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UNIVERSITY OF ALBERTA

A PRELIMINARY INVESTIGATION OF THE USE OF THE COGNITIVE ASSESSMENT SYSTEM (CAS) WITH THE DEAF AND HEARING

BY

EMMANUEL ODIGOUGOU OJILE

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY

IN

SPECIAL EDUCATION

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

SPRING 1991

ISBN 0-315-66788-5

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22nd April, 1991

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Permission is hereby given to Emmanuel Ojile to reproduce the older and newer version of the "Simultaneous, Successive and Planning Processing Model of Information Integration" developed by Das and colleagues. This model is illustrated in Emmanuel's Ph.D. doctoral dissertation.

J. P. Das

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TITLE OF THESIS: A PRELIMINARY INVESTIGATION OF THE USE OF COGNITIVE ASSESSMENT SYSTEM (CAS) WITH THE DEAF AND HEARING.

DEGREE: DOCTOR OF PHILOSOPHY

YEAR THIS DEGREE GRANTED: SPRING 1991

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Abstract

The purpose of this study was to investigate the cognitive processes of deaf and hearing subjects using the Cognitive Assessment System (CAS). The study also examined whether or not the CAS tasks could predict academic achievement of deaf students. There were two age groups of subjects, comprising younger and older deaf and hearing students. The mean age for the younger deaf subjects was 9. 9 years and the younger hearing subjects was 9. 4 yrs. The mean age for the older deaf and hearing subjects was 13. 7 years for each group. All deaf subjects were prelingually deaf and had bilateral hearing loss ranging from severe to profound. The deaf and hearing subjects covered the spectrum of socio-economic background with a wide range of academic attainment. The tests administered included eight CAS tasks, and selected subtest of the Stanford Achievement test (SAT) battery. The Stanford Achievement Test Hearing Impaired Edition (SAT-HI) was administered to the deaf. The results reveal no evidence of Attention Dysfunction in the deaf. In simultaneous and successive cognitive processing tasks, the younger deaf achieve low scores only in the verbal tasks while the older deaf subjects achieve low scores in both verbal and nonverbal tasks. The age specific period in which simultaneous and successive processing ability of the deaf would equal that of hearing however did not emerge clearly in this study. In higher order planning tasks, all deaf subjects did poorly compared to hearing groups. This reduce performance being possibly due to the relative absence of strategies, lack of effort to negotiate a solution to the planning problems and, failure to take advantage of available cues needed to complete the higher order planning tasks. The CAS tasks were also found to be significantly predictive of certain subtests of SAT/SAT-HI

academic achievement for both deaf and hearing groups. This study suggests that CAS tasks provide a viable alternative to existing intellectual assessment devices. However further study using larger samples and different populations of the deaf is recommended to validate the present results and answer some of the unresolved issues.

ACKNOWLEDGEMENT

My sincere appreciation to the following people...

To Dr. J. P. Das, my thesis supervisor for his advise and direction.

To Dr. F. D. Snart and Dr. D. Sobsey as a member of my dissertation committee, for your interest, knowledge and positive criticism.

To Dr. J. A. Naglieri for serving as the external examiner.

To Dr. M. Rodda for your interest, involvement, and direction as Advisor.

To my colleagues Dr. R. Beattie and Dr. Jonas Darko Yeboah for finding time to read and comment on part of the initial draft of the manuscripts.

To F. Russell for easing the trauma of typing.

To R. Mishra for assisting with the computer packages.

To Mr. R. Krawchuk, principal D. S. Mackenzie Junior High School, Mr. J. Marfleet, principal Mckee Elementary School, Mr. H. Miller, principal Manitoba School for the Deaf, Mr. W. J. Lockert, principal R. J. D. Williams provincial School for the Deaf, Mr. J. Anderson, principal and Ms. M. Henderson, Assistant principal, Jericho Hill Provincial School for the Deaf for making me welcome in the school environment and for your considerable assistance to see that the research went smoothly.

To all the hearing and deaf children including their parents involved directly or indirectly in this research. I hope that i have not added additional problem to the sensitive issues of assessment and testing deaf children in particular.

To M. McDonald and all hearing impaired staff who assisted with the administration of Stanford Achievement Test Hearing Impaired Edition (SAT-HI).

And finally to my late mother and father (Owobi and Ojile) for laying the foundation of my education despite their brief stay in this world. Without these two people in my life, I would not have been what i am today.

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Introduction

Researchers have consistently found the deaf to be deficient in speaking, linguistic, and academic abilities (Bonvillian, Charrow, & Nelson, 1973; Furth, 1966; Goetzinger & Rousey, 1959; Lane, 1976; Levine, 1981; Meadow, 1980; Moores, 1970; Stuckless & Birch, 1966; Tomlinson-Keasey & Kelly, 1978; Trybus & Karchmer, 1977; Vernon & Koh, 1970). Some behavioral and social characteristics (such as lack of impulse control, emotional immaturity, short attention span, egocentricity, rigidity, dependency, and lack of reflectivity) have also been reported in the deaf population (Altschuler, Deming, Vollenweiden, Rainer, & Tender, 1976; Harris, 1978; Klaber & Falek, 1969; Levine, 1976; Myklebust, 1960; Neyhus, 1964; Schein, 1975; Schlesinger & Meadow, 1972). Earlier studies suggest that the intellectual competence of the deaf ranges from inferior to concrete (Day, Furfeld, & Pinter, 1928; Mackane, 1933; Myklebust, 1964; Pinter & Patterson, 1916; Zeckel & Van der Kolk, 1939).

In the late twentieth century, several of these research findings have been challenged because of more precise knowledge of the relevant factors influencing test performance. One such factor is the utilization of verbal psychometric tasks with the deaf as opposed to nonverbal or performance tasks (Levine, 1974). The use of verbal tasks alone is certain to present difficulty for the deaf because of their limited vocabulary. There is the additional problem of communicating verbal instructions to deaf subjects, which is also certain to affect their test performance.

Other factors that were not considered in the earlier research designs investigating intellectual competence of the deaf include the age of onset of hearing loss, the degree of loss in decibels (dB), the home and school communication environment, and the presence of one or more additional handicapping conditions. Any one, or a combination of these factors, could have a significant effect on general academic, cognitive, social, and emotional development (Rodda & Grove, 1987; Wolk, 1988). When these factors were carefully weighed, researchers were able to establish that the deaf population possesses the same distribution of intelligence as the hearing population (Furth, 1966; Mindel & Vernon, 1971; Rosenstein, 1961; Vernon, 1967).

Unlike the hearing subjects whose scores of intellectual tasks have been used successfully to predict academic achievement (Fraser, 1987), such prediction has not been valid for deaf subjects. Despite the normal distribution of intelligence in the deaf, the average deaf person's academic attainment is markedly retarded. The degree of retardation is more profound in language and reading-related skills (Trybus & Karchmer, 1977; Wrighstone, Aronow, & Moskowitz, 1963; Jensema & Trybus, 1978; Servatka, Henson, & Graham, 1984). An examination of the nature of intellectual tasks used led Fraser (1987) to contend that the problem could result because of insufficient criterion validity. Fraser questions the use of nonverbal or performance IQ tasks in predicting school-related academic achievement that demand a combination of verbal and nonverbal skills. It would also appear that due to the current advance in human cognitive research, a complete cognitive picture of the deaf has yet to emerge.

Wolk (1985), for instance, criticizes cognitive researchers studying the deaf for failing to distinguish between "representational" and "executive" processes. In other words, determining the normal IQ distribution of the deaf without distinguishing what is a basic cognitive process (e.g., coding) and what are the higher order cognitive components, makes no sense.

This view has been substantiated through the use of the Cognitive Assessment System (CAS) constructed from the Das, Kirby, and Jarman (1975, 1979) Information Integration Model. The CAS assesses higher order Planning in addition to Attention, Simultaneous, and Successive processes of human cognitive functioning. The CAS components have also been utilized with various populations and found capable of predicting certain subtests of academic achievement. The results led Naglieri and Das (1990) to recommend the inclusion of the Attention and Planning factors to core cognitive assessments in addition to the simultaneous and successive "coding" components.

