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THE UNIVERSITY OF ALBERTA

A Comparison of Motor Abilities Between Hearing and Total Communicating and Oral Hearing-Impaired Children.

by

Kirsteen F.H. Edmonds

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "A Comparison of Motor Ability Between Hearing, Total Communication and Oral Hearing Impaired Children" submitted by Kirsteen F.H. Edmonds in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Special Education.

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Date: 14th. October 1987

DEDICATION

To my father who taught me that when we cease to question, we cease to learn.

Also to my husband Bob, and to my typists Wally and Pauline Klinck without whom I would never have finished.

ABSTRACT

Past studies of motor proficiency between deaf and hearing children have indicated that deaf children suffer significant developmental delays and lags in speed of execution of certain motor tasks.

This study was initiated to investigate if these delays were still so and to suggest various reasons that might lead to them. Three groups of children (N = 73) between the ages of 8.0 and 11.0 years were compared on two Motor Test Batteries. One group had normal hearing and the other two were deaf, that is, Total Communicators (T.C.) and Oral. All the deaf children were profoundly deaf (90 dB+ Better Ear Average) and had familial or unknown etiologies of impairment. Other selection criteria for all subjects included a low average and above range of intelligence, and no other known disabilities. Both males and females were selected from day and residential schools in Canada, The United States and The Netherlands.

Results showed that deaf children were indeed inferior to their hearing peers in the aspects of motor ability requiring balance, some lateral movements, some areas of visual motor speed, bilateral coordination, and sit-ups. This finding concurred with most of the previous studies. Alternatively, deaf children were superior to their hearing peers in running speed and agility. T.C. deaf

children were also superior to their oral deaf peers in response speed, and running speed and agility.

Discussion centred around the deprivation of sound leading to decreased neuron development and inferior sensory integration and cross-modal processing [illegible] action, the etiology of the impaired hearing leading to vestibular and neurological complications, the social and educational environment of the deaf child becoming over-protective and restrictive through problems with communication and the incidence of a 'handicap', the type of linguistic code that had mnemonic advantages or disadvantages for motor programs through temporal or simultaneous nature, and the overall ability of a child with language that aided the memory for motoric actions.

The conclusion was that the etiology of a hearing-impairment should always be considered for having vestibular side-effects affecting balance. Furthermore the protected social environment and/or restricted educational environment of the deaf child with its heavy emphasis on speech, language and audition, may not leave time for the full development of a child's physical abilities, along with his/her cognitive and linguistic skills.

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PART I

INTRODUCTION

> Man is highly dependent on his senses. Through his senses come the sensations which constitute his experience. Upon the information he receives from his senses he builds his world, his world of perception and conception; of memory, imagination and thought.
>
> A sensory deprivation limits the world of experience. It deprives the organism of some of the material resources from which the mind develops. Because total experience is reduced, there is an imposition on the balance and equilibrium of all psychological processes. When one type of sensation is lacking, it alters the integration and function of all the others. Experience is now constituted differently; the world of perception, conception, imagination, and thought has an altered foundation, a new configuration. Such alteration occurs naturally and unknowingly. (Myklebust, 1964, p. 1)
>
> **What will be the results?**

A. Background of the Problem

This dissertation is concerned with the motor development of deaf children. Studies of motor development and the deaf have been undertaken from the beginning of this century and have viewed varying degrees of individual ability in a variety of motoric tasks such as strength, flexibility, balance, coordination, endurance, and somewhat more recently, hemispheric laterality. One of the earliest studies concerned with motor development and the deaf was that of Long, whose original study of 1891 was finally published in 1932. Long was primarily interested in showing that deaf individuals could achieve a degree of social acceptability in industrial roles that required manual dexterity.[1]

The most recent study on motor development and deaf children however (Wiegersma and van der Velde, 1983), has shown that deaf children aged 6 to 10 years, suffer considerable lags in some areas of motor development when compared to their hearing peers. Such areas include general dynamic coordination which is the coordination of the body whilst in motion. Good examples are walking along a narrow beam or doing sit-ups. Another area is in tasks requiring manual dexterity such as lacing, cutting, or the following of labyrinths on paper (Wiegersma and van der Velde, 1983). In addition, the deaf children in Wiegersma's and van der Velde's study appeared to be less physically fit than their hearing counterparts, and their speed of motor task execution and the motor reaction time appeared to be significantly inferior at all ages tested.

Wiegersma and van der Velde stated that:

> both our test results and our observations, as well as the wider research literature, suggest that, in their motor attitudes, deaf children are slower than normal hearing subjects. (p. 107)

They went on to suggest that the reasons for such slowness and delay lay within the areas of organic, verbal, and/or emotional, or sensory problems. This can be explained in two ways. Firstly, that the loss, or reduction

---

[1] Long's study is described further in Chp. 3.

in the sense of hearing, deprives the organism of the integrative use of sound and of the value of sound in orientation. A normally hearing individual connects immediate movement in a head turn towards a sound in a basic stimulus-response pattern. The deaf individual does not. Lack of this spontaneous movement and orientation decreases opportunity for practice with an integrative function, and a delay in the development of sensory-motor integration may follow. Secondly, depending on the etiology of the hearing loss, there may be some kind of specific neurological sensory problem. That is, the lack of sound input may eliminate the development of auditory integrative pathways in the cerebral cortex and elsewhere in the brain. These authors purport that an underdeveloped part of the brain may mean a slower response time, and alternatively, that less of the brain is being used for sensory-motor integration. Thus delay may occur.

It would appear from Wiegersma's and van der Velde's (1983) research, that the role of sound then in motoric development is important. However, motor development is often overlooked in educational programing for deaf children. Specific motor programs and general movement education are not always found in schools for the deaf in Canada, and current economic policies are leading some educational administrations to limit and cut back on "extra-curricular" activities which may include the gymnastic programs of which movement is a central part. Some educational policies also try to place more focus on the language and speech difficulties of a deaf child, thereby eliminating the "extra-curricular" activities of gym and movement which are those most likely to facilitate motor development. The rationale for the elimination is the need to focus more time on the development of linguistic and communications skills. Yet it is apparent that there may be a case for the specific <u>inclusion</u> of physical education along with additional support such as physiotherapy and/or the paying of specific attention to movement education in the classroom. There may also be a need to try to make the experience of the value of sound available to a deaf child, or to compensate for its value in other defined ways. And most importantly, if educators are aware of such motor delays due to impaired hearing, they may be better equipped to approach such motor tasks as speaking and signing which are the modes of linguistic communication of significant debate in deaf education. Finally, it can be recognized that activities in the gymnastic programs in schools can offer a starting place for any necessary policies of remediation.

B. Rationale and Purpose of Study

The point of departure for the present study is the general finding reported in recent literature that children with impaired hearing show areas of deficit in their motor abilities (see Rittenhouse, 1979). Thus the first research question to be addressed is:

1. Do deaf children really show deficits in their motor abilities when compared to their normally hearing peers?

If the initial question is answered positively, then we must ask:

2. In which area, or areas, of motor ability does the deaf child show a deficit, for example, in balance, speed, locomotion, or in other similar attributes?

A final area for research then concerns the effects of the educational methods used with deaf children. For example, will there be a difference in motor ability between those children who have been raised with oral communication as their dominant means of expression and interaction, and those who have been raised using both oral and the manual communication? Although there is considerable literature on the value of linguistic coding to motor development (Cratty, 1962; Blank and Bridger, 1966; Adams, 1971; Hogan and Yanowitz, 1978; Clark, 1978; O'Connor and Hermelin, 1978; Newell and Barclay, 1982; Wall and Taylor, 1983; Wiegersma and van der Velde, 1983; Wall, McClements, Bouffard and Findlay, 1984), the literature relating to the motor ability of deaf children does not appear to have considered this distinction. Thus the third research question is:

3. Do deaf children who are educated using the total

communication method and the oral communication method show differential degrees of motor proficiency?

The answers to these research questions create further enquiries into the aspects of deafness. Although there can be no definitive answers as to why deaf children may be having motoric difficulties, trying to obtain an understanding of possible reasons why, can be beneficial in setting up appropriate remediation programs. Therefore, this study also includes the consideration of the processes involved in good motor development, and how these processes may be affected by a congenital hearing impairment.

In coming to such an understanding of the effect of hearing impairment on motor ability there are four main areas to consider. These are:

1. the relationship of sound to the development of sensory-motor integration and to the subsequent neuron development in the brain;
2. the etiological origins of a hearing impairment which may create further neurological problems directly affecting motor ability;
3. the relevance of language and experience to developing motoric abilities; and
4. the suggestion that "inner speech" is related to motor planning, and that linguistic codes of a signed versus an orally developed language may lead

to a disturbance of temporal processing in deaf children (motoric patterns being predominantly temporal in nature).

C. Delimitations

This dissertation is limited to studying the gross motor ability of two groups of profoundly deaf children (over 90dB better ear average), one group using Total Communication, the other using Oral Communication, and a comparison group of hearing children. All groups are matched on certain criteria (see Appendix I, pp. 232-237), so that the only apparent differences are in the ability to hear and the mode of communication. No attempt is being made to diagnose specific areas of difficulty with a view to remediation. It is intended as a comprehensive, descriptive study of motor development, and deafness, and to the consideration of the relationship between them.

<u>'Oral'</u> <u>versus</u> <u>'Manual'</u> <u>Ability</u>: (see Definitions, page 10)

It is to be noted that no attempt is being made to answer questions of superiority of communication modes for the deaf, that is of oralism versus manualism. It is also not the purpose of this study to provide answers about differences in the cognitive abilities of deaf and hearing children. The selection criterion of 'normal' intelligence (see Appendix I, p. 226) is taken as assuming that similar cognitive potential for motor ability exists in all the children studied.

'Good' Total Communication versus 'Good' Oral Communication Ability:

In considering the criteria of total communication versus oral communication, it is important that both these modalities are represented in their truest form. This sometimes presents a problem (for example: in the province of Alberta) since those children who are defined as 'oral' in the educational system (thus not being considered total communicators, see Glossary of Terms), have often been informally introduced to signs. Some subjects from The Netherlands were therefore also included in this study since it is known that their residential school has no signing in the environment. Regarding oral ability, however, no measure of speech intelligibility or reception was included in this study. Administrators and teachers were concerned that some students may be over-tested, and rejected the original proposal to incorporate these variables.

Cultural Considerations:

There is concern that children from different countries may differ culturally in abilities. Regarding motor ability in the general way that it is measured in this study, it is taken that children across cultures developmentally show invariant patterns. However, to help acknowledge this concern, the test of General Movement Coordination (Wiegersma and Reysoo, 1983) was used. To this date, this test has been used in various countries in

Europe, in Indonesia, and in the United States of America. Results across all countries appear similar (see Table 1, p. 10).

Finally, it is not the purpose of this study to compare educational provision by country or between schools used in the data collection. Nevertheless this study was initiated from concern over the lack of educational attention in the area of motor ability with the deaf child.

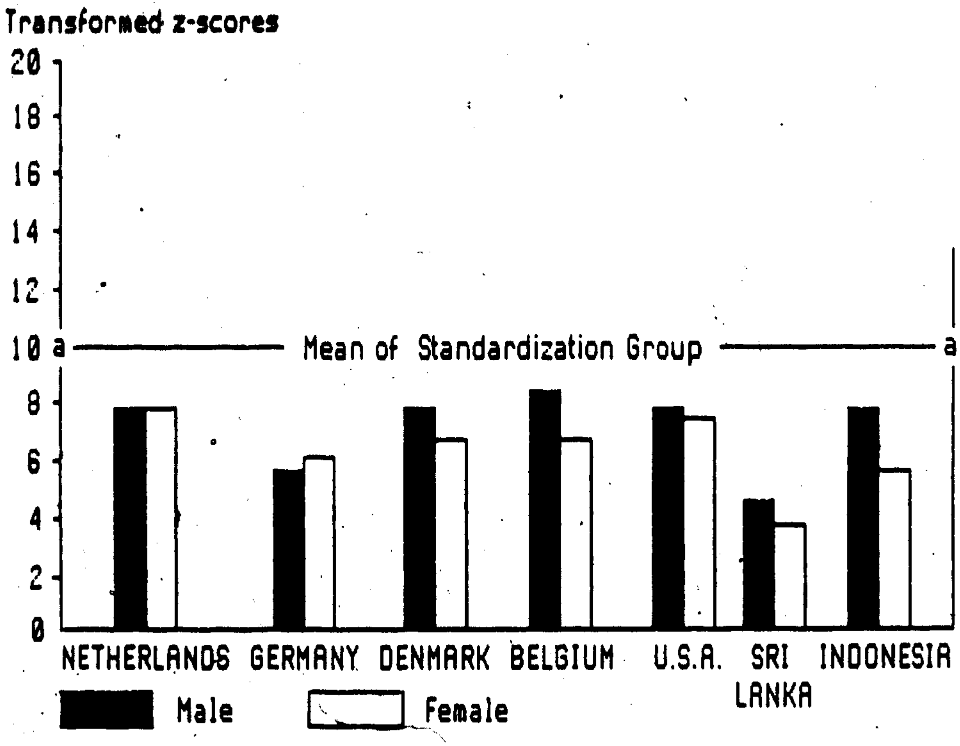
D. Definitions

1. The term '<u>hearing-impaired</u>' is usually used as a global term meaning all those individuals who have a hearing loss significant enough to interfere with communication and who thus require remedial intervention.
The term '<u>deaf</u>' is one part of this global term meaning individuals who have a hearing loss to such a degree that it precludes the natural development and acquisition of speech and oral language. Individuals who have a hearing loss to a lesser degree so that it only interferes with the natural process, form the other part of the continuum -- the '<u>hard-of-hearing</u>' (Rodda and Grove, 1987).

2. <u>Total Communication</u>: a communication system that includes the reception and production of a spoken sound system through speech-reading, audition, and speech, as well as the reception and production of a formal system of signs and fingerspelling.

TABLE 1

Psychomotor Ability of Deaf Students Aged 6 - 10 Years



"a" represents the mean of our Dutch reference group, expressed in terms of our norms.

To clarify this:
- we computed z-scores on the basis of the data of our standardization group (Dutch, 'normal' children)
- these z-scores were linear-transformed after the formula: norm = 3 x (z-score) + 10.
- in this way we constructed a 'scale' with scores from 1 through 19, with a mean of 10 and a standard deviation of 3
- the solid horizontal in the graph on 'level 10' thus represents the mean of our standardization group and the mean results on the motor test of the various groups of deaf children are 'compared' with this mean.

P.H. Wiegersma (Personal Communication
October 28 1986)

3. Oral Communication: a communication system that includes the reception and production of a spoken sound system through speech reading, audition, and speech.

4. Manual Communication: a system of communication that is based on a formal code of manual signs and manual fingerspelled symbols.

5. Pre-lingual Deafness: a hearing impairment whose onset preceded the development of language.

6. Profound Deafness: a degree of hearing loss over 90 dB, calculated over the three speech frequencies (500; 2,000; 4,000 Hz) in the better ear.

7. Motor Development: the progression through the acquisition of motoric skills usually relating to physical and mental maturity.

8. Motor Ability: the successful achievement of motoric skills with optimal efficiency.

9. Normal Hearing: ability to hear without amplification below a range of 20 dB, and as an individual who has acquired fluent spoken language through normal use of audition.

PART II

REVIEW OF THE THEORIES OF MOTOR DEVELOPMENT

This chapter will start with an analysis of the normal development of motor ability in children in order to show the importance of achieving success in this area. It will then relate this to the prevalance of deafness in the developing child with a concern towards other problems in the cognitive, linguistic, and social and emotional domain. An in-depth study of the possible reasons why impaired hearing may affect the development of good motor ability will follow in an attempt to understand why such a relationship may exist. From an educational viewpoint this is necessary in order that methods of remediation may be implemented. Part III will look more specifically at the research on motor ability and hearing-impairment, and show the problem areas that have been identified.

A. General Motor Development and Deafness: Is Good Motor Development Important?

Wiegersma and van der Velde (1983) stated that:

> . . . the first five years of a child's life can be characterized as an accelerated period of development such that a firm basis has been created for achieving full competance in many fields of performance. (p. 103)

They pointed out that, by school age, the child has command over many fundamental skills required for motor development, and quoted Rarick (1973; 1977) who has shown by factor analytic research that such skills show striking similarity to that of adults. Wall and Taylor (1983) wrote:

> . . . movement plays an important role in the lives of most children. In their early years, movement competence allows children to explore the environment, while later on it facilitates social development through different types of play experiences. (p. 1)

Fleishman (1964), in his work on the structure and measurement of physical fitness claimed that success in motor development can be typically related to intelligence levels and that "consequently, the infant's motoric abilities are often the basis for predicting his subsequent basic abilities" (p. 14). Studies with the motor abilities of Down's Syndrome children (e.g., Frith & Frith, 1974) would seem to lend credence to a relationship between intelligence and motor abilities, at least at the lower end of the intelligence scale. Further, Welford (cited in Liebert and Wicks-Nelson, 1981) has found that studies with elderly persons revealed that sensori-motor performance "correlated to various extents with intelligence test scores and other measures of cognitive or intellectual functioning" (p. 567).

Werner (1975), and Piaget (1966) (cited in Orpet, 1972) both stressed the importance of "sensori-motor" functions for the child's <u>total</u> development and learning, and "Piaget further showed how crucial concepts grow out of the manual operations of the child" (Gardner, 1982, p. 42). Orpet (1972) also mentioned that sensori-motor functioning is related to language processes. And Frostig and Maslow (also cited in Orpet, 1972) purported that a child's social and emotional well-being may often be influenced by sensori-motor abilities and defects.

Successful motor development thus appears to be fundamentally related to other aspects of development for the child. This relationship assumes importance in the development of language, social and emotional well-being, and general cognitive growth. However, although "the joy of moving is experienced by many children, not all of them gain the physical, intellectual, and social benefits that can accrue from positive movement experience." (Wall & Taylor, 1983, p. 1). For example, if a child who is deaf is showing some slowness in his motor development, his cognitive growth may also be slowed. It follows, therefore, that his future educational achievement may be similarly affected. A recent study of deaf school leavers in the U.S.A. (Office of Demographic Studies, 1980) in fact found an average reading ability of grade 3.4 with eighteen-year-old deaf school leavers. Socially and emotionally, various researchers (Altshuler, Edwards, Vollenwieder, Rainer and Tendler, 1976; Bindon, 1957; Garrison, Tesh and Decaro, 1978; Kirk, 1938; Levine, 1976; Schlesinger and Meadow, 1972; Sisco, Kranz, Lund and Schwartz, 1979; and Vegeley, 1971) have also commented on emotional problems of deaf persons when compared to the normal hearing population. Sisco, Kranz, Lund and Schwartz (1979), convincingly compared a prevailing figure of 1-2% for emotional disturbance[1] in normal hearing chil[illegible] in the local public schools (Educational Statistics Report, 1979) with a figure of 9.8% for deaf male and 5.69% for deaf female children (Office of Demographic Studies, Washington, 1979). Levine (1976) in particular, described deaf people as exhibiting "emotional immaturity, adaptive rigidity, socio-economic impoverishment, and narrowed intellectual functioning" (p. 259).

Whilst emotional or intellectual problems of the deaf cannot obviously be said to stem solely from motoric difficulties, it is basically unwise not to be aware that difficulties faced by a child in <u>any</u> part of his development, can detract from an optimal developmental process. Attention to motoric development with the deaf child may therefore possibly minimize or even eliminate some of these problems.

To conclude, considerable evidence seems to support the importance of good motor development in cognitive growth. Further, it is recognized that this society places a high emphasis on the physically strong and competent

---

[1] However, these authors did not define what they meant by emotional disturbance. Care should be taken in distinguishing the emotionally disturbed from the emotionally retarded. Emotional disturbance connotates a psychological state. Emotional retardation may be more appropriate for the deaf population since it relates to the aspect of immaturity.

individual. A child who has difficulty with smooth motor performance very often has to face negative social opinions, and exclusion from recreational group experiences. Emotional well-being is thus affected. Because of this, therefore, it is worthwhile taking a closer look at understanding the processes involved in typical motor development.

Normal Motor Development

The initial learning of children is clearly related to motor development. Malina and Rarick (1973) offered quite a comprehensive description of growth and motor performance. They start with the reflexes of the newborn infant, and follow with an outline of the development of independent skills, such as the skill of locomotion related to age and sex. Much earlier, Shirley (1931, 1933) tabled five orders of skill development and this is comparable to the Bayley Scales of Infant Development of 1969. Piaget (1966) also delineated six stages of sensori-motor development during the initial period of growth of the infant (0-2 years). He purported that children must pass through all six stages in order to become pre-operational. In fact, the young infant from a very early age appears to engage in motoric movement and development with vigor and purpose, and Gardner (1982) suggested that such exercise is a learning of patterning for later locomotion and more skilled movements. Unless a child therefore manifests a problem with some type of physical deformity or neurological malfunction all the stages outlined by Shirley, Bayley, or Piaget should be successfully completed. Success here then appears to be related to later success in the other areas discussed. But sometimes problems do occur. One possible 'malfunction', is the impairment of one of the senses that is used to make movement possible.

The senses are used to perceive the environment, and it is the perception of the environment that then enables movement within it. An individual thus needs to successfully integrate perceptions and experiences of the environment with the motivation for movement or motor action. In relation to intelligence and cognition then (as previously mentioned from Fleishman, 1964; Frith and Frith, 1974; and Welford, 1977), lack of, or slowness in interpretation by the brain of incoming information from the senses, delays response. Further, if one of the senses fails to give adequate information, efficiency of response is diminished. Theories of sensory integration help to explain this phenomenon. O'Connor and Hermelin (1978) outlined three such theories. The first is that sensory integration is an inherent skill which simply needs "fine-tuning" as the organism develops. The second is that sensory integration is developed through environmental experience. A third theory emphasizes the necessity of language for full development of sensory integration and sensory dominance. Each of these theories needs to be understood in relation to the impairment of the sense of hearing.

1. Sensory Deprivation, Sensori-Motor Integration, and Motor Development.

(a) Sensory Deprivation.

Wiegersma and van der Velde (1983) hypothesized that auditory deprivation hampers motoric development and movement adaptation of the individual for the following reasons:

> (a) Infants and babies at times try to rehearse movements which produce intriguing or pleasant sound effects. This process might be important for achieving movement control.
>
> (b) In everyday life, knowledge of performance and knowledge of results can be obtained by the normal hearing individual through analyzing the sound effects of the action, striving to learn, and in the regulation and automation of certain movements or skills.
>
> (c) The qualities of sound with regard to spatial orientation are such that they supplement vision. (p. 109)

All these are concerned with aspects of deprivation, specifically, the deprivation of sensory information gained from sound. Cohen (1980) explained this as follows:

> It is mainly through the senses that the organism mediates between inner needs and external circumstances. The sense of hearing unlike other senses of vision, olfaction, gustation and taction, cannot be stopped or started at will. It is a continuous pathway that links the individual with the environ-

> ment and is the means by which most learning is incidentally acquired. The ears are the channels through which stimuli from almost limitless, visible and hidden evironmental sources trigger reactions ranging from simple to very complex. (p. 1040)

The effects of sensory deprivation on people who continuously monitor their environment normally through their senses, were extensively studied in the late 1950's and 1960's through research on man's survival in outer space. Tests were conducted by N.A.S.A. in the U.S.A. on the reaction of individuals to deprivations of sound, touch, or gravity, vision, or exposure to continuous noise and/or light. Some Canadian researchers (Zubek and McNeil, 1977; Zubek, Aftanas, Kovach, Wilgosh, and Winocur, 1963) also made studies of the effect of similar sensory deprivation on people. Liebert and Wicks-Nelson (1981) reported studies on sensory deprivation with animals. Although little has been specifically written by these researchers on the results of the deprivation of sound as a single criterion, some other Zubek studies (1960, 1961) have shown that under conditions of prolonged isolation with absence of both light and sound, perceptual-motor ability becomes considerably impaired. Indeed, Zubek (1960, p. 240) mentions confirmation of these findings with those of other studies of a similar nature.

It can be suggested then from such sensory deprivation research, that 'sound' plays an important part in the development of ability within the perpetual-motor domain. The only caveat in relation to this study can be that the subjects in these studies were used to performing with all their senses intact. Sudden elimination of some of their feedback systems obviously has an effect. For an individual who has grown up in his environment never having had the use of one of these systems, the effect may not be quite so apparent. However, early deprivation of a feedback system could have an effect all of its own!

'Sound' is therefore important. According to van Uden (1977), Puyenbrook (1983), and Veeger (1983), it is most valuable for its spatial awareness or distal processing attributes. It also acts as an arousal or attention gaining stimulus to the reticular activating system, and as Cohen (1980) said, it maintains constant contact with the environment. Sound fills all of a person's environment. It can be in front, behind, above, below, near, or far. The receiving of these different stimuli enables an individual to orientate himself spatially. It enables a connection to be made between objects and the self. Thus it can be valuable in developing ideas of strength, speed, or the direction of force in a movement as the organism moves in space. In a series of experiments in the late 1970's (see Kelso and Clark, 1982, Chp. 4), sound also proved to be an important element for **learning** about a movement, particularly regarding the <u>speed</u> of action. Following general explanation of a task, some subjects were allowed to 'listen' to other people doing it before them. Others only had the verbal explanation. When they all performed the tasks themselves, the listeners were much more successful than those who had not listened. From this McGee (cited in Kelso and Clark) hypothesized the following:

> . . . that the subjects' listening experience may have provided information about the proper speed of the movement that they were to make, so that the movement was initially more rapid (and hence closer to the target movement time) than was the case for the subjects without this listening experience. (p. 130)

Such studies indicate the informative value of sound which deaf individuals miss. This means that they may rely on less information when learning about a required action. It might be for this reason, therefore, that the research shows deaf children to appear slower in reaction time.

But there can be other values of sound. Ijsseldijk (1983) mentioned that van Uden was concerned about eurhythmia and hearing impairment.

> It is thought that eurhythmia, i.e. the ability to execute, imitate and remember rhythmic movements, develops in a baby with normal hearing by auditory control: the child sucks, claps his hands, babbles, shakes his cradle, and so on, and perceives auditorily the sound-giving effects of his own movements. Most of these movements are not visually perceptible, but their sound-giving effects are perceived almost continually. (p. 2)

Accordingly, van Uden expected, and then found (see van Uden, 1983), a significant backwardness of deaf children in eurhythmia. And rhythm is a basic element of movement and timing. Van Uden has further noted that the deaf children in his school (Sint-Michielsgestel, The Netherlands) walk with a more proficient step when given amplification. They no longer shuffle their feet when auditory feedback of this movement is received. Here then, sound appears to be important for general coordination and perfection of movement.

Another aspect of the relationship of the deprivation of sound to the developing organism includes a further developmental element. This is physiological. Bernstein (cited in Hay, 1983) observed the following:

> Over the course of ontogenesis, each encounter of a particular individual with the surrounding environment, with conditions requiring the solution of a motor problem, results in a development (sometimes a very valuable one) in its nervous system of increasingly reliable and accurate objective representation of the external world, both in terms of the perception and comprehension involved in meeting the situation, and in terms of projecting and controlling the realization of the movements adequate to the situation. Each meaningful motor directive demands not an arbitrarily coded, but an objective, quantitative and qualitatively reliable representation of the surrounding environment in the brain. (p. 109)

The deprivation of sound may thus seriously impede the whole integrative process but worse, it may impede the development of the auditory areas in the cortex altogether. There is now some suggestion that neuron development begins <u>in-utero</u>, and that the fetus responds to sound as early as the third month of development. Bernholtz and Benercerraf (1983) experimented with various sound emissions to different fetuses and concluded:

> We conclude that hearing is established as a functionally <u>interactive</u> sensation by the start of the third

> trimester for the specific stimulus used, and with the restriction to short latency craniofacial motor-reactions. Arm or leg movements of longer latency (1.5 sec. delay) without associated head movement or blink, were seen in three of twenty-four additional subjects younger than twenty-one weeks of gestural age in whom this activity had been specifically sought. The sharp transitional occurrence of auditory startle behavior at the twenty-fifth frontier of extra-uterine viability provides an additional indicator of neuromotor activity. (p. 517)

Obviously, therefore, movement (and so motor development) begins much earlier than birth, and more importantly, begins as a reponse to sound. The deaf child may, thus, always face at least a nine-month developmental delay in motor response. It may be possible that the delay will not be so great if vibro-tactile aspects of movement for the fetus are included. But it remains to be considered if the developing brain can regain this interuterine learning post birth. This discussion emphasizes the need for extra educational attention to the motor domain of the deaf child. In fact, Veeger (1983) emphasized the need for sound/movement development in the neonate for the same reasons. He suggested that the lack of auditory stimuli may lead to a "permanent retardment in development" (p. 6), and based his theory on the supposition that cerebral development is not yet completed at birth. He mentioned Shapiro (1970) whose study with rats found that:

> the number of dendritic synapses to the pyramid cells, and the number of neurons that could be made visible by colouring, was much higher with the extra stimulated animals, than with the non-stimulated control group. (p. 6)

The conclusion is, therefore, that the absence of a sound stimulus after birth "could possibly have adverse effects on the development and extension of neurons and associative fibres in the central nervous system" (Shapiro, cited in Veeger, 1983). And both Conrad (1980) and Arnold (1983) agreed with this result of deafness. They also added a degenerative viewpoint to impedence of development. Conrad (1980) stated:

> Research on the effect of prolonged auditory deprivation in animals points strongly to the probability of transneuronal degeneration which might be irreversible, and it is argued that similar degeneration is likely in humans in the conditions accompanying profound congenital deafness. (p. 317)

Arnold (1983) went on to say that "it is a real possibility that auditory deprivation may cause <u>atrophy</u> to parts of the cortex." He concluded that "the only way of minimizing this danger is by properly fitting a hearing aid and convincing both child and parent to use it" (p. 230).

(b) <u>Sensori-Motor</u> <u>Integration</u>.

However, it is not just the deprivation of the distal processing or spatial attributes of sound that affect the individual, nor that of the deprivation of auditory feedback and rhythm for movement and speed. It may be the effect that this deprivation of sound has on the general powers of sensory integration and cognition, that are crucial. Simply, successful **sensory integration** of sound must take place before response in the form of motoric movement can occur. As Koupenick, MacKeith and Francis-Williams (cited in Cruikshank and Hallahan, 1975) noted, "motor delay can arise not only from motor disorder, it can arise from a disorder of the **other** (emphasis added) systems" (p. 110). This means that the central processing system of the brain must be intact, as well as all of the sensory pathways that transmit information. They continued to explain that learning occurs in three stages, namely:

(1) the reception of experience (i.e., sound itself);
(2) the central organization of received experience (sensory integration); and
(3) its expression in terms of behavior (i.e., motoric action), with a capacity to build further learning on the experiences that have been integrated this way (sensory re-integration).

All three of these must be functioning adequately for optimal performance. Further explanation of this aspect of sensory integration is made by O'Connor and Hermelin (1978) when they delineated the Piagetian concept that "for the first two years of life, children act within a sensori-motor space which has to be coordinated through actions and perceptions" (p. 39). Developmentally speaking therefore, the child's first experience in the world is that of himself in relation to the space around him. His experience is gained through the integration of what his senses perceive.

> The perception of space, and perception of one's own movement in space whether of limbs or the whole body,

> may rely on different kinds of sensory information. According to Holst (1954), movement in space is not only monitored from feedback, i.e., reafferance, but by the efference for a movement, that is, the motor command or "plan" for a movement leaves an "image" of itself somewhere in the nervous system. (O'Connor and Hermelin, p. 37).

O'Connor and Hermelin also mentioned the extension of Holst's argument by Held and Hein (1963) who maintained that any movement is always 'rechecked' against the continual incoming information. In sum, the organism perceives a situation, and acts according to what he/she has perceived. The result is then stored as an image, or blueprint for an action when the senses once again perceive a similar situation or environment. As the action is then replayed, the senses continue to monitor and send back information as to whether it was satisfactory, or if a correction is needed. Veeger (1983) outlined this kind of action feedback system in his diagram of the development of sensori-motor systems. A graphic representation of this is illustrated in Figure 1. Here he suggests how incoming information is received from the environment (A), and interpreted in the brain as requiring a necessary action (B). The order for the action to commence is then passed on to the motor area (C). When it has been executed, feedback occurs (D) and the information is passed back up to the brain. However, Veeger purports that this whole action-feedback system is not fully

The Figure appearing on this page has been removed due to questions regarding copyright.

The Figure represented a diagrammatic representation of the development of sensory motor systems birth to three months of age.

L.M. Veeger (1983). Unpublished paper. International Short Course, Sint-Michielsgestel, Netherlands.

functional until at least the fourth month of life.[1] If this is so, then it readily becomes apparent that with the lack of a whole sensory input experience such as that of sound, less information is available at outset, and both the initial integration for a motoric command, and the monitoring of the result, may be less efficient. The decreased efficiency may manifest itself in slowness.

The action-feedback system depicted by Veeger (1983) relates well to the theories of Schmidt (1975), Welford (1968), Adams (1971) and Whiting (1972) who have all attempted to explain human motor performance through various "loop" systems of information processing and action. Schmidt (1975) in particular defined a "schema program" for motor action that he explained in terms of recall, recognition, and generalized motor programs. Shapiro and Schmidt (cited in Kelso and Clark, 1982) wrote this as follows:

> . . . schema theory holds that movement programs are generalized, and that complex rules must be formed in order to use them. One such rule is termed the recall schema, which is concerned with the relationship between i) the kinds of commands that the subject sends to the musculature, and ii) the results of those instructions either in terms of the subject's limb movements, and/or the effects of those limb movements on the environment. A second rule is termed the recognition-schema, and is . . .

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[1] This appears to be in contrast to the theory of in-uterol learning. However, Veeger may be meaning that the system starts in-uterol, but is not fully functional until the fourth month of life.

> concerned with i) the relationship between the nature of the movement produced, and ii) the sensory information that a person receives as a result of making that movement. By considering that these 2 schemata are built up over the course of previously experienced movements, such rules can be generalized to novel situations, so that people produce a movement they have never made previously, or can evaluate a movement they have never made before. (p. 113)

Basically therefore, when an individual wishes to move, (1) he receives sensory information about the initial conditions, (2) selects the parameters (response specifications) to generate the movement, and (3) then notes the response of his movement. When a number of these responses have been executed, the performer begins to abstract the information about the relationship among the three sources of information. The schema now consists of a rule specifying the relationship among the three pieces of information. The rule (and of course, the generalized motor program) is stored in memory (Shapiro and Schmidt, p. 116), following the blue-print idea for a certain action.

Schmidt's theory is particularly important because it leads to three further predictions. The first, is that in order for the "rules" to be stored in memory, some kind of efficient mnemonic storing system is required. Such a system can be suggested as being in a code we call a "language". The concerns that an individual who is deaf has with linguistic coding are therefore important (see p. 52). The second aspect is that of the concept of "previous experience" building up the motor schemas. Handicapped children often face restricted environments where opportunity for optimal experiences and practice are limited (see p. 36). The third aspect, is that of the "ability to **abstract** the information about the relationship of the information being received". This means that some kind of sensory-integration and cross-modal referencing needs to be made. Ayres (1975), explained this in more detail when she wrote that "motor planning or praxis, is dependent upon sensori-integration" and that "sensory motor problems . . . do not lie in input, but in the internal **coordination** or **processing** of that input. The output, or motor aspect, is a problem because it is dependent upon the processing of input" (p. 301). She further noted that the studies of Birch and Lefford (1967) and Lefford (1970) have demonstrated that skilled motor development is a reflection of sensory, perceptual, and intersensory processing and patterning of sensory inputs (p. 305). A return is therefore made to the idea discussed at the beginning of this section. That is, that in order for an organism to respond to its environment, it must integrate and coordinate all incoming information gained through its senses. This means that individuals who are deaf may not only totally miss an informative sense to integrate, but worse, may also receive information through a sense that is malfunctioning or that has with it some other side-effects due to the etiology of the deafness. This etiological consideration is extremely important. At this point therefore it is vital to note that intersensory integration is a basic factor in efficiency of human functioning.

> The capacity for intersensory integration increases as one ascends the phylogenetic scale, and may account for man's superior capacity over animals in adaptive responses. A great deal of intermodality association occurs through the convergence of sensory input from several different sources on poly-sensory or convergent neurons, or a nuclei, or other structures designed to associate input from several different modalities. . . . The fact that a single neuron can and does respond to more than one memory modality, and sometimes requires input from more than one sensory source in order to discharge, points to the fact that the brain is designed to organize and utilize input from several simultaneous sources. (Ayres, p. 317)

A problem with any of the senses therefore can lead to less efficiency of integration, and therefore, to less efficiency, or slowness, of response. And the etiology of the impaired sense may further affect any of the other senses, including the central processing system in the brain itself. Birch and Lefford (1976) sum this up when they suggest that:

> the possibility does remain that intrasensory limitation , particularly in the kinesthetic modality, may to some degree underlie the effectiveness of intersensory transaction. (p. 43)

The limitation of audition leads to decreased effectiveness of intrasensory coordination necessary to respond with motoric speed. Less effectiveness means slower response.

