THE EFFECTS OF PERCEPTUAL MOTOR ENRICHMENT
UPON A SIX YEAR OLD WITH CEREBELLAR
BRAIN DAMAGE

THESIS

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This study involved the effects of a perceptual motor enrichment program upon the motor skills of a six year old boy with cerebellar brain damage, who, with a control group of ten normal six year olds, was given a pre-test of motor skills. He and a child from the control group participated in a perceptual-motor enrichment program. The motor skills of both subjects were tested halfway through the program. Following the program, the experimental child, the control child, and the control group were post-tested on their motor skills.

The testings showed that the greatest gains in motor skills were obtained by the experimental child, followed by the control child. The control group displayed little increase in motor skill performance.
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CHAPTER I
INTRODUCTION

The cerebellum plays an important role in the maintenance of muscle tone, equilibrium, and motor control (Noback and Demarest, 1972; Snider, 1968; Cooper et al, 1974). In general, the cerebellum is believed to act as a stabilizer which smooths out and synchronizes the timing of actions of groups of muscles. This puts it in the role of acting as "modulator" in the regulation of motor acts. The word synergy perhaps best describes its function. (Matzke and Foltz, 1972; Noback and Demarest, 1972; Herz and Putnam, 1946; Dow and Morruzi, 1948). Eccles describes the cerebellum as "a computer in handling all complex inputs from receptors or other parts of the brain." (1977, p. 122) This important role of the cerebellum and its effect upon the motor development of young children is the focal point of this study.

Deficits resulting from lesions or disease of the cerebellum are generally associated with "asynergy," a term coined by Babinski (in Herz and Putnam, 1946) to describe the lack of coordination among large groups of muscles needed to secure steadiness and maintain general equilibrium. Stability in movement is believed to be gained primarily through the cerebellum's "negative feedback system" which prevents overshooting in movement and helps to prevent
Oscillations and tremors during movement. According to several authors, (Noback and Demarest, 1972; Matzke and Foltz, 1972; Snider, 1968; Penfield and Rasmussen, 1968; Eccles, 1977), a large lesion of the cerebellum causes the loss of the effect of the negative feedback system, releasing the nervous system from the influence of the cerebellum. Consequently, motor control depends on the intactness of the cerebellum.

Motor control deficits due to cerebellar lesions have been studied since 1891, (Lucani's ablation experiments) with some excellent studies by Holmes in the 1920's on cerebellar World War I patients. Present experiments include work on monkeys, rats and raccoons (Butchel, 1970; Brunner and Altman, 1973; Murphy and O'Leary 1975; Goldberger and Growden, 1973). Various deficits in motor function have emerged from such experiments. Collectively, these deficits are referred to as "cerebellar syndrome." This syndrome may encompass all or some of the following conditions: (a) hypotonia; a condition in which tendon reflexes are diminished (often expressed as a knee jerk which swings back and forth freely); (b) asthenia; a condition in which muscles tire easily and/or in which the proprioceptive sense is not properly used; (c) asynergia; or lack of coordination among large groups of muscles necessary to secure steadiness and maintain general equilibrium; (d) nystagmus; or the rapid, rhythmic oscillatory involuntary movement of one or both eyes.
in which a rapid movement in one direction is followed by a slow movement in the other direction; (e) adiadochokinesis; or the impairment of the ability to execute alternating and repetitive movements in rapid succession, such as supination and pronation of the forearm, etc.; (f) dysmetria; or ataxic gait, a condition in which the legs on the side of the lesion are lifted higher than necessary, and placed down hard, due to too rapid relaxation of muscles because of lack of tone (also includes any disturbance in the wide range of voluntary movements in general); (g) decomposition of movement; the performance of an act whose components are not executed in proper sequence or measure (Dow and Moruzzi, 1958).

Specific deficits are sometimes associated with certain types and/or locations of lesions (Brunner and Altman, 1973; Murphy and O'Leary, 1973; Goldberger and Growden, 1973). For example, Goldberger and Growden (1973) found that oscillations and tremors resulted from lesions to the cerebellar dentate in monkeys. Modianos and Pfaff (1976) are among those researchers who have found that lesions to the deep cerebellar nuclei of rats produced few if any disturbances. Inferior olive lesions (which are important connectors to the cerebellum) caused severe deficits in motor control. These included poor body and head control. The deficits were attributed to the importance of the olivary efferents in the control of movement and posture. Bleek and Peters (1974) found that hemispheric lesions to rats did not affect spon-
taneous motor ability, whole vermal lesions produced much hesitation in spontaneous motor activity for several days. Total cerebellectomies in dogs and raccoons (Murphy and O'Leary, 1973; Luciani, 1891) and X-ray doses to the cerebellum of infant rats produced more long lasting and complete cerebellar ataxias.

While total agreement within and/or across experiments does not exist, Dow and Moruzzi (1958) have indicated that disturbances of gait are affected from lesions in each of the three divisions of the cerebellum (anterior, posterior, flocculonodular). The type of deficit also depends on the age of the organism at the time of the damage.

Other cerebellar research has dealt with diseases and hemorrhages which bring about the cerebellar syndrome (Freeman et al., 1973). These motor deficits resemble those associated with lesions and ablations.

Another cause of cerebellar damage, more in keeping with this review, is that of anoxia. The cerebellar cortex is purported by Dow and Moruzzi (1958) to be one of the most susceptible parts of the nervous system to oxygen deficiency. Kabat, Dennis and Baker (1941) studied the recovery of dogs after the arrest of cerebral circulation. Ataxia was the most recurrent neurological symptom of dogs who survived, but recovery from this symptom was always noted later. The most severe cases were permanently neurologically deficient, and upon examination, no Purkinje cells were found in the
cerebellum. Thus, as in lesion and ablation experiments, studies on cerebellar damage due to anoxia suggest that the organism can recover, the amount of recovery being dependent upon the amount of oxygen deprivation.

Thomas J. Boll (1973) has studied the effect of brain damage which occurs at birth vs brain damage after two to four years or five to seven years of normal development. These data indicate that brain damage at or before birth had a more impairing effect than that of brain damage in later life. However, most authors, including Teuber (1974), have concluded that the reverse is true, that recovery from brain trauma incurred in later life is less complete than recovery from injury incurred earlier in development.

Successful recovery from cerebellar damage has been documented by several authors (Goldberger and Growden, 1973; Murphy and O'Leary, 1973; Freeman et al, 1975; Schraeder et al, 1975; Bleek and Peters, 1974; Modianos and Pfaff, 1976). The amount of recovery has depended on the cause of damage, i.e. hemorrhage, lesions, infection or trauma, the subject used, and the area of the cerebellar damage. The general trend of the findings is that lesions to the deep nuclei in the cerebellum of rats as well as those to the hemispheric regions and dentate nucleus create only slight damage if any, and the pattern of recovery is rapid (Bleek and Peters, 1974; Goldberger and Growden, 1973; Modianos and Pfaff, 1976). In contrast, lesions to the inferior olive and lesions caused by
X-ray to the cerebellum as a whole result in slow recovery of motor functions (Brunner and Altman, 1973; Modianos and Pfaff, 1976). Also, recovery is slow following total cerbellectomies (Murphy and O'Leary, 1973) and severe anoxia (Kabat et al, 1941).

Recent case studies of human subjects with cerebellar hemorrhage have shown that surgery to correct arteriovenous malformations is often successful, and that following surgery, recovery from cerebellar symptoms (ataxia, dysarthria, nystagmus, etc.) is possible (Freeman et al, 1975). In each of the studies of recovery from cerebellar dysfunction, the observation which documented recovery have been those associated with motor ability or performance of skills. Behaviors observed or practiced as a part of the recovery process have included balance (static and dynamic), postural symmetry, gait, various forms of locomotion, as well as motor coordination (Freeman et al, 1975).

That stimulation plays an important role in early development of organisms is well known (Held and Hein, 1963; Schapiro and Vukovitch, 1970; Greenough, 1975). Experiments that have dealt with the effects of early sensory and motor deprivation have concluded that when the timing of a developmental event is delayed, development tends not to be normal (Greenough, 1975). When deprived of sensory stimulation early in life, animals show a delay in the development of certain skills (Hein, 1972). Certain theories state that a
plasticity or ability of the organism to "catch up" remains possible into adulthood. (Greenough 1975; Gilman, 1970).

The nature and course of the "normal" child's motor development has been fairly well outlined. (Bee, 1975; Cratty, 1967; Mussen, et al 1974). Motor development is refined as the child becomes more mature. According to Cratty, (1967) movement behavior in childhood becomes more stable as growth decelerates from ages five to ten. The specific level of motor development achieved by children at given ages for specific skills has been documented by many authors (Cowan and Pratt, 1934; Seashore, 1949; Johnson, 1962; Cratty and Martin, 1969; Keogh, 1965, 1968, Williams, 1974). Skills documented by these authors include hopping, jumping, running, balance, throwing and catching.

