they were similar to the cerebral palsied subjects in hand-dominance, age, gender, and intelligence. Similar to the cerebral palsied subjects the non-handicapped subjects resided at home. Intelligence levels were determined by the Stanford-Binet or Wechsler Intelligence Scales for Children-Revised, administered by qualified public school personnel. There was no evidence of visual and/or auditory impairment for any of the subjects. Participation in the study was voluntary and dependent upon permission being obtained from the subjects' legal guardians (Appendix B). Testing sites were selected to ensure minimal travel time for each subject.

Task

In a seated position, the subject grasped the stylus with the right hand, and depressed the starting microswitch. The subject was instructed to begin the movement immediately following the onset of the green light and move the stylus as quickly and accurately as possible to depress the red target. The stylus was moved in an upward direction, followed by a lateral movement to the right. The order of the initial presentation of the two targets was counterbalanced across subjects to minimize order effects.

Each subject performed two blocks, comprised of 30 correct trials, with a scheduled rest period of two minutes between each block of trials. Ten practice trials were given prior to each block of trials. The first five trials of each block served as warm-up trials leaving the remaining 25 as test trials. A test trial was considered incorrect and repeated if; (1) the subject did not hit the target with the grasped stylus, (2) the subject responded on a catch trial, (3) the subject moved the stylus before the onset of the green light, (4) a reaction time was under 140 msec., (5) the movement time for a non-handicapped subject exceeded 600 msec., or (6) a cerebral palsied subject's movement time exceeded 800 msec. Each subject participated in one testing session, which lasted approximately 70 minutes.

Procedures

Prior to the beginning of the experimental session, each subject and legal guardian was carefully briefed on pertinent details of the experiment. The following information was provided: (a) general purpose of the study, (b) experimental protocol to be utilized, (c) nature and function of the laboratory apparatus to be utilized in the collection of data, (d) procedures used in applying EMG electrodes, and (e) time commitment required of each subject. An informed consent form (Appendix C) was signed by the youth's legal guardian prior to the subject's participation in the study.

The biceps brachii was determined to be the prime-moving muscle for rapid elbow-flexion responses. Standard procedures were used in preparing the site and attaching the electrodes to the middle of the biceps brachii of the right arm (Basmajian, 1985). Following the application of the electrodes, the task was demonstrated by the experimenter several times. The subject was instructed to contact the target by moving the stylus as quickly and accurately as possible. Following the demonstrations, the subject was given the opportunity to ask questions and practice the movement response.

A verbal "Ready" command, spoken by the experimenter, was followed by a two second foreperiod before the onset of the visual stimulus, which signaled the beginning of the trial. To minimize the effect of the subject's anticipation, catch trials were randomly inserted in 20% of the trials in each block.

Feedback was given to both groups dependent upon the recorded movement time for each trial. The experimenter said "Excellent" to a non-handicapped subject for a movement time of 450 msec. or less and to a cerebral palsied subject if the movement time was 500 msec. or less. "Very good" was used when a non-handicapped subject's time was 451-479 msec., and a cerebral palsied subject's time was 501-529 msec. The feedback, "Good" was used if a non-handicapped subject's time was 480 msec. or more, or if the time was 530 msec. or more for the cerebral palsied subject. Upon completion of each trial, the simple reaction time and total movement time data were recorded along with the digital value of the premotor time.

Treatment of Data

A 2 x 2 (group x target size) split-plot factorial design was used to analyze the dependent measures of SRT, premotor time, motor time, and movement time. The first factor, group, was treated as a between-subjects factor, while the second factor, target size, comprised a within-subjects factor. The probability of a statistical test had to be less than the alpha level of 0.05 to be considered significant. According to Kirk (1982) to reduce Type II errors and to achieve a 0.80 level of power, ten or more subjects are required to represent the population. To determine whether the mean of the 50 test trials in blocks 1 and 2 constituted a reliable measure of each individual subject's performance, one-factor, repeated measures analyses of variance (ANOVA) were conducted for each of the dependent measures. If the resulting F ratio failed to reach significance ($p < .05$), an intraclass reliability coefficient was calculated for each dependent measure. The Standard Error of Measurement (SEM) was also calculated in conjunction with the reliability coefficient for each dependent measure.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of the study was to analyze the effects of cerebral palsy on the ability to plan and execute a gross motor movement, as measured by the fractionation of Simple Reaction Time (SRT). Answers to two questions were sought; (a) whether differences existed with respect to information-processing abilities between spastic hemiplegic cerebral palsied youth and non-handicapped youth, and, (b) whether increasing the accuracy demands of a gross motor task differentially affected the cerebral palsied youth when compared to non-handicapped youth. Data were collected from ten non-handicapped youth and ten spastic hemiplegic cerebral palsied youth over two blocks of thirty trials. The premotor, motor, SRT, and movement time measurements for each trial were obtained. This chapter is divided into the following sections: (a) description of subjects, (b) descriptive statistics of the dependent measures, (c) summary of findings, and (d) discussion.