Finally, in relationship specifically to the deaf, Tomlinson-Keasey and Ronald (1974) and Voort, Senf and Bernton (1978) considered two other elements in this problem of sensory integration. Tomlinson-Keasey and Ronald pointed out that the deaf child simply begins to process the environment cognitively without the use of the auditory monitoring channel (i.e., prior to diagnosis of hearing impairment which unfortunately is most often over one or two years of age, see Williams and Darbyshire, 1982). He/she uses vision, gestures, manipulation and olfaction as his/her dominant input channels, and starts coordination of these senses. The longer it takes to diagnose the hearing impairment, the more developed the child will be in these other senses. When identification is made however, if residual hearing is present, the auditory channel is suddenly put into effect by the application of hearing aids. The child is thereby forced to suddenly **change** his/her information processing methods, to include an entirely new one. Such a change of integration may delay processing until the new informative sense has been incorporated. This takes time. And thus, then, deaf children are slower in motor speed than hearing children. This may also be an answer to their apparent maturational age lag. Both Long (1932) and Myklebust (1968) commented on a maturational two to three year delay in deaf populations. When comparing deaf individuals in motor development with their chronologically aged hearing peers therefore, the deaf child may appear slower or inferior on some tasks, since the rate at which he/she develops full intersensory integration, has been chronologically delayed.

In summary, the following suggestions have been made in order to understand why deaf children appear delayed in motor proficiency:

(1) The deprivation of the sense of hearing, or its impairment, can seriously affect the integrative ability of the organism. This impedes the efficiency of reaction time or movements within the environment. Poor sensory integration is thus likely to manifest itself in inefficient motor functioning. This hypothesis was the basis or rationale for such motor tests as those of Stott, Myers and Henderson (1972), or the work of Frostig (1961) and Ayres (1974). These authors felt that there was a basis for the detection and remediation of learning disabilities stemming from problems of sensory, cross-modal, and intermodal integration. This was detectable from inefficient motor functioning. Thus the deaf child may appear delayed in some aspects of motor development, due to either a reduction in the reception of the individual sense of hearing (sensory integration), or as well, to the process of coordinating this poor sense of hearing <u>with</u> the reception of the other senses (cross-modal integration and central processing). This may result in an overall delay in the development of efficient integrative ability.

(2) Deprivation or lack of sound can lead to decreased distal processing and spatial awareness and lack of response rehearsal. Both of these again affect the

proficiency of motoric action. It can also decrease opportunity for cortical arousal so that learning opportunities are reduced.

(3) The lack of sound stimulus may reduce the number of developing neurons in the neonate brain, so reducing the speed of motor programing and slowing down the maturation of the developing cortical systems. It may also mean a nine month delay in the development of neurons devoted to the sensory integration of sound, and thus a corresponding experiential lag in the deaf child.

In conclusion, Veeger (1983) purported that "it becomes apparent that any failure to receive stimuli, either visually, auditorily, or socially can damage the later motoric, intellectual and social-emotional development of the child" (p. 7). The child who is born with impaired hearing may therefore also be retarded in motor development. Further, for this study it becomes possible to hypothesize two differences within the deaf population itself. Firstly, that deaf children raised manually without appropriate use of amplification, may face a greater problem than those deaf children raised orally where continuous, early and appropriate amplification has been an emphasized factor. And secondly, that if early and appropriate amplification has not been available for the oral child, then the manual deaf child may have an advantage through the extra experience he/she receives with manual/hand coordination and through being able to develop continually without the sudden addition of a 'new' sense. However, both will be inferior to the normally hearing child.

2. The Role of Experience, and Environmental Factors in Motor Development.

From discussing the theories of sensory integration and deafness, it becomes necessary to move on to the second suggestion of cause of delay in the motor development of deaf children. This emanated from Schmidt's schema theory (see p. 30) concerning the relationship between experience and the social environment. Three areas need consideration:

(a) the social environment,
(b) communication modality, and
(c) etiological considerations.

(a) The Social Environment

The adage "practice makes perfect" refers to the fact that the experience or rehearsal of an action leads to the perfecting of its efficiency. However, deaf children may be at a disadvantage through the lack of an opportunity to rehearse and perfect desired motoric skills (Wiegersma and van der Velde, 1983). There are two reasons for this. Firstly, handicapped children do not always have the same opportunities for social play as normal children. As a result "shyness" and "insecurity" can lead to withdrawal which compounds the problem further. Wiegersma and van der Velde (1983) stated that the deaf subjects used in their testing exhibited "evident lack of self-confidence, and often painful shyness" compared to the normally hearing subjects. They felt that this stemmed from a negative self-concept in the deaf child, and concluded:

> The shy and insecure child is not the kind of person who perceives the world as his rightful playground, nor will he present himself as a suitable partner in the group. Therefore, it is possible that he is deprived of many of the typical motor experiences available to the normal-hearing non-handicapped child. (p. 109)

Grove and Rodda (1985) also stated that:

> As Furth argues, the somewhat poorer performance of the deaf probably reflects a generalized lack of stimulation which is secondary to deafness. The decreased social communication, poorer reading skills, and restricted educational opportunities characteristic of the deaf clearly mitigate against cognitive development. . . . Carver also pointed out the deaf child has fewer opportunities than the hearing to interact fully with his physical environment: he must spend a high proportion of his time visually scanning for social stimuli.

The second reason may be found in considering the effect that parents and the familial environment have on their child, in the way they respond to his/her deafness. This may seriously influence the way in which the child in turn responds to his world. Research on such problem family constellations is plentiful. Wiegersma and van der Velde (1983), for example, wrote:

> The research literature indicates that parents of handicapped children often experience deep frustration, which gives rise to various reactions ranging from overprotection to neglect, and suffocating love to destructive agression. (p. 109)

Altshuler (1974) wrote of the depression of parents at the recognition of having a handicapped child, and talked of an "anger because it is an unsolvable problem. This anger threatens to spill over to the child" (p. 65). Knee (1978) talked of the tension created within the family as they adjust to the deafness and resolve feelings of blame. And Vernon (1977) summarized the situation as follows:

> Having a deaf child is traumatic to a family. It arouses responses such as grief, denial, guilt, anger, and frustration which are of an intense and deep nature. Unless these feelings are worked through in what is called a mourning or grief process, they are tremendously destructive to the entire family constellation in general, and to the mental health of the child in particular. (p. 85)

Schlesinger and Meadow (1972) found mothers of deaf children to be "more likely to appear inflexible, controlling, didactic, intrusive and diapproving," and that their children "appear to be less happy, to enjoy interaction with their mothers less, to be less compliant, less creative, and to show less pride in mastery." Freeman, Carbin, Clifton, and Boese (1981) quoted one mother's reaction to her child as follows: "Somehow when my child was diagnosed as deaf, I stopped seeing him as a child, and looked at him as DEAF." Basically, therefore, an environment of poor interaction and controlled inflexible restrictions, lends credence to the view of Wiegersma and van der Velde (1983) that lack of experiences for motor rehearsal and emotional withdrawal, can all affect the overall motoric functioning of the child.

It is reasonable to suggest however that these distortions in the nurturing process arise because of a lack of <u>communication</u> between parent and deaf child. Schlesinger and Meadow (1972) noted that the lack of parent/child interaction is more pronounced when a child "lags behind in a viable means of communication." Studies such as those of Goss (1970), Meadow, Greenberg, Erting and Carmichael (1981), and Anderson (1981), all indicate problems of communication between hearing parents and young deaf children. Their studies examined parent/child dyads in pre-school settings. Meadow, Greenberg, Erting and Carmichael (1981) specifically detected less verbal praise, more verbal antagonism, and less use of language altogether. Bell (1975) sums up this communication barrier caused by difficulties in auditory language thus:

> It is a frustrating condition, both for those who try to communicate, and those who try to receive; and it is one that can test patience and understanding to the limit. Many deaf people . . . suffer social or family exclusion, because to draw them into the conversation demands time, tolerance, and attentiveness on both parts. (p. 1)

Here, therefore, the issue of the mode of communication becomes important.

(b) <u>Mode of Communication</u>

Many studies seem to suggest that early use of manual communication overcomes this communication block faced by deaf children and their parents. If a mother cannot communicate easily with her child, she is likely to restrict his environment to a place where she can readily watch him/her, and where he/she can get into the least exploratory mischief. When easy communication <u>is</u> possible, it enables the mother to relax and thus allows increased freedom for the child. Since the deaf child does have a problem hearing his mother call, it is suggested that the use of a manual communication code will better match mother and child communication. Related to this, a recent study by Kuché, Greenberg and Garfield (1983) mentioned that deaf children of deaf parents also appear to "enter school more advanced than deaf children of hearing parents," and that "they maintain this advantage throughout their school years" (p. 458). Studies by Meadow (1967), Vernon, Westminster and Koh (1970), Alterman (1970), Stuckless and Birch (1966), Vernon (1968), Stokoe (1975, 1979), Cicourel and Boese (1972), Vernon, Coley and Ottinger (1979), and Vernon (1972) all agree with this. In fact, a few studies of motor ability and the deaf have found <u>superiority</u> of deaf children who use sign language, to hearing peers, in the area of visual-motor coordination (see pp. 110, 111). As manual communication systems involve eye-hand coordination in the movement of the hands and fingers in forming the signs, it appears that manual communication offers another advantage. Indeed, when van den Hoeven and Speth (1972) commented on their observation of poor motor development corresponding with retardation in language and speech, it may be that they refer only to those deaf children who <u>do not</u> use a manual communication code as part of their linguistic expression! Returning to the idea of family communication however, the study of Sisco and Anderson (1980) found academic superiority of deaf children and deaf parents even to hearing children with hearing parents. Such studies suggest that deaf parents with deaf children have a better family constellation. And since deaf families usually use a manual communication mode with natural proficiency, the advantage of easier communication does appear valid.

However, etiology of impairment may be a more pertinent issue here. It is only with this dyad of deaf parents with deaf children that it is reasonable to assume an etiology of genetic origin <u>without</u> compounding factors. It may rather be therefore, that deaf children of deaf parents are 'superior' in their achievements simply because they do not suffer from further complicating side-effects of a deafness caused by disease or trauma. This suggests that it is not necessarily the manual mode of communication itself that leads to superiority. The study by Sisco and Anderson (1980), found superiority only on the performance scales of the WISC-R and not the verbal. This is perhaps indication again as to the genetic origins of much of the deafness found in deaf families, and not that deaf families have superior linguistic levels to hearing families with deaf children.

There are also other questions about the studies themselves which compare the two deaf groups. The study of Weiskrantz and Conrad (1981) for example, compared its results to the study of Sisco and Anderson the year before. Weiskrantz and Conrad compared deaf children with deaf parents to deaf children with hearing parents in Great Britain, and found no superiority of the former. But their comparison is tenuous since they used the British Ability Scales and not the WISC-R Scales as their U.S. counterparts. Also, the signing ability of deaf children in Great Britain must be further questioned, since Great Britain is predominantly oral in its educational policies for deaf students. Further, British deaf students are more often sent to residential schools, thereby reducing opportunities for parental influence altogether.

Other disagreement with the studies suggesting superiority of sign language for deaf children of deaf parents comes from a methodological viewpoint. Nix (1975) offered a refutation of seventeen studies most "widely quoted" to his date (1975), and criticized their design and results. Since he included descriptive, ex-post facto, quasi experimental, and experimental research, and evaluated all the drawbacks from uncontrollable variables, the reader is left wondering if indeed there are any meaningful studies of deaf children undertaken in which researchers actually measure what the tests purport to measure! Owrid (1971) has a similar criticism of three studies in the 1960's proclaiming manual advantage. Yet the most recent study in this area by Kushé, Greenberg and Garfield (1983) listed WAIS, WISC, WISC-R scores and Stanford Achievement Tests results by various researchers over the past decade state higher achievement by deaf children with early manual communication skills when compared to orally raised counterparts. And it is to be noted that they found that the **earlier** manual communication had been used in a family (for example, with deaf children of deaf parents), and the more **extensive** the experience with the sign language was (for example, with more than one deaf child in a family), then the levels of scholastic achievement were correspondingly higher. A more proficient linguistic ability thus appears to improve **overall** cognitive functioning.

These studies of early communication lead lastly to a consideration of modelling effects. In stating that deaf families have better constellations, it could be that deaf children of deaf parents have a similar role model available since their parents are deaf also. This "decreases feelings of emotional isolation felt by many deaf children with hearing parents" (Meadow, 1980). When Corson (1973) compared deaf children of deaf parents with deaf children of hearing parents, he concluded:

> . . . employment of manual communication alone does not seem to adequately describe the superior performance of deaf children of deaf parents when compared to deaf children of hearing parents.

> The finding that deaf parents of deaf children expressed greater parental acceptance of deafness in their children than hearing parents of deaf children, provides a more plausible explanation to describe the phenomena of the superior performance of deaf children of deaf parents. (p. 6)

It should be added that he also found that socio-economic status influenced academic success.

It is necessary, therefore, to note that no conclusions can be drawn about the efficacy of the manual mode **itself** but rather to the level of **communication interaction** within a family. Kushé, Greenberg and Garfield (1983) said that "if high quality communication is not available until early childhood, efficient linguistic foundations may be difficult to improve, **even with later introduction of sign language** (emphasis added)" (p. 465). This returns to the fact that most of the deaf child/deaf parent dyads **start** manual communication earlier than many deaf child/hearing parent dyads. Deaf parents may also be more proficient with signing than hearing parents who have to quickly learn a new linguistic code after their child is diagnosed as deaf. Sisco and Anderson (1980) concluded:

> Manual communication should be viewed as an important tool that can provide a means for better and more extensive interaction of the deaf child with his or her parent(s) and other individuals in the environment. It provides a basis for reciprocal communication which increases the possibility of positive rather than negative interaction. **Manual communication, in and of itself, cannot provide the nurturing environment which is necessary for optimal growth** (emphasis added).
>
> Good communication skills without a nurturing, accepting living environment, will not result in

> greater cognitive growth in deaf or hearing children. There is a greater probability that deaf or hearing children reared in chaotic, unnurturing environments, will grow up to be fragmented with underdeveloped cognitive abilities. (p. 929)

Therefore, it may be that any communication started early, by a warm, receptive family, is equally effective. This relates well to Bruner's theory of cognitive growth (cited in Gage and Berliner, 1975) which emphasized that "systematic interactions between a tutor and a learner are necessary for cognitive development" (p. 373). Good oral interaction can be included in this.

In conclusion, the social environment, as well as the efficacy of communication, appear to enhance developmental potential in a child. Motor development is included in this developmental potential and indeed many researchers have pointed out the value of interactional experiences for the deaf child with his or her environment (see Part III, p. 104). Unrestricted environments with ease of communication are related to cognitive growth. Therefore, since as was stated earlier, motor functioning is related to intelligence and cognitive growth, the testing of a hypothesis that there may be a difference between manually and orally raised children in the motoric domain, may help to make this issue of manual superiority clearer.

In summary, the deaf child may exhibit delay in his motor development for the following reasons:

(1) He/she may face a restricted social environment

in which he/she can find his/her opportunity to perfect his/her motor skills likewise restricted, and

(2) The communication difficulty he/she often faces, along with parental attitudes, can compound this problem further since both "seem to have substantial influence on the self-concept of the child" (Wiegersma and van der Velde, 1983, p. 109).

It may be concluded therefore, that deaf children simply do not experience the appropriate circumstances in which to develop efficient motoric abilities.

(c) Etiological Considerations

It is at this point that the argument of heredity and the environment assumes importance. Is it really possible to say, for example, that the environment of a child will lead to a certain pattern of his motor development? Theories propounded by Gesell (1954) suggest alternatively that the child has a genetically determined 'biological clock' to his development. If this is so, then little can externally be done to alter the "clock". This means that etiological factors are extremely influential -- if not totally responsible for how a child develops. Carter and Campbell (1975) have found that premature infants have a different early neuromusculature developmental pattern than those infants who are carried to full term. Komich, Lansford, Lord and Tearney (1973) also commented on problems of sensory-integration in the development of infants of low birth-weight. It could be then that the deaf child exhibits the observed motoric delays because of an organic deficit from the etiology of his impairment. When considering the cause of deafness, as has been previously suggested (see p. 31), disease or trauma can include side-effects such as neurological impairment that can lead to corresponding motoric difficulties. Meadow (1980) stated:

> It is apparent that we can now expect a higher prevalence of motor disturbance along with deafness in children, because of the increased possibility of central nervous system damage. (p. 45)

Broesterhuizen (1983) further acknowledged that "according to the Russian neuro-psychologist Luria (1973), integrative ability for functioning completely depends on the functioning of that part of the cerebral cortex where the visual and auditory cortex overlap, the so-called association areas." Thus the deaf child may have adequate experience in his environment, but poor integrative ability may be due as much to the etiology of deafness affecting the central association areas, as to being deprived of sound.

Wiegersma and van der Velde (1983) take this idea further. They wrote that:

> (a) Vestibular defects may have a pervading influence on the domain of motor performance as not only balance is involved but also eye-hand (and with it total body) coordination.
>
> (b) When a neurological defect is a central determinant of various handicaps, deafness being one of them, the chances are that certain aspects of motor functioning will also be impaired. (p. 108)

Since the vestibular regions are located at the site of the organs of hearing, this might indeed be true. The vestibular system is a vital source for motoric action because it lays the groundwork which is necessary before any movement can be made at all. Gibson (1966) wrote:

> The vestibular apparatus interlocks with other organs and perceptual systems. By itself it is a force detector, providing orientation to the direction of gravity and making possible upright posture, that is equilibrium or balance. It does so by specifying any tilt of the body, and initiating compensatory tonic reactions of the antigravity muscles . . . in combination with the perceptual system of the skin, it provides orientation to the ground. The two perceptual systems together anchor another system, the awareness of the directions of the bones of the body relative to gravity and the ground, and the orientation of the head to gravity and the ground provides a stable platform as it were, for the orientation of the organs of the head -- that is, the ears, mouth, nose, and, above all, the eyes.
> (p. 71)

Another example is given by Greene (1972) who pointed out that the vestibular system in the inner ear contains accelerometers that inform the reflex centres of changes in body orientation. "If a cat is standing on a platform that is shaken, these vestibular signals must properly increase the tension in each supporting muscle, so that the cat may maintain its balance." (p. 322) Although this describes a very basic principle of reflex physiology, it helps in understanding the discussion of deafness and its etiologies. Most studies with motor tasks and deaf subjects, have continually found problems with balance (see Part III, p. 108) and the well functioning condition of the vestibular system thus appears to be important. In fact, Wiegersma and van der Velde (1983) also undertook a second study where <u>all</u> known deaf individuals aged six to nineteen years in the north of the Netherlands (other than those who had obvious motor impairments) were tested with hearing controls. The test items included dynamic coordination, physical fitness, and manual ability. Results were stated as being "strikingly different," particularly in the area of visual motor tasks. That is, tasks requiring visual-motor control seemed to be an added problem to deaf individuals with suspect etiologies. The conclusion Wiegersma and van der Velde drew was as follows:

> the deaf population (with the exception of those who are otherwise physically handicapped) is not only inferior to normal hearing controls with regard to general dynamic coordination and aspects of physical fitness, but also their performance in the field of manual ability . . . is significantly lower. **This last difference is greater than was the case when the group of healthy deaf children were considered separately** (emphasis added). (p. 107)

Thus, etiology of deafness bears a specific relation to motor development. From the Dutch results, "healthy" deaf children with no obvious other physical impairments (usually described by the researchers as being "pure deaf from genetic etiology") exhibited dynamic coordination difficulties and slowness in movement time. Deafness caused by other means, seemed to accentuate this problem and add to the areas of delay. Vegeley (1971) summed this up in her research on personality and deafness:

> It is possible that some personality deviation could be produced by biological abnormalities, perhaps quite

> subtle, associated with the factors that produced the deafness.

A parallel might be drawn to the area of motor development. Even the warmest and most nurturing of social and familial environments will be unable to eliminate such "subtle abnormalities", simply because the organism is impaired.

However, such definitive etiological influence is not so clear cut. Touwen (1974) wrote:

> Functional development is not exclusively dependent on genetically determined maturation. Gesell's Maturation Hypothesis in which the increase of the infant's functional abilities was thought to be based mainly on preset genetic programing, cannot be maintained. (p. 616)

Castle, Held and White (cited in Hay, 1983) have further observed the following:

> detailed analysis of the development of a sensori motor function . . . inevitably raises a classical theoretical problem. The human infant is born with a reflex repertoire, and neuromuscular growth is rapid and complex. In addition, however, he begins immediately to interact with the post-natal environment. Thus we face the complex task of distinguishing, to the extent that is possible, between those contributions made to this development by maturation or autogenous neurological growth, and those which are critically dependent upon experience or some kind of informative contact with the environment. (p. 27)

It could be, then, that "autogenous neurological development" is not inherent. If not, then once again the child's contact and experience with the immediate environment must be positive, especially if other experiences are needed to compensate for the lack of one of the senses.

Hay (1983) pointed out another concern. She stated that "reflexes" may play an important part for later development in that the "reflex allows initial rudimentary movements of an explorative nature" (p. 28). A return is therefore made to the position discussed earlier regarding the importance of sound (see pp. 18-24). That is, that the deprivation of the orientation reflex gained from sound for visual-auditory coordination, or head-body movement in location, or simply the arousal aspect of sound, affects the proficiency of development. And further, sound is important for the **anticipation** of movement. Hay (1983) purported that the more accurate the performer's interpretation of a task's demand, the greater the likelihood will be for a skilled response. Every incoming experience has a role because:

> skilled performance appears to be dependent upon sufficient amount of varied movement experience or practice at similar tasks. This experience in turn leads to the development of complex cognitive roles which govern motor behavior in an increasingly efficient manner. (Hay, 1983, p. 32)

She continued to mention researchers that have indicated that "the development of movement skill is dependent upon the learner's ability, to efficiently process information, thus freeing channel capacity to other events" (p. 31). The sensori-motor integration element thus reappears (see p. 24).

The debate between whether the infant's reflexes are the "building-blocks" of later motor development, or whether they are simply genetic reactions from evolution, is not clearly answerable. Both Hay (1983) and Connolly (1980) offered studies from researchers who have argued strongly for both positions. All that can be said is that if reflexes are important, then the deaf child obviously misses an important sound building-block. If not, then it must be the environment to which attention is turned, and because of this, the school environment cannot afford to eliminate programs such as physical education, where movement is basic. To conclude, therefore, definitive answers cannot as yet be given to such questions of whether the deaf child exhibits motor delay (a) because of the lack of the integrative aspects of sound, or (b) due entirely to restriction of his environment, especially regarding communication which in turn inhibits his freedom for experience of movement. Or, if (c), the delay is due solely to the fact that whatever caused the deafness, in turn, caused some other malfunction related to motoric skill. Only suggestions can be made. Such suggestions, however, do make it possible to hypothesize that deaf children may exhibit differences **between** themselves. And understanding possibilities behind problems of motor delay bears a direct relevance to the educational policies to be provided for deaf children. It should be remembered that there is always inherent danger in a theory that suggests it has "the answer" to a problem. The heredity or environment debate has been in existence in its present form since the beginning of this century, with sometimes quite interesting studies undertaken with twins (McNemar, 1933). Malmar and Rarick (1973), Connolly (1980), and Klissouras (1971) all mention the debate nearer our own time. If however, it is held that a child cannot do something **because** he is suffering from a handicap, then educators may resist attempts at remediation. It is much more likely that while positive external factors cannot "cure" impairments, they can enhance the development of the child to reach his **fullest** potential -- whatever that may be. Poor external factors, or merely the passive acceptance of a condition, can only restrict progress. **Thus**, if deaf children are facing motoric delays, schools and educational policies could help by offering appropriate remediation programs. And further, families should be receiving help in dealing with the secondary emotional and communication difficulties associated with deafness.

3. Language and Motor Planning

The last possible reason behind the difficulties deaf children face with motoric development emanates again from Schmidt's schema theory (see p.30). This concerns the relationship of language to motor programing.

Wepman (Chapter 7 in Cruikshank and Hallahan, 1975) said that "perhaps the most important thing to say about children, is that they must all learn to use (decode, recode and encode) language." He commented that for a while it was considered that the major purpose of language was to facilitate communication, communication being the most efficient method of survival when individuals came together into small groups. But language has another purpose. It helps in the cognitive organization of the environment, and provides an efficient tool for the memory.

(a) Cognitive organization and sensory mediation.

Mulholland (1980) asked:

> What does integration of sensory modalities mean? Sensory experiences are not fragmented; they form a sensory-motor gestalt. Knowledge of an object includes touching, smelling, manipulating, seeing, and hearing it. The whole spectrum of sensory modalities plays a part in this experience. The word refers to this gestalt, and its symbolization. In hearing persons, the word penetrates the experience, and helps to integrate the whole experience into one gestalt. (p. 424)

It is language therefore that provides ready and efficient uses to the memory for the execution of action, and helps to organize experiences. This can be related back to the "blue-print" or "rule" idea for movement discussed earlier (see p. 26). The blue-print and rules for movement are coded in language . O'Connor (1979) stated that through language "the nature of ontogeny of learning has reached a critical stage at the point when the existence of verbal ability makes a difference in the **permanence** (emphasis added) of an encoded signal."[1] Children who have difficulty

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[1] The exact meaning of the terms "verbalization" or "verbal ability", and language, will be discussed later (see p. 63).

in developing language, therefore, will exhibit corresponding difficulties in the efficiency of processing for the execution of an action **because they have difficulty retaining the motor blueprints or rules in memory.** O'Connor and Hermelin (1978) posed the idea further that language not only organizes experiences, but that it helps in the perfecting of efficient intersensory transfer and cross-modal processing. They stated that:

> an alternative explanation of intersensory transfer has been offered in terms of language mediation. Through language, the qualities of the stimuli in different modalities are supposed to be abstracted and thereby made equivalent. (p. 25)

They also quoted the studies of Birch and Lefford (1963), Rudel and Teuber (1964) and Blank and Bridger (1964) whose investigations on intersensory integration have had as a central issue "the significance of the role of language in acting as a means for intermodal exchange" (p. 27). The work of Blank and Bridger particularly has tended to show that "cross-modal transfer depends on verbalization" (p. 30). To be deficient in language, therefore, will pose some corresponding problems in intermodal ability since it has been seen that sensory integration is important for responding to the environment in a quick and appropriate way (see p. 24). It becomes necesary then, to recognize just how language organizes sensory integration, and how this might affect an individual with impaired hearing.

It is well documented in fact that deaf children have difficulty in English language abil[illegible] But the idea that deaf children who lack spok[illegible] language will correspondingly lack the ability to efficently process motor information, or to efficiently retain motor blueprints for action, can be explained in more detail.

Wiegersma and van der Velde (1983) explained the value of language specifically to movement, in three ways:

> 1. that in the development of a normal hearing child, a firm connection is established between a movement or skill, and the verbal description of the motor act.

Newell and Barclay (1982) also pointed out that "the verbal learning literature suggests that with age children adopt a more strategic role in maintaining their own performance" (p. 196). As children grow older, they are more able to plan strategies for movement in linguistic form. This leads on to the second and third points of Wiegersma and van der Velde:

> 2. that it is by means of language that it is possible to bring about subtle changes in the motor activities of a child (e.g., in changing pressure, controlling speed), or in appealing to the movement experience that the child has at his disposal, and
>
> 3. when learning a new complex movement, there is a "cognitive" stage in which verbal (conceptual) activity supports the execution of the activity. In many cases the individual resorts to verbal rehearsal of the movement as is seen in calisthenics and dancing.

O'Connor (1979) explained this when he said that "the power to use language, or to use words as an encoding medium, enables us to regard words as conveyors of thought or self-instructions that would not otherwise be available to the hearer" (p. 352). However, the problem is to decide if experience facilitates the organization and development of language, or if language facilitates the development and organization of experience. Bruner (cited in Gage and Berliner, 1975) said that:

> growth depends upon the development of an internal storage and information-processing system. Unless children learn a symbol system with which to represent the world, they can never predict, extrapolate, or hypothesize novel outcomes.

He continued:

> Language develops an increasing capacity to say to oneself and others, by words or symbols, what one has done and what one will do. Language is the key to cognitive development . . . most important is the fact that as we grow older, we learn to use language and to mediate events in our world.
> (p. 373-374)

O'Rourke (1974) also said that "the learning of the names of things enables the child to organize sensory data and subsequently, global categories". But the Piagetian perspective maintains that "language development is first built upon a necessary foundation of sensori-motor integration" (Beveridge and Brinker, 1980). Indeed "an object will not be represented by a name until that object has been differentiated from other objects on the basis of a specific set of actions" (Beveridge and Brinker, 1980). From this, therefore, if a child is facing difficulty with his sensori-motor development, the opportunity for the "speech set of actions" to distinguish objects from each other, is impaired. Since a linguistic "label" cannot then be given until this skill has been perfected, a deaf child if facing delay in his motor development because of his sensory deprivation, also faces a delay in the development of language. And if language then aids the organization of sensory experience, efficiency of motoric execution itself is going to be further retarded. A kind of circle of delay begins. Cognitive delay can be part of this. In sum, Piaget felt that increasing linguistic competence enabled children to move on to higher stages of functioning (see Beveridge and Brinker, 1980, p. 49). So did Bruner. The highest stages are ones of increasing proficiency in which language **accelerates** the processing of information.

It may be, then, that the problem in motor speed experienced by the deaf child, originates with the problem of ability with spoken language. And this because spoken language is dependent upon the transmission and reception of <u>sound</u>. It has been estimated that because of lack of auditory input the deaf child receives only 1/100,000th of the language a normally hearing child receives (see Pennsylvania, 1979). Newman (1974) and Knee (1978) concluded that this lack of language will therefore mean "deaf children have no effective symbol system or language to help codify, classify and store in their memories all that has happened" (Newman, p. 163) and that "individuals who are deprived of the experience of hearing sounds and speech at an early age, will lag in their abilities to conceptualize and synthesize ideas" (Knee, 1978). It is immediately obvious, then, that efficiency of functioning will be decreased when an individual cannot either integrate experiences quickly, or plan appropriate responses to movement from memory of previous experiences that are recalled quickly through linguistic coding.

(b) Memory and Language

Being able to recall information quickly leads to the mnemonic consideration of language. Since language codes the information of the environment that an individual gains through experience, it is important to realize that this 'coding ability' is a facilitator for the memory. O'Connor (1979) wrote that the nature of ontogeny of learning has reached a critical stage at the point when the existence of a verbal ability makes a difference in the permanence of an encoded signal. Relating back to the blue-print or schema rule ideas discussed earlier, therefore (see p. 26), the 'blue-print' for an action is coded in the memory in linguistic form. For example, one word can encode a whole series of related movements, such as the word "jump" being a cue for a whole schema of movements. The single word acts as a stimulator for the recalling of the motor schema or action of a jump (that is, in the bent knees, arms swing for height, two feet take-off, etc.). It thus acts as a mediator between intersensory transfer as the senses pick up a situation and code it as requiring a "jump" response (O'Connor and Hermelin, 1978). As Mulholland said (see p. 53), the 'word' has penetrated the experience and acts as a prompt or cue for more information required for the action.

Clark (1978) helps make this role of language as an aid to the memory of motor movement clearer. In her study on visual retention in children, she stated several researchers who have compared the differences in motor ability between younger and older children. They found that the younger children are, the more they appear to forget sequences that are required. Clark explained that although all age levels receive the same amount of visual information on a task, the younger subject's "recall declines more quickly than that of his older counterpart" because:

> for a person to retain information for longer than a 1/2 second, he or she must <u>transfer</u> information . . . for example, if the initial stimuli are visual, subsequent encoding may transform the information into verbal code (p. 102).

She goes on that "many studies have demonstrated that younger children do not employ verbal labels or verbal rehearsal in memory tasks (Conrad, 1971; Flavell, Beach and Chinsky, 1966; Hagen and Kingsley, 1968; and Keen[illegible] Cannizzo and Flavell, 1967), but if they are prompted to use overt verbalization, their performance does improve" (p. 102). And being able to remember infor[illegible] received from the senses is obviously necessary in [illegible] to perfect a motor response. In sum,

> changes occurring in the way information is encoded and rehearsed . . . have a two-fold effect on motor skill acquisition. First, visual stimuli are an important source of information to most motor skill performance, and differences in what is remembered in the visual array will certainly affect this performance. For example, after hitting a ball, the child must remember where the ball went -- how far and in which direction -- in order to use this information to either repeat or modify subsequent hits (p. 104). Similarly . . . in throwing a ball at a target, a miss might be made to the right. On the next attempt, the subject adjusts to the left. If you cannot remember the consequences of the previous movement, however, you are likely to continue to make the same error. Without memory, you are not likely to improve no matter how much you practice (p. 107).

Clearly then memory plays a key role in the acquisition and performance of motor skills. And the idea that verbal skills increase the power of memorization means that language is an important tool in the acquisition of these motoric skills. Deaf children thus have a disadvantage by having difficulty with their acquisition of language, and may, as a result, appear less efficient than their hearing counterparts. Without similar linguistic ability they are functioning behind the hearing children in the same way that younger children function behind the linguistically more proficient older ones. Simply, they become less efficient processors of actions because they are less efficient in retaining the blue-prints in memory. Arnold (1979) concurred with this in his discussion on the role of memory and language in the thinking process of the young deaf child when he stated that "it is likely that a young deaf child is similar to an even younger hearing child" (p. 4). It also concurs with the maturational lag mentioned by Long (1934) and Myklebust (1964).

Once again, therefore, the fact that most languages use phonological or acoustic symbols, means that the deaf child faces a large problem in acquiring a linguistic retaining strategy, or mediator, or organization element, in its coded spoken form. Thus, it may not be that deaf children appear slower than hearing children in movement execution because their impairment has caused other neurological or vestibular side-effects, nor that their familial environment has been restrictive. Nor yet is it that without sound, full motoric efficiency cannot be achieved. It is because their difficulty with language attainment **slows down** the efficiency of retrieving knowledge from the storing of environmental information useful to planning action. This slows down processing time.

(c) Verbalization and Inner Speech

At this point, it becomes necessary to try to understand the meaning of the term 'verbalization' or 'verbal ability' as it is applied to the concept of 'language'.

Wall and Taylor (1983) have described four knowledge bases that are needed for motoric action. These are:

1. declarative knowledge, i.e., factual knowledge for the action from what is perceived about a person's actions, the objects in the environment,

or the action environment itself.

2. procedural knowledge, i.e., the knowledge underlying the execution of action.

3. affective knowledge, i.e., feelings about actions and action situations.

4. metacognitive knowledge, i.e., knowing about knowing about action.

All these knowledge bases seem to be most efficiently stored and mediated through language in the way just described. Indeed Wall, McClements, Bouffard and Findlay (1984) aligned with the Piagetian theory that language follows on from the foundation of experience. They postulated that language is the tool used to help organize experience when they wrote:

> during the pre-school years, declarative knowledge about action is initially non-verbal; however, as children develop knowledge about their actions, the actions of others, and the effect of actions on objects, they begin to use language to describe them. Huttenlocker, Smiley and Chorney (1983) show that actions are one of the first class of concepts that are expressed, and children seem to develop them in relatively orderly fashion. Eventually this verbal knowledge about action will become a flexible tool for deliberately controlling action under certain conditions (p. 16).

However, it becomes apparent that these authors are referring to language as being an expression of 'verbal ability'. Other researchers do the same. Newell and Barclay (1982) explained that "the <u>verbal</u> learning literature suggests that, with age, children adopt a more strategic role in maintaining their own performance" (p. 196). Wiegersma and van der Velde (1983) stated that "in the development of a normal hearing child, a firm connection is established between a movement skill and the verbal description of the motor act" (p. 109). They go on to mention:

> when learning a new complex movement, there is a "cognitive" stage in which verbal (conceptual) activity supports the execution of the activity. In many cases the individual resorts to verbal rehearsal of the movement.

This aspect of verbalization in the learning of a new complex movement for 'verbal rehearsal' of proposed actions, can be taken further. For example, a parallel can be seen with the study of Taub and Berman (1966), who experimented on the motoric ability of deaffernated monkeys. They found that even when the lines of sensory feedback were cut, these monkeys were still capable of locomotion across a distance, or up a wire to achieve a desired object. **But these movements were gross and awkward in an ataxic form.** For refined or more efficient movements therefore, the authors concluded that sensory feedback appeared vital. This fact is important to remember when discussing the lack of auditory feedback for deaf individuals. And similarly, it becomes apparent that for the learning of the more **skilled** or complex motoric tasks particularly relevant to human design (that is those more than just locomotion, for example, piano-playing, etc.) a **linguistic** feedback appears to be another 'refining' or 'efficient-making' device. The studies of Hogan and Yanowitz (1978), Cratty (1962), Adams (1971) and Blank and Bridger (1966) support this contention.