This current problem pertaining to cognition and academic attainment of the deaf will necessitate an alternative cognitive assessment approach distinct from the widely used traditional psychometric assessment device. The CAS model could provide this alternative, because through this approach a more valid picture of the cognitive functions of the deaf population could be investigated. It is also possible that performance on the CAS tasks could be related to different subskill areas of the academic attainment of deaf subjects. This study attempts to address such problems by investigating the use of CAS tasks as potential predictors of relevant academic skills in deaf subjects as compared with hearing subjects.

The remaining chapters will be organized under the following themes. Chapter 2 will present a general overview of all relevant cognitive assessment research that has so far been investigated using deaf subjects. Chapter 3 will present a review of the CAS model as a potential alternative. Chapter 4 will discuss results of the deaf and hearing subjects performance on the various CAS tasks and academic achievement. Chapter 5 will discuss these results and relate the outcome with the outcomes of previous studies. Chapter 6 will focus on the limitations of the study and make general recommendations for future research.

Chapter II

General Overview

The Differential Cognitive Approach

The differential cognitive approach which originated from the Binet-Simon Scale (Binet & Simon, 1905), uses standardized psychometric tests to identify individual differences in cognitive ability. An elaborate use of this approach with the deaf population began with Pinter and Patterson (1915, 1916). The first set of such studies portrayed deaf people as intellectually inferior (Day, Furfeld, & Pinter, 1928; Mackane, 1933; Peterson & Williams, 1930; Pinter & Paterson, 1916; Zeckel & Van der Kolk, 1939). It was during the later part of twentieth century that researchers began to realize the limitations inherent in using such standardized instruments to evaluate the intelligence of the deaf population. One such constraint was the difficulty in communicating test instructions so that deaf students would recognize what was required in the tasks. There was the additional problem of the verbal and linguistic load of the psychometric tasks in use. These tasks were often too difficult for deaf subjects to comprehend considering their limited vocabularies and linguistic functions. In order to mitigate these problems, initial attempt focused on the modification of the test instruments through the elimination of verbally and linguistically loaded test items. Where such modification was not feasible, concerted efforts were directed at the use of nonverbal or performance cognitive tasks alone. Levine (1974) identified such cognitive tasks as the Hiskey-Nebraska Test of Learning Aptitude (1966), the Leiter International Performance Scale (LIPS)(1969), the Snijders-Ooman non-Verbal Intelligence Tests for deaf and hearing subjects (1970) and Raven's Matrices (1954). Accompanying this development was the increased interest in standardizing certain test instruments to suit the deaf population. When these newer versions of psychometric tasks were used with samples of deaf and hearing children, researchers found no significant performance differences (Graham & Shapiro, 1953; Kirk & Perry, 1948; MacPherson & Lane, 1948).

The problem, however, is that, the performance of deaf groups unlike the performance of hearing groups in such psychometric tasks bore little or no resemblance to their performance in academic-related tasks. In short, the normal intellectual distribution found in the deaf population did not reflect their academic achievement, as would be expected for a normal IQ distribution curve. While the performance of deaf people appears to be retarded in most areas of academic achievement, the deficit is more profound in language and reading-related tasks (Trybus & Karchmer, 1977; Wrighstone, Aranow, & Muskowitz, 1963). The general academic difficulties of deaf students persist despite years of formal education, since earlier studies reporting academic achievement scores (Wrighstone et al., 1963) did not differ much from the most recent studies (Jensema & Trybus, 1978; Servatka, Hesson, & Graham, 1984; Quigley & Kretschemer, 1982). The results of these studies show that the mean level of achievement is disproportionately lower than what would normally be expected, given normal scores of intellectual potential. There is the suggestion that the use of nonverbal and performance psychometric tasks may be responsible. For instance, Fraser (1987) observes that the average .50 correlation with achievement scores and combined verbal and nonverbal IQ scores for hearing subjects reported by Jensema (1980) and Matarazza (1972), is higher than the .33 correlation with achievement scores and nonverbal-only IQ scores reported by Zimmerman and Woosam (1972). Fraser contends that given this low correlation for hearing samples, there is reason to question the validity of using a nonverbal IQ score as a predictor of academic achievement for the hearing impaired.

In support of this view, other studies have also given prominence to verbal factors in cognitive tasks. Craig and Gordon (1988) found what they termed verbosequential skills correlated highly with academic achievement, whereas visuospatial skills evidenced only a weak relationship to academic performance. In another related development, Zwiebel (1989) found that there is a "verbal" nucleus of general intelligence associated with formal thinking that is distinct from the visual or perceptual cognitive mechanism. This evidence suggests that the use of nonverbal and performance tasks to determine the intellectual capacity of a deaf child may be limited in scope. This is so because nonverbal or performance tasks alone can not reveal all cognitive strengths or weaknesses associated with academic-related skills. A suggestion by Zwiebel that cognitive researchers studying deaf people aim at analyzing the underlying cognitive structure would, of course, have serious implications for future cognitive research employing the differential cognitive model with deaf pupils.

Piagetian Model

Piaget's historical antecedents in biology are known to have influenced the theory of cognitive development. In the Piagetian model, the role of genetics as a natural factor contributing to the general emergence of complex cognitive structures within individuals is emphasized. The method usually employed by Piaget is clinical, a technique of probing and questioning in problem-solving situations, but this method, according to critics, lacks standardization and controls. Through this line of investigation, Piaget postulates four major periods of cognitive development that include the sensorimotor period (Birth to 2 years), the preoperational period (2 to 7 years), the concrete operational period (7 to 11 years), and the formal operational period (11 years through adolescence). Elkind (1974) points out that these stages of cognitive development are possible only through two basic processes of assimilation and accommodation, that Piaget considered dynamic and changing variables.

Moores (1982) reports that the research work of Furth (1964, 1966, 1969, 1971, 1973, 1974) has made educators of the deaf aware of the work of Piaget and has been influential in modifying the perception of educators toward language, thought, and deafness.

Furth (1964) was interested in using deaf subjects to investigate the possible relationship between thought and concrete experience which facilitates learning. Furth hypothesized that if no inner malfunctions can be observed in the deaf using Piagetian tasks, then support for the supremacy of the relationship between thought and concrete experience can be established. However, if any difficulties in acquisition of knowledge were to be found in the deaf when there was no inner malfunction, then they would arise from deficiencies outside the deaf person such as experiential, linguistic, or communication deficits (Levine, 1976). This hypothesis has been neither supported nor rejected, as researchers have observed a similarity in performance on certain Piagetian tasks in transitivity and probabilty problems between the deaf and hearing populations (Ottem, 1980). In other tasks such as classification and concept formulation, conservation of liquids, sequential memory, and transitive thought, the deaf have been found to be backward (Blair, 1957; Furth, 1964; Furth & Milgram, 1965; Michael & Kates, 1965; Oleron, 1953; Olsson & Furth, 1966; Robertson & Youniss, 1969; Youniss & Furth, 1966; Templin, 1950).

Furth (1969) asserts however, that the inferior performance of the deaf is due to experiential and linguistic factors; by adulthood or in specific task conditions which do not favor linguistic habits, the deaf can equal the hearing subjects in performance. This position has lead to the development of projects such as a thinking laboratory for deaf children (Furth, 1969) and a book of games without words (Wolff & Wolff, 1973).

This line of investigation has been criticized for the following reasons: (a) consistent and conclusive results have yet to be obtained by researchers replicating Furth's work with hearing impaired subjects (Quigley & Kretschmer, 1982), (b) relatively little research has been done at Piaget's formal operational stage in part because of the difficulties in devising nonverbal tasks which tap these skills and which can be conveyed to deaf subjects (Meadow, 1980; Wolk, 1985), and (c) the linguistic deficiency may not be real since Moores (1982) argues that deaf people have the capacity to manipulate abstract symbols in sign language which is not necessarily a verbal language. Nevertheless, this approach is yet another attempt to examine more fully the structure of cognitive functioning in the deaf population.

Testing-the-Limits (SOMPA)

Even though the testing-the-limits or the system of process assessment (SOMPA) can not be equated with one particular cognitive model, the method recognizes certain cognitive strengths in the subjects that standardized psychometric assessments fail to reveal. A system of process assessment attempts to redirect the subjects' attention to such strengths in other to enhance performance on cognitive skills.

Dillon (1979) describes six administration conditions using the testing-the-limits procedures:

1. Standard condition of the test.
2. Simple feedback concerning the correctness or incorrectness of the response.
3. Child's "verbalization" of solution strategies following each choice.
4. Child's "verbalization" during and after solution of each item.
5. Elaborated feedback by examiners as to the reason for the correctness of each choice.
6. Examiner verbalization during and after the solution with elaborated feedback.