Description of Subjects

The subjects for the study were ten spastic hemiplegic cerebral palsied youth and ten non-handicapped youth. Group I was comprised of randomly selected non-handicapped individuals who attended the public schools in Corvallis, Oregon and Group II consisted of left side impaired, spastic hemiplegic cerebral palsied youth who were identified with the assistance of the Oregon Health Sciences University and the Portland Motor Development Team. Each subject in Group II was classified as an individual with spastic hemiplegic cerebral palsy by the subject's physician according to accepted medical guidelines. The subjects were obtained from the geographic regions of Portland, Salem, and Eugene, Oregon. Participants in the non-handicapped group were selected because they were similar to the cerebral palsied subjects in hand dominance, age, gender, and intelligence. Similar to the cerebral palsied population, the non-handicapped subjects resided at home. Intelligence levels were determined by the Stanford-Binet or Wechsler Intelligence Scales for Children-Revised, administered by qualified public school personnel. There was no evidence of visual and/or auditory impairment for any of the subjects. The subjects' ages ranged from twelve to sixteen years. Descriptive data concerning the subjects' age and gender are presented in Appendix D.

Descriptive Statistics of the Dependent Measures

A total of 50 test trials over two blocks of trials formed the basis for the calculation of intraclass reliability coefficients and standard errors of measurement for the four dependent measures, premotor, motor, SRT, and movement time. A repeated measures analysis of variance (ANOVA) was also conducted on each dependent measure for random, uncorrelated error variance due to trial-to-trial variation. The obtained F value was nonsignificant. Therefore, the mean of the 25 test trials of each block was utilized to represent each dependent measure for each subject. Computed intraclass reliability coefficients ranged from 0.93 to 0.99 for premotor, SRT, and movement time indicating that the mean for the 50 trials for these three dependent measures represented reliable scores. The computed intraclass reliability coefficients (r) ranged from 0.83 to 0.85 for motor time for the non-handicapped subjects, indicating that the mean for the 50 trials represented reliable scores. However, r ranged from 0.54 to 0.70 for motor time for the cerebral palsied subjects indicating variability within the group's scores.

The standard error of measurement was calculated for each dependent measure to study the amount of variance within the sampling distribution. Standard errors of measurement ranged from 1.90 ms to 11.09 ms. The intraclass reliability coefficients and standard errors of measurement are presented in Table IV.1.

Summary of Findings

Premotor Time

The first hypothesis predicted that spastic hemiplegic cerebral palsied youth require increased time to plan a gross motor response when compared to non-handicapped youth. A 2 x 2 (group x target size) ANOVA was computed for premotor time to test the prediction of the first hypothesis. A summary of the ANOVA results is presented in Table IV.2. The means (in ms) and standard deviations calculated as a function of group and target size for the dependent measure of premotor time are presented in Appendix E. Neither the two-way interaction between target size and group nor the main effect for target size were significant. Conversely, the main effect for group was significant (F (1, 18) = 5.18, $p < 0.05$).

Table IV.1

Reliability Coefficients and Standard Error of Measurement For Dependent Measures

Non-handicapped Large Target

	r	SEM
Premotor	.95	5.71
Motor	.85	1.90
SRT	.96	5.36
Movement	.99	5.87

Cerebral Palsy Large Target

	r	SEM
Premotor	.93	7.11
Motor	.54	2.25
SRT	.94	6.85
Movement	.99	10.69

Table IV.1 (Continued)

Non-handicapped Small Target

	r	SEM
Premotor	.95	6.71
Motor	.83	1.48
SRT	.96	6.80
Movement	.98	11.09

Cerebral Palsy Small Target

	r	SEM
Premotor	.94	7.44
Motor	.70	2.55
SRT	.93	8.47
Movement	.99	9.63

Table IV.2

Analysis of Variance

PREMOTOR TIMES

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained F	p
Group	1	7,856.81	7,856.81	5.18	.04*
Error	18	27,277.43	1,515.41		
Size	1	.03	.03	.00	.98
Size X Group	1	181.31	181.31	2.10	.16
Residual Error	18	1,550.43	86.13		

*Significant at the .05 level.