They outline language as necessary in the early stages of motor skill learning. Adams (1971) stated that the "first stage of acquisition is under verbal-cognitive control" (p. 131) and Hogan and Yanowitz (1978) wrote that:

> research by Adams (1969) and by Fleishmann and Hempel (1954, 1955) indicate that individuals who score higher in verbal tasks tend to perform better on certain motor tasks during the early stages of skill acquisition. Similarly, Kohfeld (1966) studied the relationship between verbal and motor ability during psychomotor performance, and his data also suggests that verbal comprehension is important in early motor learning. . . .These conclusions are consistent with Adam's (1971) assumption that individuals consciously, yet covertly, control movement with verbal responses during the early stages of learning. (p. 133)

They go on to mention that "the role of verbal response in motor skill acquisition is also implicitly referred to in Schmidt's (1975) schema theory of motor learning" (p. 133). It is the role of language that is important here in the early stages of learning a new skilled task because it seems to act as a valuable response and feedback mediator. Later, the role can decline as the individual perfects the skill and it becomes more automatic. Wall, McClements, Bouffard, and Findlay (1984) give the following example:

> during the initial stages of learning to juggle, the learner will more often use inner verbal cues to guide the sequence of movements that he or she makes; with learning, the basic action pattern or sequence becomes established and conscious thought may shift to monitoring the height of the balls or the distance that they are landing from the body. With further learning, the action sequences become automated and conscious verbal cues or mental images that originally guided the action sequences are no longer required. . . . In fact, in highly automated

> stages of juggling performance, the expert juggler will *not* be able to verbalize what he is doing. (p. 22)

Adams (1971) likened this to the example of the piano player who finds interference in his playing if he consistently monitors his fingers through the visual sense. Although vital in the early stages of learning finger placement, later the fingers can find their place without visual support. Thus it is apparent that the ability to verbalize language can be said to facilitate the learning of, and the monitoring of, new or skilled tasks. And in the initial stages of development, it is further important for aiding in the efficient sensory organization of the environment. Once high levels of functioning have been achieved however, language then becomes less important.

A theory by Norman and Shallice (1980) and developed by Wall, McClements, Bouffard and Findlay (1984) summarizes this concept. The role of language is specifically described by these authors as being for only the 'perfecting' of skilled motoric actions. They describe two kinds of processes called horizontal and vertical thread processing. Accordingly, everyday motoric tasks that have become automatic or well-learned are governed by 'horizontal threads'. Such actions do not require deliberate attentional control and thus do not need linguistic mediation. This returns again to the blue-print or schema idea where there is a learned pattern for a specific action.

When facing a new environment, or a highly skilled task requirement, the response is determined by how adequate the existing blue-prints (schemas) or horizontal threads are to achieve the required goal. If these are not adequate to be able to undertake this new skill, then deliberate attentional control comes into play. This control is described as the "vertical thread" processing. Wall, McClements, Bouffard and Findlay (1984) stated:

> deliberate attentional control is the responsibility of a supervisory attentional mechanism that influences the planning and monitoring of action sequences (p. 7).

And it is in this process that verbalization becomes important. With the concept of "deliberate attentional control", Wall, McClements, Bouffard and Findlay stated that "attention seems to be governed by verbal mediation in the development of a cognitive consciousness" (p. 7). As with Bruner and Piaget (see pp. 56 and 57) therefore, these authors are pointing out again that motoric ability is "developmentally tied to verbal ability", because "with further development, children's declarative and meta-cognitive knowledge bases increase along with improvements in verbal and symbolic mediation" (Wall, McClements, Bouffard and Findlay, 1983, p. 7).

It would appear then that efficient linguistic ability is a valuable tool for individuals in developing efficient learning of new motor tasks. Yet it is important to note that the two are not totally exclusive. Firstly, language is seen as only an aid which makes the learning more efficient. It can be suggested therefore, that learning can still take place without this aid. Like the example of the deaffernated cats still walking, an individual without, or with low language, will still be able to learn motoric tasks. And with experience and practice, will then be able to correspondingly increase their skill. Perhaps this is a reason that deaf children face delay in their speed and perfection of motor development rather than experiencing total inability with it. It also does not mean that the deaf cannot achieve fully efficient motoric ability, since in the final stages language as a mediator is no longer needed. This is a positive point for having movement education in schools. Secondly, such a discussion of language and 'verbal mediation' tends to assume that the deaf are inferior in verbal ability. Care must be taken with such an assumption because in all of these examples of how verbal ability helps in the learning of skilled tasks, or in the organization of experience, the term 'verbal' is never clearly defined. It may be, perhaps, that the authors are suggesting that verbal ability, for example in the "verbal rehearsal of a movement" (Wiegersma and van der Velde, 1983) or as "inner verbal cues" (Wall, McClements, Bouffard and Findlay, 1984), means that the individual 'talks' to himself. But then, how does he talk to himself?

O'Connor (1979) said that words are conveyers of 'thought or self-instructions'. He wrote that the power to use language, or to use words as an encoding medium, enables us to regard words as conveyors of thought or self-instructions that would not otherwise be available to the hearer. Bruner (1966) said that language develops an increasing capacity to say to oneself and others, by **words or symbols**, what one has done and what one will do (see p. 57). In basic terms, therefore, "thinking" or "talking to oneself" is considered as being **Internal language.** And since everyday oral language is externally presented as a spoken code, then it is this spoken "code" that is internalized. This becomes the concept of inner speech. Thus Beveridge and Brinker (1980) talked about a speech set of actions to distinguish objects from each other (see p. 57), and Conrad, (1979) stated that the ability of the child to function efficiently linguistically can be said to be related to his ability with inner speech because inner speech is a "silent, newer form of verbal activity, a sub-verbal talking to oneself while carrying out cognitive tasks." In fact, the Piagetian theory again follows the increasing development of the child as the progression toward inner speech is made.

Piaget's Evolution of Speech

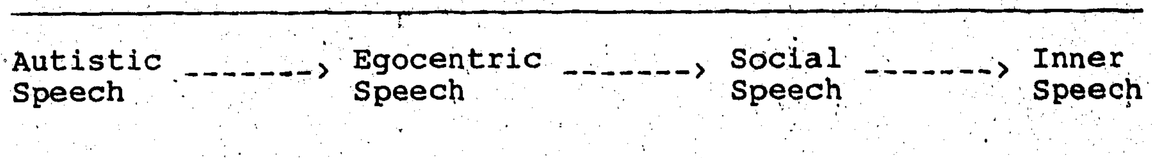

Figure 2.

The idea of inner speech was generated in Russia by Vygotsky (1896-1934), in the early part of this century, and has been extensively studied since by colleagues such as Luria (1973d). Vygotsky described an alternative to Piaget in that social speech develops first and then is maintained as egocentric and inner speech ability also develop.

Vygotsky's Evolution of Speech

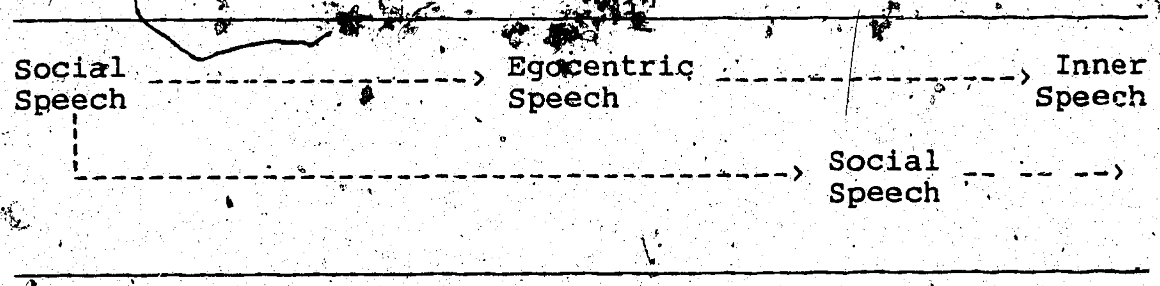

Figure 3.

Another idea is that of the Behaviorist development of inner speech.

Behaviorist's Evolution of Speech

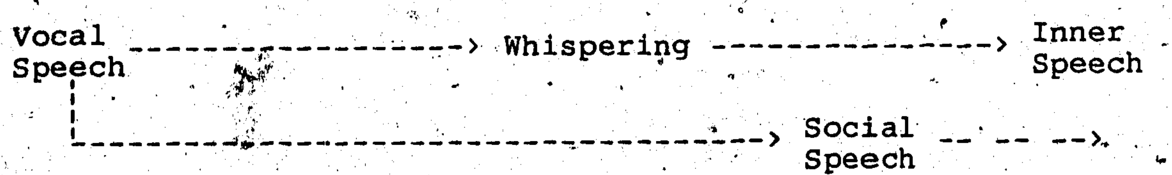

Figure 4.

Although there is presently uncertainty as to which of these theories is correct, all contain the concept of inner speech. They also have inner speech as a final stage of development, and this is because with inner speech, talking to oneself or thinking, is taken to exist. This is important, because it is this thinking ability that allows verbal mediation, and that in fact for some writers, distinguishes man from the animal kingdom. Russell (1957) summed this up as follows:

> The development of speech in humans puts us far ahead of other members of the animal kingdom. It is sometimes thought that speech is chiefly a means of intercommunication, but its chief value is probably in providing for the individual a means of cultivating those complex associations of memories and feelings which we call THOUGHTS. A mastery of speech, and the development of intelligence are so intimately connected with each other, that one cannot flourish without the other, and the dissolution of the speech mechanism, by say a stroke causing sensory aphasia, inevitably causes the disappearance of the main part of the individual's intelligence. Intelligence therefore, is largely dependent upon the integrity of the speech mechanism, and man's ideas are developed in close relation to this system. In intelligent people, there is a highly developed and personally satisfying capacity for associating one memory or thought with another.

> Indeed this is a physiological characteristic of intelligence. (p. 22)

This idea that lack of the development of speech will somehow lead to a lack of ability with language, and therefore to an inability to think that consequently leads to cognitive retardation, now becomes a problem when remembering that deaf children try to learn 'speech' that is transmitted through audition. This is brought out by Conrad (1979) in his study on the relationship of inner speech to the oral (spoken) language of deaf children. Basic to Conrad's position is that the low academic levels and overall functioning of deaf children (see p. 15), is due to their failure to acquire a developed language through the oral mode. When this lower level is transferred into the internal mode (i.e., becoming inner speech), the inefficiency is apparent. In his results, only 40% of the children with a hearing loss of 85 dB or more, could "think orally". That is, on the tasks used by Conrad, 60% of deaf children were without internal speech. These children are thus less efficient processors of environmental information. Motor reaction must be included in this inefficiency. Russell (1957) would also say that such children were less intelligent because they could not think (see p. 70). This is related to cognitive inferiority.

It would appear then, that the oral system of education, although offering obvious linguistic advantage in inner speech coding, may be too difficult for many deaf children. Conrad concluded in fact that **manual** communication for these children might provide a more efficient and serviceable internal system than speech (i.e., oral language), because "children are likely to derive more linguistic benefit from a language compatible with their sensory capacities" (Bernstein and Finnegan, 1983). But this suggests then that 'language' does not necessarily have to [illegible] oral, and returns once again to the earlier discussion of the communication modality of families with deaf children (see p. 35).

It becomes pertinent to consider now, therefore, what the internal speech ability was for all the deaf children who were found inferior to their hearing peers in studies of motor ability. And is it possible to 'think' in a manual internalized linguistic system, and to therefore obtain ~~the~~ same linguistic mnemonic benefits?

The compelling results Conrad (1979) produced in his effort to explain the academic failure of British deaf children (and one which might really parallel the motoric concerns of this paper), thus have only one drawback. The drawback is in defining what inner speech and thinking really are. Do the authors who mention the benefits of 'verbal ability' in efficiently coding motoric movement and cognitively ordering the world, mean this ability as the internalization of a phonetic sound system? Or do they rather mean it to be **any** kind of symbolic strategy that humans use to cognitively and efficiently order their world? If the former is true, then for the individual born with impaired hearing, it is to be suggested that their resulting difficulty in obtaining the phonemic code, will correspondingly lead to lower cognitive efficiency. However, it cannot be assumed that the [illegible] do not have "language" if they do not use the phonem[illegible] speech. And it certainly cannot be said that the[illegible] not think simply because they ha[illegible]fficulty with acquiring an auditory oral language. [illegible], Bellugi, Klima and Siple (1979) stated that:

> Earlier experiments support the notion that we code and remember on the basis of <u>sound</u>/form (articulatory and/or acoustics) of words and letters. For the deaf, on the other hand, Conrad suggests that this need not be true. . . . Conrad, on his part concludes "the deaf do use 'symbols' in memorizing (but) the <u>nature</u> of them is open to empirical enquiry. . . . That the deaf, with little overt speech learn and think is self-evident. **What they do it in however, remains a challenge with far-reaching implications.**" (p. 2)

This would seem to indicate that cognitive ability and thinking are dependent simply upon the ability to be able to code information **in some form.** When Conrad (1979) defined inner speech as being "basically the internalized code of the external linguistic system", the definition could be referring to <u>any</u> linguistic system. Therefore this could just as easily be a system of iconics or signs, as being one of spoken sound. Vernon (1967) in his review of studies on the relationship of language to problem-solving and cognition does in fact separate the "spoken" word from being an 'only' language. Furth (1966) has also pointed to a distinction between an oral language and thinking, and Quigley and Kretchmer (1982) discussed it in depth in Chapter 4 of their book. They concluded that deaf children can acquire high ability with language, and do become cognitively proficient, but they just do not always acquire a high ability with spoken language. The fact that the deaf do achieve motor functioning, bears this premise out. As previously discussed, since all animals and most humans do learn the basic elements of locomotion (such as sitting up, rolling over, learning to walk), it is only when the more skillful human movements become required that language is important at all. And then only in the early stages of skill learning. Further, it seems to indicate that 'verbal' ability or 'verbalization' of the individual to himself, can be in any form of coding, which we then call a 'language'.

In summary, therefore, language can be taken as being synonymous with verbalization, and an individual can 'verbalize' in any language code he has internalized. Indeed Stewart (1984) described two types of linguistic systems. These are the 'non-verbal', such as body language, and the more complex 'verbal' forms:

> More complex than non-verbal forms are examples of verbal communications which includes signs, oral symbols and written symbols. (p. 10)

He continued that "the latter two are arranged in a highly structured manner that is commonly referred to as language". It appears that the manual sign system should be included in this reference. Through language an individual can then organize the environment more efficiently because of the aid it gives to memory. Thus Wall, McClements, Bouffard and Findlay can write:

> verbal and symbolic mediation are important in the conscious control of action. Viewed from a functional distance perspective, when verbal and symbolic labels distinctly and efficiently represent large amounts of knowledge stored in well-learned schemas, they decrease the likelihood of interference in problem solving situations. Such verbal and symbolic labels facilitate the use of rules and strategies that can influence the procedural knowledge that guides skilled action. (p. 28)

It is worth noting here that this knowledge-based approach to motor development relates to another explanation for the concern with speed in the motor delay of deaf individuals. It has been seen that "planning and decision making are needed when existing schemas are not able to satisfy a goal" (Wall, McClements, Bouffard and Findlay, 1984), and that "in such cases, the attentional supervisory mechanism uses information from a variety of schemas to generate new schemas. **However, these increasing processing benefits are bought at the cost of processing speed** (emphasis added). The use of deliberate attentional control is particularly detrimental when rapid skilled actions are required" (p. 7). This leaves the idea that deaf individuals do not possess as many horizontal threads as their hearing peers due to either the lack of experience from restricted familial environments, or to the deprivation of the information provided through sound. They therefore have to use more deliberate attentional control, which slows down processing ability and the speed at which they can respond. Experience would thus seem to be the key to the automatizing of action, and not the ability with a language. Wall, McClements, Bouffard and Findlay concluded:

> As a task becomes well-learned, it will require less vertical attention from the limited capacity attentional mechanism because the whole action sequence is under the control of the horizontal processing threads . . . the whole action sequence refines itself through experience, developing and adjusting the horizontal thread structures to minimize the need for deliberate attentional control.
> (Norman and Shallice, p. 12)

It appears from this then, that if deaf children are executing motoric actions at a slower rate than their hearing peers, they should of necessity be provided with an environment where they can practice their ability until their actions can become well-learned. And, if it is also acknowledged that good language ability facilitates the development of motoric tasks, then every opportunity should also be made to ensure that deaf children are receiving language early, and appropriately. It may be, too, that deaf children who receive information through the less frustrating linguistic code of signs, and in a more accepting familial environment, will be less slow than their orally raised peers. This is because they will have had more time to use the facilitating aspects of language to develop more automatic horizontal thread structures.

To conclude, the exact role of language in motor development, or indeed the development of cognitive ability itself, is basically, as yet, unanswerable. Perhaps, therefore, before attempting to be definitive, the exact meaning of the terminology 'verbal' should be stated by all the authors who use the term. Do they mean an internalized code of spoken words, or do they mean simply a 'code' used by the individual, which can then be in any form? And then, the necessity of language itself as a source of cognitive coding and development is debatable. Some writers suggest that human beings are born with built-in neurological cognitive organizers (Lennenberg, 1967; Chomsky, 1978). Samuel Taylor Coleridge (1872-1934) many years ago believed that the process of thought might be carried on "independent or apart from spoken language" (Vernon, 1967). And in their study between deaf and hearing pre-schoolers, Blank and Bridger (1966) stated that their results suggested that "verbalization (is) not essential, but simply an accompaniment of the cognitive skills occurring in normal development." Efficient cognitive development may not necessarily be dependent therefore upon the ability to have a language -- of any kind. Bernstein and Finnegan (1983) did say that:

> While the public (external) language must be learned by the individual, the private (internal) language exists a-priori (italics added) in a person's neurological functioning. (p. 485)

And go on:

> the predominant mode of internal representation is a distinct inner computational mode that is not derived from the oral language a person uses. (p. 485)

This then is in opposition to Piaget, Vygotsky and the behaviorists' ideas of inner speech development as a final stage of development. Inner speech, that is 'thinking' exists in the <u>initial</u> stage of development (a-priori). Vernon (1967) goes on to conclude:

> there is no functional relationship between verbal language and cognition or thought process, verbal language is not the mediating symbol sy[illegible] thought, and there is no relationship be[illegible] concept formation and level of verbal language development.

Grove and Rodda (1985) stated:

> language does not play a central role in Piaget's theory: direct experience of the world is the vital factor. In view of their extreme linguistic retardation, the deaf do not show any substantial intellectual deficit, and the hypothesis of a causal link between verbal skill and cognitive development seems hard to maintain.

For the purpose of this study then, the discussion on language and motor programing has left the following consideration. It is apparent that the main advantage of having a language is that it functions as a **facilitator** for what the individual plans to do. This is the mnemonic consideration. Bernstein and Finnegan (1983) felt that "other means" of mediating the environment may exist to that of the internalization of an externally learned code dubbed language. Their study prompts the consideration that thought and planned action are indeed quite possible without linguistic mediation. It is even possible to consider that living organisms mediate their environment through a self-devised internal organization system. We do not know what these are. But Ostry (cited in Stelmach and Requin, 1980) pointed out that:

> almost everyone agrees that movements must be organized prior to their execution. There must be decisions about target locations, about angles, velocities and joint torques, about muscular activation patterns and postural adjustment (Saltzman, in press) and the decision must be coordinated over a set of movements.

Such decisions may be linguistically mediated, particularly if the movement requires skill, or is novel. **But they may not have to be.** The issue is that the auditory phonetic external linguistic codes devised by human societies have developed phylogenetically, and at present do appear to form the most **efficient** systems. Without such a language then, individuals can indeed think and function, but with such a language, they can do so with more speed and proficiency. As Newman (1974) pointed out (see p. 57), without this symbolic organization of a language, it becomes difficult to store in the memory all that has happened, or that needs to happen. Piagetian theory concurs that children proceed from concrete to higher abstract levels of functioning, **in a corresponding pattern to their language development.** Abstract functioning is a "higher" level because of the efficiency of being able to move away from the concrete present in planning. Past experiences can be used, as well as projection for the future. Past experiences must be stored in the memory, and must be retrieved in order to plan for the present. The most efficient storing of such information appears to be in symbol code we call language. Without efficiency in language, therefore, less information is able to be stored in the memory, and efficiency of retrieval and planning from past experience is hampered. Low linguistic levels thus can slow the deaf child down. And since language appears so important for proficient functioning, the question of equality of the oral and manual language codes for promoting linguistic ability in the child, becomes important.

Investigating the abilities of both oral deaf children and manual deaf children is thus a central part of this thesis. Regarding Conrad's (1979) study, Arnold (1983) said that "an alternative theory is that deafness itself is the fundamental cause of (the British deaf child's) poor performance" (p. 233). And this returns to the etiological issue (see p. 45). Bernstein and Finnegan (1983) certainly offer compelling research for alternative definitions, and pursue the idea that even writing does not require speech in order to be decoded or understood. This is an interesting idea for phonetically based reading programs in schools, and returns again to the issue of reading problems and the deaf child.[1] Perhaps reading ability is related to inner speech ability. Perhaps it is not. Such discussion, however, does make possible the hypothesis that manually and orally raised deaf children may function differently. If Conrad (1979) is correct, then orally raised children should be less efficient with motoric functioning -- if their intelligible oral speech is low. This is because their internal speech will also be low, and thus their linguistic level for motoric planning. If, alternatively, the ideas suggested by Bernstein and Finnegan (1983) or Vernon (1967) are right, then motoric functioning of oral children should show no difference from manually raised children, since the child has "other" means of cognitively mediating his environment

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[1] The problem with having a low linguistic level may further explain the poor reading achievement of the deaf as mentioned earlier (see p. 6). Reading is another high level skill. Morrison and Mavis (1977), Rozin and Glietman (1977), Velluntino (1977), and Liberman (1977) [in Brainerd and Pressley, in press] all point out that reading competence is a skill dependent upon knowledge of the language trying to be read. Hallahan and Kauffman (1975) further believe that an ability to read is "partly linguistically based". The deaf child therefore may have a problem attaining high levels of reading ability, because he does not know the full extent of the language that he is trying to read. Alternatively, and just as relevant for the deaf student, a suggestion is that reading is a phonological skill and that without the acoustic ability to decode written words, the vocabulary becomes limited to visual recognition (e.g., Wepman, 1975). Many normally hearing children are suggested to have reading problems because of perceptual deficits or auditory processing problems (Cohen, 1983). If reading is a skill dependent upon the perception of phonological cues for decoding words, the deaf child will face a problem in trying to read (see p. 7).

at his disposal. It leaves the conclusion therefore that "the means of a deaf individual to monitor, adapt, or indeed organize or create any form of motoric action -- be he/she oral or manual, is subject solely to the ability the child has to <u>cognitively encode</u>" (Hill, 1984, p. 1). The true nature of this ability is open to question.

(d) <u>Simultaneous and Successive Processing</u>

When considering the equality of the oral and manual linguistic codes in the way just described, it is finally necessary to take a closer look at the relationship of language to memory, particularly that of motor memory. Here, consideration of the relationship of language to motor planning involves the temporal aspects of action.

Connolly (1980) wrote that "voluntary motor activity becomes possible by exploiting the associative memory which is developed with it" (p. 24). However, movement has an element of temporality.

> Movement . . . refers to motions of the body and limbs which occur as a consequence of the spatial and temporal patterning of muscual contractions (Connolly, 1980, p. 245).

In fact, a motor skill may be viewed as "the harmonious coordination of component movement elements organized in time and space to achieve a desired goal" or, "the solution of a movement problem constrained with a spatial, temporal and/or force requirement" (Bernstein, cited in Clark, 1982). Clark goes on:

> Clearly, moving the multisegmented body in a smooth, precisely timed manner requires a control system which must not only signal the appropriate time for the muscular contraction, but also the precise duration of that contraction. (p. 151)

Thus, temporality, or timing within temporality, is one of the central elements of movement.

> A skilled motor act is a result of the central nervous system's sequence and timing of the commands to the musculoskeletonal system, and there is a high degree of temporal precision required in most motor tasks (Clark, pp. 144, 169).

This means that because movement or actions follow a temporally successive pattern as the individual moves in space, patterning for motor memory becomes predominantly successive in character. Once again, therefore, the deaf child may face a problem in developing a relationship between the characteristics of the linguistic code, and his motor planning. This is explained as follows.

The perception of sound is a successive experience. Van Uden (1983) pointed out that "our eyes are mainly space-directed: space is projected on the retina." He went on:

> Our hearing organ however, responds to sound waves, the waves in the basilar membrane, etc., which in our experience take especially a successive course, one after the other, whereas when we see we perceive one thing next to the other. Sound perception is consequently more dynamic than seeing, which is more statically oriented. . . . (p. 3)

The deaf individual thus misses out on a basic and continuing experience of "temporality". Further, an auditory or oral linguistic code is also essentially temporally successive in nature. Grove, O'Sullivan and

Rodda (1979) stated that most research fails to take account of the "special difficulties experienced by the deaf child in dealing with <u>sequentially</u> organized verbal material." (p. 531). A linguistic code such as signed language, is more spatial and simultaneous in nature. Bellugi, Klima and Siple (1975) for example, described American Sign Language as one that is "visually-based" where temporal order is unimportant, and meaning is dictated by the cherological features of directionality, position in space, and hand shape. So the deaf child who is raised on a signed language may lack a further experience of sequential or successive coding. And as Das (1982) pointed out, "since the essence of successive processing seems to be in memory for temporal order," a manual deaf child may be less proficient at the temporal coding in the memory of motor patterns. This means there may well be a difference between a hearing child who uses his experience of the successiveness of sound to enhance his successive coding in memory of motoric action, and the deaf child who lacks that experience. There may also be a difference between a deaf child who is orally raised, so being somewhat more exposed to temporality through the sequential aspects of spoken words, and the deaf child who is raised on a visual-spatial linguistic code. This child may be slower again in coding sequence for action, since he/she predominantly orders his/her environment in a simultaneous pattern.

As with the discussion of verbal ability and cognitive inferiority, therefore, an important question that arises from this is that of whether deaf children really are inferior in the temporal encoding strategy, in preference to the spatial. It is also important to consider if this will, or does, make a difference in processing speed. Hiskey (1955) for example felt that any tests of intelligence for the deaf should exclude any demand on speed because having a sense of time and temporality was mainly dependent on being able to hear. Beveridge and Brinker (1980) felt that such a sense was dependent upon the linguistic code that was used:

> obviously the temporal strategy is much more appropriate for decoding spoken language since there is no eidetic array which can be sorted into spatial memory. (p. 48)

And O'Connor (1979) went on to talk about the speed of learning in individuals, stating that it is perhaps "a quality of the mind of the . . . human being that for some reason can learn by <u>words</u> faster than by other means." As has been discussed, he also felt that having a language enables better retention of information (see p. 59) because 'words' have the power of conveying thought and self-instruction. Do 'words', therefore, exist in a manual language? In their review of studies on the cognitive and intellectual development of deaf children, Quigley and Kretchmer (1982) pointed out that linguistic inferiority cannot be assumed because the deaf do not use a verbal[1] language to facilitate the solution of tasks. A return is thus made to the notion of inner speech because:

> No consideration is given to the possibility that these subjects could have been mediating by a code other than an oral-verbal code. (Quigley and Kretchmer, 1982, p. 60)

But if the deaf do mediate their environment by an alternative code such as the spatial signed code it leaves the following questions: will their cognitive mediation be different and thus perhaps slower, and does a temporal verbal code in fact have more informative value to movement than a spatial cherological code?

O'Connor and Hermelin (1972), Beck, Beck and Gironella (1977), Kelly and Tomlinson-Keasey (1977), McDaniel (1980), Das (1983a), Dash (1983), and Rodda, Buryani, Cumming and Muendell-Atherstone (1983) have all undertaken studies concerning the cognitive organization abilities of the deaf. Most have concern for the question of temporal versus spatial coding abilities, and look at this in regard to hemispheric lateralization of language. Rodda, Buryani, Cumming and Muendell-Atherstone, in particular, offer a comprehensive review of research in the area of lateralization with the use of tachistoscopic testing for right brain versus left brain reception

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[1] Verbal here is being taken as meaning an auditory and spoken language.

dominance. Through such studies, it becomes possible to suggest that language lateralization in an individual who is deaf, is different from an individual who can hear. This may be important for motor development, because the two hemispheres of the brain may be differently organized, thus changing the dominance of the part of the brain that governs motoric ability. Basic theories of laterality, for example, suggest that verbal successive information is carried by the left side, whereas more spatial information is carried in the right. Since movement is also predominantly successive in nature, it too might be processed in the left hemisphere. A child using a verbal sequential linguistic code, therefore processes both movement and language in the left hemisphere. A child using a signed linguistic code which is more visio-spatial, may alternatively process information predominantly in the right hemisphere. Movement and information processing are thus in different hemispheres, and it is possible that transferring the linguistic codes for skilled motor tasks from one hemisphere into another, may slow down response time (especially too if there is a cross modal integration problem). Myklebust (1968) said that "lack of audition requires an alteration in the neurology by which this child learns," and he talked of deaf children being more dependent on the right brain:

> It should be made clear that both hemispheres are involved in learning, the information from one being transmitted to the other principally through corpus

> callosum. But . . . each hemisph[illegible] has a specialized role. Also, because the deaf have difficulty in acquiring language, there might be less interaction between the hemispheres. The right . . . becomes more dominant than is typical for the hearing child. (p. 16)

Bakwin (cited in Gubbay, 1975), further contended that "the developmental disorders of motility and language were manifestations of inborn alterations in cerebral organizations. Thus modified maturation of those areas of the brain governing motor co-ordination and language was assumed" (p. 148). O'Connor and Hermelin (1978) postulated that "sensory systems may differ in the way that they process information (so that) those obliged to employ one sense to take the place of another, may interpret the world in a different manner" (p. 34). And Kelly and Tomlinson-Keasey (1977) in their paper on hemispheric laterality of deaf children, found that the right hemisphere of the deaf subjects was "consistently more efficient than the left hemisphere for processing various content modes." They stated:

> What do these results mean for the deaf? First, the data in the present study suggest that an early severe hearing loss does indeed influence the development of cognitive organization. . . . Would it also be logical to conclude that the deaf's higher mental functions are probably controlled by visual codes, rather than language oriented auditory codes? Although the present data would not support such a broad theoretical leap, this is certainly a potential hypothesis. (p. 531)

Indeed, Kelly and Tomlinson-Keasey reached the conclusion that "apparently due to their loss of auditory input, the deaf are not able to specialize their left hemisphere for language." Thus they wonder if "the deaf subject's right hemisphere superiority for high image words is comparable to the left hemisphere's specialization for language in hearing people" (p. 532). Since the deaf individual does rely on vision more, it could be conjectured that the right part of the brain is slower at processing for [illegible] actions. Kelly and Tomlinson-Keasy do point out that speech production is critically dependent on left hemispheric ability, whereas the right hemisphere "is capable of speech and language comprehension, but not able to produce speech." This is interesting for the expected oralism for many deaf individuals, and prompts the question of whether an oral deaf child becomes once again left-brain dominant in processing various content modes?

The literature does not appear to have tested this particular distinction of processing modality between oral or manual deaf individuals. If the oral deaf child does not become left-brain dominant, then he/she is not using his/her dominant hemisphere for linguistic development and, thus, may be linguistically impoverished. And if the value of language to skilled motor ability is true, this may also be why such deaf children are motorically slow. Alternatively, even for the manual deaf child, it can be tentatively suggested that as speech production is itself a motoric task, their left hemisphere is missing an important developmental experience. This could equally decrease efficiency. In fact, Kimura (cited in Rodda, Buryani, Cumming and Muendell-Atherstone, 1983) has noted that when there is left-hemispheric damage in some deaf individuals, their ability to express themselves in even a signed language becomes correspondingly poor. She wrote that "this could be due to left hemispheric control of complex motor behavior" and goes on that "the left hemisphere is primarily specialized for certain types of motor control functioning and that its important role in language functions is derived from this specialization" (p. 8). The above examples reinforce the idea that motor ability and language are somehow interdependent upon each other, especially that of an auditory/verbal sequential language, because of its temporal nature and similar left brain processing. For the purpose of this study therefore, it means that deaf individuals as a group (that is, both manual and oral) will be inferior to their hearing peers in their speed of motoric actions.

Finally, Rodda, Buryani, Cumming and Muendell-Atherstone (1983) add another thought to the left-brain/right-brain dominance theory. Through their tachistoscopic testing they attempted to view if there were differences between young deaf oral and manual adults. They concluded that their results "can be interpreted to suggest that the type of communication training employed may affect how the cerebral hemispheres organize themselves for cognitive functioning" (p. 8). Deaf children who used total communication codes (oral and sign modalities together) were found to be slower at responding, "probably because more integrative ability from the integration of the two modalities, is required." This suggests again therefore, that the possible reason for the slowness found in deaf children in responding to motoric tasks, might simply lie in their difficulties in integration, and not in cognitive dominance. This is particularly true when the auditory code is used which if supplemented, requires more integration and therefore more time to respond.

It is beyond the scope of this paper to enter into an in-depth discussion on the true nature or make-up of the brain and its cognitive patterning. The left brain/right brain theories for example may not be entirely accurate. Das, Kirby and Jarman (1975, 1979) did extensive research on the encoding and decoding strategies of the brain, and suggested that the brain structure is not so clearly divided. Instead, they proposed a more hierarchical model of processing levels (see Figure 5, p. 92). The right-brain/left-brain thesis thus becomes suspect. However it is worthwhile noting at this point the possibilities that arise from such studies. The results return again to the discussion of the sensory integrative abilities of the deaf (see p. 25). Cumming (1982) wrote a comprehensive paper

The Figure appearing on this page has been removed due to questions regarding copyright.

The Figure represented a schematic representation of hierarchical processing models within the brain in contrast to the left-brain right-brain models of processing.

J.P. Das, J. Kirby, and R. Jarman (1979). *imultaneous and Successive Cognitive Processes*. New York: Academic Press.

explaining the Das, Kirby and Jarman (1975) model, and related it to symbolic processing which appears to occur in the same part of the brain as that of sensory integration. Deaf and hearing individuals may, therefore, really integrate and process together and not in a right versus left mode. The point is however, that **the deaf are missing a basic element to perfect this integration.** That is, the deaf miss 'sound'. Cumming reported researchers who have found that "deaf subjects could not handle tasks involving inter-modal transfer as well as hearing controls" (p. 7). She also pointed out that Kelly and Tomlinson-Keasey (1977) have concluded that "sensory deprivation affects cognitive functioning." This discussion returns to the problem of linguistic deficiency for the perfecting of inter-modal transfer (see p. 54). It could be concluded therefore, that the deaf appear slower at motoric functioning because either their sensory integration is hampered by the deprivation of one of the senses, or because they are poorer in the linguistic ability required to perform this integration. It is not then because they mediate the environment spatially instead of temporally or because they lack an internalized speech code that orders temporal sequences more efficiently.

In sum it may be more tenable to suggest that any, or all, of the factors discussed in this section can contribute to the motoric differences researchers such as Wiegersma and van der Velde (1983) have found in their studies. Cumming (1982) pointed out that research has shown that deaf children do "Have difficulty in searching for and retrieving information from long-term memory" (p. 7). And the importance of memory for actions has been discussed (see p. 60). Quite logically memory is enhanced in its retaining ability when the successive mnemonic strategies such as rhythmic clustering or associative chunking can be used. Such techniques relate directly to the phonological elements of an auditory language. O'Connor (1979) concluded that "it does seem that the use of temporal ordering and successiveness is language dependent or **speech dependent** (emphasis added)" and that "children who are unable to draw on sensory experiences from an appropriate modality, are obliged to adopt alternative encoding strategies in some circumstances --usually less appropriate ones" (p. 358). The child with impaired hearing does miss one optimal sensory experience. This omission could affect the proficiency of motor tasks requiring ability with successive processing, as 'less appropriate' strategies are then being used. Broesterhuizen (1983) mentioned van Uden's (1977) finding that "those (children) who are less fluent in their motor functions, do better in tests which appeal to the memory for simultaneously presented visual data, and vice versa (p. 6). Such a consideration leaves the question whether it is possible for a spatial language to code sequence of movement in an equally efficient way. Bellugi, Klima and Siple (1975) thought so, and Cumming (1982) concluded that when deaf children were given coding time tests, they spontaneously used simultaneous rather than successive strategies. These findings do suggest that the experience of temporality is missed by deaf individuals. However, they do not mention a corresponding decreased efficiency. Alternatively, O'Connor and Hermelin (1978) may have been showing unstated decreased efficiency when they described their study with groups of deaf, subnormal, autistic, and hearing children. When each child was asked to remember three visually displayed digits that were viewed three times at a window in no specific order, the results were:

> Normal children responded in terms of temporal order. Deaf, autistic, and sub-normal children recalled or recognized spatial order.

This groups deaf children with subnormal. Yet again, Das and Dash (1983) found the following with their deaf subjects who used a signed language:

> The deaf child performed satisfactorily in situations which required the ability to organize the information into a meaningful whole. This is evidenced in their performances on the simultaneous-processing tasks, which depends greatly on the ability to grasp spatial features of the stimulus field and to reproduce these subsequently as accurately as possible. The simultaneous tasks are spatially oriented and the deaf children's satisfactory performance on these tasks suggests that they have the ability to utilize a spatial order information for processing events in memory. Their ability to integrate the information spatially also helped them to answer the spatial probes more correctly than the temporal probes. However, they experience difficulty when the

> information needs to be ordered and processed step by step, i.e., sequentially instead of simultaneously. Their poor performance on successive tasks is indicative of not-too-well developed sequential processing ability. (p. 8)

Since these results show deaf children do have efficient spatial coding abilities, they help to off-set suggestions that deaf children are not efficent processors of information and are, therefore, cognitively inferior (as the similar results of the autistic and sub-normal children may indicate from the O'Connor and Hermelin study, 1978). Deaf individuals simply use **different** methods of cognitive mediation. Quigley and Kretchmer (1982) agreed with this suggestion (see p. 85). But it does leave the question of whether this spatial coding is as efficient as the temporal coding where movement is required. It is possible that because such processing is different, corresponding tasks requiring temporal processing skills such as required by motoric action, may not be so proficient. Do the deaf therefore have a cognitive code as efficient for the sequencing required by the temporal order of movement? O'Connor and Hermelin question this when they state that "awareness of temporal order is dependent upon the coding of successive events in short-term memory" (p. 64).