Two studies using the testing-the-limits procedures with the deaf have been reported. One study, conducted by Carlson and Dillon (1978), utilized deaf children ranging in age from 6.1 years to 10.11 years with a mean IQ of 98.3 as determined by the Leiter International Performance Scale. The subjects were administered the puzzle and booklet forms of the Raven Coloured Progressive Matrices (RCPM). Five conditions ranging from a standard condition to an elaborated feedback as described in the testing-the-limits procedures were delineated. Interaction with subjects was through Total Communication (i.e., simultaneous verbalization and signing). The results indicated that the non-elaborate conditions did not improve performance, but the elaborated conditions did increase the overall performance.

The second study by Dillon (1979) used a larger sample of deaf subjects (n=120). The measure this time was the RCPM and a Piagetian battery involving order of appearance, multiplicative classification, and asymmetrical seriation. Additionally, the six administrative conditions of testing-the-limits procedures were utilized. Results confirmed the earlier study in that subjects in the elaborated conditions performed significantly better on the RCPM and Piagetian tasks used as a measure.

Even though testing-the-limits procedures may have relative advantages over the traditional intellectual assessment, these procedures have not separated themselves completely from traditional method of assessment. Sattler (1982) argues that testing-the-limits procedures should not be initiated until standard test administration is completed so as to guard against the possible inflation of scores that might result from introducing cues and feedback. Another shortcoming is that this procedure which was shown to improve the cognitive performance of the deaf, did not provide an explanation as to why a similar improvement could not be recorded in their academic-related skills. The current use of the Feuerstein's (1979) assessment and intervention procedures should throw more light on the principle associated with the use of the testing-the-limits procedure.

Feuerstein Model

Feuerstein developed an assessment and intervention model with a base in cognitive psychology and social learning theory. Central to his work is the Piagetian notion of abstraction. The notion of abstraction is similarly recognized in

Haywood's (1968) research work. Haywood suggests that children's ability to form verbal abstraction is important in learning; the child's inability to form such abstraction is responsible for deficits which in turn affect performance (Haywood, 1968, Haywood & Switzky, 1976). Haywood further contends that the potential is there to increase the individual's ability to form abstractions. Vygotsky's (1962) zone of proximal development concept is also pivotal in Feuerstein's cognitive theoretical postulates. Vygotsky defined zone of proximal development as:

> The distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, 1962, p.86)

Feuerstein (1980) combined this earlier work with his more than 30 years of research with Israeli children who were described as culturally deprived, educable mentally retarded, and experiencing various learning disabilities to develop "The Dynamic Assessment of Retarded Performers," along with its companion volume "Instrumental Enrichment." Unlike the traditional definition of intelligence determined by an individual's score on IQ tests, intelligence to Feuerstein is the individual's capacity to use previously acquired experience to adjust to new situations. Intelligence is viewed as a dynamic, changing variable that is not an immutable fixed entity, therefore permitting individuals to learn cognitive skills.

Feuerstein (1979) observes that cultural deprivation may significantly reduce one's ability to learn cognitive skills, yet learning to overcome such deprivation is made possible through direct learning experience and mediated learning experience.

Feuerstein and Rand (1977) define direct learning and mediated learning experiences as follow:

> Direct learning experience is the learning that occurs from the earliest stage of life through direct contact with stimuli that impinge upon the child. In the mediated learning experience, direct experience with stimuli is altered through the action of an "experienced," intentioned, and active human being." (Feuerstein & Rand, 1977, p. 15-16)

The Learning Potential Assessment Device (LPAD) developed by Feuerstein (1979) was intended to be used as a diagnostic device for determining possible reasons underlying retarded performance in individuals. It was to be used also to further assess an individual's learning potential. The subsequent development of Instrumental Enrichment (IE) between 1979 and 1980 was in response to the need for mediated learning intervention experiences for culturally disadvantaged groups.

Keane (1981) explains the justification for applying Feuerstein's (1979, 1980) notion of cultural deprivation with deaf subjects. He argues that the environmental milieu in which most hearing impaired children are raised is vital. Since more than 90% of deaf children are born to hearing parents for whom this is the first encounter with the handicap of deafness, such parents have likely gone through various stages of guilt, anger, grief, and depression in coping with the reality of having a hearing impaired child. The probable outcome is that the normal channels of parent-child communication may be significantly altered. In Keane's view, all these factors can disrupt the mediational learning process. Keane concludes that the problem for some deaf and traditionally defined culturally disadvantaged individuals may arise from their inability to maximally profit from mediated learning experiences.

Katz (1984), like Keane (1981), report the LPAD to be a useful tool in delineating cognitive deficiencies, strengths, and potential in the deaf. Huberty and Koller (1984) agree with Keane and Katz but note that although there were practical limitations using Feuerstein's IE model, the model could be useful in terms of research and application for both deaf and hearing persons. Additionally, they present the view that if deaf persons failed to perform well on certain cognitive tasks, it may be that deafness has truly contributed to the development of deficient functions; remediation efforts may be indicated with Feuerstein's IE model.

Studies using Feuerstein's model of assessment with the deaf have been documented. Keane's (1983) study, which compares the LPAD, testing-the-limits procedures, and standardized traditional psychometric procedures in 45 profoundly deaf pre-adolescent children of deaf parents, found the LPAD mediated feedback produced more statistically significant learning transfer. The study also indicates that there was a great deal of cognitive potential within their sample deaf population that was obscured by both traditional psychometric approaches and testing-the-limits procedures.

In a two-year pilot study, Martin (1984) looked at the effects of IE intervention in secondary level adolescent hearing impaired students in a Total Communication environment. Martin observed that the experimental group showed consistent improvement in systematic approaches to problem solving, completeness and organization in problem solving, reading comprehension, mathematic achievement, ability to generate several problem-solving strategies, and the ability to logically defend their strategies.

Pachal (1986) also investigated the use of Feuerstein's IE in four oral hearing impaired adolescents for one year. Special emphasis was given to self-regulatory behaviors and verbal problem-solving strategies in describing changes in cognitive functioning. Results suggested the following five potential areas of benefit for students:

1. In three of the four IE students, impulsive behavior was apparently being replaced by restraint of impulsivity and more reflective thought.
2. In three of the students, planning behavior was apparently replacing unsystematic work, while each of the four IE students assumed a more active role in the learning process.
3. Three of the students were observed to generalize and to apply vocabulary concepts used in IE class to other classes.
4. Each of the four students became increasingly more precise in their work and in their use of language, as well as demanding more precision of others.
5. Three of the students demonstrated increased ability to think logically.

The general consensus from available data is that Feuerstein's model has significantly altered cognitive assessment and intervention in the deaf population. The model has as well advanced the current knowledge about the cognitive functions of the deaf population beyond what is currently known using the traditional intellectual assessment procedures.

One major drawback with the use of Feuerstein's model with the deaf population is the question of how to use the LPAD in the classroom (Epstein, 1985). LPAD results are not interpretable in traditional psychometric intelligence testing terms. By implication this means that subjects must be in the IE program or the LPAD results are open to several interpretations.

Another limitation with the use of Feuerstein's cognitive model has been the tendency to explain all cognitive and academic retardation from the cultural deprivation perspective. Such an assertion can not be completely accepted since certain cognitive deficits (e.g., attention, hemispheric specialization, and simultaneous and successive processing that are relevant to success in academic related skills) have been identified in the deaf, learning disabled, mentally retarded, and even the culturally deprived (Craig & Gordon, 1988, 1989; Cummins & Das, 1977; McKee, 1987).

Recently there has been an attempt to further extend the Feuerstein's model by relating the IE with other cognitive models. In one typical design, Craig and Gordon (1989) have related Feuerstein's Instrumental Enrichment (FIE) with specialized cognitive functions and academic achievement in deaf students. This line of investigation, if pursued with vigor, could prove very useful in cognitive research literature for the following reasons: (a) it marks the beginning of a unified cognitive research model that can provide a more valid understanding of human cognitive function, and (b) it will help educators and researchers understand more clearly the nature of cognitive functions in the deaf and other handicapped that will be relevant to their academic-related skills.