Empirical support was provided for the first hypothesis, since premotor time, assumed to be a measure of the time to plan a motor program, was significantly longer among the cerebral palsied youth when compared to the non-handicapped group. However, no empirical support was provided for the second hypothesis which predicted that the time required to plan a gross motor movement increases as the accuracy demands increase among both spastic hemiplegic cerebral palsied and non-handicapped youth.

Motor Time

A 2 x 2 (group x target size) ANOVA was computed for motor time. A summary of the ANOVA results is presented in Table IV.3. The means (in ms) and standard deviations calculated as a function of group and target size for the dependent measure of motor time are presented in Appendix F. Neither the two-way interaction between target size and group nor either of the main effects for group or target size were significant. It appears that differences observed between experimental groups were confined to the central information-processing component and not due to

Table IV.3

Analysis of Variance

MOTOR TIMES

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained F	p
Group	1	89.40	89.40	3.16	.09
Error 1	18	509.80	28.32		
Size	1	7.50	7.50	1.16	.30
Size X Group	1	.99	.97	.15	.70
Residual Error	18	115.95	6.44		

peripheral considerations (i.e., neuromuscular or biomechanical constraints).

Simple Reaction Time

The third hypothesis predicted that spastic hemiplegic cerebral palsied youth require increased time to initiate a gross motor response when compared to non-handicapped youth. Empirical support was not provided for this hypothesis, since the SRT, defined as the time from the onset of the stimulus to the initiation of the required response, of the cerebral palsied group was not significantly different from that of the non-handicapped group.

A 2 x 2 (group x target size) ANOVA was computed for SRT. A summary of the ANOVA results is presented in Table IV.4. The means (in ms) and standard deviations calculated as a function of group and target size for the dependent measure of SRT are presented in Appendix G. The two-way interaction between target size and group was not significant. Both the main effects of target size and group also failed to reach significance. Although there was not a significant difference between the obtained SRT scores of the cerebral palsied group

Table IV.4

Analysis of Variance

SRT

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained *F*	*p*
Group	1	6,131.57	6,131.57	3.73	.07
Error 1	18	29,553.72	1,641.87		
Size	1	1.85	1.85	.02	.89
Size X Group	1	186.11	186.11	1.95	.18
Residual Error	18	1,718.67	95.48		

and those obtained from the non-handicapped group, SRT approached significance ($p < 0.07$).

Movement Time

The movement time, or the time from the onset of the stimulus to the completion of the required response, was computed by using a 2 x 2 (group x target size) ANOVA. A summary of the ANOVA results is presented in Table IV.5. The means (in ms) and standard deviations calculated as a function of group and target size for the dependent measure of movement time are presented in Appendix H. The two-way interaction between target size and group was not significant. The movement time of the cerebral palsied subjects was significantly longer compared to those obtained from the non-handicapped subjects, F (1,18) = 5.28, $p < 0.03$. Similarly, the main effect for target size was also significant, F (1,18) = 13.48, $p < 0.00$. The fourth hypothesis predicted that spastic hemiplegic cerebral palsied youth require increased time to execute a gross motor response when compared to non-handicapped youth. Empirical support was provided for this hypothesis, since movement time was significantly longer for the cerebral palsied

Table IV.5

Analysis of Variance

MOVEMENT TIMES

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained *F*	*p*
Group	1	79,844.95	79,844.95	5.28	.03*
Error 1	18	272,452.59	15,136.26		
Size	1	2,669.96	2,669.96	13.48	.00**
Size X Group	1	209.40	209.40	1.06	.32
Residual Error	18	3,564.05	198.00		

*Significant at the .05 level.
**Significant at the .01 level.

group compared to the non-handicapped group in both target size conditions.

In summary, the first hypothesis, that spastic hemiplegic cerebral palsied youth require increased time to plan a gross motor response when compared to non-handicapped youth, was empirically supported.