For the purpose of this study then, it can only be suggested that, if learning a signed language decreases the experience of temporality and the deaf do spontaneously use simultaneous coding strategies, then manually raised deaf children may appear less motorically proficient than those deaf children who are exposed to the sequential oral code. If a sequential language increases the efficiency of memory for sequential tasks, then orally raised deaf children will, perhaps, have an advantage in the spontaneous choice of sequential coding that comes from having a phonemic code. However, if the oral code has not been proficiently learned, then the oral deaf child will have neither an efficient spontaneous, nor an efficient sequential code by which to relate to his/her environment.

B. Conclusion

Clearly motor delay as witnessed in deaf children can stem from many sources. If the low academic levels and emotional anxiety attained by many deaf students are a manifestation of such delays, serious attention to these problems is needed. Ayres (1974) has talked quite explicitly of the relationship of learning disabilities to motor functioning stemming from problems with sensory integration and neurological make-up. Dolman and Delaccato (1959, 1963, and 1966), although heavily criticized (see Glass and Robbins, 1967) have further suggested that difficulties with the linguistic skill of reading can often be noted in children having motoric problems. Since deaf children appear to have both reading and motor problems, these may thus be symptoms of a more intractable problem concerning language, etiology of deafness, deprivation of sound, familial environment, and all of the other reasons discussed. Slow sensory-motor functioning may serve to indicate, further, an integrative or encoding problem that can slow the proficiency of the child down in many other areas. Ayres (1974) suggested that "sensation and movement are so intimately related that they are expressed in a single word 'sensorimotor' and cannot be considered separately" (p. 301).

She went on:

> Neurobiologists in general hold that multi-sensory stimuli are more effective than messages from only one modality. (p. 317)

It is arguable that a child raised on a signed language has a immediate and continuous practice at manual or motor coordination and patterning. Certainly, gestures and hand patterns along with the finger dexterity required for finger spelling, are all motorically related. Some researchers have in fact found superior manual ability in visual-motor tasks (see p. 111), **although not when complicating etiologies are suspected** (see p. 112). Further, Norden (1981) emphasizes the problem of a declining <u>linguistic</u> prowess if signs are not used.

> Studies of infant development have revealed the amazing communicative abilities of all infants (e.g., Bullows, 1979; Schaffer, 1977) and the importance of visual signals . . . in the development of communication. During the first year of life when vision plays such an important role in communication, deaf infants are able to share in the communication with their hearing others much to the same extent as hearing infants. Their hearing

> impairment does not become a serious obstacle to communication until the age when hearing children normally begin to use speech. When the deaf child is expected to use communicative signals that are suited to auditory perception and extremely difficult to interpret visually, mutual understanding is impeded and breakdowns in communication become the rule rather than the exception. This causes language development to stall. (p. 23)

Even if oral language coding is superior, therefore, if deaf children cannot succeed orally, the resulting lack of language, or poor language, may be worse than using a manually coded language. And then the superiority of oral languages is under considerable challenge anyway. Tomlinson-Keasey and Kelly (1974) said that signs increase the <u>rate</u> of language acquisition and the development of communication, thus decreasing the risk of build-up of frustration by a child trying "desperately to use an auditory channel that does not function as normal." Chasen and Zuckerman (1976) felt that signs, because of early and easy acquisition, enhance a deaf child's self-image and psychological adjustment. Olsen (1972) emphasized signing for the very young deaf child because it presents language in an easily understood form at an age which is critical for the development of meaning. Conrad (1980) suggested that the early use of signs will, above all, help prevent atrophy of the brain's potential to develop language. Yet some deaf children do succeed in attaining an oral linguistic code, and do so both efficiently and early. And if a signed language later, then, decreases the mnemonic power for such temporal tasks as those of motor origin, oral ability may always be preferable. It does mean most importantly, however, that schools following a manual philosophy need to urgently offer extra training skills in processing sequential tasks. Thus, extracurricular activities that contain successive experience activities, such as gym with movement education, or music with rhythm, should always need to be incorporated into the daily program of the deaf child. For the oral child this will be for overall practice and experience; and for the manual child, this is for the experience of temporality missed by the learning of a spatial linguistic code.

Finally, it is of importance to be aware that poor language, **in any coded form**, can decrease the efficiency of an individual's functioning. Language aids in removing the child from the concrete, and further acts as a regulatory mechanism of self-instruction. Whether or not this is through inner-speech is debatable. Cratty (1962) wrote that "a consistent characteristic of human performance is the tendency to use word cues when learning a complex movement task" (p. 431). So Conrad's (1979) definition of the internalization of the external code may contain an element of truth. But 'word cues' as they exist as cognitive coders can exist in a signed language. Whatever inner-speech may be therefore, it is apparent that proficiency with a linguistic code facilitates efficiency of memory storage and retrieval. Being able to <u>plan</u> for a motoric execution may be just as important as the self-instruction itself.

The only other suggestion as to the motoric delays of the deaf child, lies quite simply in the etiology of the impairment itself. At this point it may be important to consider then, that the whole issue of motoric delays and slowness in reaction time, have their origins in the fact that **"deafness" is part of an organic imbalance that <u>includes</u> the comparative inefficiency of motoric functioning.** In this case, perhaps little can be done to help.

C. <u>Summary</u>

For a number of reasons, deaf children may show the motor delay and slowness in reaction time found most recently by researchers such as Wiegersma and van der Velde (1983). Each or all of these reasons may further interact, or function alone, to produce the perceived differences. Whilst it cannot be decided definitively which of these reasons cause the deaf child to have problems with motor ability, there is danger in disregarding any of them. All theories are worth considering as they may each include valid elements which can be useful in furthering understanding and in implementing remediation. In summary, motoric delay and slowness of reaction may be influenced by:

1. a deprivation of sound and its effect on the cognitive integrative efficiency of the child, (Birch & Lefford, 1970; van Uden, 1977, Kelso & Clark, 1982; Veeger, 1983; Puyenbrook, 1983).

2. a deprivation of sound stimulus with consequent effects on the neurological maturation of the brain; and the further effects of the etiology of the hearing impairment itself on the brain's development and vestibular regions, (Vegeley, 1971; Conrad, 1980; Veeger, 1983; Arnold, 1983; Bernholtz & Benecerraf, 1983; Wiegersma & van der Velde, 1983).

3. the social environment of the child, particularly negative family interactions which function to restrict the experience needed for motoric development. Parallel with this, is the ease of the communication modality and the withdrawn personality of a child who cannot interact with his environment with ease, (Goss, 1970; Schlesinger & Meadow, 1972; Altshuler, 1974; Vernon, 1977; Knee, 1978; Meadow, Greenberg, Erting & Carmichael, 1981; Wiegersma & van der Velde, 1983; Grove & Rodda, 1985).

4. a low linguistic skill that reduces the efficiency of both the encoding and the retrieval of information in, and from, memory in motoric situations, (Birch & Lefford, 1963; Blank & Bridger, 1964; O'Connor & Hermelin, 1978; O'Connor, 1979; Beveridge & Brinker, 1980; Clark, 1978; Arnold, 1979; Conrad, 1979; Mulholland, 1980; Wall & Taylor, 1984).

5. the type of communication or linguistic codes that result in poor temporal sequence, (Kelley & Tomlinson-Keasey, 1977; O'Connor & Hermelin, 1978; Conrad, 1979; Grove, O'Sullivan & Rodda, 1979; Kelso & Clark, 1982; Das & Dash, 1983).

Regarding the present study, therefore, it is clear that each of these reasons may lend themselves to there being a difference in motoric ability between deaf children and their hearing peers. Furthermore, these factors may lead to a difference in the degree of motoric delay between deaf children themselves, that is, between those who are raised using a visual-spatial **simultaneously** dominant linguistic code (Total Communication), and those who are raised using an auditory-oral **sequentially** dominant linguistic code (Oral).

As outlined briefly in Part One, the following three questions are therefore posed in this study:

1. Do deaf children, when compared with their normally-hearing peers, show deficits in motor ability?
2. If so, then in what area, or areas of motor ability do the deaf children show these deficits? and
3. Do deaf children who are educated using the total communication method and the oral communication method, show differential degrees of motoric proficiency?

PART III

REVIEW OF LITERATURE ON THE DEAF AND MOTOR ABILITY

A. Review of Studies

The most comprehensive survey of the relationship between motor development and deafness is given by Rittenhouse (1979). Rittenhouse presented an overview of various studies that show deaf children have problems in motor development, and offered possible explanations based on all the theories previously discussed.[1] He wrote that "perhaps the most important achievement of a child in the first two years of life, is to gain sensory control over the environment" (p. 14). And concluded that it is the **immediate environment** that has the most effect on motor development since "the sensori-motor period is a period during which the infant depends primarily upon direct sensory stimulation to trigger specific motor behavior" (p. 24).

Concurrence on the relationship of motor development to the **integrity of the central nervous system** are found in the studies of Myklebust (1960), Levine (1976), Goldstein (1933) and Auxter (1973). **Slower reaction times** are

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[1] 1) sound deprivation with resulting retardation of the development of the central nervous system and slowness of reaction times, 2) etiology and neurological damage, 3) poor familial and environmental conditions, and 4) linguistic or cognitive retardation.

supported by the studies of Morsch (1936), Hiskey (1955), Bills (cited in Rittenhouse, 1979), Myklebust (1964), Auxter (1973), and Wiegersma and van der Velde (1983). Auxter (1973) attempted to discern a causal relationship between deafness and learning disabilities, and in doing so found differences between deaf and learning disabled students in speed of limb movements and dynamic flexibility. The deaf were significantly inferior. Auxter concluded as follows:

> There is some evidence that the integrity of motor behavior is closely associated with the integrity of the C.N.S., as in an organismic view of development in which there is reciprocity of function. It may be that the disability of motor planning and motor speed may have a disabling effect on the total development of deaf children. Therefore, the inability to perform tasks of motor speed may be indicative of the sensory processing and motor planning, not only in the motor sphere, but also in the intellectual tasks relating to academic success. (p. 576)

Wiegersma and van der Velde (1983) did an experimental study using a video game to measure speed of movement and reaction time. A group of 19 (8-10 year-old) deaf children were matched with hearing controls on sex, age, and socio-economic status. The deaf were "definitely inferior in both areas", and the authors concluded that the difference was "due to the processes underlying execution of movement."

In other studies, the relationship between etiology and motor development appears to be the significant factor. Wiegersma and van der Velde (1983) presented a further study where, on the basis of etiology, they separated a different group of subjects into "healthy deaf" (that is, those "without manifest neurological disorders or evident brain damage") and "the rest" of the deaf population (Dutch terminology). Using a test they devised from the Hamm-Marburger Coordination Test (Wiegersma and van der Velde, 1972), the Frostig Movement Skills Battery (Orpet, 1972), Baedtke (1972), Stott, Moyes and Henderson (1972) and the Oseretsky Psychomotorik (1931),[1] these authors found that the deaf appeared to be inferior to normal hearing controls in areas of general dynamic coordination, physical fitness, and manual ability. However, this inferiority was less significant with the "healthy deaf" group. Myklebust (1960) stated that "both motor retardation and motor disturbances such as apraxia and ataxia can be expected to occur in addition to deafness in certain children." This statement is supported by Meadow (1980) and van Uden (1981). Van Uden (1981) studied 95 prelingually profoundly deaf children with normal intelligence aged two to six years, between the years 1974-1979. Like Auxter (1973), he was looking for a relationship between deafness, motor problems, and subsequent learning disabilities. Results showed motoric problems in nearly half of the deaf children. Using such information van Uden places students within different educational departments in his school (see Table 2, p. 107).

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[1] A full description of these tests, and other tests mentioned by other authors in this Chapter is given in Appendix III, p. 269.

The Table appearing on this page has been removed due to present unavailability of copyright permission.

The Table represented the educational placement of ninety-five prelingually profoundly deaf children with normal intelligence aged two to six years over the period 1974-1976. Placements were made according to degrees of problems asssociated with dyspraxia, sensory-motor integration disturbance and dysphasia along with hearing-impairment.

A.J. van Uden (1981). Journal of the British Association of Teachers of the Deaf, 5(4), 112-127.

Concern about the etiology of deafness becomes most predominant in relation to the motor problem of balance. Since the first study of deafness and motor ability by Long (1932), problems of inferiority in balance have been reported by Morsch (1936), Myklebust (1964), Boyd (1967), Case, Dawson, Schartner and Donaway (1973), Lindsay and O'Neal (1976), Penella (1979), Brunt and Broadhead (1982), and Brunt and Broadhead (1983). Morsch (1936) did find superiority of some deaf subjects in the first trial of his test of balance, but subsequently his hearing subjects improved. He commented that the test conditions and his methods of scoring were not very reliable.

Myklebust (1964) divided 198 deaf children aged 11-14 years into groups with etiologies of "acquired", "congential", "meningitic" and "undetermined" deafness, and using the Heath Railwalking Test (1946) found all groups displayed inferior balance. The meningitic group were the worst, and since meningitis may directly damage the vestibular system and semi-circular canals, the relationship to balance seems clear. The findings also relate to paediatric observations that meningitic children are often slow in sitting and achieving bodily coordination (C.P. Shah, Department Preventative Medicine and Biostatistics, University of Toronto, Personal Communication, November, 1983). However, such a direct cause does not apply with the other etiologies. Case, Dawson, Schartner and Donaway

(1973) compared deaf subjects with groups of blind and normally hearing subjects using the Brace Motor Educability Test (1927) and the Ohio State University Step Test. Again inferiority of the deaf was found in balance. Since the blind subjects also performed better than the deaf, the authors concluded that a vestibular etiology of deafness was a determining factor in poor performance on tasks requiring balance.

Boyd (1967) undertook a study in Canada and the U.S.A. of 90 deaf subjects, divided into three etiological groups related to "hereditary", "endogenous", and "exogenous" causes of deafness. He matched them with normal hearing controls on age, sex and intelligence. He used the Oseretsky Test of Motor Proficiencies (1946) and the van der Lught Psychomotor Series (1949), and found that in all three groups, deaf subjects were generally inferior in balance. However, he did note some deaf individuals who were superior to the hearing, a point which Penella (1979) felt supported the possibility of motor remediation programs for the deaf. Since Myklebust also found that some deaf individuals could have superior motor skills, it seems that poor ability is not inherent in deafness itself, but rather results from other factors such as differing etiology. Penella (1979) suggested remediation should therefore be tailored to Boyd's (1967) three etiological groupings, and this suggestion is similar to the system developed by van Uden at Sint-

Michielsgestel (see p. 108).

Regarding **degree of impairment** Lindsay and O'Neal (1976) tested 31 mentally and physically normal eight year old deaf children and hearing controls on a test devised by themselves which assessed sixteen items of static and dynamic balance. They commented that the inferiority recorded for the deaf was related to the degree of hearing loss. This finding was not replicated by Carlson (1972), who used the same Brace Test (1927) as Case, Dawson, Schartner and Donaway (1973), and found no difference in ability between groups of deaf subjects subdivided on the basis of degree of hearing loss. However, Myklebust (1964) commented that the deprivation of sound does affect an individual. He stated:

> drawings of a human figure emphasize that a sensory deprivation, such as profound deafness from infancy, alters the perceptual processes and awareness of the individual leading to perceptual distortion of body image. (p. 401)

This "distortion" could also affect balance.

Other areas of motor development and deafness have produced mixed results and mixed suggestions as to causes. Boyd (1967) undertook further testing in the following areas:

1. **Locomotor coordination:** finding older deaf children experiencing more difficulty. He suggested that "hearing" may be needed more as the child grows, or that the importance of linguistic planning increases with age for motor execution.

2. **Psychomotor-integration:** finding kinesthetic memory ability no different between the deaf and

hearing, but kinesthetic speed and force inferior with the deaf.

3. **Laterality:** finding superior manual dexterity for the deaf in the non-dominant hand, a fact opposite to the hearing.

4. **Speed:** (as measured by items in Oseretsky, 1931) (with endogenous etiology) where younger deaf children were superior to the hearing, and older deaf and hearing children demonstrated the same ability. This is the only study that disagrees with the results of Morsch (1936); Myklebust (1964); Auxter (1973); and Wiegersma and van der Velde (1983). Boyd did find kinesthetic speed (see in No. 2 above) inferior with the deaf however when used against hearing ability in reaction of stopping a movement (see Boyd, 1967, pp. 599-600).

Case, Dawson, Schartner and Donaway (1973) also tested for physical fitness, finding no difference between deaf, blind, and normal subjects. Brunt and Broadhead (1982) used the Bruininks-Oseretsky Test of Motor Proficiency (1978) to test 154 deaf subjects, divided according to age and sex, and matched with hearing controls. They found no differences between the sexes, and superiority in the deaf group on visual-motor control at all ages. Since the deaf subjects were manual communicators, Brunt and Broadhead felt this superiority might be a direct effect of experience. In a further test by these authors (Brunt and Broadhead, 1983) using the short form of the Bruininks-Oseretsky Test, "results for static and dynamic balance, for one item of bilateral coordination, and for response speed, were noticeably lower for deaf children" (p. 44). However, once again superiority of visual motor control was found, and on the other test items, deaf and hearing performances were similar. Sisco and Anderson (1980) in their study of performance between deaf children of deaf parents and deaf children of hearing parents on the WISC-R intelligence test also mentioned that "input into visual motor channels at very early ages through manual communication . . . may lead to more refined development of these skills" (p. 927). Presumably this is because experience with signing reception and production, is primarily of a visual-motor action. Studies by Best and Roberts (1976) and Lubin and Sherrill (1980) and that of Rittenhouse (1979) do agree with this conclusion. Best and Roberts (1976) tested deaf children aged 23-38 months on the Infant Psychological Development Scale (1966), finding normal sensori-motor development especially where extra environmental stimulation was apparent. However, Wiegersma and van der Velde (1983) did not find visual-motor superiority of deaf children to hearing counterparts when etiologies other than genetic were a factor.

Still relating to experience, Lubin and Sherrill (1980) tested 24, 3-5 year old deaf children on levels of motor creativity, and found the deaf scored lower. They commented that Vernon and Fair (1975) could describe the reasons for these results when they wrote that:

> services for deaf children, especially those in integrated programs with hearing children, are desperately needed. If one observes recess at any school where there are both deaf and hearing children, one thing is immediately evident. The

> deaf children as a group are isolated. The games they play are more infantile than those of their hearing peers, . . . This is not due to different intelligence or motor skills, but due to lack of adequate instruction early in life.
> (cited in Lubin & Sherrill, 1980 p. 461)

This suggestion agrees with the comments of Wiegersma and van der Velde, 1983 (see p. 36) regarding the 'shyness' of deaf children causing them to miss valuable play and exercise experiences. It also agrees with Long (1932) who stated that "it is found that the average deaf child is . . . from 2-3 years retarded as compared with the average hearing child of the same age" (p. 1).[1] It points to the necessity for attention to educational programing in this area.

Long (1932) also mentions a difference in ability between the sexes, boys being superior to girls. However, he concluded that this was due to a generally more sensitive attitude on the part of females to their impairment, and the fact that they led more "sheltered lives." This may be another comment on the effect the environment has on motor ability, since Long's study was started at the turn of the century, and the more modern studies that have controlled for sex (Myklebust 1964; Best and Roberts 1976; Lindsay and O'Neal 1976; Carlson 1972; Boyd 1967; Wiegersma and van der Velde 1983) have found no significant differences between

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[1] Long is using 'retarded' as meaning developmentally delayed in motor ability.

deaf males and females. One other study by Geddes (1976) mentioned the environmental relationship again. Geddes (1978) profiled 11 deaf and hard-of-hearing pre-school children on the Geddes Psychomotor Inventory (1978). Some children were above age in areas not requiring balance. Geddes concluded that lack of experience and training, **not the impairment of deafness itself**, was the cause of motor difficulties. The study by Vernon and Fair (cited in Lubin and Sherrill, 1980) agreed with this statement. Interestingly, Geddes also mentions two unpublished studies of motor problems and the deaf, by Vance (1968) and Logan (1969). Both these authors found inferior static and dynamic balance with the deaf, Vance finding a slight improvement only by college age.

Finally, Myklebust (1964) used the Oseretsky Test of Motor Proficiency (1946) to test eye-hand coordination and visual-motor spatial perception between deaf and hearing subjects. Results showed equality between the two groups. This concurs with the studies of Long (1932), Morsch (1936), and Brunt and Broadhead (1982). However, when **speed** was again an element, the deaf made more errors in performance. Myklebust concluded that this might be because the deaf are "inferior in thinking out motoric actions." Auxter (1973, p. 4) also mentioned motor planning in relation to speed. This relates back to the relationship of language to motor planning mentioned earlier by Boyd (1967) and to the discussion of language in Part II of this paper. Myklebust further attempted to explain a distinction between motor development and ability in respect of (1) motor retardation, that is in the developmental rate being below average for chronological age, and (2) in motor disturbance, that is with problems in executing a motoric task because of uncoordination, paralysis, ataxia or apraxia. He pointed out that motor retardation is more likely to be a direct result of impaired hearing than is the occurrence of motor disturbance. Long's (1932) statement of a 'two to three year delay' in deaf populations concurs with this. Again therefore it seems that the hearing impairment and not the etiology behind a hearing impairment, is related to motor retardation. Retardation occurs due to the deprivation of the sense of sound, and, thus, the deaf appear slow in motoric tasks when compared to chronologically similar aged hearing peers. Myklebust wrote as follows:

> in the area of aptitude . . . there seems to be some delay in maturation as compared to the normal. Growth was noted to continue until 18-21 years, the highest age level studied. A number of investigations have shown that full potential is not attained until 2-4 years later than for the hearing. (p. 401).

However, this also means that the apraxia and ataxia found in some deaf children (see van Uden, 1981) is more related to the etiology behind the impairment, rather than to the simple deprivation of sound. Traumatic etiology leads to motor disturbance rather than motor retardation, since disease-caused deafness, or trauma, often affects other parts of the central nervous system (see p. 45). To know the nature of the motor problem is important in its remediation.

The only caveat to these arguments of etiology and deprivation of sound can be that the literature on the occurrence of motor problems in the normal hearing population is increasing. Gubbay (1975), Henderson and Hall (1972), Wall (1983), and Wall and Taylor (1983) define an apparent "clumsiness" in children appearing of "normal bodily habitus, intellect, physical strength, and sensory function" (Gubbay 1975). Motor problems may exist in a deaf child, therefore, completely unrelated to the fact that he is deaf, or why he is deaf. The study of Beggs and Breslaw (1982) that looked for clumsiness as being a secondary handicap to the problem of deafness, concurs with this point since no connection could be found. Beggs and Breslaw also could not find any perceptual-motor problems in their study of 27 deaf children on items of spatial discrimination or reproduction of perceptual patterns. As the children were compared to two normal hearing school populations, the authors stated their surprise at the findings. However, they acknowledged that their tests for clumsiness may have tapped different abilities than those tests designed to measure other motor areas, such as balance and speed.

Myklebust (1964) summed up his findings with the deaf and their motor ability as follows:

> . . . the person deaf from early life falls at the normal level in maturation of ability to sit and to walk, and . . . he is not inferior in manual dexterity or synkinesia. However, he falls below the average on laterality, simultaneous movement, locomotor coordination, balance, and motor speed; speed of complex motor tasks, not simply acts of manual dexterity. (p. 200)

Most of the research appears to agree with this. However, no studies have compared adult deaf individuals with their hearing peers. Such a study may be the only way to decide if motoric problems are due to retardation through deprivation of sound rather than etiology of impairment. By adulthood developmental ceilings should have been reached by all (unless there is still some environmental delay).

B. Summary

It is apparent that motor problems have been found in most relevant research studies with the deaf. The main concerns lie in the areas of balance and speed of task execution (Morsch, 1936; Hiskey, 1955; Myklebust, 1964; Boyd, 1967; Case, Dawson, Shartner & Donoway, 1973; Auxter, 1976; Lindsay & O'Neal, 1976; Penella, 1979; Brunt & Broadhead, 1982, 1983). When considering the reasons behind the motor difficulties of deaf children, two initial causal categories arise: These are motor retardation due to developmental delay, or motor disturbances due to structural deficiencies that result in impaired motor learning and performance (Long, 1932; Myklebust, 1968; Boyd, 1967; Penella, 1979; van Uden, 1981; Wiegersma & van der Velde, 1983).

An area that is considered to a lesser extent, is that of the relationship between the degree of an individual's hearing loss, and his/her ability to use language in the planning and execution of motor tasks (Carlson, 1972; Case, Dawson, Shartner & Donoway, 1973; Lindsay & O'Neal, 1976). As noted earlier, the less the hearing impairment, the more likely the individual is to acquire the normal auditory-oral linguistic coding system of the hearing society. Thus, the only "hard of hearing" child may be able to use inner speech to code and plan actions in much the same way as the normally hearing child. Since the alternative for the 'deaf' child is to use a visual-spatial linguistic coding system, it becomes worthwhile to consider if this offers the same inner coding ability, or efficiency, as an auditory-oral, temporally successive code. From reviewing some studies, signed systems appear to offer advantages in visual and manual motor coordination (Morsch, 1936; Myklebust, 1964; Brunt & Broadhead, 1982, 1983).

Finally, it is suggested in recent studies that remediation of motor **retardation** found in the deaf child is possible through increased experience and practice with motoric tasks. Such remediation may indicate that the child needs greater motoric stimulation linked with suitable linguistic codes. It may also mean a change of focus in many educational curricula. Alternatively, if motor problems are structurally determined, the literature suggests that deaf children should be grouped according to type of disturbance, and provided with a tailor-made educational program to minimize their deficiencies. Myklebust (1964) stated:

> . . . . The program implied would be based on specific needs of deaf children, on those aspects of motor behavior which are significantly influenced by hearing loss. Motor speed is an illustration. If deaf children are inferior in speed of complex motor acts, perhaps a series of motor functions progressing from simple manual acts to complex bodily integrations could be used to improve this aspect of their motor capacities. Many other examples could be given. (p. 202)

C. Relation of the Research Questions to the Literature

Based on an examination of the literature to date, there is presently disagreement between studies that attempt to establish a relationship between degree of hearing loss and motor ability. None have, as yet, attempted to study a relationship between degree of loss and mode of communication used by the child, and that of his motor ability. Nor do any view the relationship of linguistic proficiency to motor ability and no studies have directly compared manual and oral communication modes and motor proficiency.

The present study was designed to integrate these deficiencies. This was done to glean a fuller understanding of the interrelationship of the possible contributing factors to a delay in the motor development of deaf children. The design of each research question is drawn out of the limitations of the previous literature.

Question 1. Is there a difference in motor ability between deaf and hearing children as past research has shown?

In answering this question, it is important to use certain selection controls.

Firstly, since Carlson (1972) and Lindsay and O'Neal (1976) disagreed on the relevance of the degree of hearing loss to motor ability, all the subjects in this study were selected having a degree of hearing loss where sound is totally precluded without amplification. This is 90 dB, better ear average.

Most of the research literature also mentioned exogenous etiologies of hearing impairment affecting the motor domain. This was because corresponding etiological effects would occur in the central nervous system therefore slowing down the speed of sensory integration and consequently motor coordination (Boyd 1967, Auxter 1973, Wiegersma and van der Velde 1983). In the present study then, information regarding the etiology of the impairment was obtained for all subjects, and only those of endogenous or unknown etiologies were included. Subjects with below normal IQ's were also excluded.

As environmental stimulation appears advantageous to good motor development (Best and Roberts 1976, Rittenhouse 1979, Lubin and Sherrill 1980) all the subjects selected had attended pre-school. Finally, a socio-economic checklist was used in order to eliminate those having had less opportunity for environmental stimulation.

Question 2. In what area or areas of motor ability are there inferiorities between deaf and hearing children?

It is apparent from the review of the literature that research regarding the specific areas of inferiority between deaf and hearing children is conflicting. Two motor tests were therefore used so that if similar problem areas were found on both tests, greater consistency of results could be assumed.

Some of the literature also suggested that deaf children suffer a maturational lag when compared to their chronological aged peers (Long 1932, Myklebust 1964, Vance 1978). A comparison of three age groups was therefore included between each subject group. Sex differences were further included in the analysis, although this has rarely been found to be significant (Long 1932, Brunt and Broadhead 1982).

Question 3. Is there a difference between deaf children themselves?

Previous literature has shown that in some areas of visual fine motor coordination, deaf children do <u>not</u> show an inferiority. Sometimes too, when speed is not an element, they appear superior in ability in other areas (Myklebust

1964; Boyd 1967; Case, Dawson, Shartner and Donoway 1973; Best and Roberts 1976; Geddes 1979; Brunt and Broadhead 1982). Brunt and Broadhead specifically related this 'superiority' to the fact that they used deaf subjects who were total communicators, and who thus gained a manual dexterity advantage. This study therefore included two deaf groups, one with oral deaf subjects and the other with deaf subjects who used total communication. It was postulated that such a comparison would reveal any advantages that were indeed gained from the partial manual nature of the total communication linguistic code.

PART IV

METHODOLOGY

The aim of this study was to compare the motor proficiency of two groups of deaf students who use different methods of communication and one group of normally hearing students. Two tests that measure motor proficiency were used. The hypothesis was that no difference in ability would be found between the two deaf groups, but that a significant difference would be found between the two deaf and the normal hearing group. The dependent variable was motor proficiency. This was taken as being the efficient combination of speed and accuracy in the execution of a motor activity. The independent variables were method of communication, hearing ability, sex and age. The study sought to ascertain the degree to which motor proficiency was affected by these variables. Scores were further analyzed for relationships between low motor ability and low rhythmic memory and presence of dyspraxia. Insufficient numbers of deaf parents prevented the effect of parental hearing status from also being included.

Approval of ethical standards for the study was obtained from the appropriate departmental authorities.

Subject Description

Three groups of students were included in the study. All had low-average or above intelligence taken as a range of (85-136), had attended a pre-school, had average socio-economic backgrounds, and were between the ages of 8.0 to 11.0 years. The two deaf groups were prelingually profoundly deaf (diagnosed before 24 months, >90dB B.E.A. loss), and had unknown or familial etiologies of impairment.

The initial group acted as a hearing control group and consisted of 23 students, 12 boys and 11 girls, selected from the Stony Plain School District in Alberta, Canada. Parental permission was obtained for all subjects. All the control group used spoken oral English as their only means of communication and none of them had any known hearing impairment.

The first group of deaf children were those who used the Total Communication method in their school and home. This group of 27 students, 18 boys and 9 girls, was selected from the Calgary and Edmonton School Boards, Alberta, and also from the Provinces of Saskatchewan and Manitoba, Canada. Again the group consisted only of students who received parental permission to participate in the study. All subjects used both spoken oral English, fingerspelling, and signed English and/or American Sign Language at home and in the school. Thus they were educated under the system of education known as 'Total Communication'. Selection excluded those who did not have, and who had not had, the opportunity to use amplified sound on a continuing basis. A physical checklist (see Appendix IIb) was used for this purpose.

Although a signed linguistic code can be learned without amplification, holding the input of a consistent variable sound between all three groups enabled the provision of equal potential for the use of residual hearing. Subjects came from both day and residential school settings, and from integrated classes within regular schools as well as schools just for the deaf. The group included only prelingually profoundly deaf children with pure tone audiological hearing losses over 90dB (I.S.O. standards) calculated in the better ear at the following speech frequencies: 500, 1,000, and 2,000 Hz. With losses of this severity, the student is unable to hear his/her own voice without amplification. Using this criterion therefore ensured that the deaf subjects relied equally on amplified sound to input any oral language or auditory learning experience.

The final group consisted of the deaf students who used the Oral Communication method in their school and home. This group consisted of 23 subjects, 10 boys and 13 girls, selected from the Calgary and Edmonton School Boards, Alberta, Canada; the New York District School Board, U.S.A.; and the school of Sint-Michielsgestel, Brabent, The Netherlands. Subject availability and difficulty in acquiring parental permission necessitated obtaining students from such a wide geographical area. All the subjects were educated under the system of education known as 'Oral' and therefore used predominantly spoken oral Dutch at home and in the school. The same criteria for hearing loss and etiology were used in this group as were used in the T.C. group.

Each of the above groups were also divided into three age groups. Table 3, p. 127, shows the number of students in each group by age and sex, and indicates the nationality of the students in the oral deaf group.

Instruments

Motor Test Batteries:

Two test batteries were administered in this study. Appendix I a and b contain full details on the instructions, apparatus, and requirements of the "Test for General Movement Coordination: A Psycho-Motor Battery" (Wiegersma and Reysoo, 1982) and "The Bruininks-Oseret[illegible] Test of Motor Proficiency: Short Form" (Bruininks, 1978).

a) *Wiegersma-Reysoo*. This test battery had two major components. The subtests under each of these components are listed below.

Visual Motor Coordination

Poles and Rings
Lacing Board
Aiming
Beads and Matchsticks

General Dynamic Coordination

Balance

TABLE 3

Age and Sex Categories of Subjects within Groups

Group	Age	8.0-8.11	9.0-9.11	10.0-10.11	Subtotal
I HEARING					
	Male	4	4	4	12
	Female	3	3	5	11
		7	7	9	23
II DEAF Total Communicators					
	Male	5	9	4	18
	Female	3	2	4	9
		8	11	8	27
III DEAF Oral					
	Dutch				
	Male	2	3	1	6
	Female	3	0	1	4
		5	3	2	10
	U.S.A.				
	Male	2	0	0	2
	Female	0	3	3	6
		2	3	3	8
	Canadian				
	Male	2	0	0	2
	Female	1	2	0	3
		3	2	0	5
	Overall				
	Male	6	3	1	10
	Female	4	5	4	13
		10	8	5	23
TOTAL					
	Male	15	16	9	40
	Female	10	10	13	33
		25	26	22	73

Standing Broad Jump
Lateral Jumping
Moving Platforms
Sit-ups
High Jump

b) Bruininks-Oseretsky. This test battery consists of the following subtests.

Visual Motor Coordination
Upper Limb Coordination
Response Speed
Visual-Motor Control
Upper Limb Speed and Dexterity

General Dynamic Coordination
Running Speed and Agility
Balance
Bilateral Coordination
Strength

Other variables that are important considerations when studying the motor performance of deaf children were also tested with the following tests:

i. Bergès and Lézine.

According to A.J. van Uden (personal communication, November, 1984) at least "30% of prelingually profoundly deaf children suffer from the syndrome of dyspraxia. This is in several degrees, slight through heavy. These heavy ones, about 10% of the population, will not be able to learn to speak well." It was therefore felt that a significant relationship might exist between oral ability, inner speech (Conrad, 1979), linguistic mnemonic support, and the whole development of motor proficiency itself (see pp. 53-83). Although dyspraxia is in itself related to smooth motoric ability, and its presence should therefore similarly affect the ability of all the children in the study, the fine motoric task of speaking might be affected through lack of audition as a feedback source. Thus deaf children with dyspraxia may face a retardation in language that relies on oral ability for input. As discussed earlier then, lower inner language ability could mean slower processing for motoric action.

The presence of dyspraxia in the subjects was measured by the "Imitation of Gestures" test (Berges and Lezine, 1963, adapted by van Uden, 1967). These tests measure the extent of finger-eupraxia for intransitive movements and were standardized on deaf populations in The Netherlands in 1967 (see Appendix I). The scores were studied later to see if there was any positive relationship between the presence of dyspraxia and the motoric ability of the students. Further studies on motor ability could include the presence or absence of dyspraxia as an independent variable, that is, attempt to discern if proficient motor ability is dependent upon the level of dyspraxia present in an individual.

ii. Van Uden.

An attempt was made to have some measure of successive memory ability to see if there was any foundation for the theories of relationships between motor ability and the experience of successive processing from auditory-oral, phonological linguistic codes (see pp. 83-98). Van Uden (1984) pointed out that the coordination of diaphragmatic and intercostal breathing is also sometimes a problem in deaf children; and Gubbay (1975) mentioned a higher incidence of dysrhythmia in clumsy children. Since correct breathing is a fundamental determinant of speed of dynamic motor coordination, it could be that successive rythmic oral ability is related to smoothness of motoric ability and movement.

The ability of all the subjects in rhythmic successive memory was therefore measured by the use of the test of "Rhythm for Oral Movements for Prelingually, Profoundly Deaf Children of 6-12 years of age" (van Uden, 1983b), and classified as high or low (see Appendix I d). For Group Two, the oral element was supplemented by having the children clap the sequences since it was felt insufficient to find rhythmic successive memory ability through the oral element alone.

iii. Parental Hearing Status.

According to some studies (see pp. 38-40), deaf children of deaf parents appear to have superior communication skills and academic ability. It is also suggested that they have had more opportunity for explorative experience, and have a better self identity.

Deaf children included in the study that had deaf parents were therefore noted with a view to analyzing their score to see if any positive relationship did potentially exist between these suggested 'advantages' and the development of proficient motoric ability. However insufficient numbers of deaf children with deaf parents were found within the selection criteria to make this possible.

Procedure

Before undertaking the study, some schools for the deaf and school boards were contacted informally to enquire of availability of profoundly deaf students with 'normal' profiles, that is, not having any other known disabilities. When a sufficient population indicated feasibility for the study, school boards and/or principals of schools were contacted formally by letter with an outline of the proposed study, and request for participation. If agreement was gained, letters of permission were in turn sent out to the parents of the students within the schools that fit the selection criteria. Testing itself was then arranged with the schools and the teachers for a mutually convenient time.