Statement of the Problem

While the nature and results of cerebellar damage have been well documented, the specific connections of the cerebellum to the motor cortex and cerebral hemispheres are still somewhat of a mystery. The problem of this study was the effect of perceptual motor enrichment upon the motor ability of a child with cerebellar brain damage.

Purposes of the Study

The purposes of this study are as follows.

1. Compare the level and nature of motor development in a six year old boy with known cerebellar damage and to compare his
present level of motor development with that of normal six
year old boys;
2. To determine the effects of eight weeks of sensory-motor
enrichment therapy upon motor skill development by a normal
six year old child and a six year old child with cerebellar
brain damage.

Research Questions

The basic research questions to be answered in this study were as follows.
1. What was the effect of perceptual-motor enrichment upon
the motor ability of a child with cerebellar brain damage?
2. How does the level and nature of motor development in a
six year boy with known cerebellar brain damage compare to
that of normal six year old boys?
3. What was the effect of eight weeks of sensory-motor
enrichment therapy upon motor skill development in a six year
old boy with known cerebellar damage to that of normal six
year old boys?

Significance

The value of the research described here is great
considering the importance of motor skills in everyday life.
If motor skills may be improved upon through an enrichment
program, and if this program will benefit the motorically
deficient, then the resulting improvement may be of great
worth towards helping motorically deficient individuals
become more like their normal counterparts.

Definition of Terms

Ablation - removal of an organ or part by surgery

Anoxia - hypoxia (lack of oxygen) as to result in permanent damage to the affected individual or part

Ataxia - an inability to coordinate voluntary muscular movements

Archicerebellum - the part of the cerebellum comprising the flocculus, nodules, and part of the vermis

Cortex - the outer or superficial part of an organ

Decerebrates - to remove the cerebrum from

Dentate - having toothlike projections

Exteroceptive - action by or relating to or constituting stimuli impinging on the organism from the outside

Flocculus - a small irregular lobe on the under surface of each hemishere of the cerebellum

Folia - one of the lamella of the cerebellum cortex

Gyri - convoluted ridges between grooves

Lesion - an abnormal change in structure of an organ or part due to injury or disease

Nodulus - a prominence on the inferior surface of the cerebellum; forms the anterior end of the vermis

Paleocerebellum - a phylogenetically old part of the cerebellum concerned with normal postural relationships, made up of the anterior lobe of the vermis and the pyramid

Proprioceptive - activated by, relating to or being stimuli produced within the organism

Somatic - of, relating to, or affecting the body

Vermis - either of two parts of the inferior surface of the cerebellum; the vermis forms the anterior end of the cerebellum
Delimitations

This study is delimited to the effect of a perceptual-motor enrichment program upon the motor ability of a child with cerebellar brain damage.

Procedure

Ten six year old boys (one with known cerebellar brain damage) were given a pre-test which measured their current level of motor skill development. The control child was picked randomly from the nine normal children. He and the child with cerebellar brain damage were enrolled in an eight week perceptual motor enrichment program. At the four week (halfway) interval, a middle testing of motor skills was done. At the end of the eight week period, all subjects were given a final testing of motor skills. In addition to the testings, a videotape of the experimental subjects was made to analyze their motor progression. Further descriptions of the methods used are found in Chapter III.


Lucianai, L., Il cervelletto, Le Monnier, Firenze, 1891.


Williams, H. G., Williams' Gross Motor Coordination Test Battery, Univ. of Toledo, Toledo, Ohio, 1974.
CHAPTER II

REVIEW OF LITERATURE

The cerebellum plays an essential role in the coordination of muscle tone, equilibrium and motor activities (Snider, 1968; Noback and Demarest, 1972). The cerebellum functions as a stabilizer to smooth out and synchronize timing among groups of muscles. It is also a processor of sensory input of ongoing motor activity derived from stretch receptors, general sensors, the vestibular system, as well as auditory and visual systems (Matzke and Foltz, 1972).

The cerebellum consists of an outer gray mantle, called the cortex, a medullary core of white matter composed of nerve fibers projecting to and from the cerebellum, and four pairs of deep cerebellar nuclei (fastigii, globosus, emboliformis and dentatus). The nuclei globosus and emboliformis are also called the nucleur interpositus. The cerebellar surface is corrugated into folia, or long, narrow gyri. The cerebellum is divided into two large bilateral hemispheres and the unpaired narrow median vermis. The lateral zone consists of the cortex of the cerebellar hemisphere and the nucleus dentatus. The median zone consists of the vermal cortex and the nucleus fastigii. The intermediate zone consists of the peraveral cortex (between vermal and hemisphere cortex) and the nucleus interpositus.

The cerebellar cortex is divided into three layers, the
molecular layer, the middle of Purkinje layer, and the
granular layer (Noback and Demarest, 1972).

The cerebellum is usually divided into three sections
(Noback and Demarest, 1972; Matzke and Foltz, 1972). The
phylogenetically oldest area of the cerebellum is the
archicerebellum and consists of the paired flocculi of the
hemisphere and the unpaired nodulus of the vermis. The
archicerebellum is closely integrated with the vestibular
system and appears to play a significant role in the main-
tenance of muscle tone, equilibrium and posture. The paleo-
cerebellum consists of the anterior lobe and is primarily
associated with the proprioceptive and exteroceptive input
from the head and body, regulation of muscle tone, and gross
movements of the head and body. The middle, or posterior
lobe is known as the neocerebellum, and has a significant
role in muscular coordination (Matzke and Foltz, 1972; Dow
and Morruzi, 1958; Cooper et al, 1974; Herz and Putnam,
1946). The cerebellum operates as a stabilizer during
movement, giving constant feedback or ongoing comment to the
body to prevent overshooting of a target, loss of balance,
etc. When lesions are present in the cerebellum, the nervous
system has no gauge by which to measure feedback during
movement (Snider, 1968; Cooper et al, 1974; Noback and
Demarest, 1972; Eccles, 1977).

There was for many years some dissent on the nature of
cerebellar function, most of it due to difference (usually
overlooked) between species studied. Also, most authors have studied mainly the somatic motor system (Dow and Morruzi, 1958).

The first indication that there was localization of different functions within the cerebellar cortex was in 1897 and 1898. The experiments conducted by Lowenthal and Horsely (1897) and Sherrington (1898) implied that when the cerebellum was stimulated in limited areas, rigidity of decerebrates was inhibited. While the cerebellar cortex remains histologically homogenous, modern day theory holds that different functions occur within different areas.

Modern research on the cerebellum has focused on plotting the patterns of stimulation to determine which area is involved in what function (Dow and Morruzi, 1958). Although this information is far from complete, it is known that the functions associated with the body's equilibrium are localized in the extreme anterior and posterior surfaces of the cerebellum. The homunculi or projection areas appear on the cortex, and stimuli from the sense organs of touch and proprioceptive areas are found here (Snider, 1958). The investigation by Stowell and Snider in 1942 lent credence to the notion that the cerebellum was involved in sight, touch and hearing. They found that the auditory and visual senses register in an area over that of the two proprioceptive areas. Feedback circuits (tactile, visual and auditory) were mapped by these authors, following the stimulation of each
area in the cerebellum to a matching area in the cerebrum and vice versa, creating a feedback circuit. The cerebellum was thus described as an "accessory control system imposed upon the basic ascending (sensory) and descending (motor) circuits of the nervous system" (Snider, 1958, p. 7).

More recently, Butchel (1970) found that when the cerebellum of rats was damaged, learning in visual tasks was impaired. The location and size of the cerebellar lesions were important variables, and the author speculated that the cerebellum may be a modulator in motor arousal, preventing overfacilitation of inappropriate responses during learning.

The cerebellar dentate was the site of damage in a 1973 study by Goldberger and Growden. Their subjects were monkeys who had been trained to perform simple motor skills previous to the bilateral lesions. Their postoperative performances revealed ataxic oscillations in extended, abducted positions, and ataxic tremors in more flexed-adducted positions. Recovery from these lesions occurred rapidly. The author suggested that the cerebellum provided a timing device for movement which allows limb fixation to stop at the right moment for the phasic component to begin. Thus, the cerebellum is seen here as a modulator in motor arousal, an accessory control system and a tuning device which allows movement to stop at the right moment.

Bleek and Peters (1974) performed vermal and hemispheric cerebellar lesions on 108 rats and tested them in a shuttle
box task. The subjects had to avoid shock within the box by moving to one area of the box. Another task required them to move to an area, stay a certain length of time, then move to the other side of the box. This was considered a more difficult task. Reduced spontaneous motor activity was noted in the rats with lesions to the vermal cortex, especially with the more difficult tasks. Within a few days, however, rats with vermal lesions were able to recover their abilities to the level of their control counterparts. The rats with hemispheric lesions showed no disturbances in spontaneous motor activity.