The second hypothesis, which stated that the time required to plan a gross motor movement increases as the accuracy demands increase among both spastic hemiplegic cerebral palsied and non-handicapped youth, was not empirically supported. It appears that the small target might have been too large for the size of the target to affect the length of the motor program constructed.

The third hypothesis, that spastic hemiplegic cerebral palsied youth require increased time to initiate a gross motor response when compared to non-handicapped youth, was also not empirically supported. However, SRT approached significance.

The fourth hypothesis, that spastic hemiplegic cerebral palsied youth require increased time to execute a gross motor response when compared to non-handicapped youth, was empirically supported. Cerebral palsied youth exhibited significantly longer movement times in both the small and large target conditions when compared to non-handicapped subjects.

Discussion

Reaction time has proven to be a very useful measurement of the processing of information (Donders, 1868; Henry and Rogers, 1960; Sternberg, 1969; Sternberg, Monsell, Knoll and Wright, 1978). The more recent use of electromyography (EMG) has provided researchers with the opportunity to more precisely fractionate reaction time into a central (premotor) and peripheral (motor) component. Behaviorally, the premotor time component is hypothesized to reflect the information-processing or motor programming operations occurring within the central nervous system. The motor time component reflects peripheral processes more related to biomechanical constraints and/or physiological processes occurring at the site of the prime-moving muscle.

The empirical findings from this study indicate that the premotor times of the cerebral palsied subjects were significantly longer than the premotor times obtained for the non-handicapped subjects. The significant difference provides support for the hypothesis that cerebral palsied youth require more time than their non-handicapped peers to process information. Increases in premotor time have also been found in fractionated reaction time studies conducted on adult non-handicapped subjects by Clarkson and Kroll, (1978); Fischman, (1984); and Christina and Rose (1985). The manipulation of such variables as practice, direction of the movement, or number of movement parts comprising the response on the premotor and motor time components of SRT were conducted using adult non-handicapped populations. Although the present study manipulated the variable of accuracy using spastic hemiplegic cerebral palsied youth, it is apparent that research needs to be conducted with special populations to empirically measure the effects of variables on the fractionation of SRT. A longer premotor time reflected the effect of the dependent variable on the retrieval and execution of a preprogrammed movement. Therefore, the premotor time measurement appears to be a better dependent measure for the investigation of preprogrammed movements.

In keeping with Henry and Rogers' (1960) memory drum theory, Sternberg, Monsell, Knoll and Wright (1978) forwarded a sequence-preparation hypothesis based upon the idea that a motor program consists of unorganized subprograms which are stored in a memory buffer separate from short-term memory. Sternberg et al., further postulated that because the content in this memory buffer might decay rapidly, the organization of the subprograms into the order in which they are to be executed might not take place until after the onset of the stimulus. Furthermore, prior to the initiation of the preprogrammed response, each subprogram must be further unpacked into its lower order components before it can be executed. The unpacking of the subprogram components therefore represents advanced planning or retrieval on a lower level of the response hierarchy.

The results of the present study indicate that the premotor time, or the time to plan a movement response, of the cerebral palsied subjects is significantly longer than that of the non-handicapped group. This finding might suggest that cerebral palsied subjects experience greater difficulty in retrieving the first subprogram for the response unit it controls resulting in a longer search time. In addition, the unpacking of the components of each subprogram prior to execution might also be significantly delayed. Sternberg et al., (1978), have postulated that the time to unpack individual subprograms is affected by the size or type of response unit to be executed (e.g., as in typing, the successive keystrokes by the same versus alternating hands), unlike the earlier retrieval process which is affected by the number of subprograms or units in the response sequence to be executed. If, indeed, the cerebral palsied youth requires a longer motor program than a non-handicapped youth to perform a gross motor task, one would expect longer premotor times to result. Such a significant difference in premotor times was observed in the present experiment. The longer premotor time obtained for the cerebral palsied subjects might indicate that the retrieval or unpacking process for this population requires more time.

The effect of target size did not significantly affect the premotor times obtained for either group of subjects. This finding did not support the work of Christina and Rose (1985). These authors found, by increasing both the number of movement parts comprising the movement response as well as accuracy demands of the task, that the programming time was increased as reflected by significantly longer premotor times. This disparate finding may have resulted due to the present study's small target measuring 5.1 cm in diameter as compared to the 0.79 cm in diameter small target used in the Christina and Rose experiment. The target size used in this investigation may not have been sufficiently small enough to increase the accuracy demand of the task.