Collection of data was started in May, 1984. It was completed in May, 1985. Testing averaged approximately 20 to 30 minutes per subject and was mainly accomplished during recess, lunch or after school. Once testing was set up (see Limitations of Research, p. 194), no major problems were encountered and the children were all highly motivated. No shyness or refusals were found, and many children wished to continue trying after testing was ended.

Test Administration:

a) Signal for the initiation of a response:

There is some suggestion that deaf children may experience a delay in initiation of response if they are relying on visual attention for identifying commencement cues. During the testing of all motor tasks therefore, a tactile 'tap' on the arm or shoulder was therefore given to all subjects, along with the verbal command of "Go!".

b) Number of trials:

It was felt that the novelty of the test items, or the misunderstanding of instructions, might prevent students from reaching their optimal performance. Two attempts were therefore offered on all test items and the better score taken as correct. It was noted that the deaf children listened attentively to instructions whereas the hearing children appeared to understand requirements before instructions were finished.

c) Other test factors:

It is possible that test anxiety may have influenced results, especially since speed was an element under consideration. It is also possible that the withdrawal sometimes shown by deaf children (as noted by Wiegersma and van der Velde, 1983) may have inhibited optimal performance. However, the following points were felt to overcome these difficulties:

a. Two trials were offered on each item and the better score taken as correct. However, not a significant number of improvements were noted.

b. Subjects were all addressed in the language and communication modality of their choice. The tester used oral English, sign language or oral Dutch.

c. Refusals would have been accepted, and the subjects excluded from the study. However, none occurred.

d. The tester was an experienced teacher of both normal and deaf children.

Analysis

The results of the performances of the children were analysed as follows:

a) Means and standard deviations were calculated on the scores of the three groups (Group I = hearing; Group II = T.C. deaf; Group III = oral deaf) on the fourteen subtests of the Bruininks-Oseretsky Test and the ten subtests of the Wiegersma-Reysoo Test.

b) A Hotelling T^2 statistic was calculated to determine if significant gender differences were present.

c) One-way MANOVA's (multiple analysis of variance) were used to show significant differences between

i. the means of the three groups on the subtests of the two Motor Test Batteries

ii. sex within and between the three groups

iii. age within and between the three groups

A significance level of .05 was established for all post-hoc tests.

d) Means and standard deviations were calculated for the scores of the three groups on the tests for dyspraxia and rhythmic memory. A correlational analysis was also run between these tests and the twenty-four subtests of the motor tests.

e) A factor analysis was completed on the twenty-four subtests of the two Motor Test Batteries using a principal component analysis with a varimax rotation. A second factor analysis was also completed in the same way using only the 50 deaf subjects. This was to determine which factors were being identified as constituting motor ability by both tests.

PART V

RESULTS

The results are discussed within the following framework.

A table is presented giving a summary of the differences found between the three groups on each of the subtests of the two motor tests (see Table 4, p. 136). Individual analyses of the results of the Bruininks-Oseretsky Test and the Wiegersma-Reysoo Test are then presented. Group and gender differences are reported for each of the subtests, and so are gender by group and age by group differences.

The results of the correlational analysis between the two motor tests and the tests for rhythmic memory and dyspraxia are then given. Results of the factor analyses identifying the major motor categories that were tested follow, and a summary of the findings is at the end of the chapter.

TABLE 4

Summary Table of the Differences between the Groups on the Two Motor Tests

Motor Subtests	Significant Group Comparisons	Superior Group
Bruininks-Oseretsky		
Running Speed & Agility	1V2 1V3 2V3	2 3 2
Balance: Static	1V2 1V3	1 1
Dynamic	1V2 1V3	1 1
Bilateral Coordination:		
Tapping Feet	1V2	1
Clapping Hands	1V2 1V3	1 1
Standing Broad Jump	1V3	1
Upper Limb Coordination:		
Catching a Ball	1V2	1
Throwing a Ball	---	
Response Speed	1V3 2V3	1 2
Visual Motor Control:		
Drawing a Line	---	
Copying Patterns	---	
Copying Circles	---	
Upper Limb Speed & Dexterity:		
Sorting Cards	---	
Aiming Dots in Circles	1V2 1V3	1 1
Wiegersma-Reysoo		
Rings on Poles	1V2 1V3	1 1
Lacing Board	1V2 1V3	1 1
Aiming	---	
Beads & Matchsticks	---	
Balance (Dynamic)	1V2 1V3	1 1
Standing Broad Jump	1V2 1V3	1 1
Lateral Jumping	1V2 1V3	1 1
Moving Platforms	1V2 1V3	1 1
Sit-Ups	1V2 1V3	1 1
High Jump	1V2	1

Group 1 = Hearing
Group 2 = T.C. Hearing Impaired
Group 3 = Oral Hearing Impaired

--- = No significant difference found.

Group Differences in Performance

One-way MANOVAs (multiple analysis of variance) were used to establish whether significant differences existed between the means of the three subject groups.

Bruininks-Oseretsky:

The F statistic used to test the significance of the Wilks Lamda associated with the Bruininks-Oseretsky was found to be 4.96 (df1/28; df2/114, p = <.001). Post-hoc contrasts at .05 significance revealed the differences given in Table 5, p. 138.

Hearing children were superior to their oral deaf peers in the areas of:

i. balance, static and dynamic;

ii. the aspect of bilateral coordination requiring a number of claps in one jump;

iii. strength (standing broad jump);

iv. the aspect of upper limb speed and dexterity requiring making dots in circles;

v. response speed.

There appeared to be no significant difference in ability between hearing and T.C. deaf children on any of the subtests. The means between the three groups on each subtests are shown in Table 6 (p. 139) and Figure 6 (p. 140). Although the means between Group 1 and Group 2 do show differences, the latent variable was not significant. As

TABLE 5

Significant Pairwise Difference Between Groups on the Bruininks-Oseretsky

		df1	df2	F Ratio	Probability	Superior Group
Motor Ability	Latent Variable	2	70	7.64	0.001	
	1V3	1	70	13.59	0.001	
	2V3	1	70	9.15	0.003	
Running Speed & Agility	Subtest 1	2	70	27.38	0.001	
	1V3	1	70	8.44	0.004	3
	2V3	1	70	18.54	0.001	2
Balance (static)	Subtest 2	2	70	11.24	0.001	
	1V3	1	70	21.58	0.001	1
Balance (dynamic)	Subtest 3	2	70	8.73	0.001	
	1V3	1	70	17.32	0.001	1
Bilateral Coordination (jump & clap)	Subtest 5	2	70	3.90	0.024	
	1V3	1	70	6.60	0.012	1
Standing & Broad Jump	Subtest 6	2	70	4.84	0.010	
	1V3	1	70	9.55	0.002	1
Response Speed	Subtest 9	2	70	5.97	0.004	
	1V3	1	70	11.30	0.001	1
	2V3	1	70	5.88	0.017	2
Upper Limb Speed & Dexterity (dots in circles)	Subtest 14	2	70	7.73	0.001	
	1V3	1	70	13.53	0.001	1

Group 1 = Hearing
Group 2 = T.C. Hearing Impaired
Group 3 = Oral Hearing Impaired

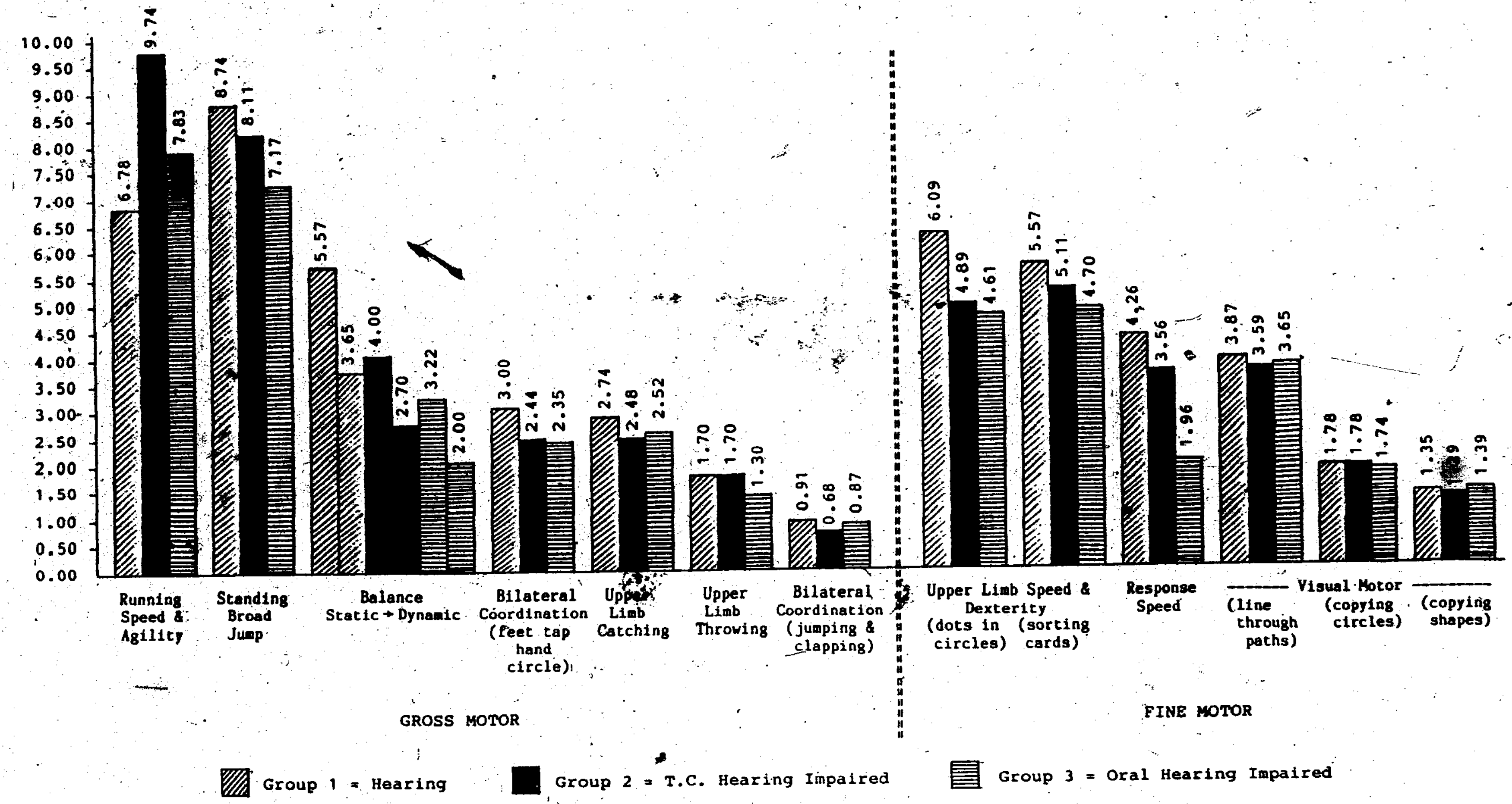
TABLE 6

Bruininks-Oseretsky Means and Standard Deviations by Group

Subtests		Running Speed & Agility 1	Balance Static 2	Balance Dynamic 3	Bilateral Coordination Feet Taps & Circles 4	Jump & Clap 5	Standing Broad Jump 6	Catching 7	Throwing 8	Response Speed 9	Visual Motor Coordination Through Lines 10	Copying Circles 11	Copying Shapes	Upper Limb Speed & Dexterity Sorting Cards 13	Dots in Circles 14	Total Point Score
Group 1 Hearing	$\bar{X}$	6.78	5.57	3.65	0.91	3.00	8.74	2.74	1.70	4.26	3.87	1.78	1.35	5.57	6.09	53.13
	(SD)	2.18	1.31	0.86	0.28	0.72	1.25	0.43	1.30	1.91	0.61	0.41	0.47	1.52	1.13	5.56
Group 2 T.C.	$\bar{X}$	9.74	4.00	2.70	0.68	2.44	8.11	2.48	1.70	3.56	3.59	1.78	1.29	5.11	4.89	51.85
	(SD)	2.63	1.98	1.38	0.47	1.03	2.20	0.83	0.85	2.85	0.87	0.42	0.67	1.95	1.57	12.55
Group 3 Oral	$\bar{X}$	7.83	3.22	2.00	0.87	2.35	7.17	2.52	1.30	1.96	3.65	1.74	1.39	4.70	4.61	44.35
	(SD)	2.10	1.61	1.59	0.34	0.70	1.31	0.77	0.69	1.81	0.70	0.44	0.49	1.56	1.21	5.22
Overall	$\bar{X}$	7.26	4.25	2.78	0.81	2.59	2.01	2.58	1.58	3.27	3.70	1.77	1.30	5.12	5.18	50.21
	(SD)	3.12	1.93	1.47	0.39	0.89	1.79	0.99	0.99	2.46	0.75	0.42	0.57	1.64	1.47	9.66

Figure 6

Bruininks-Oseretsky Means of the Three Groups



the latent variable was not significant, further examination of the group scores was inappropriate.

The only differences between the two deaf groups themselves were in response speed and running speed and agility where T.C. children were superior.

Wiegersma-Reysoo:

The F statistic used to test the significance of Wilks Lamba associated with the Wiegersma-Reysoo test was found to be 3.63 (df1 20; df2 122, p = <.001). Post-hoc contrasts again at .05 significance, revealed the differences shown in Table 7, p. 142.

It appeared that hearing children were superior to both groups of deaf peers in the areas of:

<u>Visual motor</u>

i. putting rings on poles
ii. lacing

<u>General motor</u>

i. balance
ii. strength (standing broad jump)
iii. lateral jumping
iv. moving sideways on platforms

They were also superior to oral deaf children in sit-ups. There was no apparent difference in ability between the two deaf groups. The means are shown in Table 8, p. 143 and Figure 7, p. 144.

TABLE 7

Significant Pairwise Differences Between Groups on the Wiegersma-Reysoo

			df1	df2	F Ratio	Probability	Superior Group
	Latent Variable	Motor Ability	2	70	15.96	0.001	
	1V2		1	70	20.43	0.001	
	1V3		1	70	27.51	0.001	
Poles & Rings	Subtest 1		2	70	8.17	0.001	
	1V2		1	70	11.31	0.001	1
	1V3		1	70	13.42	0.001	1
Lacing Board	Subtest 2		2	70	3.82	0.027	
	1V2		1	70	7.11	0.009	1
	1V3		1	70	4.04	0.048	1
Balance (dynamic)	Subtest 5		2	70	6.09	0.004	
	1V2		1	70	11.21	0.001	1
	1V3		1	70	6.68	0.012	1
Standing Broad Jump	Subtest 6		2	70	25.72	0.001	
	1V2		1	70	36.10	0.001	1
	1V3		1	70	41.85	0.001	1
Lateral Jumping	Subtest 7		2	70	6.67	0.002	
	1V2		1	70	5.01	0.028	1
	1V3		1	70	13.17	0.001	1
Moving Platforms	Subtest 8		2	70	17.37	0.001	
	1V2		1	70	19.51	0.001	1
	1V3		1	70	31.70	0.001	1
Sit-ups	Subtest 9		2	70	6.75	0.002	
	1V3		1	70	13.39	0.001	1

Group 1 = Hearing
Group 2 = T.C. Hearing Impaired
Group 3 = Oral Hearing Impaired

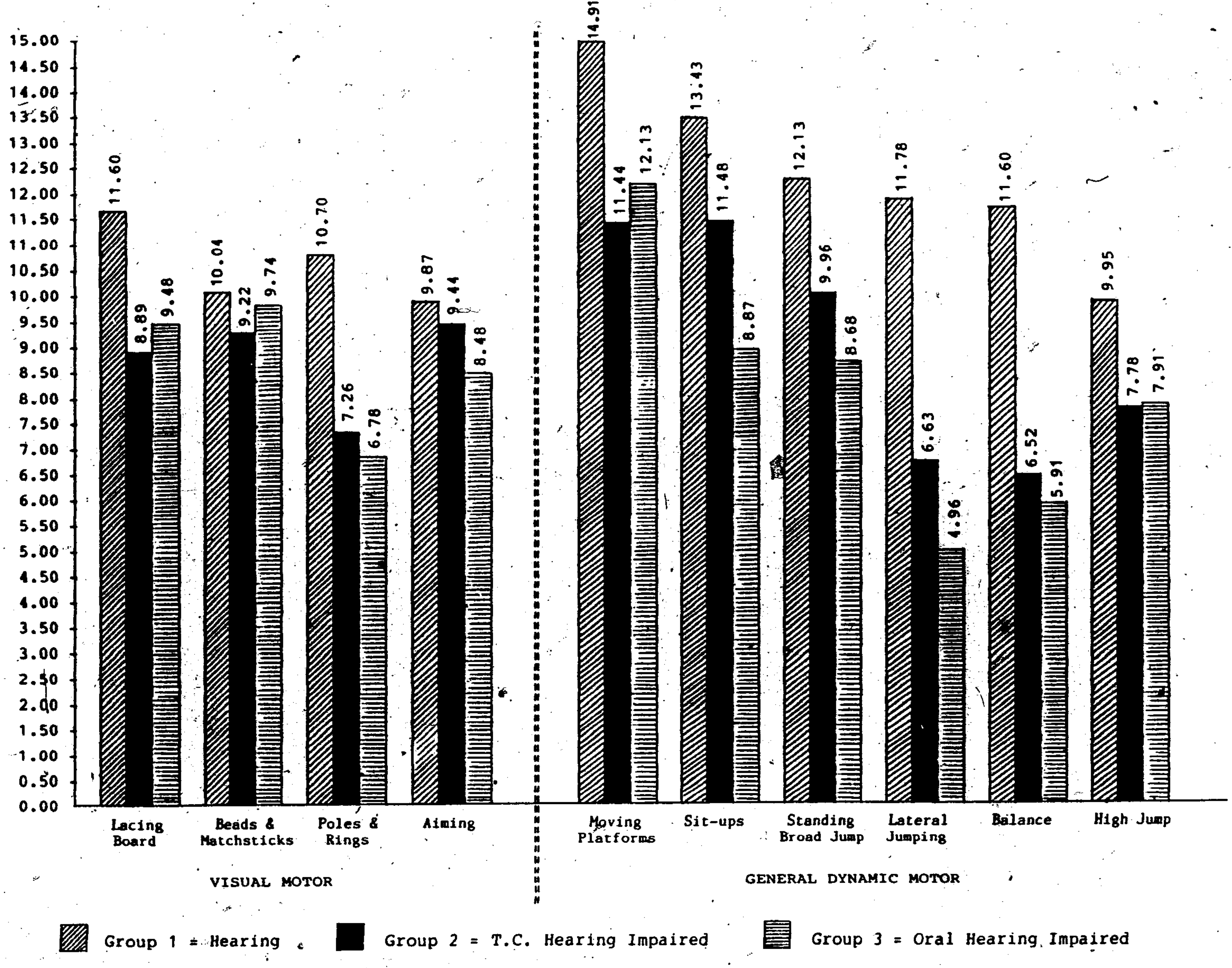
TABLE 8

Wiegersma-Reysoo Means and Standard Deviations by Group

Subtests		Poles & Rings 1	Lacing Board 2	Aiming 3	Beads & Matchsticks 4	Balance 5	Standing Broad Jump 6	Lateral Jumping 7	Moving Platforms 8	Sit-ups 9	High Jump 10	Visual Motor Total	General Motor Total	Total Point Score
Group 1 Hearing	X̄	10.70	11.60	9.87	10.04	14.91	11.60	12.13	11.78	13.43	9.95	11.17	13.34	12.65
	(SD)	2.54	2.29	2.19	2.61	3.12	2.29	2.25	4.37	2.93	3.07	2.64	3.19	2.74
Group 2 T.C.	X̄	7.26	8.89	9.44	9.22	11.44	6.52	9.96	6.63	11.48	7.78	8.37	8.61	8.19
	(SD)	4.66	4.12	4.93	4.70	4.32	3.20	4.32	4.02	3.97	3.71	4.87	4.07	4.81
Group 3 Oral	X̄	6.78	9.48	8.48	9.74	12.13	5.91	8.68	4.96	8.87	7.91	7.83	7.17	7.00
	(SD)	3.32	3.75	2.02	2.52	2.98	3.13	2.92	3.65	5.24	3.31	2.35	2.85	2.49
Over[illegible]	X̄	8.25	9.93	9.27	9.96	12.75	7.93	10.18	7.73	11.27	8.51	9.08	9.58	9.22
	(SD)	4.11	3.71	3.48	3.59	3.87	3.85	3.65	6.93	4.51	3.34	3.85	4.33	4.30

Figure 7

Wiegersma-Reysoo Means of the Three Groups



A comparison of the means of the similar subtests on the Bruininks-Oseretsky and Wiegersma-Reysoo is shown in Figure 8, p. 146.

Gender Differences in Performance

A Hotelling T^2 Test was used to assess the mean differences between the sexes on all the subtests of the two Motor Test Batteries.

A Hotelling T^2 statistic tested in terms of the F distribution associated with the Bruininks-Oseretsky test was non-significant (F = 1.33; df1 14; df2 58, p = 0.219). Similarly, for the Wiegersma-Reysoo test, the F was not significant at 0.51 (df1 10; df2 60, p = 0.877). The means for each sex on both test batteries are presented in Tables 9, p. 147 and 10, p. 148. Clearly there were no significant differences between gender on any of the items of the two Motor Test Batteries.

However, when the three (T.C., Oral, Hearing) ability groups were included in the analysis, significant differences in performance were found.

One-way MANOVAs were run in terms of a two-way MANOVA to examine the differences of sex within the subject groups.

Bruininks-Oseretsky:

The F statistic associated with the Bruininks-Oseretsky was found to be significant at the 0.001 level (F

Figure 8

Means of Same Subtests on the Wiegersma-Reysoo and the Bruininks-Oseretsky

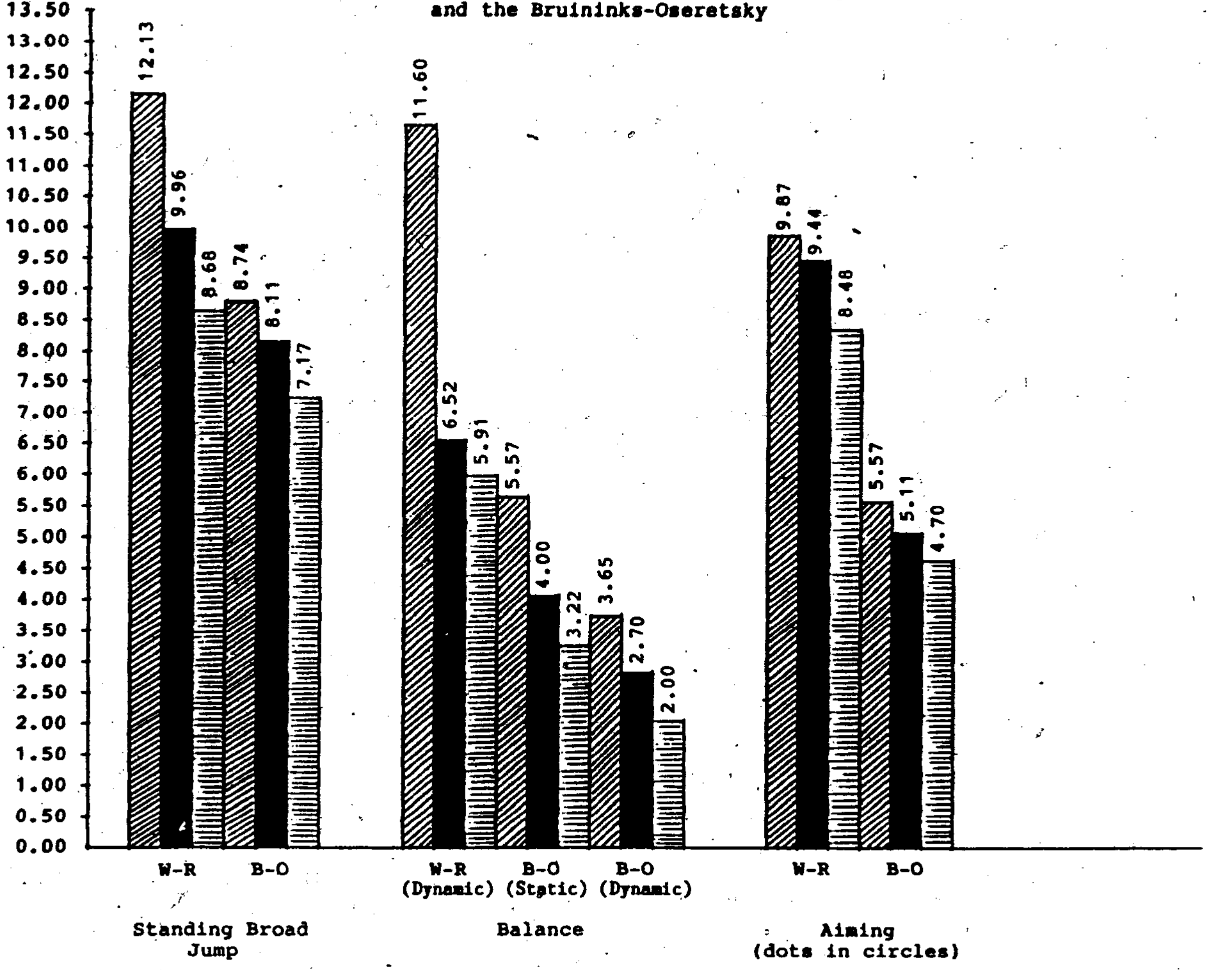


TABLE 9

Means by Sex on the Bruininks-Oseretsky

SUBTEST		Male N = 39	Female N = 34
1	Running Speed & Agility	7.61	6.85
2	Balance	4.17	4.32
3	"	2.79	2.76
4	Bilateral Coordination	0.79	0.82
5	"	2.51	2.67
6	Standing Broad Jump	8.30	7.67
7	Upper Limb Coordination	2.53	2.61
8	"	1.74	1.38
9	Response Speed	3.64	2.85
10	Visual Motor Control	3.69	3.70
11	"	1.76	1.76
12	"	1.33	1.26
13	Upper Limb Speed and Dexterity	4.89	5.38
14	"	5.05	5.32

TABLE 10

Means by Sex on the Wiegersma-Reysoo

SUBTEST		Male N = 39	Female N = 34
1	Rings on Poles	7.71	8.85
2	Lacing Board	9.66	10.23
3	Aiming	9.38	9.16
4	Beads & Matchsticks	9.66	10.29
5	Moving Platforms	12.17	13.41
6	Balance	8.12	7.70
7	Standing Broad Jump	10.02	10.35
8	Lateral Jumping	7.33	8.17
9	Sit-ups	10.94	11.64
10	High Jump	8.17	8.88

= 2.335, df1/70; df2/261). Post-hoc contrasts at .05 level of significance revealed the differences given in Table 11, p. 150. The sex and interaction effects were non-significant, but the main effect for groups was significant. The latent variable for Group 1 versus 2 was also now significant.

Analysis of the means showed the same superiority of Group 1 (hearing) over Group 3 (oral deaf) as found in the initial group mean analysis. However, Group 1 was now superior to Group 2 (T.C. deaf) on the same subtests. Group 2 was again superior to Groups 1 and 3 in running speed and agility.

Wiegersma-Reysoo:

The F statistic associated with the Wiegersma-Reysoo was also significant at the 0.001 level (F = 1.958, df1/50; df2/268). Again post-hoc constrasts at the .05 level of significance revealed no significant sex and interaction effects, but significant differences between the groups. The results are presented in Table 12, p. 151. Analysis of the group means showed the same superiority of Group 1 (hearing) as found in the initial group analysis, with the addition of the subtest high jump.

Age Differences in Performance

One-way MANOVAs were run in terms of a two-way MANOVA to examine differences of age within the subject groups.

TABLE 11

Significant Differences Between Sex by Group on the Bruininks-Oseretsky

		df1	df2	F ratio	Probability	Superior Group
Latent Variable	Interaction Effect	28	108	1.040	0.424	
Latent Variable	Main Effect for Sex	14	54	1.154	0.336	
Latent Variable	Main Effect for Group	28	108	4.617	0.001	
	1V2	14	54	7.736	0.001	
	1V3	14	54	4.504	0.001	
	2V3	14	54	2.934	0.002	
Running Speed and Agility	Subtest 1					
	1V2	1	67	51.50	0.001	2
	1V3	1	67	8.75	0.004	3
	2V3	1	67	17.28	0.001	2
Balance (static)	Subtest 2					
	1V2	1	67	10.49	0.002	1
	1V3	1	67	21.39	0.001	1
Balance (dynamic)	Subtest 3					
	1V2	1	67	6.80	0.011	1
	1V3	1	67	17.17	0.001	1
Bilateral Coordination (jumps and claps)	Subtest 5					
	1V2	1	67	5.74	0.019	1
	1V3	1	67	6.70	0.012	1
Standing Broad Jump	Subtest 6					
	1V3	1	67	8.80	0.004	1
Response Speed	Subtest 9					
	1V3	1	67	10.94	0.002	1
Upper Limb Speed and Dexterity (dots in circles)	Subtest 14					
	1V2	1	67	10.20	0.002	1
	1V3	1	67	13.47	0.001	1

Group 1 = Hearing
Group 2 = T.C. Hearing Impaired
Group 3 = Oral Hearing Impaired

Sex and Interaction Effect
= Non-significant
Group Effect = Significant

TABLE 12

Significant Differences Between
Sex by Group on the Wiegersma-Reysoo

		df1	df2	F	Probability	Superior Group
Latent Variable	Interaction Effect	20	116	1.300	1.192	
Latent Variable	Main Effect for Sex	10	58	0.514	0.873	
Latent Variable	Main Effect for Group	20	116	3.645	0.001	
	1V2	10	58	4.698	0.001	
	1V3	10	58	5.650	0.001	
	2V3	10	58	1.571	0.138	
Poles and Rings	Subtest 1					
	1V2	1	67	8.609	0.004	1
	1V3	1	67	12.878	0.001	1
Lacing Board	Subtest 2					
	1V2	1	67	6.964	0.010	1
	1V3	1	67	3.696	0.058	1
Balance (dynamic)	Subtest 5					
	1V2	1	67	11.461	0.001	1
	1V3	1	67	6.861	0.011	1
Standing Broad Jump	Subtest 6					
	1V2	1	67	38.872	0.001	1
	1V3	1	67	42.279	0.001	1
Lateral Jumping	Subtest 7					
	1V2	1	67	3.905	0.052	1
	1V3	1	67	12.918	0.001	
Moving Platforms	Subtest 8					
	1V2	1	67	20.004	0.001	1
	1V3	1	67	31.677	0.001	1
Sit-ups	Subtest 9					
	1V3	1	67	12.719	0.001	1
High Jump	Subtest 10					
	1V2	1	67	4.965	0.029	1

Group 1 = Hearing
Group 2 = T.C. Hearing Impaired
Group 3 = Oral Hearing Impaired

Sex and Interaction Effect
= Non-significant
Group Effect = Significant 1V2
1V3
Non-significant 2V3

Bruininks-Oseretsky:

The F statistic associated with the Bruininks-Oseretsky was significant at the 0.001 level (F = 1.849; df1/ 112, df2/369). Post-hoc contrasts at .05 significance level revealed the differences presented in Table 13, p. 153. There were no signifcant age or interaction effects, but there were the same significant differences between the three subject groups as in the sex by group analysis, with the addition of two more subtests. The hearing group were superior to the T.C. group in catching a ball and tapping feet while making hand circles.

Wiegersma-Reysoo:

The F statistic associated with the Wiegersma-Reysoo test was also significant at the 0.001 level (F = 1.922; df1/80, df2/357). Post-hoc contrasts at .05 significance revealed the differences shown in Table 14, p. 154. There was no significant interaction effect, but the main effect for both age and group was significant. Analysis of the means showed the same significant differences between the groups as evidenced earlier in the sex by group analysis, but there was also a significant difference between the ages 101-111 months and >112 months. The older group were superior in the areas of:

i. aiming (dots in circles)

ii. balance (dynamic)

iii. sit-ups (also strength)

TABLE 13

Significant Differences Between Age by Group on the Bruininks-Oseretsky

		df1	df2	F ratio	Probability	Superior Group
Latent Variable	Interaction Effect	56	205	0.970	0.5393	
Latent Variable	Main Effect for Age	28	102	1.244	0.2139	
Latent Variable	Main Effect for Group	28	102	3.176	0.0001	
	1V2	14	51	5.142	0.0001	
	1V3	14	51	3.291	0.0009	
	2V3	14	51	2.070	0.0300	
Running Speed and Agility	Subtest 1					
	1V2	1	64	24.504	0.0001	2
	1V3	1	64	6.317	0.0144	3
	2V3	1	64	7.605	0.0075	2
Balance (static)	Subtest 2					
	1V2	1	64	13.067	0.0005	1
	1V3	1	64	17.311	0.0001	1
Balance (dynamic)	Subtest 3					
	1V2	1	64	14.619	0.0003	1
	1V3	1	64	19.684	0.0001	1
Bilateral Coordination (feet-tap and hand circles)	Subtest 4					
	1V2	1	64	4.275	0.0427	1
Bilateral Coordination (jump and clap)	Subtest 5					
	1V2	1	64	5.893	0.0180	1
	1V3	1	64	4.951	0.0296	1
Standing Broad Jump	Subtest 6					
	1V3	1	64	7.532	0.0078	1
Catching a Ball	Subtest 7					
	1V2	1	64	6.509	0.0131	1
Response Speed	Subtest 9					
	1V3	1	64	6.792	0.0113	1
Upper Limb Speed and Dexterity (dots in circles)	Subtest 14					
	1V2	1	64	8.512	0.0048	1
	1V3	1	64	11.049	0.0014	1

Group 1 = Hearing
Group 2 = T.C. Hearing Impaired
Group 3 = Oral Hearing Impaired

Age and Interaction Effect
= Non-significant
Group Effect = Significant 1V2
1V3
2V3

TABLE 14

Significant Differences Between Age by Group on the Wiegersma-Reysoo

		df1	df2	F ratio	Probability	Superior Group
Latent Variable	Interaction Effect	40	210	1.306	0.1185	
Latent Variable	Main Effect for Age	20	110	1.821	0.0265	
	<101 v 101-111 months	10	55	1.571	0.1400	
	<101 v >112 months	10	55	1.058	0.4091	
	101-111 v >112 months	10	55	2.764	0.0077	
Latent Variable	Main Effect for Group	20	110	3.035	0.0001	
	1V2	10	55	4.986	0.0001	
	1V3	10	55	5.206	0.0001	
	2V3	10	55	1.405	0.2026	
<u>GROUP</u>						
Poles and Rings	Subtest 1					
	1V2	1	64	7.853	0.0067	1
	1V3	1	64	7.145	0.0095	1
Lacing Board	Subtest 2					
	1V2	1	64	4.020	0.0491	1
Balance (dynamic)	Subtest 5					
	1V2	1	64	11.238	0.0013	1
	1V3	1	64	5.938	0.0176	1
Standing Broad Jump	Subtest 6					
	1V2	1	64	37.539	0.0001	1
	1V3	1	64	32.678	0.0001	1
Lateral Jumping	Subtest 7					
	1V2	1	64	4.651	0.0347	1
	1V3	1	64	11.816	0.0010	1
Moving Platforms	Subtest 8					
	1V2	1	64	16.989	0.0001	1
	1V3	1	64	22.444	0.0001	1
Sit-ups	Subtest 9					
	1V2	1	64	4.752	0.0329	1
	1V3	1	64	6.592	0.0125	1
<u>AGE</u>						
Aiming	Subtest 3					
	101-111m v >112m	1	64	6.664	0.0121	>112 months
Balance (Dynamic)	Subtest 6					
	101-111m v >112m	1	64	6.230	0.0151	>112 months
Sit-ups	Subtest 9					
	101-111m v >112m	1	64	4.403	0.0398	>112 months

Group 1 = Hearing
Group 2 = T.C. Hearing Impaired

Group 3 = Oral Hearing Impaired

- Interaction Effect = Non-significant
Group Effect = Significant 1V2
1V3
Non-significant 2V3
Age Effect = Significant 101-111 months v 112m
Non-signifcant <101 v 101-111 months
<101 v >112 months

Results of the effects of rhythmic memory and dyspraxia

A correlational analysis was run between the twenty-four items of the two motor tests and the tests for rhythmic memory and dyspraxia.

Results showed very few significant correlations between any of the tests. These are shown in Table 15, p. 156. The highest correlations between the Bruininks-Oseretsky and the Rhythm Test were in the areas of balance (0.424) and upper limb speed and dexterity of sorting shape cards (0.428). The highest correlations between the Wiegersma-Reysoo and the Rhythm Test were in the areas of balance (0.456), strength (0.591), and moving on platforms (0.606). Sorting shape cards at speed and moving on platforms at speed might both incorporate an element of rhythm in the repetitive bilateral movements, but it is unknown why balance in both motor tests should be somewhat correlated to rhythmic ability.

The total General Dynamic motor score on the Wiegersma-Reysoo was also correlated to the Rhythm Test at 0.648 and the overall point score incorporating both visual and general motor ability was 0.575. As the Bruininks-Oseretsky total score was only 0.322, the Wiegersma-Reysoo test appeared to incorporate the need for rhythmic ability more than the Bruininks-Oseretsky. Further examination [illegible] Table 15 revealed that the tests for dyspraxia were not highly correlated with any of the two motor test items.