Cognitive Information Processing Model

Early cognitive information processing theory compared human learning with computer operations using term such as input, storage, retrieval and output (Estes, 1976; Newell & Simon, 1972). The information-oriented cognitive psychologists believe that such collection, storage, interpretation, understanding, and use of environmental or internal information is cognitive; an understanding of such processes is fundamental to understanding reading, speech production, comprehension, and creative thought (Lachman, Lachman, & Butterfield, 1979). One area of the Cognitive Information Processing model investigated in the deaf deals with the two dichotomous modes of cognitive processing involving verbal and nonverbal, spatial or temporal, simultaneous or successive processing respectively.

Snart, Das and Barriault (1987) define simultaneous coding as the synthesis of various separate elements into a group, with spatial overtones such that all parts of the group are accessible regardless of their position in the group. Successive synthesis, on the other hand, is defined as the integration of separate elements into series or groups that are related temporally rather than spatially. This definition provides an essential guiding post for the dichotomous label associated with the two processing scales.

Closely associated with the two modes of processing is the established function of the left hemispheric area of the brain which is the analytic, serial, and time dependent processor, uniquely specialized for speech, writing, and other language skills. The right hemispheric field was found to be more simultaneous, less sequential, and less auditory (Bradshaw & Nettleton, 1983).

Proponents argue that there is a correlation between auditory stimulation and hearing level for temporal lobe organization associated with verbal processing (Neville, 1988). The English language, upon which reading is based, may be auditorally acquired (Conrad, 1979), while the loss of auditory experience such as in the deaf alters the cerebral development and normal lateralization of specific cognitive tasks associated with brain functions, particularly in the left cerebral hemisphere (Craig & Gordon, 1979). Investigators using the simultaneous and successive processing scale of the Information Integration Model have also found certain academic skills to be related with the verbal and nonverbal mode of processing (Mensink & Das, 1989).

The most recent study in the field of hemispheric specialization to deaf subjects suggests that the left hemispheric area might be truly deficient. In one clinical study of hearing impaired patients with left hemispheric brain damage, expressive and receptive sign language abilities were found to be severely impaired just as spoken language skills are reduced by left hemisphere damage in normal hearing persons (Poizner, Battison, & Lane, 1979).

The second study by Craig and Gordon (1988) using the Cognitive Laterality Battery (CLB) uniquely designed to measure the verbosequential and visuospatial function attributed to the left and right cognitive hemispheres, found the cognitive profile of about 62 deaf adolescents in deaf schools to be better on the visuospatial tasks than the verbosequential tasks. Another study by McKee (1987), using hearing impaired university students who were tested with the CLB, supports Craig and Gordon's study. All deaf subjects performed significantly below average on the composite verbosequential tasks and significantly above average on the composite visuospatial tasks. In contrast, the verbal and nonverbal or temporal and spatial order processing scales investigated in the deaf suggests that no actual differences exist (Anooshian & Bryan, 1979; Beck, Beck, & Gironella, 1977; Das, 1983; O'Connor and Hermelin, 1973; McGurk & Saqi, 1985; McDaniel, 1980).

It has been proposed that any experimental differences found between the deaf and the hearing on these tasks could be a function of other variable factors such as materials used, mode of presentation, and the linguistic content of the stimulus tasks (Marlowe, 1989). In a related development, age was found to be another confounding variable (Altom & Weil, 1977; Freeman, 1975; Klapper & Birch, 1971; Zwiebel, 1989). These studies suggest that younger hearing or deaf children may lag in test of cognitive processing but that the lag is often not evident at the older age. The emergence of the Kaufman Assessment Battery for Children (K-ABC)(1983) lends credibility to the theories of the two processing scales and brain localization.

One of the major drawbacks with the use of the Information Processing Model with deaf subjects is that, like the Piagetian model, this line of investigation has also not moved beyond the analysis of input and output storage in memory processing to an examination of the executive roles or the planning factors acknowledged by such cognitive researchers as Das & Naglieri (1989), Flavell (1978), Gagne (1977), Miller, Galanter and Pribram (1960), Posner (1973), Reitman (1965), Snow (1978), and Sternberg (1979). Secondly, further examination of this line of investigation suggests that the subject's role in determining which of the two processing scales would be more economical and more profitable is not considered (Tsui, Rodda, & Grove, 1989). Instead, the subjects remain passive participants while the presentation of the tasks in either a sequential or spatial modality is predetermined by the experimenters' skillful manipulation.

The third limitation is that by controlling for such factors as verbal or linguistic loads of successive processing tasks to show that no significant difference exist between the deaf and hearing subjects, it is very likely that the vital roles of verbal or linguistic demands of successive processing as opposed to simultaneous processing is suppressed. The result is that a complete picture of the cognitive functions of the deaf population has not emerged.

Researchers in this field have also failed to recognize that both simultaneous and successive tasks can be represented in either a verbal or nonverbal modality as has been successfully demonstrated using the Das et al. (1979) Information Integration Model. This new discovery that simultaneous and successive processing could be demonstrated verbally and nonverbally will of course have implications for researchers using this model with deaf subjects.

In summary, this section has attempted to provide a general overview of all models of cognitive research investigation using deaf subjects. These include the differential model which utilizes standardized psychometric tests to identify individual differences, the Piagetian model with clinical underpinning, the Feuerstein cultural deprivation model, and the Cognitive Information Processing Model with focus on the two processing dichotomies associated with the left and right hemispheric lateralization.

The general picture which tends to emerge from the overview suggests the following:

1. It would appear that cognitive researchers do not completely understand the nature of cognitive functioning in the deaf population so that help may be given to resolve their related academic difficulties.
2. A model of cognitive functioning which cuts across the verbal and nonverbal dichotomy or the left and right hemispheric lateralization and which can also account for cultural, developmental, and individual factors in task processing has yet to emerge and be investigated in the deaf.
3. There is a general tendency for cognitive researchers to focus only on the investigation of the representational processes such as the input and output unit mechanism. The higher order executive process or the planning factors as they relate to the representational process are frequently ignored. This observation is in agreement with Wolk's (1985) observation that cognitive researchers have yet to move from the representational process to the executive process.

The Purpose of the Study

The purpose of this study is both theoretical and practical. The theoretical aspect is to explore the Das et al. (1975, 1979) Information Integration Model using deaf and hearing subjects, because the model cuts across the verbal and nonverbal dichotomy and the left and right hemispheric lateralization. It can as well accommodate elements of cultural and individual differences in cognitive processing. Additionally, the model has the potential to move beyond the input and output processing modality to examine other relevant cognitive functions such as attention and the higher order executive or planning factors. The model also makes provision for the potential role of the subjects in selecting which mode of processing scale is the most beneficial. This approach will provide an opportunity to examine in detail the cognitive functions of the deaf and the relationship between the various cognitive structures. The practical aspect is to determine whether the cognitive functioning of the deaf and hearing subjects will be relevant to their respective academic related skills.

Significance of the Study

The outcome of the investigation will add to the knowledge of cognitive assessment of the deaf population. The Cognitive Assessment System (CAS), which is an assessment device based on the Information Integration Model, could be a welcome addition to psychologists' existing evaluating instruments for deaf and hearing populations alike.

Future research testing and refining of this model and other competing cognitive assessment models could provide educators with a complete cognitive picture of the deaf, the non-deaf, and the atypical handicapped population. The possible relationship between cognitive profiles and related academic skills could be established, which in turn could facilitate remedial training.

Chapter III

Review of Related Literature.

Introduction

The review of literature is organized under three headings. The first section focuses on the Kaufman Assessment Battery for Children (K-ABC), its use with deaf children, and the limitations inherent in its use. Because the K-ABC uses the simultaneous and successive processing constructs of Luria and Das, it is important to know how the deaf have performed on it so that we can anticipate their performance on the Das-Naglieri Cognitive Assessment System (CAS). The second section discusses the Information Integration Model, which provides the constructs for the CAS, the past and current research using the model, its practical applications and the current criticism of the model. The third and concluding section summarize the potential for using the Information Integration Model. The four objectives of this study are also stated in this section.