A significant difference was not found in the motor time between the cerebral palsied group and the non-handicapped group. The motor time measures the time from the first change in electrical activity in the prime-moving muscle to the initiation of the required response. Since a significant difference was not found between the two groups of subjects, it appears that the differences in performance were due to information-processing delays occurring within the central nervous system and not due to electro-mechanical delays occurring at the neuromuscular junction or biomechanical constraints occurring within the prime-moving muscle. This conclusion must be regarded as tentative however, given the non-significant findings observed for SRT.

The empirical findings of this study also indicate that the movement times of the cerebral palsied subjects were significantly different from the movement times obtained from their non-handicapped peers. This observation provides support for the hypothesis that cerebral palsied youth require more time than the non-handicapped youth to execute a movement response. The slower response may be due to the biomechanical constraints resulting from the cerebral palsy.

Two important movement variables in the field of motor behavior are a movement's speed and accuracy. This relationship is seen when a movement's speed increases resulting in a decrease in the accuracy of the movement. Fitts (1954) systematically studied this phenomenon and, as a result of his findings designed a mathematical model of the relationship between the speed plus accuracy requirements of a movement which is known as Fitts' Law. The model is based upon the average movement time which is linearly related to the distance to be moved and/or the width of the endpoint target.

Target size used in the present study was found to significantly affect only the movement time measurement. When the small target was the endpoint of the measured response, the movement time was longer than the time obtained when the large target was used. This finding lends support to the speed-accuracy trade-off principle of motor performance. The finding also provides support to the possibility that visual feedback may have been used by the cerebral palsied youth when the small target was the endpoint. Instead of incorporating the accuracy component within the motor program developed, the cerebral palsied subjects moved to a closed-loop mode of operation during this more difficult condition of the required response. A closed-loop mode of operation employs the use of visual feedback to achieve the endpoint.

Empirical support was provided for the prediction that spastic hemiplegic cerebral palsied youth require more time than their non-handicapped peers to plan a gross motor response. This information might aid the practitioner in designing the most appropriate teaching techniques when presenting gross motor tasks. The longer premotor time obtained for the cerebral palsied subjects suggests that cerebral palsied youth might experience greater difficulty in retrieving the first subprogram for the response unit it controls, thus requiring a longer search time. Alternatively, the finding might suggest that a longer time might be required by the cerebral palsied youth to unpack the subprograms into smaller components before their execution can take place. Taking this into account, it might be easier for a cerebral palsied youth to learn a gross motor task if the task was not separated into a large number of parts and each part taught separately. Rather, a more appropriate teaching technique might be to teach the gross motor task in a few large parts and thereby reduce the number of subprograms comprising the motor program developed. Also, a common practice used to teach a gross motor skill requiring accuracy, such as the overhand throw at a target, is to use a large target when the skill is first introduced. As the student's skill level increases a small target replaces the large target. This teaching technique seems to be an appropriate one. However, it appears that cerebral palsied youth, similar to the population in this study, may benefit more if the skill is taught by stressing the speed of the movement rather than the accuracy. Thus, a large target is used for the introduction of the skill and the movement is performed at a somewhat slower rate. During the learning of the skill the speed of the whole movement should be increased until the skill is performed as a rapid movement placing the learner in an open-loop mode of operation. Since speed is stressed rather than accuracy, when a smaller target is used the cerebral palsied youth might continue operating in an open-loop mode. This teaching technique may reduce the probability that cerebral palsied youth will alternate their movement strategy from a more open-loop mode of operation to a closed-loop mode by utilizing the visual feedback. The use of stressing speed rather than accuracy may aid the cerebral palsied individual to program the accuracy component of the movement and decrease the time required to perform the movement. Thus, a teacher might construct a learning environment to optimize the learning process of the handicapped.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of the study was to analyze the effects of cerebral palsy on the ability to plan and execute a gross motor movement, as measured by the fractionation of Simple Reaction Time (SRT). Answers to two questions were sought: (a) whether differences existed with respect to information-processing abilities between spastic hemiplegic cerebral palsied youth and non-handicapped youth, and (b) whether increasing the accuracy demands of a gross motor task differentially affected the cerebral palsied youth when compared to non-handicapped youth. This chapter is divided into the following sections: (a) summary of procedures, (b) summary of the findings, (c) implications, and (d) recommendations for further research.