TABLE 15

Correlation Scores for the Rhythm Test and the Tests for Dyspraxia with the Subtests of the Two Motor Tests

	Rhythm 1	Bergès & Lézine 2	Van Uden 3	Bergès & Lézine and Van Uden 4
1. Rhythm	1.000			
2. Bergès & Lézine	0.328	1.000	0.443	
3. Van Uden	0.046	0.443	1.000	
4. Total Bergès & Lézine with Van Uden	0.082	0.580	0.955	1.000
SUBTESTS BRUININKS - OSERETSKY				
1. Running Speed and Agility	0.399	0.394	0.349	0.365
2. Balance: Static	0.424	0.047	0.084	0.089
3. Dynamic	0.328	0.079	0.005	0.030
4. Bilateral Coordination	0.287	0.121	0.332	0.325
5.	0.334	0.132	0.102	0.128
6. Strength	0.323	0.005	0.030	0.038
7. Upper Limb Coordination	0.138	0.071	0.013	0.36
8.	0.186	0.160	0.171	0.178
9. Response Speed	0.297	0.096	0.062	0.047
10. Visual Motor Control	0.106	-0.129	0.176	0.111
11.	-0.034	-0.203	-0.117	-0.177
12.	-0.004	0.076	0.135	0.086
13. Upper Limb Speed and Dexterity	0.153	0.260	0.316	0.304
14.	0.428	0.084	0.281	0.263
Total Point Score	0.322	0.249	0.300	0.298
WIEGERSMA - REYSOO				
1. Poles & Rings	0.443	0.006	0.194	0.175
2. Lacing	0.305	0.082	0.245	0.218
3. Aiming	0.117	0.236	0.051	0.069
4. Beads & Matches	0.225	0.043	0.188	0.177
5. Balance: Dynamic	0.456	0.066	0.301	0.320
6. Broad jump (strength)	0.591	- 0.133	-0.083	-0.100
7. Lateral jumping	0.389	- 0.076	0.091	0.079
8. Moving platforms	0.606	- 0.120	0.163	0.104
9. Sit-ups	0.357	- 0.013	0.170	0.191
10. High jump	0.383	0.008	0.119	0.121
Visual Motor Total	0.373	0.094	0.188	0.171
General Motor Total	0.648	-0.081	0.166	0.149
Total Point Score	0.575	-0.021	0.159	0.171

Diagnosis of Dyspraxia can therefore apparently not provide a sound basis for the modification of a motor development program. Whereas in previous literature (van Uden, 1983b) it has been significantly correlated to success in oral communication development, having dyspraxia does not appear to be related to success in the development of general motor ability. Insignificant correlations between levels of dyspraxia and levels of ability on the various motor subtest items used in this study may also mean that the question of low language being correlated to low motoric functioning (because of poor inner speech from deaf children being taught with an oral communication code), is also insignificant. Alternatively, however, the oral deaf subjects in the study may have had good inner speech and, therefore, as is found with the hearing children (van Uden, 1983b), have overcome the problems associated with being dyspraxic.

The means and standard deviations of the three groups on the rhythm and dyspraxia tests are shown in Table 16, p. 158. Visual comparison of these scores shows a significant difference between the groups only on the Rhythm Test. Here the hearing children were markedly superior. However, there were large standard deviations around the means in each group. This indicates a wide range of abilities within this test and, therefore, the results should be interpreted with caution.

TABLE 16

Means and Standard Deviations for the Rhythm Test and the Tests for Dyspraxia

Tests		Hearing GROUP 1 N = 23	T.C. Hearing Impaired GROUP 2 N = 27	Oral Hearing Impaired GROUP 3 N = 23	Overall = 73
1 Rhythmic Memory	$\overline{X}$	182.73	41.03	61.60	92.16
	(SD)	57.60	19.52	24.06	72.21
2 Bergès & Lézine Finger Patterns	$\overline{X}$	11.34	13.63	13.26	12.79
	(SD)	1.50	1.85	1.46	1.91
3 Van Uden Finger Touching	$\overline{X}$	26.65	29.59	30.78	29.04
	(SD)	5.23	10.19	8.90	8.65
4 Total Bergès & Lézine with Van Uden	$\overline{X}$	37.56	42.55	43.47	41.27
	(SD)	6.08	11.52	8.43	9.47

Factor Analysis

A principal component factor analysis was run on the twenty-four subtests of the two motor tests using all 73 subjects. Eight eigen values greater than one were extracted. A varimax rotation was then applied to the solutions of eight factors through to two factors. Results can be seen in Table 17, p. 160.

Four factors were identified accounting for approximately 53% of the total variance.

Factor I appeared to reflect Gross General Dynamic Coordination and Strength, and accounted for approximately 33% of the common variance within the sample. Speed was included in this. Variables identified as representative of this factor were (a) running speed and agility, (b) number of claps in one jump, (c) a standing broad jump (B), (d) throwing a ball at a target, (e) response speed, (f) sorting shape cards with one hand, (g) lateral jumping, (h) sit-ups, and (i) a standing high jump.

Factor II appeared to reflect Visual Fine Motor Coordination, and accounted for approximately 30% of the common variance. Variables identified as representative of this factor were (a) copying circles, (b) placing dots in circles (W), (c) putting rings on poles, (d) lacing, (e) aiming dots in circles (B), (f) placing matchsticks and beads simultaneously in a box, and (g) walking along a rail forwards and backwards.

TABLE 17

Rotated Factor Matrix of the Bruininks-Oseretsky Test and the Wiegersma-Reysoo Motor Test

N = 73 (all subjects)

Subtests	h^2	General Dynamic Coordination and Strength	Visual Fine Motor Control/ Coordination	Balance	Coordination Bilateral and Upper Limb
		I	II	III	IV
Standing Broad Jump (B)	0.692	0.802			
Lateral Jumping (W)	0.637	0.745			
Sit-ups (W)	0.565	0.717			
High Jump (W)	0.620	0.691			
Response Speed (B)	0.610	0.503		0.485	
Upper Limb Coordination (throwing B)	0.452	0.497			
Upper Limb Speed and Dexterity (sorting cards B)	0.300	0.451			
Running Speed and Agility (B)	0.550	0.428			
Moving Platforms (W)	0.566	0.425		0.478	
Bilateral Coordination (jumping and clapping B)	0.318	0.422			
Beads and Matchsticks (W)	0.674		0.810		
Poles and Rings (W)	0.637		0.712		
Balance (W)	0.367		0.673		
Lacing (W)	0.523		0.659		
Upper Limb Speed and Dexterity (aiming B)	0.467		0.517		
Visual Motor Coordination (copying circles B)	0.381		0.400	-0.444	
Balance (B) (Dynamic)	0.678			0.766	
(Static)	0.715			0.731	
Standing Broad Jump (W)	0.680			0.660	
Upper Limb Coordination (catching B)	0.566				0.683
Bilateral Coordination (tapping feet and hand circles B)	0.622				-0.639
Visual Motor Coordination (line through a path B)	0.178				-0.404
% Common Variance		33.29	29.96	23.29	13.44
% Total Variance		17.68	15.91	12.37	7.14

(B) = Bruininks-Oseretsky subtest
(W) = Wiegersma-Reysoo subtest

Factor III was called Balance, and accounted for approximately 23% of the common variance. Variables underlying this factor were (a) standing on one foot for 10 seconds, (b) walking heel-to-toe along a beam, (c) a standing broad jump (W), and (d) moving sideways on platforms.

Factor IV was called Coordination, upper limb and bilateral. It accounted for approximately 13% of the common variance. The variables underlying this factor were (a) tapping alternate feet while making circles with the hands, (b) catching a ball with both hands, (c) drawing a line through a straight path.

A second principal component factor analysis was run on the same twenty-four variables using only the 50 deaf subjects. Ten eigen values greater than one were extracted, and a varimax rotation applied again to the solutions of the factors through to two. The results were similar to the initial factor matrix, but not in the same order. The results are shown in Table 18, p. 162.

Four factors were identified again accounting for approximately 53% of the total variance.

Factor I appeared again to reflect Gross Dynamic Coordination and Strength and accounted for approximately 33% of the common variance within the sample. Variables identified as representative were the same as for the total group analysis except did not include sorting shape cards

TABLE 18

Rotated Factor Matrix of the Bruininks-Oseretsky Test and the Wiegersma-Reysoo Motor Test

N = 50 (deaf subjects)

Subtests	h^2	General Dynamic Coordination and Strength I	Balance II	Visual Fine Motor Control/ Coordination III	Coordination Bilateral and Upper Limb IV
Sit-ups (W)	0.657	0.784			
Broad Jump (B)	0.664	0.761			
High Jump (W)	0.51	0.682			
Lateral Jumping (W)	0.587	0.671			
Running Speed and Agility (B)	0.375	0.588			
Moving Platforms (W)	0.379	0.578			
Response Speed (B)	0.630	0.510	0.604		
Bilateral Coordination (jumping and clapping B)	0.372	0.473			
Upper Limb (throwing B)	0.553	0.424	0.491		
Balance (B) (Dynamic)	0.694		0.825		
(Static)	0.555		0.711		
Standing Broad Jump (W)	0.585		0.635		
Visual Motor (line through a path B)	0.275		-0.514		
Upper Limb Coordination (catching B)	0.555		0.443		-0.539
Beads and Matchsticks (W)	0.731			0.836	
Balance (W)	0.666			0.732	
Lacing (W)	0.594			0.730	
Poles and Rings (W)	0.616			0.681	
Aiming (W)	0.499			0.586	
Bilateral Coordination (feet taps and hand circles B)	0.557				0.681
Upper Limb Speed and Dexterity (sorting cards B)	0.541				0.510
Upper Limb Speed and Dexterity (aiming B)	0.555				0.489
Visual Motor (copying circles B)	0.451				-0.468
% Common Variance		33.04	26.36	25.28	15.31
% Total Variance		17.60	14.04	13.47	8.16

(B) = Bruininks-Oseretsky subtest
(W) = Wiegersma-Reysoo subtest

with one hand. This variable now loaded in Factor IV, Coordination: upper limb, and bilateral.

Factor II appeared now to reflect Balance and accounted for approximately 26% of the common variance. This was higher than the same factor in the total group analysis and included drawing a line through a path and catching a ball along with the same balance variables as before.

Factor III appeared to reflect Visual Fine Motor Coordination, and accounted for approximately 25% of the common variance. This was lower than the same factor in the total group analysis, as placing dots in circles and copying circles now loaded in Factor IV instead. Variables identified as underlying visual fine motor coordination were a) aiming dots in circles, b) putting rings on poles, c) lacing, d) lacing matchsticks and beads simultaneously in a box, g) walking forwards and backwards along beams.

Factor IV appeared to reflect Coordination: upper limb, visual and bilateral, and accounted for approximately 15% of the common variance. This was higher than the same factor in the total group analysis because of the addition of two visual motor coordination subtests. Variables identified as representative of this factor were a) tapping alternative feet while making circles with the hands, b) sorting shape cards with preferred hand, c) placing dots in circles, and d) copying circles. A comparison of the two factor analyses is shown in Table 19, p. 165.

One variable, copying shapes (subtest 12, Bruininks-Oseretsky), did not appear under any of the factors in either analysis. The two motor tests were also different. Except for the subtests balance and strength, the Wiegersma-Reysoo test loaded into the same factors identified by the author in the make-up of the test. All subtests named general dynamic coordination (subtests 7-10) loaded together under Factor I, Gross General Dynamic Coordination and all subtests named visual motor coordination (subtests 1-4) likewise loaded together under Factor II or III, visual fine motor coordination. The balance subtest of walking backwards and forwards along narrow beams loaded under visual motor coordination in both analyses and a standing broad jump loaded under balance. The Bruininks-Oseretsky test did not load so clearly. The main subtest loadings were under Factor I Gross General Dynamic Coordination, but most of the subtests did not load according to their label (as well as the one not loading at all). However, this pattern was also found by the author (see Bruininks, 1978, p. 30).

Summary

Multiple analyses of variance were run to reveal if significant differences were present between the motor proficiency of the three subject groups, and also between gender and age within these subject groups. Analysis of the

TABLE 19

Comparison of Variables Underlining
Factor Loading for Total Group and Hearing-impaired
Group Factor Analysis

FACTOR	TOTAL GROUP N = 73	DEAF GROUP N = 50
I Gross General Dynamic Coordination	Standing Broad Jump	Standing Broad Jump
	Sit-ups	Sit-ups
	High Jump	High Jump
	Running Speed and Agility	Running Speed and Agility
	Lateral Jumping	Lateral Jumping
	Response Speed	Response Speed
	Jumping and Clapping	Jumping and Clapping
	Throwing	Throwing
	Sorting Shape Cards	
II/III Balance	Static Balance	Static Balance
	Dynamic Balance	Dynamic Balance
		Line Through a Path
		Catching
III/II Visual Fine Motor Coordination	Beads and Matchsticks	Beads and Matchsticks
	Poles and Rings	Poles and Rings
	Moving Platforms	Moving Platforms
	Lacing	Lacing
	Aiming	Aiming
	Copying Circles	
	Dots in Circles	
IV Coordination: Bilateral and Upper Limb (and visual)	Feet Tapping and Hand Circles	Feet Tapping and Hand Circles
	Catching	Sorting Cards
	Line Through a Path	Dots in Circles
		Copying Circles

results revealed:

a) Bruininks-Oseretsky

There were no significant differences between age or gender on any of the items of this motor test battery. There were also no significant interaction effects of age or gender within the three subject groups. However, when subject group differences were included in the analysis, significant differences in performance were found. Hearing children were superior to both groups of deaf peers in balance, bilateral coordination of a number of claps in a jump, and upper limb speed and dexterity requiring placing dots in circles at speed. Hearing children were also superior to T.C. deaf children in catching a ball, and in bilateral coordination of tapping feet, and making simultaneous hand circles. They were further superior to oral deaf children in response speed, and in the distance gained in a standing broad jump.

Alternatively, deaf children were superior to their hearing peers [illegible] running speed and agility. T.C. deaf children were also superior to their oral deaf peers in running speed and agility and in response speed.

b) Wiegersma-Reysoo

There were no significant differences between gender on any items of the test battery. There was also no significant interaction effect of gender or age within subject group. However, again, when subject group differences were included in the analysis, significant differences in performance were found. Hearing children were superior to their deaf peers in putting poles on rings at speed, lacing at speed, balancing, lateral jumping, moving sideways on platforms, and in sit-ups. They were also superior to T.C. deaf children in a high jump. There were no significant differences in proficiency between the two deaf groups themselves, and subjects aged >112 months across all the three subject groups were significantly superior to their younger peers in aiming, balance, and sit-ups.

A correlational analysis was run between the twenty-four items of the two motor tests and the tests for low successive rhythmic memory and the presence of dyspraxia. There were no significantly high correlations found between any of these tests.

Factor analyses were run on data from the total group subjects, and on the deaf subjects. Results revealed generally the same four main factors underlying the motor proficiency of the deaf and hearing children. The order of sensitivity differed between the two analyses however, and some variables were identified under different factors. For the total group analysis, the factors in order of sensitivity were:

Factor

I. Gross General Dynamic Coordination and Strength

II. Visual Fine Motor Coordination

III. Balance

IV. Coordination: upper limb, bilateral.

For the deaf group analysis, the factors were:

Factor

I. Gross General Dynamic Coordination and Strength

II. Balance

III. Visual Fine Motor Coordination

IV. Coordination: upper limb, visual and bilateral.

A comparison of the variables under each factor are presented in Table 19, p. 165.

PART VI

DISCUSSION AND CONCLUSION

The first research question posed by this study was did deaf children really show deficits in their motor ability when compared to their hearing peers. Present results of the study affirm this question. Deaf children as a group are inferior in some aspects of their motor ability.

The second question that res[illegible]om this affirmation was, in wha[illegible]fic area or areas of motor ability, did these infer[illegible]s show? This research found that deaf children, aga[illegible] a group, were inferior in the areas of balance (static and dynamic), the number of sit-ups they could do in twenty seconds, in some aspects of fine motor control that require speed and dexterity, and in lateral and bi-lateral movements requiring speed with balance. However, it also found that the deaf as a group were superior to their hearing peers in one aspect of their motor ability. This was in running speed and agility.

The last research question asked was if there were differences in ability between the deaf children who had been educated using the oral communication method, and those who had been educated using the total communication. The results showed that the T.C. deaf children were superior to the Oral children in the areas of response speed and running speed and agility. There were also some individual differences between the two deaf and the hearing groups. T.C. deaf children were inferior to the hearing specifically in the areas of catching a ball, bi-lateral coordination of tapping feet while making hand circles, and in the height gained in a high-jump. Oral deaf children were inferior to the hearing specifically in the areas of response speed, and in the distance gained in a standing broad jump.

The results of the study further showed no gender differences in motor ability, and there were no specific differences apparent between the groups of the deaf and hearing children when matched for age. However, a significant gain in ability was noted in the oldest children (>112 months) across all three groups. This was in correct aiming at speed, balance, and in the number [illegible] sit-ups achieved.

These results concur with most of the previous research. Brunt and Broadhead (1983) noted a similar gain in ability in their oldest age groups, and Myklebust (1964), Boyd (1967), Carlson (1972), Best and Roberts (1976), Lindsay and O'Neal (1976), and Wiegersma and van der Velde (1983) all found no gender differences. Long (1932), Morsch (1936), Myklebust (1964), Boyd (1967), Case, Dawson, Shartner and Donoway (1973), Lindsay and O'Neal (1976), Penella (1979), Brunt and Broadhead (1982, 1983), and Wiegersma and van der Velde (1983) found inferiority of the deaf to their hearing peers in balance. Morsch (1936), Bills (1948), Hiskey (1955), Myklebust (1964), Auxter (1973), and Wiegersma and van der Velde (1983), all found the deaf to be slower in their speed of task execution.

Discussion

Several theories were discussed as to why the deaf children might be found to be inferior.

1a. Deprivation of sound

Firstly, it was considered that the deprivation of sound would lead to less efficient sensory and cross-modal integration (Birch and Leffard 1970, van Uden 1977, Kelso and Clark 1982, Veeger 1983, Puyenbroek 1983) as well as atrophy of the auditory integrative pathways in the brain (Arnold, 1983). In addition, it was considered that the neuron development in the brain would be decreased, so leading to less efficient processing at speed (Veeger, 1983).

The deaf subjects as a group were found to be inferior in ability for tasks shown by the factor analysis as falling into the areas of both gross general dynamic motor coordination and that of visual fine motor coordination (see p. 159). Further, all the items were ones that were timed, thus requiring speed of task execution.

	Hearing $\bar{X}$	T.C. $\bar{X}$	Oral $\bar{X}$
<u>Gross general dynamic motor coordination</u>			
Lateral jumping	11.78	6.63	5.96
Moving sideways on platforms	14.91	11.24	12.13
Sit-ups	13.43	11.48	8.87
Jumping and clapping	3.00	2.44	2.35
<u>Visual fine motor coordination</u>			
Lacing	11.60	8.89	9.48
Rings on poles	10.70	7.26	6.78
Aiming dots in circles (B.O.)	6.09	4.89	4.61

Since the inferiorities found between the hearing and the deaf children were in both areas of motor ability (gross general dynamic coordination and visual fine motor coordination), and the research has linked poor sensory integration to less efficient processing, and lack of optimal neuron development to less efficient processing at speed, one explanation for the inferior ability shown by the deaf children could indeed be because they suffer from a profound deprivation of the sense of sound. Thus they have only four senses giving optimum information and are missing neurons devoted to sound and temporal knowledge.

However, it was also noted that on the visual fine motor task of aiming dots in circles the deaf subjects were not inferior on both of the motor tests. On the Wiegersma-

Reysoo test, there were no significant differences apparent between the three subject groups (Hearing $\overline{X} = 9.87$, T.C. $\overline{X} = 9.44$, Oral $\overline{X} = 8.48$). Furthermore, on the Bruininks-Oseretsky test, the gross dynamic motor task of running speed and agility was **superior** for the deaf (Hearing $\overline{X} = 6.78$, T.C. $\overline{X} = 9.74$, Oral $\overline{X} = 7.83$). Since the task of aiming requires speed of eye-hand coordination, and the task of running speed and agility requires zeroing in on an object at distance, picking it up and returning with it as fast as possible, the sensory integration ability and speed of the task execution of the deaf children for these tasks, was quite adequate. Presumably, if the deprivation of sound had led to less efficient processing ability, this inefficiency would have been apparent in all the areas that required processing at speed.

Perhaps then, because amplification was a selection criteria of this study, applying appropriate and consistent amplification at 24 months or sooner, allows for a 'catching up' of neuronal and sensory integration development. Thus the suggested atrophy or lack of development of the auditory integrative pathways appears not to affect the sensory integrative processing ability for movement, unless it does so after the 24 month chronological age. There must therefore be another explanation for the lack of speed shown by the deaf children.

2. Etiology of hearing impairment

The second theory discussed was that of the etiology of the impairment causing some other neurological side-effect(s) in a deaf child. These 'side-effects' would involve central nervous system processing for motor development and vestibular functioning (Vegeley 1971, Auxter 1973, Rittenhouse 1979, Berholtz and Benecerraf 1983, Wiegersma and van der Velde 1983).

This study found both groups of deaf children significantly inferior to the hearing children in the area of balance, both static and dynamic. The inferiority was also apparent on both motor tests.

	Bruininks-Oseretsky		Wiegersma-Reysoo
	static	dynamic	dynamic
Hearing $\overline{X}$	5.57	3.65	11.60
T.C. deaf $\overline{X}$	4.00	2.70	6.52
Oral deaf $\overline{X}$	3.22	2.00	5.91

Other studies that have found inferior balance usually mention vestibular complications rather than sensory deprivation. Case, Dawson, Shartner and Donoway (1973) for example, found the deaf inferior to the blind in balance, and Myklebust (1964) pinpointed meningitis as affecting vestibular function. Brunt and Broadhead (1983) also purported that the autonomic reflex system in the vestibular regions that controlled balance, was slower at responding in individuals with impaired hearing. Although this present research did attempt to eliminate all complicating etiologies of deafness (such as meningitis) by selecting under only unknown or genetic causes, both the 'unknown' and the 'genetic' could have had effects in the vestibular regions. Boyd (1967) for example, found no differences in balance between endogenous and exogenous etiologies, both being inferior to the hearing peers.

It is important to recognize here then, that since it is not possible to 'see' if there are complicating neurological side-effects to a hearing impairment, the factor of sound deprivation can never be isolated as a single cause to a subsequent problem. However, vestibular complications for balance, and effects in the central nervous system for processing with speed, could both affect a deaf child's motoric ability. Etiologies of hearing impairment must thus always be considered when dealing with questions of inferior motor ability and the deaf.

3. Environmental experience and communication

The third theory discussed was that of lack of experience through a restricted environment leading to inferior motor ability (Goss 1970, Schlesinger and Meadow 1972, Altshuler 1974, Vernon 1977, Knee 1978, Meadow, Greenberg, Erting and Carmichael 1981, Wiegersma and van der Velde 1983).

The present study found that the deaf children were inferior in some visual motor tasks at speed (putting poles on rings and lacing), some gross dynamic motor tasks requiring lateral and bilateral movements at speed (lateral jumping, moving sideways on platforms, the number of claps in one jump) and in tasks requiring strength (standing broad jumps and sit-ups). Restricted or protected environments either through poor communication or by viewing a child as handicapped (see p. 36), do not allow much opportunity for the practicing of motor tasks that can achieve speed through familiarity. It was interesting to note from the environmental checklist used in this study (see Appendix Ib), that only a few deaf children were enrolled in any kind of recreational sports. This lack of experience compared to the normal hearing child might lead to obvious inferiorities with tasks that require a certain degree of skill and fluency. The school environment must also be considered. The type of heavy educational focus on speech and language which usually follows a deaf child from the time of diagnosis may further limit the normal play and exercise experiences that are available to the regular hearing child. Again for example, although pre-school attendance was a selection criteria in this study for both the deaf and hearing groups, it was noted that the pre-schools for the deaf child often started at the age of three (or earlier) rather than at the age of five for the hearing child. The deaf child thus has less free play and explorative time at home. This lack of experience then could mean a delay in ability for the deaf child when compared to his/her chronological aged peers.

Regarding strength, Wiegersma and van der Velde (1983) particularly mentioned that their deaf subjects were less physically fit than their hearing counterparts. In this study the deaf children were unable to jump as far, or to do as many sit-ups as the hearing children. This could be an indication that they were less physically fit. Although physical weakness may be a component of the etiology of a hearing impairment, it is more likely that the deaf children again are simply facing a lack of exercise in restricted environments. It would be useful for future studies to compare the height and weight, and physical stature of subjects being tested to see if deaf children appear physically inferior to their hearing peers.

Wiegersma and van der Velde (1983) also found that their deaf subjects were 'shy and withdrawn' indicating what they described as a situation of insecurity that would deprive them of many "typical motor experiences available to the normal hearing non-handicapped child" (p. 109). Whilst this study did not find the deaf children to be particularly shy and withdrawn,[1] the shyness may rather exhibit itself in

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[1] But the tester was an experienced teacher of both Oral and T.C. deaf children and this could have helped to make a comfortable atmosphere.

the more social situations that offer practice with motor ability. Here the ease of communication may be a crucial factor. Since both the T.C. and the Oral deaf children were found to be inferior to the hearing in both the motor areas of gross dynamic coordination and visual fine coordination, it could be that deaf children -- as a group -- withdraw from situations where unfamiliarity with deafness exists. Thus they may miss more social play interactions where motor development plays a major part. As Wiegersma and van der Velde said therefore, they do miss "typical motor experiences available to the normal hearing child."

Since then, the research literature has shown experience as being fundamental for the perfecting of motor skills, and deaf children through their impairment and communication difficulties are often found to face restricted and/or over-protected environments, another explanation for the inferior motor ability appears to lie in the amount of free interactive play experience deaf children have when they are young.

4. Linguistic ability and coding

The last theory discussed was that of language ability affecting motor proficiency. This is because of the coding aid of language to the memory which results in verbalization during novel motor learning (O'Connor and Hermelin 1978, Clark 1978, O'Connor 1979, Conrad 1979, Beveridge and Brinker 1980, Mulholland 1980, Wall and Taylor

1984), and because of the type of language code employed (either simultaneous or successive, i.e., total communication or oral) offering superior advantages to motor sequencing (Conrad 1979; Grove, O'Sullivan and Rodda 1979, Kelso and Clark 1972, Das and Dash 1983).

Regarding the superiority of the two language codes (Oral and T.C.), it was suggested that the signed linguistic code would lead to a superior ability with motor tasks because of the practice it offered with manual dexterity (Brunt and Broadhead, 1983). It would also be superior because the oral linguistic code for deaf children led to poor internal speech (Conrad, 1979) and thus poor thinking out or planning of motoric actions. However, this study found **both** groups of deaf children inferior to their hearing peers on many of the motor subtests. It further found only two areas of difference in ability between the two deaf groups themselves. These were in running speed and agility (T.C. $\overline{X}$ = 9.74; Oral $\overline{X}$ = 7.83) and response speed (T.C. $\overline{X}$ = 3.56; Oral $\overline{X}$ = 1.96). Two alternative reasons can be given for these differences that are not related to the question of superior linguistic coding.

Firstly, the task of running speed and agility was the only motor task in which both groups of deaf children were superior to their hearing peers. It is suggested therefore, that this superiority may have been due to this task being the first subtest of the whole test battery.

Morsch (1936) for example, mentioned that his hearing subjects were inferior to the deaf on the first trial of his balance subtest -- but that they subsequently improved. It could be likely therefore, that the hearing children in this study also simply took more time to settle into the testing situation. Thus, on the first subtest only, they appeared inferior to their deaf peers. Secondly, regarding the difference in response speed, the Oral deaf children were also inferior to the hearing children whereas the T.C. deaf children were not. An advantage for the T.C. children might have been because they do not have to rely solely on audition to respond. They spontaneously visually cue in also. The Oral deaf children have to rely more on audition, and even when amplified, this audition is not as normal. As they attend more to the auditory cue therefore, a few seconds delay may occur.

It would appear then, that the visual nature of the signed communication code does offer an advantage in the initial responding to a stimulus. However, because of the similar areas of inferiorities found between the two deaf groups in the actual execution of most of the motor ta[illegible], this advantage is obviously not maintained. Furthermore, from the results of this study, the T.C. deaf children were also inferior to their hearing peers in two different subtests than the Oral deaf children. These areas specifically involved abilities determined by the factor analysis as involving bilateral and upper-limb coordination (catching a ball, and tapping feet while making simultaneous hand circles). Thus the superiority of the signed linguistic code from manual experience does not seem likely either. This is even further emphasized by the lack of significant differences in ability being found between the hearing or either of the deaf groups themselves in any other areas of visual motor control and upper limb coordination.

	Hearing $\overline{X}$	T.C. $\overline{X}$	Oral $\overline{X}$
Copying pencils	1.35	1.29	1.39
Copying circles	1.78	1.78	1.74
Drawing a line through a path	3.87	3.59	3.65
Sorting shape cards	5.57	5.11	4.70
Throwing a ball at a target	1.70	1.70	1.30
Putting beads and matchsticks simultaneously in a box	10.04	9.22	9.74

Since, then, the T.C. children were inferior in the two different areas just mentioned (bilateral and upper limb coordination), it is suggested that there may alternatively be some kind of benefit gained from using the oral communication code. Perhaps because the temporal and sequential nature of the oral communication code is particularly compatible with movement. Van Uden (1983), for example, postulated that breathing and rhythm were major components of good motor ability. Some areas of inferior ability of the deaf children such as sit-ups, require good breath control and a degree of rhythm in their repetitive up-down nature. Also lateral jumping or lacing or the putting of rings on poles at speed can be aided by rhythmic counting in a sequential manner. Thus the temporal nature of the oral language code may provide an advantage. Indeed, in the rhythm test that this study incorporated (see Appendix Id), the T.C. deaf children scored most poorly. However, again, these suggested advantages of the oral communication code are not maintained. The overall scores of the rhythm test revealed that both groups of deaf children were significantly inferior to their hearing peers, and although the rhythm test itself was not particularly highly correlated with any of the motor test subtests, the similar areas of inferiority found between the two deaf groups may be indicating that deaf children as a group lack a sense of rhythm that hearing children use spontaneously to aid in repetitive movement tasks.

The oral language code itself therefore, despite its temporal and sequential nature, does not appear to provide the Oral deaf children with motor ability equal to that of the hearing children. The T.C. language code as well does not appear related to superior motor ability. Does the deprivation of sound itself therefore lead to less experience with rhythm? Perhaps Myklebust (1968) was correct when he suggested that simply being deaf led to an "alteration in the neurology by which the child learned" (p. 16)? This returns to the question of processing abilities and deprivation of sound discussed earlier.

The similar areas of inferiority found between the Oral and the T.C. deaf children lead alternatively to a consideration over and above the questions of superiorities of linguistic codes. That is in considering for these children, what their actual level of ability is with whichever language code they are using. In other words, the consideration that deaf children, whether T.C. or Oral, just do not have the same levels of language as the hearing children. Myklebust (1964) and Long (1932) in fact suggested that deaf children were inferior in motor ability because they functioned two years behind the hearing linguistically and maturationally. As this study found no significant differences at any of the ages between the three subject groups, a maturational delay cannot be claimed. But this still leaves the possibility of a linguistic delay. In this study, the small number of subjects showed no individual age differences, but the actual language levels between the three subject groups were not tested. If differences favoring the hearing were found it might mean that the deaf children as a group were unable to code the actions for motor movement as efficiently as the hearing children, and thus they were slower at executing the motor tasks required.

The results of this study then do not really answer the question of which of the two language codes is superior for developing motor ability. In contrast, they point to questions of the superiority of the language levels themselves between the three subject groups. In this way the coding aid of language to memory suggested by the research provides a valuable answer to the areas of inferior ability shown by the deaf children. It could be argued that the two deaf groups were linguistically similar to each other since they were inferior to the hearing in similar tasks. The signed and oral codes therefore provided equal information. But the results of this study unfortunately cannot answer how much language ability does influence performance on motor tasks. Before this can be answered, it is necessary to include subjects with both high and low levels of language within each subject group. In this way the real value of language to motor planning and execution (whether T.C. or Oral) can then be fully claimed or disclaimed.

5. Horizontal and vertical thread processing

The question of language ability itself influencing motor proficiency, leads this author to a contention that a combination of factors affect the motor ability of the deaf child.

Firstly, it is obvious that the etiology of a hearing impairment may incorporate damage to the vestibular regions, and thus the balance of deaf children is affected. But, if **experience** and **linguistic** elements are considered together, it is more likely that the theory of horizontal and vertical thread processing described by Wall, McClements, Bouffard and Findlay (1984) provides an answer (see p. 61).

In most of the subtests on [illegible] motor tests, except those specifically for balance, speed was an elem[illegible] The deaf child's inferiority thus seems related to their speed of task execution. It was suggested that through the generally controlled environments where the deaf children spend their younger years, there was a lack of exposure to freedom of play and therefore practice with motor tasks. According to the theory of Wall, McClements, Bouffard and Findlay (1984), this means that these deaf children consequently have fewer abilities tranferred into the horizontal (or automatic) thread modalities. When approaching new tasks or novel situations therefore, they must rely on the vertical threads of more verbal (linguistic) cognitive control. This slows down their responding time. As Wall, et al. said, "the use of deliberate attentional control is particularly detrimental when rapid skilled actions are required" (p. 7).

This is where the consideration of language ability comes in because the deaf child's general ability with language now plays a further part in slowing him/her down.

By having to use the vertical threads to process for action, it means that 'cognitive' control is needed. To Wall, McClements, Bouffard and Findlay (1984), this is defined as meaning 'linguistic' control. If then, as discussed earlier (see p. 53), the contention is accepted that language acts as a mediator and prop to the memory for planning new motoric actions, a return is made to the question of whether children with profoundly impaired hearing (be they oral or total communicators), have equivalent linguistic levels to their chronological aged hearing peers. If they do not, then even if both the hearing and the deaf children are using vertical thread processing to execute novel motor tasks, the deaf children will always be slower at processing for the actions required. Therefore they will also be slower at executing them. Both lack of experience and that of linguistic efficiency have thus played a part in the inferior motor abilty shown by the deaf children. The lack of experience prevents horizontal thread functioning, and the linguistic inefficiency prevents equivalent vertical thread functioning.

With the theory of Wall, McClements, Bouffard and Findlay (1984), since it is not known in this study whether the deaf children did have inferior language levels to their hearing peers, it is further worthwhile noting that vertical thread reliance does not mean an inability to perform. It might be therefore, that lack of experience plays a greater part in the motor inferiorities that were found. For example, a most recent study on motor ability and the deaf by Cratty, Cratty and Cornell (1986), found no significant differences between hearing and T.C. deaf children in tasks requiring understanding and planning (but not execution) of motoric tasks. As the deaf children in the study used sign language these authors contended that sign language, by its manual nature, either adequately prepared the deaf children to execute motor sequence tasks, or that it led to no deficit in internal speech -- in other words, no deficit in language needed to plan for actions. Unfortunately Cratty, et al. did not have an oral deaf group to back up these sign advantages, but the study does seem to indicate that deaf children, per se, are not inferior in their understanding or planning of motoric tasks. They are inferior only in the **execution** of them.

The differences between the deaf and hearing children thus basically appear in the **performance** of motor tasks. And this relates to the amount of practice and experience they have had, not so much to their levels of language ability. Cratty, Cratty and Cornell's (1986) study was also not speed orientated. Inferiorities in the execution of timed motor tasks can therefore be due merely to the lack of practice to perfect them and not in the understanding or capacity of planning how to do them. All of the deaf children in this study performed all of the tasks and did so with enjoyment. But because they were noted to attend carefully to directions before beginning (in contrast to the hearing children who would often indicate knowledge of a task and eagerness to begin before the directions were finished), it could be an indication that deaf children just do not have as many horizontal threads available from which to quickly transfer experience of similar abilities needed in novel situations. Thus they do have the language to understand and code for the motoric tasks, but their lack of experience with the actual execution of the actions slows their performance of them down.

It would appear then that the theory of horizontal and vertical thread processing can supercede the questions surrounding language ability and the deaf child. The questions of the superiority of the signed versus the oral language codes are further answered in this way. Once knowledge of certain actions has become well learned, it is transferred into the horizontal (automatic) thread modality. Then the blueprints or rules for the actions are readily stored and do not require cognitive (or linguistic) mediation. It will not matter therefore in which 'code' these blueprints are, nor will it mean that they are less efficient prints if they lack the temporal information that comes from normal audition. The similar areas of inferiority found between the two deaf groups indicate that it is more appropriate to say that the overall language level of deaf children -- be they in oral or total communication codes -- are the crucial factors for operating in the vertical thread modality. And since operation in the horizontal thread modality then appears to supercede the need for linguistic mediation, if deaf children can receive optimum exposure to practice with motoric tasks (so ensuring horizontal thread functioning), their inferiorities in motor task executions may be eliminated.

Conclusion

To conclude, there are many theories that can attempt to explain why deaf children are inferior to their hearing peers in some aspects of their motor ability. This study has shown that while the etiology of a hearing impairment must be considered, 'speed' seems to be the major factor underlying this inferiority. Further, since how fast a person can do a task is directly related to his/her knowledge and experience with it, this speed factor is related to the amount of experience deaf children have had in their environments to freely interact and develop motoric skills, and to the level of their language ability to code these skills in memory.