Kaufman Assessment Battery for Children (K-ABC)

The Kaufman Assessment Battery for Children (K-ABC) was designed to assess the intelligence and achievement of 2.5 to 12.5 year olds (Kaufman & Kaufman, 1983). The intelligence scale, a derivation of the cognitive process oriented approach, was constructed to assess two types of mental functioning--sequential and simultaneous processing. According to the authors, the processing scales represent a remarkable and persistent convergence among the theories and research findings emerging from many different clinical and laboratory settings. These include sequential versus parallel or serial versus multiple (Neisser, 1967), successive versus simultaneous (Das, Kirby, & Jarman, 1975; Luria, 1966), analytic versus gestalt/holistic (Levy, 1972), propositional versus appositional (Bogen, 1969), verbal versus imagery or sequential versus synchronous (Paivio, 1975), controlled versus automatic (Schneider & Shiffrin, 1977), and time-ordered versus time-independent (Gordon & Bogen, 1974).

The nonverbal scale is a special combination of K-ABC subtests which can be given gesturally and responded to motorically. The scale is designed to serve as a good estimate of intellectual potential for children in the 4 to 12.5 year age range who manifest communication problems, such as in the deaf, hearing impaired, speech or language disordered, autistic, and non-English speaking children.

The first reported use of the K-ABC with the hearing impaired (HI) is the Hayes, Courtney, Wattkins, and Frick (1982) study which form a part of the K-ABC standardization sample. In this study, Hayes et al. tested 40 hearing impaired children between the ages of 8 and 11.11 years on the K-ABC nonverbal scale and the Wechesler Intelligence Performance Scale for Children (WISC-R) using the Ray Adaptation (Ray, 1982) through sign language. The sample consisted of 18 females and 22 males, 25 of whom were white and 15 of whom were black. The Gestalt Closure subtest was also administered in order to compute both simultaneous processing and nonverbal standard scores for this group. The results indicate that the HI children scored highest on the Gestalt Closure and Triangles subtests but were backward in the Matrix Analogies, Photo Series, and Hand Movements subtests. The scores were interpreted to mean that hearing impaired children as a group succeeded on tests that were heavily simultaneous but had considerable difficulty on subtests demanding integration of sequential and simultaneous processing. Another alternative explanation for the low scores, according to the authors, could be the factor of poor reasoning ability or difficulty in understanding the nature of tasks via nonverbal administration. The study also reported a correlation of .63 between the performance IQ of the WISC-R and the nonverbal scale of K-ABC.

Since the Hayes et al. (1982) study, Porter and Kirby (1986) have investigated the effect of American Sign Language (ASL) versus mime and gesture on the use of the K-ABC with the hearing impaired. Their results suggest that there is no difference in scores between subjects instructed in ASL and subjects using mime or gestures in their performance on the K-ABC nonverbal scale. They found a significant correlation between the K-ABC nonverbal scale and the performance section of the WISC-R, even though the overall scores on the K-ABC were considerably lower than the overall scores on the WISC-R. The study also found that the HI performed poorly in the Spatial Memory tasks of the K-ABC.

Ulissi, Brice, and Gibbins (1989) criticize these two studies for failing to agree on which of the subtests of K-ABC the HI performed more poorly. Although Hayes et al. (1982) found significantly poorer performance on Matrix Analogies, Hand Movements, and Photo Series, Porter and Kirby (1986) reported poor performance on Spatial Memory Tasks only. Ulissi et al. also criticize the studies for failing to report the deaf subjects degree of hearing loss, the demographic characteristics, and the overall mean scores achieved on the test. They observe further that the limited age range of the sample and the lack of a recognized and systematic communication system made it impossible to generalize the results.

The additional problem that Ulissi et al. (1989) found with the Porter and Kirby (1982) study was the failure to explore the significant difference between scores on the K-ABC and the WISC-R, since the low scores on the K-ABC might suggest that the K-ABC underestimates the true abilities of HI children.

In a replication study, Ulissi, Brice, and Gibbins (1989) administered the WISC-R performance scale and the K-ABC nonverbal scale to 26 male and 24 female hearing impaired elementary school students ranging in age from 6 to 12.5 years. Their results suggest the following:

1. Hearing impaired subjects are poorer in sequential processing tasks than in simultaneous processing tasks.
2. Subjects do not show differences in performance on the K-ABC and the WISC-R tests.
3. There is a high correlation between the nonverbal simultaneous processing scale of the K-ABC and the reading and mathematic scores, but correlation with the sequential processing scale and reading and mathematic scores is very poor.
4. The correlation between the WISC-R test scores and the reading and mathematics scores are moderate.

In another study related to this topic, Gibbins (1988) administered the WISC-R performance and the K-ABC nonverbal scale to 51 deaf children in an oral educational environment in Scotland and to 50 deaf children in a Total Communication environment in the United States (US). Results revealed no significant statistical differences between the Scottish and US deaf samples in their performance on the WISC-R and K-ABC tests. Gibbins noted, however, a lower mean average in the K-ABC tests for the Scottish population as compared with the mean average of the US population. Gibbins found a correlation of .71 for the

Scottish sample score on the WISC-R performance scale and the K-ABC nonverbal scale. The correlation for the same two tests for the US sample was .84. When the two samples were combined, their correlation was .79.

In these studies under review (Gibbins, 1988; Hayes et al., 1982; Porter & Kirby, 1986; Ulissi et al., 1989), there has been a general tendency to correlate the K-ABC with the WISC-R performance scale. However, it is only in Ulissi et al.'s study that the correlation between the K-ABC scale and the WISC-R was found to be lower than expected. It appears also that each of these studies fails to recognize the differences between the WISC-R and the K-ABC intelligence scales. For example, while the K-ABC is process based, with a focus on whether the stimuli are manipulated one at a time or simultaneously regardless of item content, other intelligence tests--notably the WISC-R--are known to be either verbal or nonverbal in content (Kaufman & Kaufman, 1983). Unfortunately, the pre-occupation of these series of studies with the correlation factor between the K-ABC and the WISC-R did not permit an in-depth analysis of the processes utilized by deaf subjects to perform intellectual tasks.

There is a further need to examine the simultaneous and sequential task loading, the mode by which the tasks are presented and the mode in which the task is represented in the deaf subjects' memory to bring about the outcome.

Out of these four studies, only the Ulissi et al. (1989) one attempts to relate the processing scales of the K-ABC and the WISC-R tests with the academic achievement of the deaf. Although the sequential processing scale of the K-ABC in this study was found to have a lower correlation with the reading and mathematic achievement scores, higher correlation was found between the K-ABC simultaneous processing scale and the reading and mathematic achievement scores. However, this study fails to report the specific academic-related skills that are associated with the K-ABC processing scale.

Another problem with Ulissi et al.'s study is that despite the use of subjects ranging in age from 6 to 12.5 years, no age factor as it influences the simultaneous and successive processing scale of the K-ABC is reported. It seems likely that an agc related factors as it effects the cognitive processing scale, is underestimated. Age factors as they affect the cognitive processing scale cannot be ignored; their effects have been reported in other similar studies (Naglieri & Das, 1987; Snart, Das, & Barriault, 1987). As a result of these limitations, the Ulissi et al. (1989) replication study is open to various interpretations.

Criticisms of the K-ABC

Despite the problems associated with studies using the K -ABC scales with the HI, the K-ABC as a whole has received a mixed review. Hopkins and Hodge (1983), in their review of the K-ABC, make several criticisms. These include the normed and standardized procedure and the validity and reliability of the measuring scales. They feel that the chief and critical weakness of the K-ABC is an overreliance on a particular theory rather than on the more eclectic and pragmatically oriented Wechsler and Stanford-Binet tests. Das (1983), in another review of the K-ABC, disagrees and instead lauds the primary goal of the K-ABC, which is to develop a test of intelligence that has a strong theoretical and research base and which also makes reference to other theories and empirical investigations. Das' most serious reservation, however, includes the following aspects:

1. The inability of the K-ABC simultaneous and successive processing scale to cut through the verbal and nonverbal dichotomy, specifically because the seven simultaneous tasks are nonverbal and the only nonverbal tasks of the sequential processing tasks, Hand Movements, begin to load on simultaneous factors by age 10 years.
2. The authors of the K-ABC, in their theoretical constructs, have considered only the simultaneous and successive processing factor of cognitive components. Other cognitive aspects, notably the attention-arousal and the planning or executive components, are ignored, even though they are vital for learning-related tasks.

The emergence of the Cognitive Assessment System (CAS) based on the Information Integration Model (Das, Kirby, & Jarman, 1975, 1979) proves that beyond the simultaneous and successive cognitive processing scale there are other cognitive components that can contribute to success in academic-related skills. The next section outlines the Cognitive Information Integration Model and its unique aspects.