Summary of Procedures

The 20 subjects, 10 spastic hemiplegic cerebral palsied and 10 non-handicapped youth, ages 12 to 16 years old, were randomly assigned to the order of testing. Each subject performed two blocks of 30 trials. Premotor, motor, SRT, and movement time measurements were obtained for each trial.

The task required the subject to grasp the stylus with the right hand, and depress the starting microswitch. Immediately following the onset of the visual stimulus, the subject moved the stylus as quickly and accurately as possible to depress the target. The stylus was moved in an upward direction, followed by a lateral movement to the right.

The design of the study was a 2 x 2 (group X target size) split-plot factorial design. The data collected in this study were treated with Analysis of Variance (ANOVA) procedures. The probability of a statistical test had to be less than the alpha level of .05 to be considered significant. Intraclass reliability coefficients and standard errors of measurement were calculated for each dependent measure. The dependent measures used were premotor time, motor time, SRT, and movement time.

Summary of the Findings

Within the limitations of this study, a significant difference was found in the premotor time between the cerebral palsied subjects and the non-handicapped subjects indicating that spastic hemiplegic cerebral palsied youth require more time than their non-handicapped peers to plan a gross motor response.

Empirical support was provided for the first hypothesis which stated that spastic hemiplegic cerebral palsied youth require increased time to plan a gross motor response when compared to non-handicapped youth.

There was no significant difference between the SRT scores of the cerebral palsied group and those obtained for the non-handicapped group. However, the SRT approached significance, ($p < 0.07$). The SRT measurement was fractionated into two components, premotor time and motor time. Although a significant difference was found in the premotor time between the cerebral palsied subjects and the non-handicapped subjects, a significant difference was not found in the motor time between the two groups.

The empirical findings of this study also indicate that the movement times of the cerebral palsied subjects were significantly longer than the movement times obtained from their non-handicapped peers. This finding supports the prediction that spastic hemiplegic cerebral palsied youth require increased time to execute a gross motor response compared to their non-handicapped peers. The longer movement time is a consequence of the cerebral palsied youth altering their movement strategy from a more open-loop or preprogrammed mode of operation to a closed-loop operation utilizing visual feedback in order to contact the smaller target endpoint. This conclusion is supported by the failure to observe increases in premotor time as a consequence of reducing the endpoint target width. The effect of target size did not significantly affect the premotor times obtained for both groups of subjects.

Implications

The results from this study suggest that spastic hemiplegic cerebral palsied youth require more time than their non-handicapped peers to plan a gross motor response. The significance in the premotor time could reflect a possible difference in the time required by the cerebral palsied youth to retrieve or unpack each subprogram's unit into further components before the subprogram can be executed. When teaching a spastic hemiplegic cerebral palsied youth a gross motor skill it is important to know that the processing of information is slower and will subsequently affect the initiation of the required response.

A significant difference was found between the movement times obtained from the cerebral palsied youth and the scores obtained from their non-handicapped peers indicating that the cerebral palsied subjects' execution of the gross motor response is slower. This finding might reflect the cerebral palsied youth altering their movement strategy from more of an open-loop mode of operation to a closed-loop operation by utilizing visual feedback.

The effect of target size did not significantly affect the obtained premotor times, indicating that the accuracy component of the movement response did not form a part of the cerebral palsied youth's motor program.

Recommendations for Further Research

The findings of this study form the basis for the following recommendations for further research:

1. This study should be replicated with cerebral palsied youth, ages 12 - 16 years old, that demonstrate a greater degree of biomechanical restrictions. This study was conducted with spastic hemiplegic cerebral palsied youth who experienced the characteristics of cerebral palsy basically on the subject's left side. It is not known how a more severely involved cerebral palsied subject processes information and the subsequent effects of a more severe cerebral palsy on the premotor, motor, SRT, and movement times of a SRT task.

2. The same testing site should be used for all of the subjects. This might eliminate any possible effects due to the use of different testing environments.

3. Research should be conducted using the research technique designed for this study with other types of handicapping conditions (e.g., Down Syndrome, learning disabled).