Today we have separate 'olympics' for the deaf. This may be a sociological factor stemming from inferiority in ability of the deaf being taken for granted. Maybe in balance this is necessary. But even here, more experience and practice with this task might lead to an improvement. The oldest age groups in this study were noted to improve in balance too. In balance then, and in the other areas, the key would seem to be to try to make the deaf children have as many horizontal threads for motor functioning as are possible. Once actions have then become automatic, cognitive control is no longer needed, and questions of superiority of language codes, or language ability itself, can become immaterial to motor functioning.

The automatizing of motor knowledge is only achieved through practice and wider experience increasing familiarity. This element of experience and familiarity becomes fundamental since this study found a significant increase in ability across all the subject groups. The older the child, the more time he has had for practice, and the wider his experience therefore at more physically demanding activities.

A conclusion must therefore be drawn to the reasons for the initiation of this study. That is, that not enough attention is being given to the physical educational curriculum of the deaf child. Since research continually finds deaf children to be inferior in many of their motor abilties through their speed of task execution, it is the contention of this author that whilst resulting partly from the etiology of the hearing impairment ~~itself~~, this inferiority results from a comparative lack in the amount of experience which is available to the normally hearing child. This can only be rectified by increasing the amount of time a deaf child spends in physical activities.

Summary

This study was initiated from a concern with the motor ability of deaf children. Concern was that an inferior ability might be associated with later problems in the cognitive, academic, social, and emotional areas of their development.

It was hypothesized that, using two different motor test batteries, an inferiority of ability would be found between two groups of deaf children (T.C. and Oral) and their hearing peers, but that there would be equal ability between the two groups of deaf children themselves.

Results showed that the deaf children were indeed inferior to their hearing peers in performing motor tasks that required balance or speed of task execution. There was also a difference between the deaf groups themselves in the area of response speed. Here, deaf children who used total communication were superior to those who were oral.

It was suggested that parental hearing status would positively influence motor development. Insufficient numbers prevented this from being analysed. It was also suggested that the presence of dyspraxia and having a low successive rhythmic memory would negatively influence motor ability. There appeared to be no significant relationships between dyspraxia and low motor ability, or low rhythmic memory and low motor ability.

Various reasons have been discussed as to why the inferiorities found between the deaf and hearing children might be so. The conclusion is that the etiology of a hearing impairment, along with a restricted and often over-protected childhood environment with a heavy educational emphasis solely on speech, audition and language development, slows down the opportunity for a deaf child to automatize his knowledge of actions. Time must therefore be found within the deaf child's educational curriculum, for him/her to develop to fullest potential, the physical abilities along with the cognitive and linguistic.

LIMITATIONS

The following limitations of this study are recognized.

1. Availability of Subjects

Although the initial informal enquiries indicated belief by schools that adequate numbers were available to undertake this study, in reality very few deaf students were found within the age groups chosen and according to the selection criteria of profoundly deaf, unknown or familial etiology, and low average or above IQ with no other known learning disabilities (see Table 20, p. 195). Surprise at the low numbers was continually expressed by many educators.[1] Thus higher numbers of deaf subjects could not be obtained. This restricts the generalization of this study.

2. Testing Permission

It was found that many school administrators, and most particularly parents, were extremely concerned with the area of research in deaf education. When open communication was offered by this researcher, much concern was found to centre around perceived lack of support and help by

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[1] This should signal caution to educational administrators against eagerness to adopt curricula made in the normal hearing schools, since close attention to the real profile of the young deaf student in school today is obviously necessary.

TABLE 20

Example of Subject Selection under Etiology within One School

(N = 21 profoundly deaf 8-11 years old)

EXCLUDED CHARACTERISTICS		ACCEPTED CHARACTERISTICS	
Physical Disability	1	Hereditary	4
Rubella	3	Unknown Etiology	3
Meningitis	1		
Visually Impaired	4		
Severe Visual-Perceptual Problems	1		
Cerebral Palsy	2		
Severe Language Problems	1		
Dull Normal	1		
TOTAL EXCLUDED	14	TOTAL SELECTED	7

government and university bodies in the social-emotional areas. Some informal counselling sessions were found necessary before permission to use subjects could be obtained. This again restricted numbers through lack of willingness to participate. It appears that social-emotional or psychological testing is felt needed by parents rather than motoric assessment, and testing regarding linguistic modality felt needed by educators. Six potential subjects were therefore excluded due to parental refusal of participation, and three schools for the deaf also refused participation of their pupils.

Within most schools, testing itself was only allowed out of academic school hours, that is, during recess, lunch or after school. Since the tester was restricted to school timetabling and testing was therefore accomplished at different times, there may be some question as to the time of day affecting functioning level.

3. Selection of Group III: 'Oral'

When contacting educational programs for the deaf which defined themselves as offering the oral system of communication for their students, it was noted that the students in North America had also been exposed informally to signed English and/or American Sign Language and fingerspelling. Thus they frequently used signs among themselves and/or as cues for their speech. The Dutch children alternatively had had no exposure to any formal signed linguistic system. The scores of the students in Group III (Oral) were therefore recorded separately by country as well as being taken as a total (see Appendix II, Table 3a, b, & c). Future studies could analyze these scores to see if being purely 'oral' made any differences. It was felt necessary to include the North American children under the title of 'oral', since this is the educational definition of their system of schooling, and thus no distinctions were made between the oral subject groups in this analysis. Financial and other constraints prevented larger numbers of oral Dutch children being included.

4. Selection under degree of hearing loss

It is important to note that the pure tone audiogram is not a definitive measure of deafness, and that due to the recent availability of better hearing aids, profound deafness is sometimes referred to as being over 95 dB (van Uden, 1984). It is also important to note that the lower audiological frequency range of 125 and 250 dB is valuable for vibro-tactile information on movement control. Children with losses greater than 60 dB at these frequencies should therefore have been excluded. However, information on other measures of the integrity of the auditory system such as auditory short-term memory, or tone discrimination, proved difficult to obtain from the audiological departments of schools. Also, the available number of <u>oral</u> children with losses of over 90 dB severity in North America, was already severely limited. Most of the personnel contacted in the selection of oral students with a greater than 90 dB+ loss did initially expect to have many of such children in their programs. On closer analysis however, it may be that most profoundly deaf children in North America are being educated using the system of Total Communication.

As it was felt that restraints on numbers were thus already high, the pure-tone audiological evaluation alone of a profound hearing loss at 90 dB+ calculated at the three speech frequencies, was taken as acceptable.

5. Selection under etiology of impairment

Information on the etiological profiles of students falling under the criterion of being profoundly deaf was made available by only two schools. Thus a detailed account could not be made regarding the true etiological profiles of profoundly deaf students and again, reliance on selection by different school personnel was necessary. Table 21, p. 194, gives an example of the selection categories under this criteria. Correct 'unknown' and 'genetic' profiles can therefore only be assumed.

6. Selection on the basis of intelligence

It was initially hoped that each subject would undergo a further evaluation of intelligence levels for this study by the use of a known test such as the Raven's Progressive Matrices (1978 Standardization). Most schools however, were of the opinion that this was not necessary since school records already contained intelligence quotients from within the last two years. Some schools in North America also preferred that no definitive number IQ be quoted on each subject at selection.

It was further noted that until recently, intelligence tests used with deaf children have had no deaf norms. Such tests that do now exist are still not widely used and schools may therefore use different IQ tests on different students. Thus for this study it was accepted that the IQ range would be between 85-136.

7. Linguistic proficiency

It is an important consideration that linguistic fluency may influence the speed of efficient motor planning. To see if this was really so, it would have been necessary to include deaf and hearing children with both high and low levels of languages within each of the three groups being studied. However, as this would have required an in-depth analysis of language ability and there was concern with amount of testing (see Limitations, p. 191), it was proposed to ignore this variable for this study. Future research could include linguistic proficiency as an independent variable in a study of motor ability.

8. Individual differences

a) Many of the hearing children were noted to be involved in specific sport activities such as ice-hockey or skiing. Both these activities allow high experience with speed of response and lateral movements. This may have led to better motor ability for these subjects.

b) In observation, there was some indication that longer fingernails may have aided in a few of the Wiegersma-Reysoo subtests (such as the picking up of beads and matchsticks, or lacing). Nail-biting however was apparent in all three subject groups and thus it was decided not to select on this criterion.

c) The children were asked whether they preferred to keep their shoes on or off. It was decided to give a choice as the best results were being sought.

9. Although equal for all subjects, the equivalence of the clapping and the tapping of the Rhythm Test must be questioned. There is also the consideration that tiring or boredom at continual repeating of patterns, especially oral, may have influenced true results of successive ability. In Sint-Michielsgestel for example, there are suggestions to replace the oral part of the Rhythm Test with the Kauffman Hand Movement Test. This may be better for successive memory as a physical tactile aid is given.

10. <u>Homogeneity of variance</u>

Wide variation in variance of the different groups on a few of the test items means that statistical interpretation of the data must be cautious (see Tab[illegible] 6 and 8, pp. 139 and 143). Had the variance within these subtests proved more homogeneous, generalization to large populations could be made with more certainty. Within this sample therefore, the indication is that confident generalization can be made only in the areas of motor ability where the variances appear more homogeneous.

IMPLICATIONS FOR FUTURE RESEARCH

The following implications for future research are made from the results and limitations of this study:

1. A replication of the study with larger subject groups would enable generalization of findings to be made with greater confidence.
2. The presence of the factors of dyspraxia, low ability with rhythmic successive memory tasks, and parental hearing status (with equal numbers of deaf and hearing parents) could be included as independent variables. In this way, more information could be gained as to the possible impact of these factors as contributing to a potential delay in motor development.
3. The inclusion of high and low language levels within the three subject groups would enable closer analysis of the hypothesis that efficiency of motor ability improves with linguistic coding strategies.
4. A replication of this study with hard-of-hearing subjects and hearing subjects would enable closer analysis of the effect of deprivation of sound on motor ability.
5. A longitudinal study from infancy to adulthood examining the motor development of hearing, hard-of-hearing and deaf children would provide further supportive evidence for questions of maturational delay due to impaired hearing.

GLOSSARY OF TERMS (Alphabetically)

"Deaf" and "hearing-impaired": See page 9.

"Dyspraxia": a low level of skill in making intransitive movements.

"Extra-pyramidal tract": a motor system that originates in the cerebral cortex, the synapses in the basal ganglis, and the mid-brain and neighbouring regions, and that ends on the motor neurons of the spinal cord. It controls postural mechanisms and gross movements.

"Horizontal threads" or "horizontal thread processing": overlearned motoric tasks that do not require conscious thought or verbal cueing for control in production or initiation.

"Inter-sensory transfer": the same as "intermodal integration". Both these terms refer to the receiving and understanding of information from one sense, and the coordinating of it with the information from another in order to make the best response in an action.

"Intra-sensory transfer": the receiving and understanding of information from one sense only to result in an action.

"Manual communication" is used as meaning a system of communication that is based on a formal code of manual signs and manual fingerspelled systems.

"Oral communication mode: a communication system that includes the reception and production of a spoken sound system through speech reading, audition, and speech.

"Otitis-media" is used as meaning an infection of the middle ear that impedes the vibrations of the osscular chain.

"Prelingual deafness": the onset of a hearing impairment before the production of language.

"Profound deafness": a degree of hearing loss over 90 decibels, calculated over the three speech frequencies (500; 2,000; 4,000 Hz) in the better ear.

"Pyramidal tract": a system of neurons originating in the motor area and other regions of the cortex, and ending on motor neurons of the spinal cord. It controls the production of skilled and discrete movements.

"<u>Schema</u>": basic units of intellectual growth defined as patterns of thinking and behavior that grow increasingly abstract and complex with age and experience. They are constantly being changed and modified through experience (i.e., through assimilation and accommodation).

"<u>Total communication mode</u>": a communication system that includes the reception and production of a spoken sound system through speech reading, audition, and speech, as well as the reception and production of a formal system of signs and fingerspelling.

"<u>Vertical threads</u>" or "<u>vertical thread processing</u>": motor tasks that require conscious thought and verbal cues for their initiation and control in production.

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APPENDICES

APPENDIX I

Instruments Used

APPENDIX I

Instruments Used

A. The Motor Tests

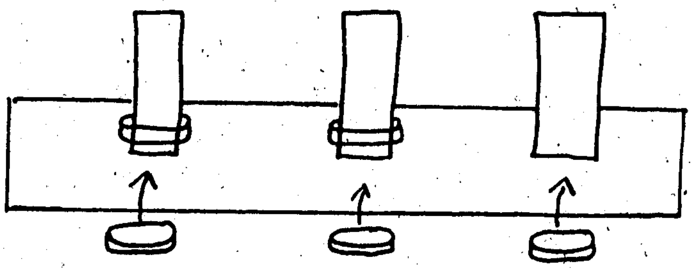
i <u>Title</u>: "Test for General Movement Coordination: A Psycho-motor Battery" (Wiegersma & Reysoo, 1982).

<u>Content</u>

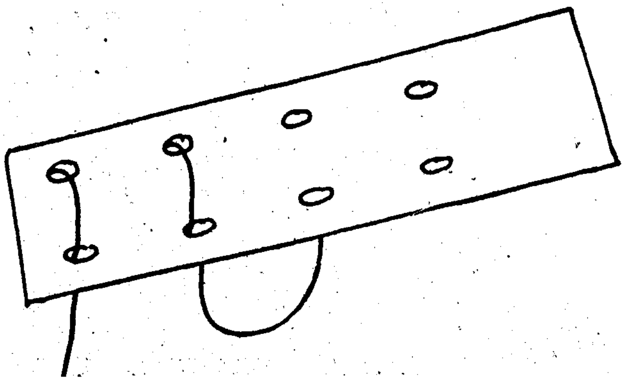
The areas of motor ability that were tested were as follows:

Part A. <u>Visual Motor Coordination</u>

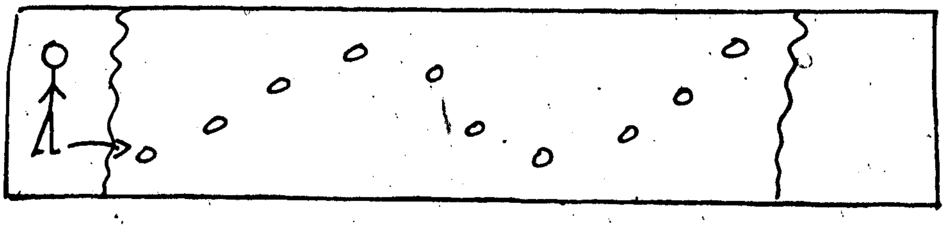
i. <u>Poles and Rings</u>: child must place 4 rows of 6 rings on three poles on a board. Both hands are individually tested and speed in timed. A composite score is taken.



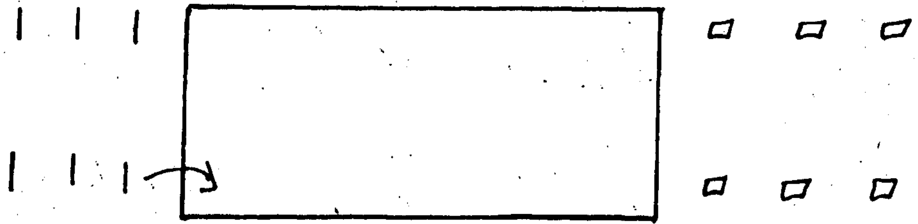
ii. <u>Lacing Board</u>: child must pass 2 laces through a perforated board, one row at a time, as fast as possible.



iii. <u>Aiming</u>: child must follow a dotted pathway across a picture hitting only the dots. Speed is timed.



iv. <u>Beads and Matchsticks</u>: matchsticks and small square beads are placed in rows at either side of a box. Child must simultaneously pick up a bead in one hand, a matchstick in the other, and place both in the box. Speed is timed.



Part B. <u>General Dynamic Coordination</u>

v. <u>Balance</u>: railwalking forwards and backwards (beams of 6 cms, 4 cms, and 2 cms width; 250 cms length).

vi. <u>Standing Broad Jump</u>: from a line on the floor, child must jump as far forward as possible. Take off and land position must be with both feet.

vii. <u>Jumping laterally over a Line</u>: child must jump with feet together over a lateral line on the floor as fast as possible in 20 seconds.

viii. <u>Moving with Platforms</u>: standing on one (light) platform, the child places another in the desired direction, steps onto it, takes the former platform, and proceeds in same way trying to cover the most distance in 20 seconds.

ix. Sit-Ups: lying on the floor with knees at a ninety-degree angle and hands behind the head, the child must sit up and lie down as many times as possible in 20 seconds.

x. Standing High-Jump: taking off from 2 feet, the child must jump over a rope of varying heights. No run-up is allowed.

All items were devised by Wiegersma and Reysoo (1982).

Purpose

The authors state that this test is for screening purposes only. It is not diagnostic. As such, its aim is to focus attention on areas of motor ability needing possible further diagnostic attention. Since speed is an element of motor movement, this test measures speed of movement with its accuracy. For optimum efficiency, the child of normal ability with balance these two elements.

Validity

The English version of this test is presently being published by Swetz and Zeitlinger, Lisse, and is being copyrighted. It has been standardized on both deaf and hearing populations and there are individual and group norms on all items for normal hearing, deaf, hearing-impaired, speech and language delayed, and educably mentally retarded children 6 to 12 years of age. Norms were further calculated from various countries in Europe, Asia and the U.S.A. As such, it forms the first test of motor ability standardized on a deaf population. All items have been factor analysed. Validity and reliability can be further assessed once this test has been published and made for general circulation and use.

ii. <u>Title</u>: The Bruininks-Oseretsky Test of Motor Proficiency: Short Form (Bruininks, 1978).

<u>Content</u>

The areas of motor ability that were tested were as follows:

Subtests:

1. <u>Running Speed and Agility</u>: child must run, pick up a block and return to start as fast as possible.

2. & 3. <u>Balance</u>: child must stand for 10 seconds on preferred leg on a balance beam. Child must then walk heel-to-toe for 6 steps along the beam.

4. & 5. <u>Bilateral Coordination</u>: child must tap feet alternatively while making circles with fingers. Child must also jump up and clap

hands as many times as can before landing.

6. <u>Strength</u>: child must do a standing broad jump as far as possible.

7. & 8. <u>Upper Limb Coordination</u>: child must catch a tossed ball with both hands. Child must throw a ball at a target with preferred hand.

9. <u>Response Speed</u>: child must stop a falling stick with preferred hand.

10., 11. & 12. <u>Visual-Motor Control</u>: child must draw a line through a straight path with preferred hand. Child must copy a circle with preferred hand. Child must copy overlapping pencils with preferred hand.

13. & 14. <u>Upper-Limb Speed and Dexterity</u>: child must sort shape cards with preferred hand as fast as he can. Child must make dots in as many circles as he can with preferred hand.

Purpose

The Bruininks-Oseretsky was developed in 1972 from the 1946 Oseretsky Test of Motor Proficiency. The 1972 version is stated to "reflect important advances in content, structure and technical qualities" (Bruininks-Oseretsky, p. 11) and is used to assess the motor skills of individual students aged 4 1/2 to 14 1/2 years. Normative data are available from North American children, and standard scores, percentile ranks and stanines are given for each age group.

Age equivalents are provided for each subtest.

The short-form of this test was developed in response to the need to easily assess general motor proficiency in children without detailed analysis. It therefore again forms a screening role rather than diagnostic. Although not standardized on deaf populations, it has proved especially successful with deaf children (see Brunt and Broadhead, 1983) in defining areas of remediation and Bruininks has asked that all researchers using the test with deaf populations advise him of the results. It requires little verbal comprehension or memory from subjects.

Validity

According to Bruininks (1979), the validity of the Bruininks-Oseretsky Test is based on its ability to assess the construct of motor development or proficiency. It has been significantly compared to six other tests of motor ability and the items agreed upon by other motor researchers surveyed for opinion. All subtest items have been factor analyzed. Results of these in statistical properties are available in the test manual. The Bruininks-Oseretsky has satisfactory inter-rater consistency even when raters have no formal training in scoring the t[illegible]t-scores increase with chronological age, and two subtests appear under most labels.

Reliability

The test-retest scores of Bruininks-Oseretsky have been found to have a low standard error of measurement, and the correlation tables in the Factor Analysis showed good correlations between the test items.

Since the Bruininks-Oseretsky test has been successfully used and developed in North America, and has been satisfactorily used with deaf children, it was felt valuable to include it in this study, along with the test of "General Movement Coordination" (Wiegersma and Reysoo, 1982). The Wiegersma-Reysoo test, although European in origin, was used because it was developed specifically for deaf children. A cultural bias was [illegible] to be eliminated by using both tests and a factor anlaysis [illegible]ould also be run on both for greater consistency of results.

Subject Selection

The following variables were used in selecting the subjects to try to control for possible alternative interpretation of results.

a) Age

All students included in the study were 8.0 to 11.0 years of age (see Table 3, p. 127). An attempt was made to select equal numbers of all three ages for each group, but this was not possible in Groups Two and Three due to restraints arising from the other selection criteria. Children younger than eight years were excluded since they may not yet have sufficient competence in motor skill to perform some of the items on the test. Children above eleven years of age were excluded since:

1. during puberty, differential development rates can vary and the major psychological changes can affect motor performance differentially.
2. during puberty, different developmental rates can become increasingly sensitive to social pressures. For example, hearing-aids may be removed so that easier identification is made with the peer group who are normally hearing.

b) Sex

Selection attempted to include equal numbers of boys and girls balanced between the three groups. Again this was not possible for Groups Two and Three due to the limited numbers of students available (see Table 3, p. 127).

c) Degree of Hearing Loss

Selection included only prelingually profoundly deaf children in Groups Two and Three. Pure tone audiological hearing loss was over 90 dB (I.S.O. standards) calculated in the better ear at the speech frequencies (500; 1,000; and 2,000 Hz). The deafest child had a loss over 120 dB. With losses of this severity, the student is unable to hear his own voice without amplification. Using this criterion therefore ensured that both Groups Two and Three relied equally on amplified sound to input any oral language.

d) Etiology of Impairment

Since the purpose of the study was to investigate motor ability and its relationship to the deprivation of sound and communication modality, selection excluded children with hearing loss resulting from certain etiological factors, specifically those resulting from disease, trauma, and/or ototoxic drugs (see Table 20, p. 195). Such etiologies are known to have potential neurological side-effects. Additional exclusion was made of any students with exogenous causes of deafness which could have other neurological or physical ramifications. A physical checklist (see Appendix Ib) was used to help identify under this criterion. Unknown etiologies were included as there is a general consensus in the field of hearing impairment that most 'unknown etiologies' are of familial origin (see Moores, 1978, Chp. 4). However, certain specific genetic conditions were excluded. Such conditions as Ushers Syndrome, for example, are known to cause diffuse or additional neurological, sensory, or physical impairments.[1]

e) Age of Diagnosis

An attempt was made to select subjects for Groups Two and Three with similar ages of diagnosis of hearing impairment. Whilst it is acknowledged that overall behavior,

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[1] See Veeger, 1983 for a list of specific genetic syndomes know to cause other impairments to deafness.

including speech, is better in children that become deaf at 18 months (van Uden, 1984; see also Ross, 1982 for explanation of deprivation in the first 3 years of life by a small hearing loss or chronic otitis media), the age limit of up to 24 months for diagnosis was used in this study. This was due again to the limited numbers of students who met the other selection criteria. The actual age of 18 months is anyway an abitrary cut-off point on a developmental continuum.

f) Parental Socio-economic Status

Children from lower socio-economic backgrounds were excluded from this study. Children from such backgrounds do not always achieve their full developmental potential due to limitation of opportunity for experience, deprivation of stimulation, or because of the failure to encourage independent exploration of different environments (Wardle, 1978). Under these conditions it becomes hard to isolate deafness as a possible cause of apparent motoric delay. Exclusion was therefore made of children from restricted environments such as highrise or basement appartments with no play area near their homes, or from families with parents in low income occupations. Status of physical environment was recorded by a checklist (see Appendix Ib) that based status on occupation on dwelling environment.

g) Intelligence

Selection was made from children of "normal intelligence" as recorded in school records. Selection by intelligence was necessary since low levels of intelligence may have an inherent relationship to slowness in motoric processing, and may affect speed of strategy adaptation for motoric tasks [illegible]man, 1964; Welford, 1977 in Wicks-Nelson, 1981; Jensen, 1979). It may also have etiologies independent of deafness (for example: 'Downs Syndrome', Frith and Frith, 1974). In such situations, it becomes difficult again to isolate deafness as a possible cause of motoric problems. A broad criteria of IQ scores between 85 to 136 was thus given to schools to select subjects for th[illegible] groups.

h) Pre-School Experience

It could be that attending pre-school includes the opportunity for motor experience, as well as the opportunity for deaf children to facilitate language development. Selection was therefore made from only students who had had some kind of pre-school experience. Pre-school experience was defined as:

a) students who had attended a pre-school for the deaf on a regular basis, or who had received regular home instruction by a qualified teacher of the hearing impaired, or

b) students who had attended government-sponsored

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kindergarten or day-care centres (so ensuring the presence of trained educational personnel).

B. Checklists

Hearing-Impaired Program

a) ENVIRONMENTAL CHECKLIST (please and/or fill in answers)

The following information is necessary so that the everyday environment of a child may be assessed. This will help us in understanding motoric development. However, if there are any of the questions that you would particularly not wish to answer, please leave them, but indicate your reasons if possible.

Thank you.

MOTHER ______________ FATHER ______________ DATE __________

1. What is your profession?

____

2. Where do you work?

____

3. Are you a single parent?

YES ______________

NO ______________

4. In which of the following do you live now?

APARTMENT ______________

OWN HOUSE ______________

SHARED HOUSE (eg., parent's house, basement apartment,

etc. ____

5. In which of the following did you previously live?

APARTMENT ______________

OWN HOUSE ______________

SHARED HOUSE ____

6. Is there are a garden with your home?

YES ______________

NO ______________

7. Is there a park area near your home?

YES ______________

NO ______________

8. Does your child like to spend most of his/her free time at home?

YES ______________

NO ______________

9. Does your child prefer to play alone?

YES ______________

NO ______________

10. Does your child play any sports such as ice-hockey, baseball, etc.?

YES ______________

NO ______________

Thank you.

Hearing-Impaired program

b) PHYSICAL CHECK LIST

(please ✓ and/or fill in answers)

PARENT ______________________ DATE ____________________

1. Do you have a hearing impairment yourself?

MOTHER Yes ______________

No ______________

FATHER Yes ______________

No ______________

2. Has your child a history of illness that has kept him home a lot?

Yes ______________

No ______________

3. Has your child a history of respiratory problems?

Yes ______________

No ______________

4. Does your child wear glasses?

Yes ______________

No ______________

5. Does your child wear continuous amplification during waking hours?

At Home Yes ______________

No ______________

At School Yes ______________

No ______________

6. When standing stationary, does your child appear to sway?

Yes ______________

No ______________

7. When standing stationary, does your child show any tremors in any body part?

Yes ______________

Which part of the body? ________________

No ______________

8. Does your child walk across the room with jerky steps?

Yes ______________

No ______________

9. Does your child walk across the room with a swinging gait/step?

Yes ______________

No ______________

Thank you.

Hearing-Impaired Program

b) PHYSICAL CHECKLIST

(please and/or fill in answers)

TEACHER ________________ DATE ________________

1. Has this child a history of illness that has kept him home a lot?

   Yes ____________

   No ____________

2. Has this child a history of respiratory problems?

   Yes ____________

   No ____________

3. Does this child wear glasses at any time?

   Yes ____________

   No ____________

4. Does this child wear continuous amplification during waking hours?

   Yes ____________ At Home ____________

   No ____________ At Home ____________

   Yes ____________ At School ____________

   No ____________ At School ____________

5. When standing stationary does this child appear to sway?

   Yes ____________

   No ____________

6. When standing stationary, does this child show any tremors in any body part?

Yes ______________

Which part of the body? ____________________________

No ______________

7. Does this child walk across the room with jerky steps?

Yes ______________

No ______________

8. Does this child walk across the room with a swinging gait/step?

Yes ______________

No ______________

Thank you.

C. TESTS FOR DISPRAXIA

a) ADAPTED TEST OF BERGÈS AND LÉZINE (1963, Paris) "IMITATION OF GESTURES" from van Uden (1983b).

OVERVIEW (van Uden, 1983, pp. 84-91)

The experimenter puts his fingers in a certain position and keeps them like that until the child has imitated him. One hand is not allowed to help the other. If the child cannot imitate the position of the fingers without some help, the score is 0. If the child does not put his fingers in the correct postion within 5 seconds, but puts it right finger by finger, the score is 1/2. If the child manages to get it right within 5 seconds, the score is 1. Maximum score = 16.

PROCEDURE

1. The examiner shows a particular position of his hand(s). This must be done in such a way that the child does not see how he does it. The examiner must know the positions by heart so that he is able to show it quickly. If the examiner has some difficulty himself, he can "construct" the positons under the table.

2. The examiner requests the child to imitate the hand position (not by heart). The investigator keeps his position until the child has imitated it unless it becomes clear that the child is unable to do it. There is no time limit.

3. The child is allowed to use his right or left hand, but if he has imitated the investigator's right hand with his left hand (mirror position), he has to use his other hand for the left hand of the investigator. (Until +9 years of age, the child is expected to use mirror positions, never beyond that age. If he does, and/or if not consistent in his right-left use, this is a sign of trouble within the body scheme.)

4. Instruct the child that he is not allowed to help his one hand with the other. Each hand has to find its own position.

SCORING

1. If child achieves the positioning immediately, i.e., within at least 5 seconds = 1 point.

2. If child has to try to "construct" and/or correct its finger positions = 1/2 point.

3. If child fails correct positioning = 0 points.

SCORING

Items:

2 - 2	0 - 1/2 - 1
2 - 1	0 - 1/2 - 1
2 1 ◇	0 - 1/2 - 1
L. V	0 - 1/2 - 1
R. V	0 - 1/2 - 1
L. ó	0 - 1/2 - 1
R. ó	0 - 1/2 - 1
L. ⊔	0 - 1/2 - 1
R. ⊔	0 - 1/2 - 1

5 1 ◇	0 - 1/2 - 1
⚭	0 - 1/2 - 1
⟠	0 - 1/2 - 1
X	0 - 1/2 - 1
[ ]	0 - 1/2 - 1
[ ]	0 - [✓ 1/2] - 1
8~	0 - 1/2 - 1

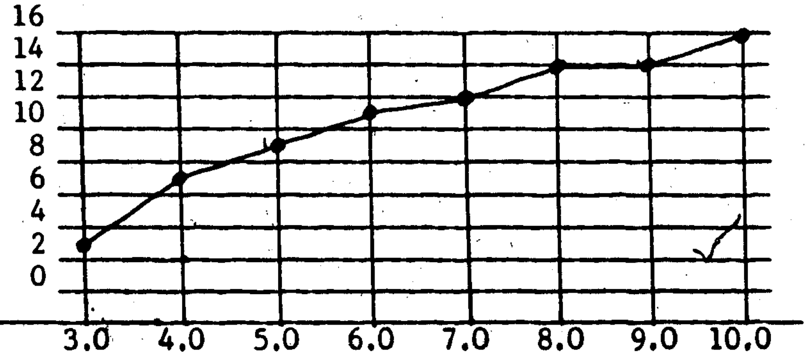
Score: ____________
(Max. 16)

Standardization of Bergès and Lézine's test of handpositions. (van Uden, 1967):

Age	Number of Children Involved	Average Score
3 yrs.	5	3 ± 1
4 yrs.	21	7 ± 1
5 yrs.	18	9 ± 2
6 yrs.	23	11 ± 4
7 yrs.	27	12 ± 3
Ceiling 8 yrs.	27	14 ± 3
9 yrs.	30	14 ± 3
10 yrs.	22	16 ± 3

NB. Deleau (1978) did not find any difference between deaf and normally hearing children on this test.

Standardization of Bergès and Lézine's test of handpositions.



Age	3.0 N.5	4.0 N.21	5.0 N.18	6.0 N.23	7.0 N.27	8.0 N.27	9.0 N.30	10.0 N.22
Average	3	7	9	11	12	14	14	16
Stand. dev.	1	1	2	3	3	3	3	3

b) IMITATING FINGER-MOVEMENTS FROM MEMORY (van Uden's Test, 1967) from van Uden (1983b), pp. 92-96.

OVERVIEW

The experimenter puts his/her hands up behind his/her head so that the fingers cannot be seen by himself/herself. He/she then touches the tip of the thumb with the tip of the index finger three times. The child is asked to imitate this without looking at his/her own fingers. Next, the experimenter does the same with the middle-finger, then with the ring-finger and the little finger; then all fingers in a row at a tempo of one second per touch, then of 1/2 a second, then of 1/4 of a second. The score is 0 if the child uses the wrong finger(s); 1 when he touches the right finger but not the finger-tip; 2 if both aspects are correct. Maximum score = 42.

PROCEDURE

1. The examiner puts the hand or hands in question upward, next to, and a little behind his head so that he cannot see his hand(s). He executes the prescribed movement. After that, he requests the child to imitate him.

2. The movements involve the finger-tips. These must contact each other exactly, and in the same tempo.

3. Special care should be taken that the child does not look at his hand.

SCORING

1. Perfect imitation = 2 points.

2. The right fingers(s) move(s), but the contact of the finger-tips is not exact, and/or more fingers move together to the opposite thumb, and/or the child corrects himself spontaneously and similar = 1 point.

3. The child does not use the right finger(s) = 0 points.

N.B. For items 5-13:

Sometimes the child does not stretch the fingers after a movement, but pushes the 4 fingers over the thumb. The examiner must correct it. If the child continues doing so, it is = 0 points.

Sometimes the child bows its finger(s) too much, without moving it/them towards the thumb. The score can be 2 points, but note it down because it can be an indication of lack of differentiation (immaturity) of motor control. This is just a clinical note.

For items 1-4 and 11-13:

The movements left and right should be synchronic = <u>eutaxic</u>. If not, the score can be 2 points, but note it down, just as a clinical observation of dystaxia.

SCORING

I. Fingertip of *one finger* with the thumb tip (both hands synchronically)

1. 3 times the *forefinger-tip* contacts the *thumb-tip*; before and after this the hand is *stretched* (see photographs):
   0 - 1 - 2   0 - 1 - 2   0 - 1 - 2 = ... points (max. 6)
2. The same with the *middle-finger*:
   0 - 1 - 2   0 - 1 - 2   0 - 1 - 2 = ... points (max. 6)
3. The same with the *ring-finger*:
   0 - 1 - 2   0 - 1 - 2   0 - 1 - 2 = ... points (max. 6)
4. The same with the *little-finger*:
   0 - 1 - 2   0 - 1 - 2   0 - 1 - 2 = ... points (max. 6)

II. Successively - forefinger, middle-finger, ring-finger, little-finger; before and after each movement the hand is *stretched* (see photographs):

5.	R.	Tempo	1	Second per finger	- 0 - 1 - 2
6.	L.	"	1	" " "	0 - 1 - 2
7.	R.	"	1/2	" " "	0 - 1 - 2
8.	L.	"	1/2	" " "	0 - 1 - 2
9.	R.	"	1/4	" " "	0 - 1 - 2
10.	L.	"	1/4	" " "	0 - 1 - 2
11.	R.+L.	"	1	" " "	0 - 1 - 2
12.	R.+L.	"	1/2	" " "	0 - 1 - 2
13.	R.+L.	"	1/4	" " "	0 - 1 - 2

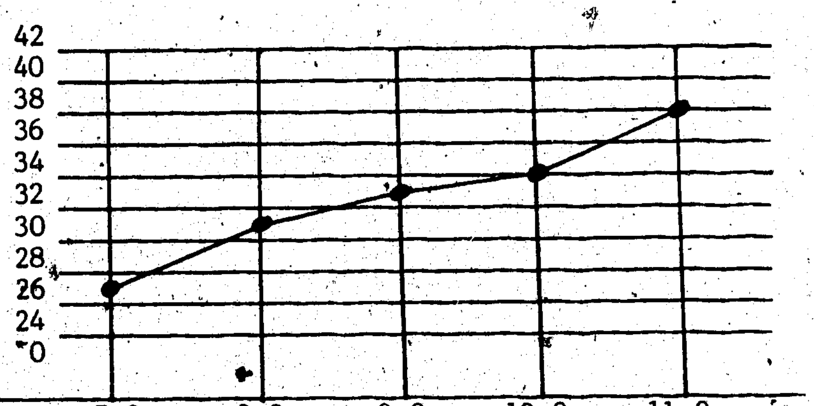
Σ ....
(max. 42)

Total Score:
Bergès ....
Van Uden ....
Σ ....
(max. 58)

Standardization of van Uden's fingermovements test (van Uden, 1967)

Age	Number of Children Involved	Average Score
7 yrs.	27	27 ± 9
8 yrs.	31	31 ± 9
9 yrs.	20	33 ± 7
10 yrs.	22	34 ± 6
Ceiling:		
11 yrs.	20	38 ± 6

Standardization of van Uden's fingermovements test (1967)



Age	7.0 N.27	8.0 N.31	9.0 N.20	10.0 N.22	11.0 N.20
Average	27	31	33	34	38
Stand. dev.	9	9	7	6	6

c) TEST FOR RHYTHMIC MEMORY

From van Uden (1983b), pp. 100-102.

Repeating rhythmically spoken syllables.

This test is executed by asking the child to repeat the syllables "baba" in different rhythmic patterns. The test is stopped when the child cannot do this with three consecutive items the first and second presentation.