Information Integration Model

Das, Kirby, and Jarman (1975, 1979) propose a cognitive model of Information Integration based on Luria's (1966, 1970, 1973, 1980) theory of the working brain (see Figure 1). The model arose from Luria's clinical work with brain-damaged subjects; however, it has been operationalized through studies of persons varying in age, sex, mental ability, achievement, and cultural background (Das, Kirby, & Jarman, 1975, 1979). In fact the model goes beyond neuropsychology to include elements of psychological principles of information

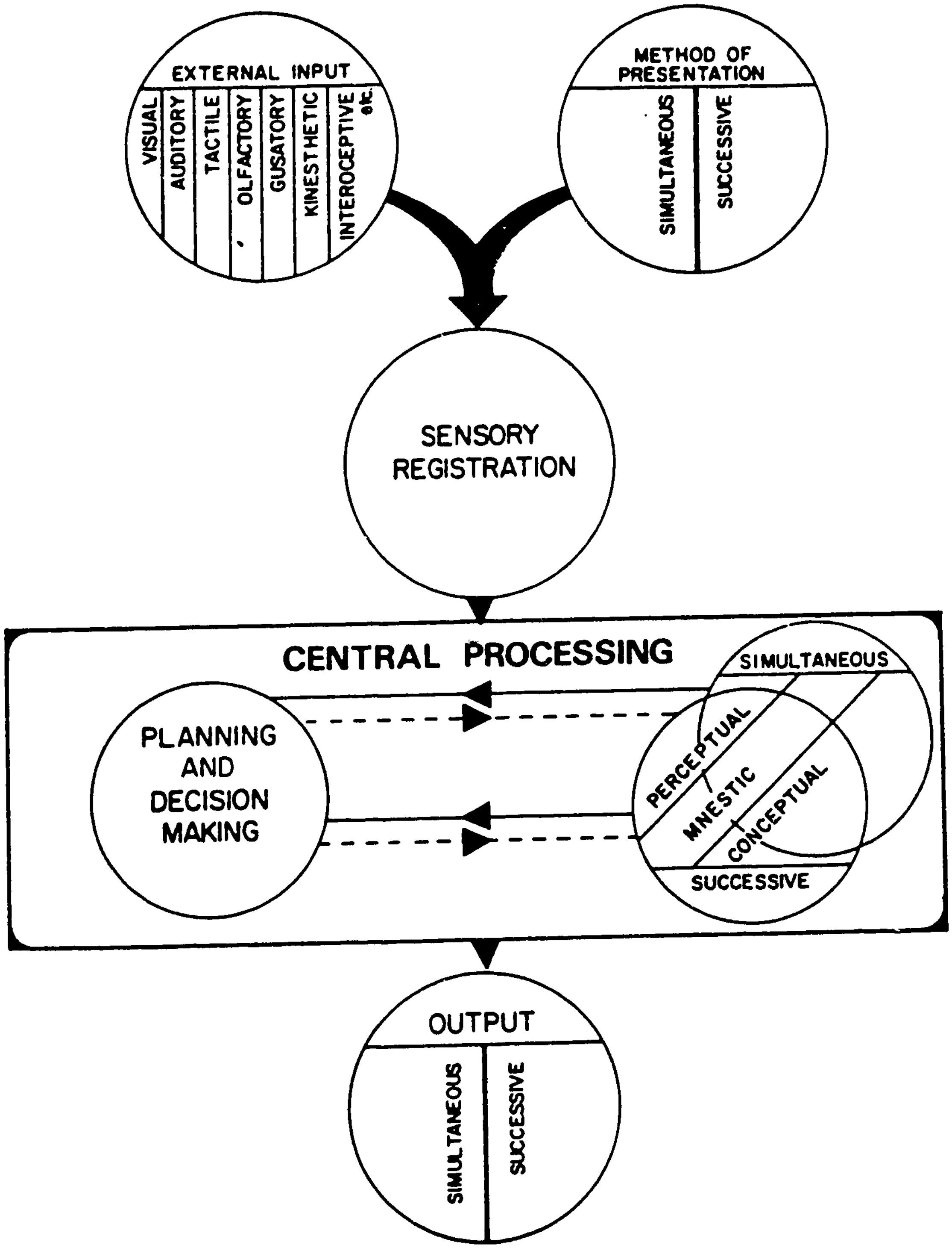


Figure 1. The Simultaneous, Successive and Planning Processing Model of Information Integration (From Das, Kirby & Jarman, 1975, P.81)

processing. Like the Cognitive Information Processing Model (the early model) the Information Integration model proposes four components: input, sensory register, central processor, and output. Sensory input may be presented through any of the sensory receptors. While input could be in a parallel or simultaneous dimension or in a sequential/ successive manner, the information input reaches the sensory register, which acts essentially as a buffer. It receives sensory information in the form initially coded by the sensory receptors and transmits the information to the central processing unit. This transition occurs in a serial fashion regardless of the mode or manner of stimulus presentation. The central processing unit is comprised of two major components which include simultaneous and successive processes and planning or the decision-making processes. In simultaneous processing, separate units of information are synthesized into a quasispatial relational organization. Successive processes synthesize separate units of information into a temporally organized sequence. Planning includes a variety of processes associated with the generation of plans or strategies, selection and execution of plans, as well as decision making and judgement.

Recently, the Information Integration Model has been modified to include attention or arousal and knowledge base (see Figure 2). Arousal, in Das' (1988) view, is manifested in attention, and is much more than the maintenance of wakefulness and the general energy level of mental activity. It may be the physiological label for a host of cognitive processes such as orienting response, expectancy and intentions which blend with the process of planning. Further, arousal interacts with learning and memory which are included in coding, in the acquisition of information, its analyses, syntheses, storage and retrieval.