Donaldson, Pycock and Marsden (1976) experimented with unilateral lesions (mild, moderate and severe) were made to the superior cerebellar peduncle. The mild lesions produced no motor deficits, while moderate lesions produced both ataxia and tilting of the body toward the side of the lesions. Severe damage caused ataxia, tilting, plus ipsi- versive rotation, or circling behavior.

Motor impairment was again noted in a study by Brunner and Altman (1973) in which X-rays were given in either two of four doses to rats in their infancy. As adults, they were tested on several motor abilities. The swimming speed and treadmill endurance of both the four dose and two dose rats was assessed to be normal when compared with the normal control group. However, the running speed of the four dose group was reduced when they were required to run either
uphill or down hill. Horizontal jumping ability was impaired with both groups, the impairment more marked in the four dose group. Both groups again showed lowered ability in a task which required running up a rod to escape water. The narrower the rod, the poorer the performance of rats with lesions. Exaggerated body sway was also observed in both groups. The authors suggest that when multiple exteroceptive and proprioceptive information must be coordinated concurrently, there is increased involvement of the cerebellum. Thus tasks requiring the use of such information proved to be difficult for the rats with cerebellar damage.

Murphy and O'Leary (1973) observed hanging and climbing functions in the raccoon and sloth after a total cerebellarotomy. The sloths showed no changes in these functions, but the raccoons showed classic post-operative cerebellar symptoms such as dysynergia, ataxia, etc., which were compensated for within a few days after surgery. The explanation by the authors concerning the sloths' functioning was that the sloth is much lower down on the neurological scale.

One of the most recent and perhaps the most complete study of cerebellar damage was done in 1976 by Modianos and Pfaff. Their subjects were female rats who were subjected to lesions of brain stem and cerebellum. The rats were divided into seven groups, each with lesions to a different structure. Ten tests of posture and movement were given to the subjects beginning the second day after surgery and given eight times
up to and including the forty-first day. All groups showed improvement and recovery of function with time. The tests included tremor, both in movement and at rest, balance beam performance, body and head elevation, posture, tonus and locomotion. The results were as follows: Lateral vestibular lesions (52 percent of area damaged) resulted in asymmetrical posture, tilting of head, splaying of limbs, severe tremor, less locomotion and poor body elevation. These subjects performed the most poorly on the ten tests. They had showed difficulty with balance beam performance, static tremor, body elevation, head elevation, and motion tremor. Superior vestibular lesions (33 percent of area damaged) resulted in dysfunction much as those of the lateral lesions, with the exception that body elevation was not disturbed. This group had the weakest righting reflex and the poorest tonus, but showed quick recovery. Medial vestibular lesions (25 percent of area damaged) did not effect body elevation but did tend to elicit fits of rolling on the part of the animal during the first week. They were weak in symmetrical posture, balance beam and static tremor. Fastigial lesions (41 percent of area damaged) resulted in slight motor tremor and lowered ability in the balance beam test, but performance improved rapidly. Dentate interpostius lesions (38 percent of area damaged) resulted in more obvious dysfunction, the mean score in all but body elevation being the highest of any group. Inferior olive lesions (58 percent area damaged)
resulted in hindlimb asymmetry. The rats would lift one leg during locomotion; they gave evidence of body sway and were hesitant and unsteady. They were also the poorest in postural symmetry and were impaired in every test except tonus.

Nucleus giganto-cellularis lesions produced a very different array of symptoms. The rats would vocalize loudly upon being picked up or touched. They further evidenced ventroflexion of the vertebral column in movement and at rest and kept their heads to the ground. They were poorer in all tests than the dentate interpositus group. These results indicate that the greatest effects were found with lateral vestibular lesions, superior vestibular lesions, and inferior olive lesions. These areas, while not within the cerebellum proper, are important efferents to the cerebellum, and damage to these areas results in cerebellar syndrome. Deep cerebellar lesions produced few signs of dysfunction. It should be noted that the specific percentage of tissue damage was not a factor in the behavioral dysfunctions which resulted. The lesions to the nucleus giganto-cellularis were the largest yet produced only moderate impairment. The authors attributed the severe dysfunction in movement following inferior olive lesions to the important role of olivary efferents to the cerebellum in control of movement and posture. One characteristic found in all groups was marked recovery during postoperative testing; the rate in most cases
being greatest in the first two weeks following surgery.

Cerebellar damage and its accompanying symptoms in humans has been noted in certain cases involving infectious mononucleosis and cerebellar hemorrhage. A case report of five persons with infectious mononucleosis was discussed by Schraeder, et al (1975). All but one of the subjects was under twenty-five and experienced as a result of the infection varying degrees of the cerebellar syndrome.

The symptoms included ataxic gait, dysynergia, hypotonia, choreiform movements, dysmetria, and slurred speech. Cerebellar symptoms were also noted in patients with intracerebellar hemorrhage (Freeman, et al, 1975). In seventy-five percent of the cases discussed, the symptoms (dysarthria, nystagmus, and ataxia) were due to hypertensive bleeding in the cerebellum.

Arteriovenous malformations were also noted as causing cerebellar symptoms in a thirty-one month old child. Surgery was performed and was considered successful; recovery was rapid with only slight ataxia being noted within a few months after surgery. The authors pointed out, however, that cerebellar hemorrhage often does not result in cerebellar symptoms.

Cerebellar trauma due to anoxia, or lack of oxygen, has been reviewed by several authors (Kabat, et al, 1941; Sugar and Gerard, 1938). The experiment by Kabat, et al, in 1941 lent credence to the theory that the cerebellum is more sensitive than other areas of the brain to oxygen depriv-
tion. He subjected thirty-one dogs to oxygen deprivation. The dogs who were subjected to eight minutes or more oxygen deprivation showed severe loss of function; they were not able to stand or walk. They remained in a comatose condition from two and one half hours to two and one half months and then died. The greatest amount of recovery noted was that of the righting reflex and the ability to lick in order to eat and groom. The dogs who were deprived for six minutes or less recovered to a much greater degree. They remained comatose from twenty-four to forty hours. The earliest signs of recovery involving restoration of vestibular function and the righting reflex. Once standing and walking ability was regained, the authors observed the same severe ataxia as is seen in cerebellar dysfunction of man. The ataxic gait remained as a residual deficiency although previous learning and emotional stability were regained in a few days. The ataxia persisted from twenty to forty days on the average and was still seen thereafter when the animal was excited, or when the floor was wet. The authors reported that their microscopic studies of the cerebellum revealed no Purkinje cells left in dogs who were given eight minutes of oxygen deprivation, while areas to the cerebrum were not affected. They concluded that the cerebellar neurons are most sensitive to anoxia, and that as with previous studies, the Purkinje cells of the cerebellar cortex are most susceptible to the arrest of blood flow. They further stated
that since the Purkinje cells are an essential link in the neuronal chain of cerebellar activity, damage to these neurons is reflected immediately in loss of function. These results are very similar to findings associated with patients recovering from acute strangulation as they, too, display cerebellar symptoms. The most prevalent finding of this study is the presence of cerebellar ataxia in each animal who was subjected to oxygen deprivation. It was interesting to note that after recovery, the dogs displayed ataxic gait when the floor was wet, this seeming to be a more difficult function in motor coordination. A similar result was found by Brunner and Altman (1973) in which rats with cerebellar lesions performed poorly in running uphill or downhill. A more recent study of anoxia by Hossman and Olsson (1970) showed that ischemia up to thirty minutes in cats still resulted in early signs of neuronal recovery with cerebrovascular perfusion.

The results of the studies reviewed support the theory that damage to certain areas of the cerebellum does result in motor impairment. Recovery is possible following this damage, depending on the type of damage, the extent of the damage, as well as its location. These variables are also interrelated in that large damage to certain areas may result in no cerebellar syndrome, while small damage to other areas may result in severe motor impairment.
Recovery in most experiments cited is spontaneous in nature. However, in all studies, animals and humans have been allowed to move about in order that results of the experimentation may be noted; thus a certain amount of therapy, or sensorimotor involvement, has been a part of the recovery process. This process and/or experience in movement and positioning in space may have aided in the rate of recovery. It would seem plausible that sensorimotor enrichment other than normal, daily activity might enhance and increase the rate of recovery.