4. Research should be conducted with cerebral palsied youth to study the effects of increasing the task complexity (i.e., number of movement parts, change in direction, accuracy) demands of a movement response and/or accuracy demands on fractionated reaction time.

5. Research should be conducted with spastic hemiplegic cerebral palsied youth when teaching a gross motor skill to compare the teaching techniques of the whole versus the part method of teaching.

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APPENDICES

APPENDIX A

Approval From Human Subjects Committee

OREGON STATE UNIVERSITY

Committee for the Protection of Human Subjects

Chairman's Summary of Review

Title: Fractionation of Simple Reaction Time to Examine the Information Processing of Cerebral Palsied Youth

Program Director: John Dunn, Physical Education

Recommendation:

- X Approval*
- ____ Provisional Approval
- ____ Disapproval
- ____ No action

*The informed consent forms obtained from each subject need to be retained for the long term. Archives Division of the OSU Department of Budgets and Personnel Service is willing to receive and archive these on microfilm. At present at least, this can be done without charge to the research project. Please have the forms retained in archives as well as in your files.

Remarks:

Date: January 23, 1986

Signature Redacted for privacy

If the recommendation of the committee is for provisional approval or disapproval, the program director should resubmit the application with the necessary corrections within one month.

JAN 24 1986

APPENDIX B

Letter of Introduction

Dear

My name is Susan Parks and I am a PhD student at Oregon State University in Corvallis. I am currently pursuing a PhD degree in the area of Special Physical Education and have several years' experience working with disabled youth, including those with cerebral palsy. I am particularly interested in researching the effects of cerebral palsy on the performance of gross motor tasks in children and would like to enlist your child's participation in this project.

In order to better understand the effects of cerebral palsy on the execution of a large motor movement, Simple Reaction Time, or the time required to begin a movement after a signal to "go" is presented, will be measured independently on children as they perform an aiming movement. Each child will be in a seated position facing a green light. When the light goes on, the child, as quickly as possible, will grasp a rubber ball with the right hand and move the ball to the right to hit a round target. There will be two blocks of 30 trials, each with a rest period of two minutes between the blocks of trials. This will make the total test time around 70 minutes. During the testing session, if your child elects to stop he or she may do so.

Three electromyograph electrodes or disks will be placed on the skin over the large muscle, biceps brachii, of the right upper arm, in order to measure the electrical signals in the muscle which initiates the movement. This technique has been successfully used with non-handicapped individuals as well as aged and mentally handicapped persons.

Confidentiality of all information collected will be ensured by using an assigned number for each child as identification. The data will be accessible only to the investigator directly involved in the study.

The major purpose of this study explores the information processing abilities and strategies used by cerebral palsied children to plan a movement. Also, the question of how accuracy affects these strategies is tested. The information gained through this study can provide valuable insights to theoreticians and practitioners, such as teachers, about the effects of spastic hemiplegic cerebral palsy on the underlying information processing abilities.

I will be happy to discuss any part of the research study with you or answer any questions. If you would like to become familiar with the testing environment and procedures, please contact me at my office during the day, 754-2631, or at home in the evenings at 929-6822. At your convenience, I will show you the site and the instrumentation to be used. If you wish, you may perform a few trials of the task to aid in your decision.

Thank you for your cooperation.

Sincerely,

Susan Parks
Health and Physical Education
Oregon State University
Corvallis, Oregon 97330

_______ Yes, my child will serve as a volunteer for your research study. You many contact me to further discuss his or her participation.

_______ No, I feel my child would not be an appropriate volunteer for your study.

____
Signature

Dear

My name is Susan Parks and I am a PhD student at Oregon State University. I am currently pursuing a PhD degree in the area of Special Physical Education and have several years' experience working with non-handicapped youth, and disabled youth--including those with cerebral palsy. I am particularly interested in researching the effects of cerebral palsy on the performance of gross motor tasks in adolescents. For performance comparisons, non-handicapped youth are needed and I would like to enlist your child's participation in this project.

In order to better understand the effects of cerebral palsy on the execution of a large motor movement, Simple Reaction Time, or the time required to begin a movement after a signal to "go" is presented, will be measured independently on handicapped and non-handicapped youth as they perform an aiming movement. Each child will be in a seated position facing a green light. When the light goes on, the child, as quickly as possible, will grasp a rubber ball with the right hand and move the ball to the right to hit a round target. There will be two blocks of 30 trials, each with a rest period of two minutes between the blocks of trials. This will make the total test time around 70 minutes. During the testing session, if your child elects to stop he or she may do so.