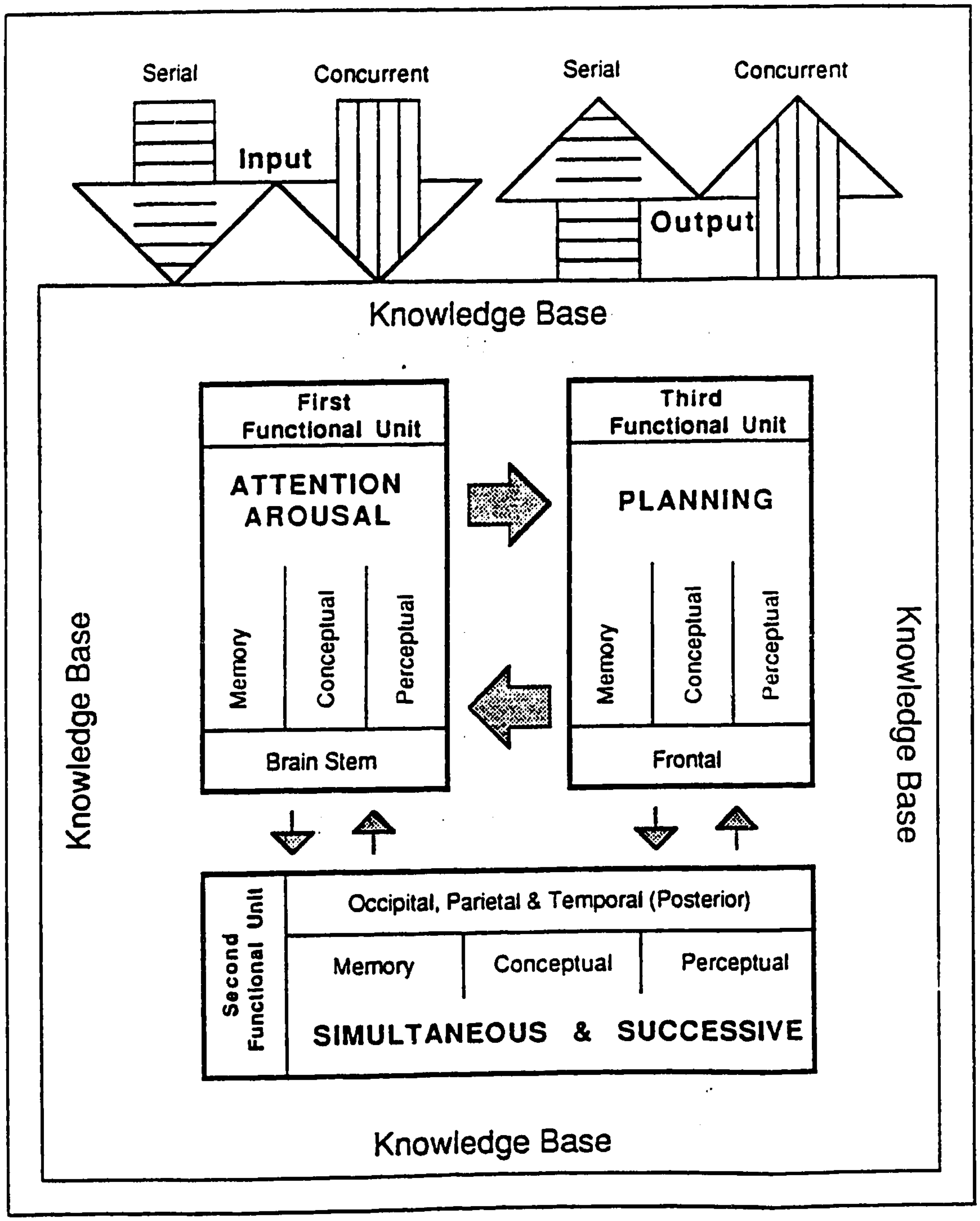


Figure 2. The Newer Version of Simultaneous, Successive and Planning Processing Model of Information Integration Showing Attention-Arousal and Knowledge Base (copyright held by Das & Naglieri, 1991 and reproduced with permission)

The knowledge base, on the other hand, is defined as "the sum total of a person's experiences, habits and predispositions, conscious or unconscious, must make up the knowledge base" (Das, 1988, p. 42), and it is dependent on instruction, experience and reflection on what has been acquired.

Some of the major factors that differentiate the Information Integration Model from the Cognitive Information Processing Models according to Das (1988) and Naglieri and Das (1987) include the following:

1. In the Information Integration Model, not all the information received by sensory register is automatically transmitted to the central processor. A complex interaction between states of arousal and attention, coding of information and planning (that is in Luria's three functional units) determine which information is transmitted by the sensory register to the central processing unit.
2. The two codings, simultaneous and successive processing hypothesized in he Information Integration Model, can occur at perceptual, memory, and conceptual levels. Simultaneous processing, for example copying a design such as a cube, is a simultaneous perceptual task; reproduction of the same figure from memory (memory for designs) requires memory as well as simultaneous processing. Solving matrices (e.g., Naglieri, 1985; Raven, 1956) is an example of a simultaneous conceptual task. Similarly in successive processing, following one line in a design of interwoven lines (Talland, 1965) is an example of a perceptual successive task. Digit span involves successive processing with memory, whereas appreciation of

syntax (such as "The house that Jack built was painted blue") involves successive processing at the conceptual level (Stutzman, 1986).

3. The processing tasks cut across the usual dichotomy associated with visual/auditory, memory/non-memory, and verbal/nonverbal hypothesized in research literature. Das, Kirby, and Jarman (1979) demonstrated that tasks involving different modalities such as auditory (WISC-R Digit Span) or visual (Visual short-term memory task), load on successive factors. Similarly, while the methods of presentation for Figure Copying and Memory for Designs tasks employed by Das et al. are different (since memory is not involved in Figure Copying), both tasks measure simultaneous processing.

4. In the Information Integration Model, the type of processing unit is not affected by either the mode or the manner in which the sensory information is originally received by the sensory receptor. The actual type of information process selected depends upon three factors: (a) the individual's preferred mode of processing (which is influenced by the individual's experience, socio-cultural, and genetic factors); (b) the task demands; and (c) the interaction between the preferred mode and the task demands. For example, a child who has memorized his or her addition facts using a number table may process a verbally presented addition problem simultaneously, examining a mnemonic number table and selecting the correct answer. A child who has learned addition facts through flashcard practice may, on the other hand, process the same addition problem

sequentially, sorting through serially ordered memory traces for the correct problem and answer.

5. The output unit of the Information Integration Model determines and systematizes the execution of response in accordance with task demands. Output can be simultaneous or successive in nature and is independent of input mode, manner of presentation, and manner of processing. A case to substantiate this occurs when we recall a series of words according to semantic categories. This requires simultaneous processing output, even though the words were presented successively. On the other hand, recalling he same list in correct serial order requires successive processing at output.

Information Integration Model, Past and Current Research

Earlier studies using the Information Integration Model have employed mainly factor analytic techniques to verify the model and to distinguish simultaneous-successive and planning processes (Ashman & Das, 1980; Das, 1973; Das & Heemsbergen, 1983; Das, Kirby, & Jarman, 1975, 1979). Recently, research has been concerned with detailing the interactions between different modes of processing and various cognitive behaviors relating to a variety of abilities, such as language, reading, writing, and arithmetic across age, IQ, cultural, and ethnic groups (Das,1988; Naglieri, 1989). Outcomes of selected studies will be summarized under this section.

1. Simultaneous-Successive processing and reading

Kirby and Das (1977) studied the correlation between simultaneous and successive processing, reading vocabulary, and reading comprehension using grade four students. They found that those subjects who were high on both modes of processing scored the highest on vocabulary and on comprehension, whereas those who were below median or low in both modes of processing scored the lowest. Those high in one coding process but low in the other had scores in between these extreme groups in reading subtests.

Simultaneous and successive processing roles in reading and other linguistic functions have also been shown to vary between groups of subjects who are at different developmental levels. For subjects who are at a higher levels of fluency in reading, simultaneous processing may be somewhat more relevant than successive processing. Cummins and Das (1978) examined possible correlations between scores in simultaneous and successive processing and decoding and reading comprehension using grade three students. They found that for those subjects who were at the top in simultaneous distribution, simultaneous processing correlated significantly with comprehension. This did happen, but not with subjects who were at the bottom half of the distribution. When scores in decoding were similarly divided into top and bottom halves of distribution, the relationship between decoding and simultaneous processing was not found. Cummins and Das viewed the results as further confirmation that simultaneous processing may be necessary for the development of more advanced levels of comprehension skills.

2. Reading, Spelling and Arithmetic

In the study of educable mentally retarded children (Cummins & Das (1978), the scores on simultaneous and successive processing factors were correlated with spelling, arithmetic, and oral reading subtests of the Wide Range Achievement Test. Results indicate that scores in successive processing factors correlated significantly with oral reading and spelling sub-tests, while simultaneous processing evidenced high correlation only with arithmetic subtests.

Garofalo (1983) gave a test of simultaneous-successive processing and planning to grade five students. Factor analyzing the simultaneous-successive processing and planning tasks, he found evidence of three clearly defined orthogonal factors. Garofalo then introduced mathematics abilities test scores into the factor analysis one at a time. The scores included problem solving and computation subtests. The results showed that problem solving has a loading of .51 on simultaneous factors, .31 on successive factors, and .28 on planning factors respectively. Subjects computation skills, another aspect of mathematical abilities, had the highest loading on planning factor (.56) and smaller loadings on simultaneous and successive factors (.34 and .22, respectively). This study appears to indicate that there are two distinct processes, simultaneous and planning, which correspond with the two mathematic abilities.

3. Comprehension and Inference

Macleod (1978) investigated the relationship between simultaneous and successive processing and inference in reading comprehension. The reading comprehension texts required that subjects initiate forward-looking and backward-looking inferences. Results suggest that high simultaneous groups, irrespective of their status in successive processing, produce significantly higher numbers of inferences supported by the texts. Successive processing was not found to contribute to reading comprehension. The outcome led the author to conclude that simultaneous processing is significantly related with reading comprehension.

4. CAS and Academic Achievement

Recently, Warrick (1990) investigated the relationship between the CAS Planning, Attention, Simultaneous and Successive (PASS) scores and the Mathematic Achievement scores using the Metropolitan Achievement Test (MAT). The sample include 208 elementary (Grade 3, 6) and high school (Grade 9) students. Results indicate that all four PASS processing scores correlated significantly (.67, $P < .001$) with the Math Concepts, Problem Solving, and Math Computation of the MAT. The total Math ability was, however, predicted best by the combination of Simultaneous and Attention scores. The unique aspect of this study is that for the first time the role of attention in predicting subtests of academic achievement is highlighted.