Support for the positive effects of sensory stimulation on the improvement or refinement of motor development and neuronal development may be found in a variety of sources, i.e. (Denhoff, 1969; Greenough, 1975; Riesen, 1961; Held and Hein, 1963; Gilman, 1970). The crux of the position taken by these authors is that sensory motor enrichment and/or stimulation may overcome deficits in motor ability. Various experiments have dealt with both controlled animal experiments and with clinical observations of humans. While stimulation may not aid recovery of all motor deficits, improvement in many aspects of motor performance has been noted. Animal studies by Woods (1959) have shown that early sensory and motor deprivation produces learning deficits in rats, but that exposure to an enriched environment aids recovery to a marked degree in these animals. One additional study supported the effects of environmental enrichment.
following postweaning brain lesions in rats. Will and Rosenzweig (1977) studied the effect of enriched environments on rats with and without brain lesions (occipital/bilateral) for two time periods, twenty-four hours daily and two hours daily. The findings indicated that those rats given the enriched environment for only two hours benefitted as much as those receiving twenty-four hours. Further, the enriched environment was found to be of greater benefit to the rats with lesions than the rats who were not operated on. However all rats who were exposed to the enriched environment performed better than those in the impoverished environment. The authors suggested that there was a possibility that enriched experience may help to overcome the effect of lesions through a greater number of synaptic connections found in the cortex of rats with lesions treated with the enriched environment and may further protect against the loss of cortical cells in regions away from the lesion, as this loss was smaller in the enriched condition group than in the impoverished condition group. Thompson and Schaefer (1961) report that early enrichment in motor activities is crucial in producing differences in adult human motor behavior. The American Association of Health, Physical Education and Recreation (Proceedings of the Perceptual Motor Symposium, 1969) supported this statement, saying that early sensory stimulation has merit, and that both physical educators and parents could do much to enhance the competency of movement.
One important variable which may influence the effect of the stimulation is age. The earlier a traumatic event occurs in development, the more likely is recovery from that event. In addition, one or more critical periods may exist which influence the effect of the stimulation (Thompson and Schaefer, 1961; Gilman, 1970).

Stimulation during a critical period may be more effective than that which occurs at a later time. Early stimulation (two to five years) of humans is thought to be most effective, but current research is not complete enough to dictate when the critical periods for stimulation are, nor the exact influence of stimulation at a given age upon later performance.

Ito (1975) theorized that the cerebellum may be "learning" to modify movement through a feedforward control system may manage complex input-output relationships which cannot be managed by feedback control systems. This view is consistent with the neurological concept that the cerebellum is a coordinator of very complex movements. Ito's main support for this theory of the increased role of the cerebellum lay in his study of the vestibulocular reflex arc of the rabbit, which has no return of information (feedback loop) from the eye to the vestibular organ, and this is considered to be a feedforward control system. He deduced that the cerebellum should have a plasticity for learning and that possibly activity prior to movement shifts from the
cerebrum to the cerebellum during motor learning. Ito's theory suggests that the cerebellum itself could be altered with environmental (sensorimotor) enrichment, giving more weight to a rationale which incorporates an enrichment program for subjects with cerebellar damage. If a treatment program required movement, the cerebellum is involved. If indeed the cerebellum can learn, it can learn to improve through movement.

The literature on motor development among children is replete with studies documenting the level of achievement in various motor skills at different ages. Table I summarizes some studies which provide information about the course of motor development in normal children.

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<th>Test</th>
<th>Task</th>
<th>Mean</th>
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</thead>
<tbody>
<tr>
<td>Keogh (1965-1968)</td>
<td>Standing Broad Jump</td>
<td>39.30 inches</td>
</tr>
<tr>
<td></td>
<td>Hopping Task</td>
<td>50 percent</td>
</tr>
<tr>
<td></td>
<td>50 Foot Hop</td>
<td>7.40 seconds</td>
</tr>
<tr>
<td></td>
<td>Running</td>
<td>12.80 ft.p/s</td>
</tr>
<tr>
<td>Cratty and Martin (1967)</td>
<td>Static Balance</td>
<td>7.50 seconds</td>
</tr>
<tr>
<td>Cowan and Pratt (1934)</td>
<td>Hurdle Jumping</td>
<td>11.25 seconds</td>
</tr>
<tr>
<td>Johnson (1962)</td>
<td>Vertical Jump</td>
<td>7.02 seconds</td>
</tr>
<tr>
<td>Seashore (1949)</td>
<td>Dynamic Balance</td>
<td>2 steps/fall</td>
</tr>
<tr>
<td>Williams (1974)</td>
<td>Static Balance</td>
<td>13.70 seconds</td>
</tr>
<tr>
<td></td>
<td>Balance Beam Walk</td>
<td>24.50 seconds</td>
</tr>
<tr>
<td></td>
<td>Balance Beam Walk</td>
<td>1.80 falls</td>
</tr>
<tr>
<td></td>
<td>Balance Beam Kneel</td>
<td>15.60 seconds</td>
</tr>
<tr>
<td></td>
<td>Shuttle Run</td>
<td>17.50 seconds</td>
</tr>
<tr>
<td></td>
<td>Run and Under</td>
<td>7.90 seconds</td>
</tr>
<tr>
<td></td>
<td>50 Foot Hop</td>
<td>7.80 seconds</td>
</tr>
<tr>
<td></td>
<td>20 Yard Dash</td>
<td>4.80 seconds</td>
</tr>
<tr>
<td></td>
<td>Standing Broad Jump</td>
<td>44.30 inches</td>
</tr>
<tr>
<td></td>
<td>Ball Bounce</td>
<td>18.00 bounces</td>
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</table>
Such data provide a basis for evaluating skill achievement in normal children, and a basis for identifying differences between normally developing and atypical children.

In general, research has shown that cerebellar damage produces deficits in motor control and that recovery from these deficits is possible, either in part or completely. Stimulation and/or sensory motor enrichment of the organism has been shown to be indirectly involved with the recovery process. The motor development of normal children has been documented and provides a basis for comparing motor skill achievements of normal and atypical children.
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Murphy, H.G. and J.L. O'Leary, "Hanging and Climbing Functions in Raccoon and Sloth after Total Cerebellecctomy," Archives of Neurology, 1973, (Feb.), Vol. 28,


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CHAPTER III

METHODS

Subjects

Participants in the study were ten six year old boys, one with known cerebellar damage, nine with no known cerebellar and/or neurological involvement (normal).

Performance Measures

Data on the background and history of development of the child with cerebellar damage was collected. This data included a documentation of the child's general developmental landmarks and neurological diagnosis. A Perceptual-Motor Integrative Developmental Checklist taken from A. Dekaban's Neurology of Early Childhood' (Williams and Wilkins, 1970) was used as a guide for determining the health of the history of the birth and the developmental landmarks of motor skills.

A profile of sensori-motor characteristics was taken on all children. The profile served to describe the level of sensori-motor development achieved by both the cerebellar damaged child and the nine normally developing children. A post treatment profile was taken on the two children participating in the enrichment program as well as the control children who did not participate in the program. This profile consisted of tests of fine and gross motor control and strength. The tests are described on the next page.
Process Analysis of Gross Motor Performance

The children in the Enrichment Program were video-taped and a process analysis of movement characteristics of these children performing the following fundamental motor skills was undertaken: running, hopping, skipping, throwing and catching. Checklists for process assessment of motor skill performance developed by Williams (1974) were used. Post-treatment video tapes were made of the two children performing the same motor skills. These tapes were also subjected to a process assessment analysis by an independent observer.

Williams' Gross Motor Coordination Test Battery

(see Appendix I for a complete description of the test)

This battery includes the following nine items:

1. Balance
   a. Static Balance
   b. Balance Beam Walk
   c. Balance Beam Kneel

2. Agility
   a. Shuttle Run
   b. 50 Foot Hop
   c. Run and Under

3. Speed--20 Yard Dash

4. Power--Standing Broad Jump

5. Eye-Hand Coordination--Ball Bounce
Southern California Sensori-Motor Integration Tests,

Design Copying:

The child is asked to look at a completed design, and complete another one next to it which is the same, but is incomplete. The reported reliability was .802.

Frostig Developmental Test of Visual Perception:

Eye-Motor Coordination

This subtest required the child to draw lines within set boundaries, attempting to draw them as accurately as possible, not going outside the boundaries. Performances were scored in terms of intrusion by the child into or over the boundary lines. Reported reliabilities range from .69 to .98. Neurologically handicapped children have shown much greater scatter in subtest scores and their scores have been consistently lower than those of normal children.

Bender Gestalt

This task had a varied number of subtests which required the child to reproduce a number of geometric shapes which are different in design, spatial position and amount of detail. Performances were scored in terms of the number of errors made in figure reproduction.

Grip Strength

Measurement of grip strength as measured by the grip dynamometer was made. The average of four trials determined the score.
Experimental Program

One normal child who was selected at random from the group of nine children and the cerebellar child participated in a sensorimotor enrichment program for eight weeks. The other eight normal children served as a baseline control group and did not participate in the program. All children were tested at the beginning and at the end of the program as indicated above. The sensorimotor enrichment program began immediately following the initial evaluation session. This program continued for eight weeks, four days per week, one hour per day. The program was designed to stimulate the development and refinement of a wide family of gross and fine motor abilities.