Three electromyograph electrodes or disks will be placed on the skin over the large muscle, biceps brachii, of the right upper arm, in order to measure the electrical signals in the muscle which initiates the movement. This technique has been successfully used with non-handicapped individuals as well as aged and mentally handicapped persons.

Confidentiality of all information collected will be ensured by using an assigned number for each child as identification. The data will be accessible only to the investigator directly involved in the study.

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Thank you for your cooperation.

Sincerely,

Susan Parks
Health and Physical Education
Oregon State University
Corvallis, Oregon 97330

______ Yes, my child will serve as a volunteer for your research study. You may contact me to further discuss his or her participation.

______ No, I feel my child would not be an appropriate volunteer for your study.

APPENDIX C

Informed Consent Form

INFORMED CONSENT

The primary objectives of this study are:

1) To study the effects of cerebral palsy on the ability to perform a gross motor task, as measured by fractionating Simple Reaction Time (SRT) into its premotor and motor time components.

2) To determine whether increasing the accuracy demands of the task differentially affects the cerebral palsied youth when compared to non-handicapped youth.

PROCEDURES

At the onset of a green light, your child while seated, will respond as quickly as possible by grasping a stylus with his or her right hand and moving the grasped stylus to the right to hit a round target. There will be two blocks of 30 trials each. A rest period of three minutes is scheduled between the blocks of trials. An Automatic Performance Analyzer interfaced with the apparatus will record the Reaction Time and total movement time of each response. An electromyograph will record the electrical activity in the biceps brachii (muscle) of your child's right arm. The procedure has been used on several previous occasions by the experimenter and is extremely safe. The main adaptation is becoming familiar with the two EMG electrodes placed on the right upper arm. A slight physical discomfort may be experienced as a result of the skin being lightly abraded and rubbed with isopropyl alcohol prior to the application of the three electrodes. The testing session will last approximately 70 minutes.

CONFIDENTIALITY

Confidentiality of all information collected will be ensured by using an assigned number for each subject as identification on recorded data which will be accessible only to the investigator directly involved in the study.
If you and/or your child decide at any time to withdraw from the study, you may do so.

I fully understand the conditions and procedures described and give my voluntary informed consent for my child to participate in the above described research study.

Participant's Name (print)______________________________

Parent/Guardian's Signature______________________________

Date____________________

APPENDIX D

Age and Gender of the Subjects

Age in years	Female CP	Female NH	Male CP	Male NH
12	1	1	2	2
13	1	1	0	0
14	1	1	1	1
15	2	2	1	1
16	0	0	1	1

Note: CP = Cerebral Palsied, NH = Non-Handicapped

APPENDIX E

Means (in ms) and Standard Deviations for Groups and Target Size

PREMOTOR TIMES

PREMOTOR TIMES

Group	Number	Means	Standard Deviations
Non-handicapped	10	158.06	27.41
large target		160.22	25.54
small target		155.90	30.39
Cerebral Palsy	10	186.09	27.85
large target		183.99	26.65
small target		188.19	30.28

APPENDIX F

Means (in ms) and Standard Deviations for Groups and Target Size

MOTOR TIMES

MOTOR TIMES

Group	Number	Means	Standard Deviations
Non-handicapped	10	78.00	4.22
large target		77.41	4.86
small target		78.59	3.63
Cerebral Palsy	10	75.01	3.95
large target		74.73	3.38
small target		75.28	4.66

APPENDIX G

Means (in ms) and Standard Deviations for groups and Target Size

SRT

SRT

Group	Number	Means	Standard Deviations
Non-handicapped	10	236.33	28.56
large target		238.27	25.80
small target		234.39	32.37
Cerebral Palsy	10	261.09	28.99
large target		259.72	27.84
small target		263.46	31.40

APPENDIX H

Means (in ms) and Standard Deviations for Groups and Target Size

MOVEMENT TIMES

MOVEMENT TIMES

Group	Number	Means	Standard Deviations
Non-handicapped	10	480.10	66.00
large target		474.92	64.80
small target		486.68	70.13
Cerebral Palsy	10	570.15	101.60
large target		559.70	110.80
small target		580.62	96.30