Score

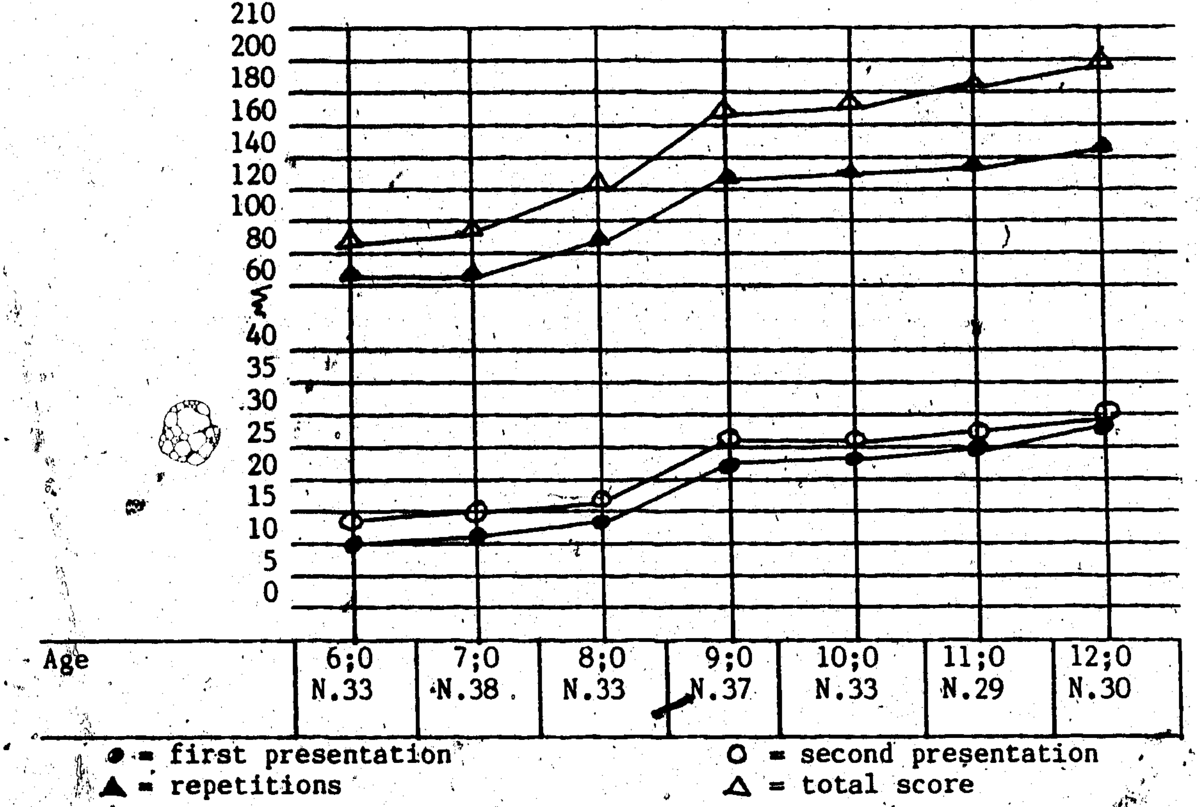
0 = no or entirely wrong reaction
1 = a reasonably good reaction
2 = an entirely correct reaction

a) One should hide the graphic symbols from the child. Each pattern is spoken only once for one scoring.

b) After the first reaction the child's memory is tested: the rhythm pattern is again spoken and repeated, and after this the child is asked to repeat this pattern 5 times from memory. Each time one scores 0 or 1 or 2.

Standardization of van Uden's rhythm test.

Age	Number of children involved	First presentation (max. 30)	Second presentation (max. 30)	Repetition from memory (max. 150)	Total Score (Max. 210)
± 6 yrs	33	10 ± 6	14 ± 5	70 ± 21	74 ± 30
7 yrs	38	12 ± 6	14 ± 4	70 ± 18	96 ± 26
8 yrs	33	14 ± 5	18 ± 4	90 ± 17	122 ± 24
9 yrs	37	22 ± 8	26 ± 6	129 ± 30	177 ± 31
10 yrs	33	23 ± 8	26 ± 4	130 ± 18	179 ± 28
ceiling: 11 yrs	29	25 ± 9	28 ± 7	134 ± 24	187 ± 37
12 yrs	30	28 ± 7	30 ± 6	142 ± 23	200 ± 35


210
200
180
160
140
120
100
80
60
40
35
30
25
20
15
10
5
0
Age
6;0 N.33
7;0 N.38
8;0 N.33
9;0 N.37
10;0 N.33
11;0 N.29
12;0 N.30
● = first presentation
○ = second presentation
▲ = repetitions
△ = total score

APPENDIX II

Raw Data Results

TABLE 1

Normal Hearing All Have Hearing Parents N = 23

Child	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Age	8.3	8.4	8.4	8.5	8.10	8.11	8.11	9.2	9.4	9.5	9.6	9.7	9.8	9.10	10.2	10.2	10.3	10.5	10.8	10.11	10.11	10.11	10.11
Sex	M	M	F	F	F	M	M	F	F	M	M	F	M	F	F	F	F	M	F	M	M	F	M
Rhythm	138	146	149	236	226	180	232	232	236	100	208	236	152	50	179	236	234	146	118	220	236	236	73
Bergès & Lézine	11.5	11.5	12.0	12.0	11.5	10.5	10.5 (L)	11.5 (L)	11.5	7.5	11.5 (L)	12.0	11.0	10.0	14.0 (L)	15.0	12.0	9.5 (L)	12.0	11.5 (L)	13.0	10.5	9.5 (L)
Van Uden	32	23	22	26	29	28	26	29	37	18	13 (L)	28 (L)	22	20 (L)	30 (L)	33	27	30	26 (?L)	23 (L)	31	37	21 (L)
Bruininks Oseretsky Stanine	4	7	6	7	6	3	5	8	7	4	3	4	5	4	3	5	4	2	5	6	5	2	1
Wiegersma Total	12	11	13	12	14	12	12	17	17	13	11	14	11	13	13	16	11	11	15	12	13	15	3
Dyspraxia	N	N	N	N	N	S	S	N	N	Y	S	N	?S	Y	N	N	S	?S	S	Y	N	Y	Y
TOTAL MOTOR ABILITY	Av.	H.	Av.	H.	Av.	L.	Av.	H.	H.	Av.	L.	Av.	Av.	Av.	L.	Av.	Av.	L.	Av.	Av.	Av.	L.	Very L.

Av. = Average, H. = High, L. = Low (L) = Below Age Norms N = None, Y = Yes, S = Slight

TABLE 2

Canadian Total Communicators   Hearing-Impaired   N = 27

Child	24* LH	25*	26 LH	27	28	29	30	31	32	33	34 LH	35	36 R	37
Age	89m 7.5	91m 7.7	97m 8.1	100m 8.4	101m 8.5	103m 8.7	104m 8.8	107m 8.11	110m 9.2	113m 9.5	114m 9.6	114m 9.6	115m 9.7	116m 9.7
Sex	Male	Male	Male	Male	Female	Female	Female	Male	Female	Male	Female	Female	Male	Male
Rhythm Total	54 (low)	28 (low)	26 (low)	43 (low)	26 (low)	44 (low)	48 (low)	29 (low)	34 (low)	26 (low)	35 (low)	56 (low)	30 (low)	33 (low)
Bergès & Lézine	14.0	14.0	10.0 (low)	12.0	7.5 (low)	12.5 (low)	13.0	11.0 (low)	13.5	15.0	12.0	14.5	15.0	14.5
Van Uden	39	27	0 (low)	38	1 (low)	12 (low)	30	25 (low)	31	29	31	36	35	33
Bruininks Oseretsky Stanine	7	1	1	7	1	3	3	3	6	2	4	7	2	1
Wiegersma Total	10	7	2	10	1	11	1	3	13	4	9	12	8	5
Dyspraxia Total	None	None	Yes	None	Yes	Slight	None	Yes	None	None	None	None	None	None
TOTAL MOTOR ABILITY	High	Low	Very Low	High	Very Low	Low	Low	Low	Average	Low	Average	High	Low	Very Low

*Hearing-Impaired Parents
L.H. = Lefthanded

R = Residential Students
(low) = Below Age Norms

TABLE 2 (Cont'd)

Canadian Total Communicators Hearing-Impaired N = 27

Child	38	39	40	41	42	43 R	44	45	46	47	48	49	50
Age	115m 9.7	117m 9.9	118m 9.10	119m 9.11	120m 9.12	120m 10.0	124m 10.4	124m 10.4	125m 10.5	127m 10.7	129m 10.9	130m 10.10	131m 10.11
Sex	Male	Male	Male	Male	Male	Female	Male	Male	Female	Female	Female	Male	Male
Rhythm Total	32 (low)	36 (low)	102 (low)	28 (low)	50 (low)	228 (low)	228 (low)	37 (low)	46 (low)	31 (low)	40 (low)	34 (low)	104 (low)
Bergès & Lézine	13.5	15.0	15.0	13.5	15.0	14.0	15.0	13.5	14.0	16.0	13.5	15.5	16.0
Van Uden	35	35	35	23 (low)	35	24 (low)	32	39	40	39	28 (low)	31	36
Bruininks Oseretsky Stanine	2	7	8	8	5	3	6	5	4	7	1	8	9
Wiggersma Total	1	13	13	6	11	4	3	13	8	15	5	16	17
Dyspraxia	None	None	None	Slight	None	Slight	None	None	None	None	Slight	None	None
TOTAL MOTOR ABILITY	Low	High	High	High	Average	Low	Average	Average	Average	High	Very Low	High	Very High

*Hearing-Impaired Parents
L.H. = Lefthanded

R = Residential Students
(low) = Below Age Norms

TABLE 3

a) Dutch Oral Hearing-Impaired All are Weekly Residential All have Hearing Parents

Child	51	52	53	54	55	56	57	58	59	60
Loss (db) R/L	97/97 *Flat	108/105	110/108	107/95	102/113	107/107	102/102	120/120	120/120 *Ski-slope	118/113
I.Q.	86	96	115	121	87	116	108	124	136	116
Etiology	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Age	46m 8.0	99m 8.3	99m 8.3	101m 8.5	105m 8.9	109m 9.1	114m 9.6	115m 9.7	120m 10.0	120m 10.0
Sex	Male	Male	Female	Female	Female	Male	Male	Male	Male	Female
Rhythm	107 (low)	85 (low)	54 (low)	62 (low)	60 (low)	99 (low)	109 (low)	42 (low)	101 (low)	63 (low)
Bergès & Lézine	12	13	13.5	12.5	14	13	14	15	14	13.5
Van Uden	32	32	29	31	25 (low)	33	32	24 (low)	34	37
Bruininks Oseretsky Stanine	4	3	2	3	1	3	2	2	4	4
Wiegersma Total	10	7	9	2	4	5	4	6	8	6
Dyspraxia	None	None	None	None	Slight	None	None	Slight	None	None
TOTAL MOTOR ABILITY	Average	Low	Low	Low	Very Low	Low	Low	Low	Average	Average

*Ski-scope Audiogram = Low Frequency Only
*Flat Audiogram = Across All Frequencies
R/L = Right Ear/Left Ear

IQ Scores = WIPPSI or WISC within Last 2 Years
Low = Below Age Norms
LH = Lefthanded

TABLE 3 (Cont'd)

b) U.S.A. Oral Hearing-Impaired   All are Non-Residential   All Have Hearing Parents

Child	61	62	63	64	65	66	67	68
Age	104m 8.8	106m 8.10	112m 9.4	114m 9.6	116m 9.8	125m 10.5	125m 10.5	125m 10.5
Sex	Male	Male	Female	Female	Female	Female	Female	Female
Rhythm Total	437 (low)	59 (low)	43 (low)	36 (low)	42 (low)	73 (low)	31 (low)	51 (low)
Bergès & Lézine	12.5	14.0	12.5	12.5	14.5	15.0	14.5	14.5
Van Uden	32	38	8 (low)	40	4 (low)	32	40	44
Bruininks Oseretsky Stanine	4	1	2	2	1	3	1	1
Wiegersma Total	5	7	5	8	7	7	8	9
Dyspraxia	None	None	Slight	None	Slight	None	None	None
TOTAL MOTOR ABILITY	Average	Very Low	Low	Low	Very Low	Low	Very Low	Very Low

(low) = Below Age Norms   LH = Lefthanded

TABLE 3 (Cont'd)

c) Canadian Oral Hearing-Impaired All Are Non-Residential All Have Hearing Parents

Child	69	70	71	72	73
Age	8.1	8.4	8.8	9.0	9.0
Sex	Male	Female	Male	Female	Female
Rhythm Total	38 (low)	87 (low)	41 (low)	45 (low)	46 (low)
Bergès & Lézine	11.5 (low)	8.0 (low)	13.0	13.5	14.5
Van Uden	30	28 (low)	34	35	34
Bruininks Oseretsky Stanine	5	3	4	2	3
Wiegersma Total	9	11	9	3	12
Dyspraxia	Slight	Yes	None	None	None
TOTAL MOTOR ABILITY	Average	Low	Average	Low	Low

LH = Lefthanded (low) = Below Age Norms

TABLE 4

Bruininks-Oseretsky Short-Form

		Subtests																		
	Child	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Point Score	Standard Score	Percentile Rank	Stanine	Motor Ability
	01	2	5	4	1	2	9	2	1	1	4	2	2	5	5	45	46	34	4	Average
H	02	9	4	4	1	3	10	3	2	5	4	2	1	4	5	57	62	88	7	High
E	03	4	6	4	1	3	7	3	0	3	4	2	1	5	7	50	53	62	6	Average
A	04	6	6	4	1	2	8	3	1	6	4	1	1	6	5	54	58	79	7	High
R	05	5	6	4	1	3	9	3	1	4	1	2	2	5	6	55	56	72	6	Average
I	06	3	6	4	1	3	9	2	1	0	4	2	1	1	6	43	40	10	3	Low
N	07	3	5	4	1	3	10	3	1	4	4	2	1	3	5	49	48	42	3	Average
G	08	7	6	4	1	5	10	3	2	5	4	2	2	5	8	64	64	92	8	High
	09	6	6	4	1	3	10	2	3	4	4	2	1	7	7	60	59	82	7	High
	10	3	6	3	0	3	9	3	1	3	4	2	2	7	5	51	46	34	4	Average
	11	3	6	3	1	2	8	3	1	5	4	1	1	6	5	49	38	12	3	Low
	12	4	6	1	1	3	9	3	0	4	4	2	2	7	8	54	46	34	4	Average
	13	5	6	4	0	3	9	3	1	7	4	2	1	5	8	58	52	58	5	Average
	14	5	6	4	1	3	8	3	0	3	4	2	2	7	7	55	47	38	4	Average
	15	3	8	4	1	3	7	3	2	3	4	1	1	7	7	54	39	14	3	Low
	16	1	6	4	1	5	7	2	5	5	4	2	2	6	8	58	48	42	5	Average
	17	6	6	4	1	3	8	3	2	6	4	1	1	6	6	57	47	38	4	Average
	18	1	6	4	1	3	7	2	5	5	4	2	1	4	6	51	37	10	2	Low
	19	5	6	4	1	3	8	3	2	8	4	2	1	8	5	60	49	46	5	Average
	20	7	6	4	1	3	11	3	3	7	4	2	1	6	5	63	54	66	6	Average
	21	9	6	4	1	3	11	3	2	5	4	1	1	5	6	61	50	50	5	Average
	22	7	1	4	1	3	10	3	2	1	4	2	1	7	5	51	33	5	2	Low
	23	6	3	1	1	2	7	2	1	4	4	2	2	6	5	46	24	1	1	Very Low
	24	6	6	3	1	4	8	1	1	0	4	2	2	6	6	50	62	88	7	High
	25	8	1	1	1	0	6	2	0	1	4	2	0	2	2	30	31	3	1	Very Low
	26	7	0	0	0	2	7	2	1	0	3	2	2	2	4	32	30	2	1	Very Low
T.	27	11	2	1	1	2	11	2	3	2	3	1	1	9	7	56	61	86	7	High
	28	7	1	2	0	0	6	1	1	0	3	2	0	2	3	28	24	1	1	Very Low
C.	29	7	3	1	1	2	9	1	2	4	4	2	1	3	4	44	41	18	3	Low
	30	13	4	1	0	2	5	3	0	0	4	2	1	6	3	44	41	18	3	Low
	31	7	2	1	1	3	6	2	2	6	4	2	2	2	2	42	39	14	3	Low

TABLE 4 (Cont'd)

Bruininks-Oseretsky Short-Form

		Subtests																		
	Child	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Point Score	Standard Score	Percentile Rank	Stanine	Motor Ability
	32	9	6	4	1	3	9	2	1	3	4	2	1	6	7	58	56	72	6	Average
H	33	8	4	4	1	1	6	2	2	1	4	1	1	5	4	44	36	8	2	Low
E	34	8	6	3	0	3	9	3	1	5	4	2	1	5	5	55	47	38	4	Average
A	35	14	6	4	1	3	9	3	2	6	4	2	1	4	6	65	62	88	7	High
R	36	8	6	4	1	3	8	2	2	1	2	1	1	4	5	45	33	5	2	Low
I	37	7	2	2	0	2	4	2	2	2	4	1	0	5	4	37	-24	-1	1	Very Low
N	38	8	6	4	0	2	4	3	2	4	4	2	1	4	4	48	37	10	2	Low
G	39	10	6	4	1	2	7	2	2	7	4	2	2	8	6	63	59	82	7	High
	40	15	6	4	1	3	10	3	3	7	4	2	1	5	5	69	67	95	8	High
I	41	14	6	4	1	3	9	3	3	7	4	2	1	4	5	66	63	90	8	High
M	42	13	3	1	0	3	8	3	2	5	4	2	2	5	5	56	49	46	5	Average
P	43	11	3	2	1	4	10	3	1	1	4	1	1	5	2	49	38	12	3	Low
A	44	9	4	4	1	3	10	2	2	4	4	1	2	8	7	61	53	62	6	Average
I	45	11	3	4	0	3	10	5	1	3	3	2	2	6	6	59	50	50	5	Average
R	46	13	2	2	1	2	8	3	2	4	4	2	0	6	6	55	44	27	4	Average
E	47	10	6	4	1	3	13	3	1	4	4	2	2	6	6	65	58	79	7	High
D	48	7	2	1	0	1	6	3	1	0	4	2	1	4	4	36	-24	-1	1	Very Low
	49	9	6	4	1	3	11	3	3	9	0	2	2	8	7	68	63	90	8	High
	50	13	6	4	1	4	10	3	3	10	3	2	1	8	7	75	75	99	9	High
	51	8	2	0	1	2	8	2	2	3	4	2	1	4	4	43	44	27	4	Average
	52	7	5	1	1	3	6	2	0	2	4	1	1	4	4	41	41	18	3	Low
O	53	5	3	1	1	2	8	2	1	0	4	2	1	4	3	37	36	8	2	Low
R	54	9	4	1	1	1	5	1	1	0	4	2	2	5	4	40	40	16	3	Low
A	55	4	2	1	1	2	6	2	1	0	4	2	2	4	5	36	31	3	1	Very Low
L	56	8	6	1	1	1	8	2	2	2	4	2	2	4	4	47	40	16	3	Low
	57	9	2	1	1	2	8	2	1	2	2	2	1	6	6	45	33	5	2	Low
H	58	5	2	1	1	2	9	2	1	2	4	2	2	5	5	44	33	5	2	Low
E	59	10	2	1	1	3	10	3	2	3	4	2	2	6	7	56	45	31	4	Average
A	60	9	4	2	1	2	6	3	2	7	4	1	1	5	7	54	44	27	4	Average
R	61	7	4	4	1	2	9	3	1	1	4	2	1	4	4	47	45	31	4	Average
I	62	3	3	4	1	2	6	3	1	1	4	1	1	2	4	36	31	3	1	Very Low
N	63	3	6	4	0	3	7	5	1	3	2	2	1	3	4	44	36	8	2	Low
G	64	7	6	1	1	3	6	3	1	2	3	1	1	5	5	45	33	5	2	Low

TABLE 4 (Cont'd)

Bruininks-Oseretsky Short-Form

		Subtests																		
	Child	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Point Score	Standard Score	Percentile Rank	Stanine	Motor Ability
	65	3	4	4	0	4	8	3	1	2	2	2	1	5	3	42	28	1	1	Very Low
I	66	7	6	6	1	2	6	2	3	6	3	1	1	6	4	54	42	21	3	Low
M	67	7	2	1	0	3	7	2	1	0	4	2	2	6	5	42	24	1	1	Very Low
P	68	7	3	1	1	2	5	2	0	1	4	2	2	5	6	41	24	1	1	Very Low
A	69	8	2	4	1	2	8	3	2	4	4	2	1	3	4	48	50	50	5	Average
I	70	8	2	1	1	2	7	2	1	2	4	2	1	4	4	41	41	18	3	Low
R	71	9	1	1	1	3	8	3	2	2	4	2	2	5	3	46	44	27	4	Average
E	72	5	2	1	1	3	6	3	2	0	4	1	2	6	7	43	35	7	2	Low
D	73	9	1	4	1	3	8	3	1	0	4	2	1	7	4	48	42	21	3	Low

TABLE 5

Wiegersma and Reysoo (1983)

		Visual Motor Coordination Subtests 1 - 4				General Dynamic Motor Coordination Subtests 5 - 10								
	Child	1	2	3	4	5	6	7	8	9	10	Visual Mt. Ttl.	General Mt. Ttl.	Total Motor Ability
	01	10	10	9	12	16	15	13	13	9	6	10	13	12
	02	10	10	9	8	14	10	15	4	14	12	9	12	11
	03	7	8	11	11	17	12	8	17	14	10	9	15	13
H	04	7	12	9	8	17	10	12	14	14	10	8	14	12
	05	9	12	7	10	16	12	13	19	14	10	9	16	14
E	06	13	12	8	12	15	10	14	10	7	9	12	11	12
	07	12	14	6	10	17	9	14	10	13	9	11	13	12
A	08	14	14	13	12	18	11	15	12	15	13	15	16	17
	09	12	16	13	14	17	10	14	12	13	16	16	16	17
	10	14	7	10	13	15	12	13	13	13	7	11	13	13
R	11	8	8	10	10	14	15	9	12	11	7	9	12	11
	12	12	10	12	14	17	8	14	11	16	10	13	14	14
I	13	9	13	12	13	12	12	11	4	13	5	12	9	11
N	14	15	13	12	11	15	12	11	7	15	10	14	12	13
	15	10	15	11	11	15	11	10	14	16	10	12	[illegible]	13
G	16	16	14	12	17	16	12	10	16	16	12	17	15	16
	17	12	11	5	8	13	12	11	10	16	10	9	[illegible]	11
	18	9	11	12	11	14	10	9	12	11	9	11	11	11
	19	10	13	11	12	17	12	10	17	18	12	12	16	15
	20	13	12	10	14	14	15	15	19	15	13	13	18	17
	21	9	9	10	7	16	17	14	12	13	13	8	16	13
	22	13	13	7	11	16	13	15	11	17	14	11	16	15
	23	6	10	8	5	2	7	9	2	6	2	6	2	3
	24	12	6	7	9	16	8	13	9	8	10	8	11	10
	25	7	11	11	10	14	4	7	4	8	6	10	6	7
T.	26	2	8	8	8	1	4	4	1	9	8	5	2	2
	27	4	10	6	13	15	4	18	5	11	12	7	11	10
	28	1	2	1	2	2	2	7	1	7	2	1	1	1
	29	10	13	12	13	12	4	13	3	14	12	13	10	11
	30	6	9	1	7	12	2	3	1	5	3	3	2	1
C.	31	1	4	1	1	8	5	7	14	4	11	1	7	3
	32	10	13	14	14	17	4	13	9	11	11	14	11	13
	33	1	9	13	6	10	8	7	3	7	3	6	4	4
	34	6	11	10	15	9	9	9	7	14	2	11	7	9
D	35	9	9	15	11	15	12	10	10	12	10	11	12	12
	36	1	5	9	11	11	9	11	8	13	11	5	11	8
E	37	8	7	9	7	12	5	4	2	9	7	6	5	5
	38	3	5	7	1	[illegible]	2	1	2	12	5	1	2	1
A	39	13	[illegible]	14	13	[illegible]	9	7	12	11	9	15	10	13
	40	9	9	14	9	13	11	13	13	15	9	10	13	13
F	41	4	8	14	10	12	4	10	4	8	5	9	6	6
	42	9	14	13	13	13	6	11	6	13	9	13	9	11
	43	1	1	1	1	1	5	13	9	19	12	1	10	4
	44	2	2	4	1	12	8	11	5	8	5	1	7	3
	45	13	13	9	17	13	9	10	11	15	7	14	11	13
	46	13	8	3	10	14	7	11	9	12	2	8	9	8
	47	14	16	13	8	13	9	19	8	19	12	14	14	15
	48	3	5	17	10	11	2	7	1	12	2	8	5	5
	49	12	13	13	17	16	13	14	10	15	11	15	15	16
	50	14	15	16	12	17	11	16	12	19	14	16	16	17
	51	10	6	8	10	12	4	5	13	18	12	8	11	10
	52	8	13	10	13	15	4	1	3	9	6	12	5	7
	53	10	10	5	10	13	7	10	5	14	10	8	10	9
O	54	4	7	7	10	17	3	9	1	4	1	5	4	2
	55	10	1	11	10	12	2	3	[illegible]	3	8	6	4	4
	56	8	2	6	4	8	8	10	7	6	7	3	7	5
R	57	1	3	12	10	12	4	9	4	4	5	5	4	4
	58	2	12	9	7	12	5	11	3	6	9	6	6	6
	59	13	15	8	5	6	4	11	1	19	9	10	7	8
A	60	3	9	9	5	4	6	7	10	12	6	5	7	6
	61	3	8	11	9	14	8	5	2	4	10	6	6	5
	62	7	14	9	12	11	7	8	9	5	2	11	6	7
L	63	6	8	13	10	10	8	10	1	3	5	9	4	5
	64	11	13	8	13	13	4	8	1	9	10	12	7	8
	65	6	9	9	8	12	13	10	4	3	8	7	8	7
D	66	9	8	8	13	12	9	8	3	3	8	9	6	7
E	67	6	11	7	13	14	4	8	9	6	10	9	8	8
A	68	8	14	8	10	15	2	7	9	12	8	10	8	9
	69	8	12	5	8	14	9	9	2	19	12	7	[illegible]	9
F	70	2	8	10	11	16	9	14	12	12	12	6	14	11
	71	9	12	6	11	10	3	13	3	13	11	9	8	9
	72	2	11	8	11	12	1	8	1	7	1	7	9	3
	73	10	12	8	11	15	12	11	5	13	12	10	12	12

TABLE 6

Rhythmic Memory and Dyspraxia

	Child	Rhythm Memory Totals			Dyspraxia Total (Bergès & Lézine & van Uden)	Rhythmic Memory (Low = below age norms)	Presence of Dyspraxia
		1.	2.	3.			
	01	16	16 138	80	43.5	Average	None
	02	17	19 146	84	34.5	Average	None
	03	22	22 149	79	34.0	Average	None
H	04	30	30 236	150	38.0	High	None
E	05	30	30 226	146	40.5	High	None
A	06	22	22 180	110	38.0	Average	Slight
R	07	30	30 236	150	38.5	High	Slight
I	08	30	30 232	146	40.5	High	None
N	09	30	30 236	150	48.5	High	None
G	10	12	12 100	50	25.5	Low	Yes
	11	26	26 208	130	24.5	High	Slight
	12	30	30 236	150	40.0	High	None

TABLE 6 (Cont'd)

Rhythmic Memory and Dyspraxia

Child	Rhythm Memory Totals			Dyspraxia Total (Bergès & Lézine & van Uden)	Rhythmic Memory (Low = Below age norms)	Presence of Dyspraxia
	1.	2.	3.			
13	20	20 152	86	33.0	Low	Slight
14	6	4 50	14	30.0	Very Low	Yes
15	21	22 179	110	44.0	Average	None
16	30	3[illegible] 234	[illegible]50	48.0	High	None
17	30	30 234	148	39.0	High	Slight
18	20	20 146	80	39.5	Low	Slight
19	30	30 118	132	38.0	Low	Slight
20	25	28 220	141	34.5	High	Yes
21	30	30 236	150	44.0	High	No
22	30	30 236	150	37.5	High	Yes
T. 23	7	8 73	32	30.5	Very Low	Yes
C. 24	6	6 54	16	53.0	Low	None
25	2	0 28	0	41.0	Very Low	None

TABLE 6 (Cont'd)

Rhythmic Memory and Dyspraxia

Child	Rhythm Memory Totals 1.	2.	3.	Dyspraxia Total (Bergès & Lézine & van Uden)	Rhythmic Memory (Low = below age norms)	Presence of Dyspraxia
26	0	0 (26)	0	10.0	None	Yes
27	4	6 (43)	7	50.0	Low	None
28	0	0 (26)	0	8.5	None	Yes
E 29	5	5 (44)	8	24.5	Low	Slight
A 30	4	8 (48)	10	46.0	Low	None
R 31	2	1 (29)	0	36.0	Very Low	Yes
I 32	2	33 (34)	33	44.5	Very Low	None
N 33	0	0 (26)	0	43.0	None	None
G 34	2	2 (35)	5	43.0	Very Low	None
35	2	6 (56)	22	50.0	Low	None
36	2	2 (30)	0	50.0	Very Low	None
37	5	2 (33)	0	47.5	Very Low	None
38	3	1 (32)	2	48.5	Very Low	None

TABLE 6 (Cont'd)

Rhythmic Memory and Dyspraxia

Child	Rhythm Memory Totals			Dyspraxia Total (Bergès & Lézine & van Uden)	Rhythmic Memory (Low = below age norms)	Presence of Dyspraxia
	1.	2.	3.			
39	4	4 (36)	2	40.0	Very Low	None
I 40	2	14 (102)	60	40.0	[illegible]	None
M 41	2	0 (28)	[illegible]	36.5	Very Low	Slight
P 42	9	6 (50)	[illegible]	50.0	Low	None
A 43	2	0 (28)	0	38.0	Very Low	Slight
I 44	2	0 (28)	0	47.0	Very Low	None
R 45	6	3 (37)	2	52[illegible]	Very Low	None
E 46	6	8 (46)	6	54.0	Low	None
D 47	3	2 (31)	0	35.0	Very Low	None
48	4	2 (40)	8	41.5	Low	Slight
49	2	4 (34)	2	46.5	Very Low	None
50	12	12 (104)	54	52.0	Low	None
51	16	16 (107)	49	44.0	Low	None

TABLE 6 (Cont'd)

Rhythmic Memory and Dyspraxia

Child	Rhythm Memory Totals 1.	2.	3.	Dyspraxia Total (Bergès & Lézine & van Uden)	Rhythmic Memory (Low = below age norms)	Presence of Dyspraxia
O 52	11	12 (85)	36	45.0	Low	None
R 53	8	4 (54)	16	42.5	Low	None
A 54	8	10 (62)	18	43.5	Low	None
L 55	8	6 (60)	20	39.0	Low	Slight
56	9	14 (99)	40	46.0	Low	None
57	15	13 (109)	55	46.0	Low	None
58	6	2 (42)	8	39.0	Low	Slight
59	16	14 (101)	55	48.0	Low	None
H 60	6	10 (63)	21	50.5	Low	None
E 61 A	7	5 (43)	5	44.5	Low	None
R 62	6	9 (59)	18	52.0	Low	None
I 63 N	2	4 (42)	10	20.5	Low	Slight
G 64	4	4 (36)	2	52.5	Low	None

TABLE 6 (Cont'd)

Rhythmic Memory and Dyspraxia

	Child	Rhythm Memory Totals 1.	2.	3.	Dyspraxia Total (Bergès & Lézine & van Uden)	Rhythmic Memory (Low = below age norms)	Presence of Dyspraxia
	65	6	5 (42)	5	18.5	Low	Slight
IMPAIRED	66	11	12 (73)	24	47.0	Low	None
	67	4	1 (31)	0	44.5	~~Low~~	None
	68	10	9 (51)	6	55.5	Low	None
	69	3	4 (38)	5	41.5	Low	Slight
	70	16	14 (87)	31	43.0	Low	Yes
	71	5	3 (41)	7	47.0	Low	None
	72	7	8 (45)	14	41.5	Low	None
	73	6	4 (46)	10	48.5	Low	None

1. 2. 3. = 1st, 2nd and 3rd repetition
0 = overall total

APPENDIX III

Explanation of Motor Tests Mentioned in Review of Literature

APPENDIX III

Explanation of Motor Tests Mentioned in Review of Literature

Tests mentioned in the review of the literature are as follows:

1. <u>The Stanford Motor Skills Test</u>
used by Long (1932)

A test of mainly visual-motor tasks. It contains no maturational norms.

2. <u>The Heath Railwalking Test</u> (1946)
used by Myklebust (1964)

A test of dynamic balance in which the subject has to walk on beams of varying widths. It tests location and coordination.

Heath, S. "A Mental Pattern Found in Motor Deviates." <u>Journal Abnormal Psychology</u>, '41, pp. 223-232.

3. <u>The Brace Motor Ability Test</u> (1927)
used by Carlson (1972)

A test which contains a number of complex motor tasks, mostly of short sequence, designed to test the motor educability of the subject.

Brace, O.K. "Measuring Motor Ability." Barnes, New York.

4. <u>The Ohio State University Step Test</u> (1969)
used by Case, Dawson, Schartner & Donoway (1973)

A test developed for physical fitness. It measures cardio-vascular rates.

Kurecz, R.L. & Matthews, D.K. "Construction of a Submaximal Cardio-Vascular Step Test." <u>Research Quarterly</u>, 40; 1.

5. The Infant Psychological Development Scale (1966)
used by Best & Roberts (1976)

A test developed as a research instrument based on Piagetian theory. It is used to measure early sensorimotor development.

Uzgiris, U.I. & Hunt, H.J. "An Instrument for
Assessing Infant Psychological
Development."

Urbana, I.L. University of Illinois, (Mimeo)

6. The Van Der Lught Psychomotor Series (1949)
used by Boyd (1967)

A test to measure motor development in children.

Van Der Lught, Maria J.A. V.D.L. "Psychomotor
Test Series for Children." New York
University.

7. The Geddes Psychomotor Inventory (1978)
used by Geddes (1978)

A test to measure the need for individualized psychomotor educational program.

Geddes, D. 6272746 L.

Longwood Division
Allyn & Bacon Inc.
Link Drive
Rockleigh, N.J. 07047

8. The Oseretsky Test of Motor Proficiency (1931, original; 1946, translation).
used by Boyd (1967)

A test following a neurological framework operating on a dichotomous (fail-pass) scoring basis.

Doll, E.A. Editor "The Oseretsky Test of Motor
Proficiency." Minneapolis Educational Test
Bureau.

Further adaptations are:

The Bruininks-Oseretsky Test of Motor Proficiency.

Circle Pines: Minneapolis
American Guidance Service, 1978

This test uses fourteen items assessing eight subtests of motor proficiency. Has U.S.A. norms.

9. *The Hamm-Marburger Coordination Test* (1975) used by Wiegersma and Van der Velde (1983)

Wiegersma, P.H. & Van der Velde, A. "De Hamm-Marburger Korpeskoodinationstest for Kinder." Swets en Zeitlinger, Lisse.

10. *The Frostig Movement Skills Battery* (1972) used by Wiegersma and Van der Velde (1983)

A test for sensori-motor ability comprising of twelve subtests. It is age-scaled for elementary school children. It evaluates strengths and weaknesses.

Orpet, R.E. "Frostig Movement Skills Test Battery." Consulting Psychological Press, Palo Alto, U.S.A.

11. *The Stott, Moyes and Henderson Test of Motor Impairment* (1972) used by Wiegersma & Van der Velde (1983)

A test used to diagnose areas of motor impairment in children. It bases many items on those of the Oseretsky Test (see no. 8 above).

Stott, B.H.; Moyes, F.A.; Henderson, S.E. "Test of Motor Impairment," Brooks Educational Publishing, Ontario.

12. Beadke, D. "Empirische Untersuchungen Zur Differenzierung der Manuellen Geschiclichkeit im Kindesalter. Thesis. University of Giessen, 1972 used by Wiegersma and Van der Velde (1983)

13. In General:

Diagnosing the motoric development of the deaf child

1. The most scientific instrument and the real tes[illegible] is:

   the Bruininks-Oseretsky test of motor proficie[illegible]
   (Publisher: A.G.S., Circle Pines MN 5501[illegible]
   U.S.A.)

2. Observation and Screening instrument is:

   For children of 2.6 to 5.6 years:
   S. Gubbay (1975): The clumsy child, A study of developmental apraxia and agnostic ataxia.
   (Publisher: Sanders, Philadelphia, U.S.A.).

3. Also useful to observe the gross and fine motor development (1.0 to 6.0 years)

   The Denver Developmental screening test
   (Publisher: Frankenburg, University of Colorado, Medical Center).
   Example of the record form given in J. van Dijk, Rubella Handicapped Children, p. 199.

4. Observation lists in relation to eupraxia.

   Children 0 to 4.0 years:
   A van Uden: Test of development of eupraxia in hand and fingers (in J. van Dijk, Rubella Handicapped Children, pp. 200-204).

   Children 4.0 to 7.0 years
   A. van Uden: Eupraxia Questionnaire.
   In F. Ijsseldijk, Inventory etc., page 7 and page 15 (test norms).
   Ijsseldijk (1983)