Specific activities and areas of motor development which were emphasized in the program included (1) balance; walking on balance beam, line walking, standing on one foot, balance board activities, (2) body agility; rolling, twisting, activities on the mat, turning, change of positions rapidly, obstacle courses, (3) fundamental locomotor skills; running, jumping, hopping, skipping, galloping, leaping, (4) object manipulation skills, throwing, catching, kicking, striking, etc., and (5) fine motor coordination; peg board tasks, bolt assembly, drawing, cutting, etc. A daily schedule of these specific activities is found in Appendix II.

Expectations were that in the beginning, the cerebellar child would perform consistently poorer in all tests than
would the normal children, but this discrepancy in performance would decrease with motor enrichment. Greatest gains for the cerebellar child were predicted for balance, general body agility and fundamental locomotor skills. Moderate gains were predicted for fine-motor skills and little or no gain was predicted for the measure of muscle strength. On the basis of Will and Rosenzweig's observations on animals (1977), greater gains were expected for the cerebellar child than the normally developing child.

Data Analyses

Data analyses were primarily descriptive in nature. A subjective case history profile was developed for the cerebellar child. A descriptive comparison of pre and post-treatment effects on development of motor control was made by plotting a profile of pre and post treatment performances for (a) the cerebellar (experimental) child (b) the normal (control) child participating in the enrichment program, and (c) the control group of normal children. A written description of the pre-post process characteristics of the experimental child and the control child was also compiled from video tapes before and after the enrichment program.
CHAPTER BIBLIOGRAPHY


Williams, H.G., Williams' Gross Motor Coordination Test Battery, University of Toledo, Toledo, Ohio, 1974.
CHAPTER IV

ANALYSIS OF THE DATA

The term significant used within this chapter does not denote statistical significance, but is used as a descriptive tool in the interpretation of the raw data. Figure 1 illustrates improvements and/or decrements in each area and is found on pages 55 and 56. Appendix III contains the raw scores for each subject on each test.

During the initial testing, the time for eyes open static balance right leg (SBOR) for the control subjects was 8.7 seconds. The final testing showed an improvement in performance to 12 seconds. The control child had a score of 6.0 upon the initial testing, an improved score of 11.0 on the middle testing, and another improved score of 13.5 on the final testing. Similar results were found with the experimental child. The initial testing score was 1.0 seconds, the middle testing was 2.5, the final testing showed a slight decrement in performance to 2.4. The experimental child's scores were improved during the enrichment program, and this reflected noticeable improvement in performance during the final testing. He was able to keep his hands on his hips and adjust his body weight for longer periods of time. Also, his time improved when he relaxed and was standing in a balanced position just prior to raising his leg.
The same task with the left leg (SBOL) yielded a mean time for the control group of 10.7 seconds at the initial testing and 11.4 at the final testing, showing a score which was improved but only slightly. The control child's scores were 16.2 seconds at the initial testing, 11.8 middle testing, (a decrement in performance) and 8.5 upon the final testing, representing a further decrement in performance. The decrement may have been due to a lack of enthusiasm for this task on the part of the control child, especially on the left leg, as it was more difficult to balance on. The experimental child's scores improved steadily across trials, from 1.35 (seconds) to 2.1 to 4.2; the final score being the best of any of the static balance tasks. Again, this improved score was due to an increased emphasis on the experimental child being balanced before beginning the task, and keeping his body upright and balanced during the task. Thus, the eyes-open static balance task for the control group had little change, the control child improved significantly on scores of the right leg, but not the left leg, and the experimental child also improved significantly across both trials.

Static balance with the eyes closed (SBCR) resulted in an insignificant improvement in the mean of the two trials in the control group, right leg from 3.6 to 3.7, and left leg (SBCL) 2.82 to 3.17. The control child's scores improved slightly between the initial and middle testing on the right
leg (3.9 sec. to 5.0 sec.) but fell to 4.4 in the final testing. The left leg scores were 3.6 to 3.0 between the initial and middle testing. The total of the left leg scores were 3.6 to 3.0 to 4.0. This improvement was not considered significant. The experimental child's scores generally improved, the scores of the right leg improved from 1.0 to 1.8 between the initial and middle testings, then dropped slightly at the final testing to 1.4. The left leg score improved steadily from .72 to 1.5 to 1.8 seconds. These improvements were considered to be of greater significance than those of the control child because while the number of seconds was not always greater, the percentage of improvement was much greater. The quality of movement on the static balance with the eyes closed task improved in the same manner as the eyes-open task for the experimental child. His movements were more relaxed leading up to the task, and more effort was made to maintain balance during the test.

In the Balance Beam Walk (BBW) the mean time for the control group declined insignificantly between initial and final testings, 9.3 to 9.7 seconds but the mean number of falls decreased (improved) significantly from 1.3 to .68. For the control child, the balance beam walk scores steadily improved over trials from 7.9 to 6.5 to 5.8; with falls remaining constant at zero. This was a significant improvement in performance. The experimental child's scores improved from 21.5 to 15.8 to 3.3, as did the number of falls from 8.5
to 3.5 to 2.0. The amount of improvement across trials was much greater and more significant for the experimental child than for the control child. Similar results were found in the Balance Beam Kneel (BBK) task. The control group's score showed no significant improvement between trials (12.2 to 11.2 seconds) on time and 1.9 to 1.3 falls. The control child's score improved significantly from 7.6 to 6.5, as did his falls, from 1.0 to 0.50 to .25. The experimental child's scores improved to a greater degree, from 23.0 to 13.8 to 14.3, though the final testing represented a drop in the gain seen between the initial and middle testing. The mean number of falls for the experimental child improved from 10.0 to 3.5 to 2.0 across the trials. This task showed much improvement in movement for the experimental child. At the initial testing he could not walk one step on the beam without falling. His movements at that time were not balanced, he seemed to go to either side of the beam when he began to lose his balance, and as a result of the aforementioned, he was not able to make or to carry out purposeful forward motion. Further, he had much difficulty in carrying out the task in a heel to toe manner, as he tended to take larger steps in an effort to hurry down the beam before balance was lost. In the middle and final testings, the experimental child was able to walk with fewer falls and the movements produced were more refined. A general trend of improvement between most trials in all groups was seen in the balance beam tasks, with the experi-
mental child showing the most significant improvement.

The Run and Under (R&U) task for the control group resulted in a slightly poorer performance on the final testing; 11.6 seconds to a final score of 12.1. The decrement was not considered significant. The control child's scores showed improvement between the initial and middle testings, 10.6 to 9.3, but a poorer performance on the final testing, 9.3 to 10.4. Both the changes in the scores were considered insignificant. The experimental child's scores improved steadily from 17.7 to 17.4 to 13.0 seconds. The final score came very close to the control group's final score of 12.1. The movements on this task by the experimental child were improved primarily during the "under" phase of the task. Initially, he would run toward the bar, stop just before reaching the bar, and then begin movement to go under the bar. Also, he would halt at various other stages of the task. By the final testing, he became more adept at starting his downward movement to go under the bar earlier, as well as going from one phase of the task to another with less hesitation in his movement. In addition, he was able to judge the timing of when to get down to go under the bar with more accuracy and his performance was much more fluid. This task showed no significant improvement for the control group, but significant improvement on the part of the experimental child.

Scores on the Twenty-Yard Dash (20YD) on the initial and
final testing remained constant for the control group at 5.0 seconds. The control child's scores remained constant and then improved slightly from 5.1 to 5.1 to 4.8 sec. The experimental child's scores showed improvement, but only at the final testing; ranging from 6.5 to 6.9 to a final score of 5.6. The experimental child's movements during this task changed only slightly, but the start seemed to become quicker and balance while running was attained earlier. Thus no significant changes were seen in the control subjects while a more significant improvement was seen in the experimental child.

The Fifty Foot Hop (50H) resulted in very few significant changes in the scores of the control group and the control child. The control group scores increased very slightly between trials from 12.9 to 13.1, and the control child's scores increased from 10.2 to 10.2 to 10.3 between trials. The experimental child's scores improved from 17.5 to 13.8 to 13.8 (constant). The experimental child showed several changes in movement in this task. Initially, a second hopping step was not able to be completed without simultaneous contact by the other foot. Therefore, balance on one foot for more than one hop was not possible. During the enrichment program and in subsequent testing, more than one hopping step was completed without additional contact to the floor to maintain balance. However, this task was never performed correctly with any degree of balance for any period
of time. This dynamic balance task was the most difficult of all tasks for the experimental child. No significant changes were noted in the control subjects, and the experimental child showed improved scores and performance, but an overall performance level which remained well below normal.

The Standing Broad Jump (SBJ), measured in inches, showed an insignificant decrement between testings in the control group. The mean was 38.4 inches on the first testing, and was lowered to 26.8 inches on the second testing. The control child exhibited slight but insignificant improvement from 36.0 to 36.3 to 38.6 inches. The experimental child improved to a greater and more significant extent, from 17.6 to 22.0 to 25.6 inches. Improvement by the experimental child was seen in the skills related to this task, much more refined as arm movement prior to the jump, and increased propulsion of the body forward (as opposed to upward). The experimental child was further seen to have more balance and control of his body after he had landed, as well as an even push off and landing with both feet together. No significant changes occurred in the performance of the control subjects, but the experimental child did have an improved performance and score.

The results of the Ball Bounce (BB) task showed that some improvements had been made in all three groups. In the
control group, the scores increased only slightly, but insignificantly from 9.2 bounces (mean) to 10.4 bounces. The control child's scores showed an overall improvement from 4.0 to 2.5 to 6.2 bounces, with the middle testing was significant, but the overall performance was not significant. The experimental child's scores showed improvement for all testing, from 1.0 to 2.7 to 3.2 bounces. The experimental child's improvement was dramatic as he was not able to bounce the ball two times consecutively before the perceptual-motor program. During and after the program, he was able to control the ball manually for a longer period of time while keeping his hand closer to the midline of his body.

The Design Copying Task (DC) resulted in no improvement for the control group, as their scores decreased (were insignificant) between the initial and final testing from 13.1 to 12.5. The control child's scores reflected no change whatever from 16 to 16 to 16. The experimental child's scores reflected an improvement between the initial and middle testings, and no change for the middle and final testing: 6 to 10 to 10. The experimental child had difficulty in controlling his marks, and no motoric changes were observed in this task.

Improvement in all three groups was noted in the Bender Gestalt (BG) test. The control group's score dropped sharply (representing an improvement) between the initial and final testing, 9.8 to 3.8. The control child showed an overall
improvement with scores ranging from 6.0 to 5.0 to 5.0. The experimental child's scores also improved overall from 13.0 to 8.0 to 8.0. The latter two subjects showed no change in the final testing as noted. The improvements in performance in each of these groups in the Bender-Gestalt task was not evident as the task was being performed. The subjects in all groups performed these tasks in the same manner during each testing, and the reason for the significant improvement in their performance is not known.

A close score was obtained between the initial and final testings of the Eye-Motor Coordination (EMC) task for the control group. The initial score was 14.8 and the final score was 14.6. This change was not considered significant. The control child's scores fluctuated from 19 to 13 to 17, showing no significant change in performance. The experimental child's performance improved between the initial and middle testings from 7 to 11, but then fell sharply to 3 in the final testing. The final testing on the experimental child occurred at the close of a testing session, during which the experimental child was noticeably tired and withdrawn. A re-testing was considered but was not made due to time limitations, and the possibility of inconsistency in testing among groups.

The control group's mean score on the Grip Strength Task (right hand) (GSR) did not change significantly across the trials from an initial score of 9.3 kilograms to a final
score of 10.0 kilograms. The Grip Strength Task revealed an insignificant change in performance between trials for the experimental child and the control child. Right hand grip strength scores decreased from 10.2 to 10.1 to 9.5 kilograms for the experimental child and 9.7 to 9.6 to 8.7 kilograms for the control child. The left hand scores (GSL) for each group were somewhat different. The control group again showed insignificant change from 8.9 to 9.1 dropping from 10.5 to 9.9 to 9.7 kilograms. The experimental child showed initial improvement between trials, but a final score which was poorer. The specific scores were 8.5 to 9.5 to 5.2, the latter being quite a sharp decline in performance.

The specific reason was not known for the experimental child's decreased final performance with the left hand. This task, however, was another which occurred at the end of the testing session and the experimental child seemed hesitant and restless during this last part of the final testing session.

The percentage of improvement for all test items is discussed below. Figure 2, illustrating these percentages, is found on page 57. The experimental child showed improvement between the initial and middle testing on 38.2% of all the test items. The control child showed and improvement of 58.9%. Between the initial and middle testing, 11.3% of the test items showed decreases, or poorer performance scores for the experimental child, and 23.4% for
the control child. 47.2% of the tests showed improvement between the middle and final testings for the experimental child and 52.9% for the control child. The decrements between these trials were 41.1% and 35.3% (respectively), and no change was observed in 11.7% and 11.85% respectively. An overall improvement (initial to final testing) occurred in 88.2% of the test items for the control child, and 64.7% of the test items for the control child, and 58.1% of the test items for the control group. Decreased percentages were 11.8%, 29.4% and 36.0% respectively. No change percentages were 0.0%, 5.9%, and 5.9% across groups. These percentages indicate that the greatest gains were found between the initial and middle testings for the control child and the experimental child. Further, the experimental child had a lower percentage of tests which reflected no change than either the control group or the control child. The greatest gains in improvement between the three groups were found with the experimental child, followed by the control child, and then the control group.

A Process Analysis of gross motor performance was carried out using videotape before (pre-program) and after (post-program) the enrichment program. The control child and the experimental child were videotaped while throwing a ball, catching a ball, skipping, hopping and running. An independent trained observer critiqued the videotapes using a checklist for a process assessment of motor skill assessment.
This observer did not know which child was the control child and which child was the experimental child, nor which testing session occurred first. The forms which were used have been condensed and are found in Appendix IV. On some of the motor skills no differences were seen between the experimental child and the control child, however, the components of motor skills in which a difference was noted are discussed below.

In catching, an eight inch ball was thrown to each subject at chest height or lower from a distance of six feet. Both subjects performed correctly on the preparatory phase of this movement. In the executory phase of the pre-program tape the experimental child did not make adjustments in the elbow and shoulder joint positions. Also, in the pre-program tape, the experimental child did not close his fingers immediately around the ball and "give" to absorb the momentum of the ball after initial contact with the hands, but this component was performed correctly in the post-program videotape. The control child executed all phases of catching correctly, both in the pre and post program videotape.

In throwing, a tennis ball was used. The subjects threw six to eight tennis balls each. In the executory phase of the pre-program videotape, the experimental child did not stand with feet apart and with the forward foot opposite to the throwing arm. He did, however, execute this component correctly in the post-program videotape. All other components within this motor skill were performed correctly. The
control child performed incorrectly on three portions of the executory phase of throwing, but only on the pre-program videotape. His arm did not "lag" behind the body motion and move forward with the elbow leading; at the time of release, complete extension, shoulder medial rotation and elbow extension were not attained; and the wrist was not flexed (snapped) rapidly just before the release of the ball. These components were performed correctly during the post program videotape.

Hopping was a task which was most difficult for the experimental child due to his poor balance skills. No component within this motor skill was performed correctly in either the pre or the post program videotape. The experimental child could not balance on one foot, nor extend his hips, knees or ankles, nor keep the non-support leg from touching the floor. In addition, his arms and his head were also positioned and utilized incorrectly. The control child was able to perform all components correctly.

Skipping was another motor skill which was not adequately performed by the experimental child. On both the pre and post program videotapes, he did not transfer his weight onto one foot, did not complete an alternating step-hop pattern, and did not swing his arms in opposition with the legs. The control child was able to perform adroitly on all components of skipping, with the exception of the swinging movement of the arms.
In running, the experimental child performed well on most components. Three components, however, were not performed correctly in the pre-program videotape, but were performed correctly in the post program videotape. The arms did not swing freely close to the body, nor was extension and flexion evident in both limbs. The control child performed all of the components correctly both in the pre and post program videotape.

Developmental History and Milestones of the Experimental Child

The experimental child is the firstborn of two children. His family history reveals no heritable conditions and the health of both parents and both children is excellent. Gestation was uneventful. The mother carried the child nine months. During birth, the child's head was turned sideways and a saddle block was performed on the mother, after unsuccessful attempts at repositioning his head. Forceps were used to deliver the child. Birth occurred after twelve hours of medium to hard labor. The child weighed seven pounds, one ounce at birth, was bright red in color, and cried before he was out of the mother's body. He held his head up on his own the first day of life. All of his early developmental landmarks were well within the normal time limits, with the exception of walking, which he did not entirely accomplish until the age of three years. His later developmental landmarks in the motor area still lagged behind
those of his peers as revealed in this study. At the age of four years, the experimental child was examined by a neurologist whose diagnosis was "cerebellar syndrome due to anoxia at birth." Currently, the experimental child is performing at grade level in school, but has difficulty in performing the same motor skills as his peers.
Figure 1 - Graph of Motor Tests (Raw Data) Shown in Seconds
Figure 1 -- Continued
Improvement in Performance = Decriment in Performance
o = No Change in Performance

**Experimental and Control Child Percentage**

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<th>Cont. Child (Middle to Final Testing)</th>
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**Experimental Child, Control Child and Control Group**

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<th>Control Group</th>
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**Figure 2** - Bar Graph - Percentages of Overall Improvements, Decriments or No Changes in Performance
Summary of Data Analysis

The standing balance task resulted in many improved performances for each of the three groups. A constant improvement between testing sessions was seen in the control group, in both right and left leg trials, with eyes open and closed. The control child's performance fluctuated more, and improvement was seen in the eyes open right leg task, but not the left leg. Also, in the eyes closed portion of the task, the scores were not uniformly improved between trials, but were improved overall. The experimental child's performance exhibited fairly constant improvement, and to a greater extent than that of the control group, but the average score remained well below that of either the control group or the control child. It is interesting to note that for all groups, the least amount of change in either direction was found within the balance with eyes closed task.

The scores on the Balance Beam task for the control group showed that their performance on the walk portion of the task declined slightly and on the kneel portion it improved slightly, but neither performance was a very significant change. The experimental child's performance reflected the greatest and most significant improvement. The time and number of falls on this task declined markedly, therefore showing an improvement on the task. This improvement was the sharpest of the entire test battery in terms of time. All of the balance test scores tended to
support the theory that the experimental child's performance on tasks dealing with balance would improve and to a greater degree than either of the other two groups. The control child was predicted to have an improvement in performance over that of the experimental group due to the enrichment program, and this was so.

Those tasks which dealt with running and agility were the Shuttle Run, Run and Under, Fifty Foot Hop, and the Twenty Yard Dash. The control group had decrements in performance in all tasks but the Shuttle Run, and only slight improvement in this task. The control child's performance was similar in that no improvement was seen in any task other than the Shuttle Run. This improvement may have been due to adjustments in the mechanics of the task which various children made as the testing occurred. The experimental child's performance on all running and agility tasks showed steady improvement, as a result, the experimental child's final performance scores came closer to the norm of the other groups than on other test items. The initial scores were closer to the norm, therefore the amount of improvement in these tasks was not nearly so dramatic as in the balance tasks. This finding is in keeping with the premise that speed and agility would not improve as much as balance for the experimental child.

The performance on the Ball Bounce task was fairly constant for the control group, with insignificant improve-
ment seen. The control child's performance showed in a decrement in performance, then an improvement in performance, resulting in an overall score which was slightly higher than that of the control group. The experimental child's performance improved steadily across trials, and to a greater degree than that of the other groups.

The scores of the fine motor tasks (Design Copying, Eye-Motor Coordination and Bender Gestalt) indicated no improvement in performance for the control group with the exception of the Bender Gestalt. This improvement was considered significant and is discussed below. The control child's scores in performance reflected insignificant improvement in performance, and one decrement in Eye-Motor Coordination. The experimental child also showed a decrement in performance on the eye-motor coordination task, but showed improvements in performance on the Design Copying Task and the Bender-Gestalt task. This improvement on the Bender-Gestalt for the control group and the experimental child seems to have been dramatic, and the causes for this improvement are not known.

The Grip Strength scores for all groups showed little improvement or decrement in performance, as was theorized earlier. Strength, therefore, was not shown to be a factor in the improvement of motor performance through a perceptual-motor enrichment program.

The videotaped process analysis of movement reflected the difference in motor development between the experimental
child and the control child. The experimental child did not perform correctly on a number of the components, in particular the advanced motor characteristics of hopping and skipping. The other motor skills (throwing, catching, and running) which were performed incorrectly by the experimental child showed improvement from the pre-program analysis to the post-program analysis. The control child performed consistently better on all motor characteristics than the experimental child.
CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Summary

The main focus of this study was to discover if motor enrichment program would have an effect upon the motor performance of a six year old with cerebellar brain damage. A motor enrichment program was implemented, and continued over a six week period. The subjects of the program (control group, control child, experimental child) were tested prior to the program, in the middle of the program (not control group) and at the end of the program.

Findings

1. The performance of the control group on the static balance task revealed much variability on the part of the control groups as individuals. Many of the subjects showed an improvement in their performance between the first and second trials on the right leg with eyes open. This improvement was fairly marked in some instances and might be due to the fact that at this age, there is much variability in performance as well as continual improvement in motor skill development. The performance of this group on the same task with the left leg did not improve as much between trials, but a slight trend of improvement was noted in the overall mean. The performance of the control child was also improved in
this task on the right leg. The experimental child's performance improved on both the right and the left leg. This marked improvement in performance was seen as significant because as a balance task, it was theorized that these tasks would result in more improvement for the experimental child. While the experimental child's improvement was not as great as the other two groups in terms of number of seconds difference between trials, the experimental child's performance on this task was improved by an average of 150 percent, whereas with the control child and group this improvement in performance was approximately 75 percent. The task dealing with static balance eyes closed resulted in an insignificant amount of improvement in performance for almost all control subjects and a significant improvement in the performance of the experimental child.

2. The balance beam tasks showed no improvement in performance for the control group. The control child showed some improvement across trials, however, this improvement was not as significant as that of the experimental child. The experimental child improved his performance to a tremendous amount on this task. Such a significant improvement was suggested in the introduction from the nature of cerebellar damage and the effect of perceptual motor enrichment upon motor performance. The experimental child showed much more improvement in performance on balance tasks than the other two groups, and thus the effects of the enrichment program
may have been of greater benefit to the experimental child.

3. The control group as a whole had very little improvement in performance within the area of speed and agility. Their scores between trials on the Shuttle Run, Run and Under, Twenty Yard Dash and Fifty foot Hop remained relatively unchanged, with no outstanding improvements or decrements in performance noted. This same consistency in performance was seen with the control child. In the introduction, speed and agility were theorized to show less improvement in performance than the balance tasks. Also theorized was an improvement in performance by the experimental child, whose performance scores did improve steadily across trials. However, this improvement in performance was not as great as the improvement in performance on the balance tasks, as expected. This general area of speed and agility can be seen overall as remaining constant for the normally developing children, both within and without the perceptual motor enrichment program, but as being changed and improved for the experimental child.

4. The Ball Bounce task was treated here as a separate task. Almost every subject in the control group improved in performance to a small degree upon this task, as did the control child. The experimental child showed a higher degree of improvement upon this task, which may have been due to the perceptual motor enrichment program. During this program, various components related to bouncing the ball were shown to
the experimental child, such as placement of the fingers on the ball and use of the wrist in propelling the ball downward. As may be noted by the scores, however, the skill level of the experimental child in this task remained extremely low in comparison with that of the control child and group. The control group's mean on the ball bounce task was higher than that of the experimental and the control child primarily because of one particular child in the control group whose performance was exceptional.

5. It was stated earlier that the fine motor tasks would result in the least amount of improvement in performance for the experimental child, but that any improvement would be greater than that of the control group and child. Of the three tasks, (Design Copying, Bender-Gestalt and Eye-Motor Coordination) the only improvement in performance made by the control group was on the Bender-Gestalt, where the improvement was considered quite notable. The reasons for this sharp improvement in performance were not known. The control child showed no significant improvements upon any of these tasks. The experimental child showed the predicted amount of improvement, but a sharp decrement in performance was noted in the final testing of the Eye-Motor Coordination task. The measurement of this task came at the end of a testing session, and the experimental child showed both fatigue and dislike of the task prior to its testing. Overall, the theory which stated that the fine motor tasks would show the
least amount of improvement for the experimental child was supported, as was the theory that the experimental child would show more improvement than the other group.

6. The strength measurements showed almost no improvement in performance for any group. For the experimental child, control group and child, performances measured by grip strength showed no significant improvements, and the scores were extremely close both initially and finally for all three groups. Strength was shown to be a task which was not altered by the perceptual motor enrichment program. Strength appears not to be a factor where cerebellar brain damage is concerned, as the experimental child's scores were very similar to those of the control subjects, both before and after the perceptual enrichment program.

Conclusions

One of the purposes of this study was to compare the motor development of normal children with that of a child with cerebellar brain damage. In addition to the tests of fine and gross motor skills, a process analysis of movement was made by videotaping the control child (normal) and the experimental child (cerebellar). This videotape resulted in the following conclusions: The experimental child evidenced much difficulty in managing the more complex motor skills of hopping and skipping. These motor skills required a higher level of motor development, as well as advanced balance skills. Therefore, it is concluded that the videotapes show
clearly a deficit in balancing ability as well as a comparatively lower overall level of motor development.

The experimental child's initial level of motor development was found to be considerably lower than that of his normal counterparts. The nature of his motor development was well defined in terms of specific weaknesses and strengths.

It has been documented that cerebellar brain damage results in a myriad of motor deficits in humans. Sensorimotor enrichment may overcome these deficits as proposed by Thompson and Schaefer (1961) and Greenough (1975). The enrichment program utilized in this study was designed to promote refinement of motor skills, particularly balance, which is known to be a motor skill most affected by cerebellar damage. Balance was shown to be the area with the greatest developmental lag, but was the skill which was most improved during the program as measured by the balance tests. This degree of improvement in balance was not achieved with the normal control child who participated in the same program. This finding agrees with the study by Will and Rosenzweig (1977) which showed that an enriched environment was of greater benefit to rats with brain lesions as opposed to rats with no organic deficiency.

Based on the review of literature, the findings of the sensory motor enrichment program, the pre, middle and post-testing, and the videotape, the following conclusions were drawn.
1. There has been no research on motor enrichment programs dealing specifically with increasing motor performance of brain damaged individuals.

2. The sensory motor enrichment program was able to produce changes in motor behavior which were visible.

3. The experimental child's repetition of various tasks did not produce a loss of challenge or complacency with the activities that was found with the control child. Therefore, an intense program with repetition is not favorable to improvement in performance to normal individuals, but only to motorically deficient individuals.

4. Sensory-motor enrichment resulted in improvements in motor performance with a cerebellar brain damaged child.

5. Balance was seen as the task which had the most significant improvement.

Recommendations

Based on the preceding conclusions, the following recommendations are made.

1. The scope of the enrichment program could be widened to include more tasks where balance is a factor.

2. Further research with brain damaged individuals and motor enrichment programs is indicated.

3. Research where more than one brain-damaged child participates in a motor enrichment program is indicated.

4. More program variability for the sake of the experimental child is indicated, also.
CHAPTER BIBLIOGRAPHY


APPENDIX I

Williams' Gross Motor Coordination Test Battery

I. Balance

A. Static Balance

The child is asked to stand on one foot (preferred) with hands on hips, open eyes (then closed eyes), and is requested to balance for as long as he can. The source for a single trial is the number of seconds (to the nearest tenth) that the child remains in a controlled balance position.

B. Balance Beam Walk

Time and number of falls. The child is asked to walk forward the length of a standard two-inch balance beam in a heel-to-toe fashion. Two scores are recorded for each trial: (a) the total number of falls, and (b) the time (to the nearest tenth of a second) required to complete the balance beam walk. Four trials are given. The measure of the performance is the average of four trials.

C. Balance Beam Kneel

Time and number of falls. The child is asked to walk forward to the center of a two-inch balance beam. When he reaches center, he is to kneel down touching either knee to the beam. He then arises and walks to the end of the beam. Falls are measured and scores recorded as for the balance beam walk. Four trials are given, the measure of performance is the average of four trials.

II. Agility
A. Shuttle Run

Two tape marks are placed ten feet apart on the floor. The child stands with his toes behind one tape mark, facing the second tape mark. On the signal, he runs and touches tape B, turns and runs back and touches tape A. He continues to run back and forth ten trips (touches each line five times). Time is measured to the nearest tenth of a second. Four trials are given. The measure of the child's performance is the average of four trials.

B. Fifty-Foot Hop

A fifty-foot distance is marked off on the floor. The child stands behind the start line and on the signal attempts to hop the fifty-foot distance to the finish line. The score is the total time to the nearest tenth of a second. Four trials are given, the measure of the performance being the average of the four trials.

C. Run and Under

A thirty-foot distance is marked off on the floor with tape. An obstacle which the child must go under is placed twenty-five feet from the starting line. On the signal, the child runs down the floor, goes under the barrier, gets up, runs to and touches the second tape mark, turns, runs back and goes under the obstacle and back across the starting line. The score is the total time to the nearest tenth of a second, four trials are given, and the measure of performance is the average of the four trials.
III. Speed

A. Twenty-Yard Dash

A sixty-foot distance is measured off on the floor with tape. The child is asked on the signal to run 60 feet as quickly as possible. The score is the time (to the nearest tenth of a second) required to complete the dash. Two trials are given, the measure of performance is the average of the two trials.

IV. Power

A. Standing Broad Jump

Standard procedures for executing the broad jump are followed. Scores are recorded to the nearest inch. Three trials are given. The measure of performance is the average of three trials.

V. Eye-Hand Coordination

A. Ball Bounce

A twelve inch square is marked off on the floor. The child is given a nine-inch playground ball and stands in front of the square. The child bounces the ball within the square as many times as is possible with one hand. The score is the total number of bounces performed for each trial, four trials given, the measure is the average of the four trials.
APPENDIX II

Schedule of Daily Enrichment Program
for the Experimental and the Control Child

(t) = timed activity

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### APPENDIX III

**Raw Scores of Motor Tests**

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APPENDIX IV

Checklist for Motor Characteristics of Perceptual-Motor Development for Process Analysis

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E = Experimental Child  O = Component performed correctly
C = Control Child      X = Component performed incorrectly

= Component performed correctly

Component performed incorrectly
APPENDIX IV

Checklist for Motor Characteristics of Perceptual-Motor Development for Process Analysis

E = Experimental Child  O = Component performed correctly
C = Control Child    X = Component performed incorrectly

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APPENDIX V

Written Description of Process Analysis for Components in Checklist

Components of Catching

Preparatory Phase

1. The body is upright with the feet positioned slightly apart in either a juxta- or forward-stride position.

2. Arms moved to a position in front of the body, hands juxta- posed with the palms of the hands facing forward.

3. a. Chest High Catches: hands are raised to that level; palms toward the floor -- but with fingers facing forward and slightly upward.
   
   b. Low Catch: hands are lowered; palms up, with the fingers pointing forward.

4. Hands, fingers "loose" but slightly cupped and pointed in the direction of the oncoming object.

5. The eyes pick up and follow the flight of the ball until ball contact is made.

Executory Phase

6. Initially ball contact is made with both hands simultaneously.

7. Adjustments in the elbow and shoulder joint positions are made to accommodate "changes" in perception of the flight of the ball.

8. Fingers immediately close around the ball and arms "give" to absorb the momentum of the ball.

9. After initial ball contact, the hands, arms, and body continue to "give" with the ball.

Components of Throwing

Preparatory Phase

1. The feet are slightly apart with the forward foot opposite to the throwing arm.

2. Trunk is rotated to the right and the weight shifted onto
the rear foot.

3. The throwing arm is moved backward with lateral rotation occurring at the shoulder joint.

Executory Phase

4. The weight is shifted forward to the forward foot (a step is taken).

5. The hips and trunk rotate forward (to the left) with the hips leading.

6. The arms "lags" behind the body motion and begins to move forward in the horizontal plane with the elbow leading.

7. Shoulder medial rotation and elbow extension occur, and the elbow point is nearing complete extension at time of release.

8. The wrist is flexed rapidly (snapped) just before ball release.

9. On the follow-through, the body and arm continue to rotate forward.

Components of Hopping

1. Can balance on one foot.

2. Hips, knees, ankles flex prior to take-off.

3. During push-off weight is transferred through entire foot from heel-to-toe.

4. Hips, knees and ankles extend while the body is suspended in the air for a brief moment.

5. When landing the toes touch first and weight is transferred through entire foot.

6. When landing the ankles, knees and hips, flex to absorb shock of landing.

7. The non-support leg is flexed and does not touch the floor.

8. Arms are either held out to the side to assist in balancing the body, or they move in a controlled up and down manner to assist in propelling the body upward.
9. Head is held up and faces forward.

10. Balance is maintained and non-support foot does not touch floor.

11. Rhythm of hop is smooth.

Components of Skipping

1. There is a transfer of weight onto one foot, i.e., a walking step, then a hop on that same foot.

2. The opposite foot then takes a walking step then there is a hop on that same foot.

3. There is a continuous alternating pattern of step-hop movement.

4. The legs flex at the hips, knees and ankles both before the leg propels the body upward on the hop and after the foot contacts the floor to absorb the shock of landing.

5. There is a moment of suspension in the air during the hopping action.

6. There is a free swinging movement of the arms performed in opposition with the legs.

7. The rhythm and flow of the skip is smooth.

Components of Running

1. Trunk inclined slightly forward.

2. Arms and legs used in opposition.

3. Arms swing freely; close to the body (large arc in sagittal plane).

4. Arms bent (slightly) at elbows.

5. Head erect; facing forward.

6. Support foot hits floor, heel first. The placement of the foot may become approximately flat as speed increases and is very close to the body.

7. Body stays close to ground (little elevation).

8. Extension and flexion evident in both limbs. (Knee flexed as it swings through; support leg extends as it pushes off.)
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Williams, H. G., Williams' Gross Motor Coordination Test Battery, Univ. of Toledo, Toledo, Ohio, 1974.