5. Developmental Trends

A study by Snart, Das, and Barriault (1987), which indicates a predictable improvement on all simultaneous-successive tasks as children's age increases, has been supported by other similar studies (Naglieri & Das, 1987). In the more detailed study by Naglieri and Das utilizing a sample of 434 students in grades 2, 6, and 10, the construct (developmental changes) and criterion related (correlations with achievement) planning and coding factors were examined. The achievement tests used were the Multilevel Academic Survey Test (MAST), reading and mathematics, respectively. Initial findings showed a significant increase in the raw scores on all planning and coding tasks with respect to increase in developmental age. However, while simultaneous and successive processing scores correlated approximately the same with the MAST total scores across the three age groups, the planning and coding correlations with total achievement as with reading and mathematics separately increased with age. Reading was found to relate with coding rather than planning at grade 2 and to become more integrated (involving both coding and planning) at grades 6 and 10. Mathematics achievement was found to relate with simultaneous and planning processes at grade 2 and was correlated with both forms of coding as well as planning at the older grades.

Practical Applications

Three practical applications of the Information Integration Model have been reported in research literature. Krywaniuk and Das (1976) report the success of using varieties of successive training tasks with grade 3 and 4 children from a school on a Canadian native reservation. All subjects were found to be doing poorly on language achievement tests, so they were divided into two groups--experimental and control. The experimental group received training in a variety of tasks and were compared with the control group not receiving any training. In contrast to the control group, the experimental group demonstrated significantly better performance on the successive tasks than on the simultaneous tasks in the post-test battery. The experimental group also showed distinct improvement in word recognition.

In another study, Kaufman (1978) used a remedial program based heavily on successive and some simultaneous strategy training with underachieving white Canadian children who were poor in both reading and arithmetic. When those in remedial training were compared with the control group which received no program of remediation, the treatment group improved not only in the cognitive tests but also in reading and arithmetic.

The third study reported by Brailsford (1982) divided severely reading disabled children into two groups, experimental and control. The experimental group received 15 hours of remedial training in both simultaneous and successive processing; the control group received the normal remedial training in resource rooms.

On the post-test scores, the severely reading disabled children in the experimental group made significant gains, in the two coding processes; the same gains were not found in the control group. Because the tasks emphasized simultaneous processing, there was a significant improvement in the experimental group's performance in reading comprehension.

Criticism of the CAS Model

Cowart and McCallum (1988) used the Multi-Trait-Multi-Method design to investigate the Simultaneous-Successive and Planning (S-S-P) model of the CAS. Their subjects included 120 underclassmen, average age 22.9 years and standard deviation of 5.4 years, attending a mid-sized southern university. Results failed to produce conclusive evidence of convergent or discriminant validity of the Simultaneous, Successive and Planning constructs. Cowart and McCallum, on the basis of this result, concluded that: (a) the Simultaneous, Successive and Planning constructs may be narrow and incapable of influencing problem-solving significantly, (b) evidence from their study suggests that the Simultaneous/Successive dichotomy may be confounded considerably by a verbal/visual influence, and (c) because the deficits in Simultaneous and/or Successive Processing in the CAS model are observable in people with specific organic damage to the cortex, the rationale for applying the same model to healthy or non-lessioned people is questionable. Consequently, the value of using intervention strategies based on identified strengths as described by the model and recommended by Kaufman and Kaufman (1983) and by Das et al. (1979) requires empirical investigation.

Naglieri and Das (1990) counter Cowart and McCallum's (1990) criticism by citing the following methodological errors and the wrongful assumption regarding the CAS model:

1. Cowart and McCallum's (1990) investigation involves analysis of two of the three functional units described by Luria and Das (1975, 1979); all three of Luria's functional units should be included in any test of the theory.
2. Administration of the Simultaneous, Successive and Planning constructs as in Cowart and McCallum's (1988) study in group format, is inconsistent with the research in this area. It is a complete departure from the typical individual administration that is well established. Such inconsistency is certain to confound Cowart and McCallum's (1990) results.
3. The selection of tasks such as the Simultaneous/Verbal (Orientation to Direction),Verbal/Planning (Verbal Fluency) and Nonverbal/Successive (Hand Movements) has not been shown to be a marker variable for the process intended by Cowart and McCallum (1990). The interpretation of results on this basis alone is questionable.

Das and Naglieri (1990) conclude that the purpose of the CAS model of research is to advance our understanding of the cognitive beyond what is available with tests such as the WISC-R and the K-ABC. The value of tests developed to measure the CAS processes is that they may better inform the psychologist about the intellectual status of a child than previous tests. It is not designed to instruct the teacher how to teach, as is implicitly assumed by Cowart and McCallum (1988).

Conclusions

In conclusion, the literature review and the available research data on the Information Integration Model indicates that the model has the potential to accommodate, relate, and explain certain elements of cognition, cultural, and specific academic skills (Das, 1988; Naglieri & Das, 1987). The model appears also to be sensitive to developmental changes as they affect the various cognitive processing abilities hypothesized (Naglieri & Das, 1987; Snart, Das & Barriault, 1987). In terms of practical application, the results of process training with native Canadian children living on a reservation, underachieving white Canadians, and severely reading disabled children suggest a positive trend (Krywaniuk, 1974; Krywaniuk & Das, 1976; Kaufman, 1978; Brailsford, 1981).

Additionally, the limitations already discussed inherent in the use of the Information Processing Model with the deaf contrast greatly with the positive results of using the Information Integration Model. There is a possibility that the assessment and remediation procedure using the latter model could prove useful to educators and psychologists serving the deaf population.

Objectives of the Study

Since the Information Integration Model has yet to be investigated in the deaf population, the four major objectives of this study are:

1. To examine the possibility of using the Cognitive Assessment System (CAS) based on the information integration model with the deaf to see if a more valid picture of their cognitive processing will emerge.
2. To investigate, by using the CAS, the possibility of a specific cognitive processing preference or specific processing deficits in the deaf.

3. To further investigate if the verbal/nonverbal, visual/auditory, memory/non-memory characteristics of the CAS's tasks have any effect on the cognitive processing ability of the deaf.
4. To examine the possible relationship in the deaf between certain cognitive processing factors of the CAS and specific academic skills such as reading comprehension, decoding, mathematics computation, and problem solving

Chapter IV

Rationale and Hypotheses

Rationale for Dependent and Independent Variables

Dependent Variables.

1. CAS tasks.

Earlier research studies on visual-spatial or auditory-temporal order processing have not clearly explained why deaf subjects may prefer one order of processing as opposed to the other. There is a suggestion that the linguistic load of tasks may have a significant effect on the processing preference of the deaf (Marlowe, 1989; Moores, 1982; Ottem, 1980).

CAS tasks were selected because all the marker tests cut across the usual dichotomy of visual and auditory, verbal and nonverbal, memory and non-memory hypothesized in the cognitive information processing research literature (Das, 1988; Naglieri & Das, 1987). The use of the CAS should reveal any possible effects of linguistic load influencing task processing. In addition, the CAS tasks includes the Attention and higher order planning factors. When these two factors are considered along with the simultaneous-successive marker tasks, a more valid picture regarding the nature of cognitive processing in the deaf and hearing population should emerge. The previous review also indicated that the CAS tasks have been related successfully with specific academic skills in reading comprehension, decoding, mathematics computation, and problem solving respectively (Cummins & Das, 1980; Cummins & Das, 1978; Garofolo, 1983). Moreover, since learning-related skills of the hearing impaired have never been satisfactorily predicted from psychometric test of intelligence (Levine, 1981), the selection of CAS tasks may be able to serve such a purpose.

2. Stanford Achievement Test (SAT)

An article by French (1987), although upholding the construct validity of the Stanford Achievement Test-Hearing Impaired (SAT-HI), did question the content and criterion-related validity. French criticized the Primary 2 level SAT-HI for its verbally dictated nature which may be a bias for deaf students in different communication environments such as oral as opposed to signing. French expressed concern about the language complexity of certain items, notably the Mathematics Concept subtests; he also questions the use of American orientation of some items (especially in the Social Sciences or Environment tests) with Canadian students.

Despite these criticisms, the SAT and SAT-HI, Seventh Edition, were selected as measures of academic-related skills for three reasons: First, the SAT-HI is the only available achievement test norm for the hearing impaired population (Trybus & Karchmer, 1977). The special procedures for use with hearing impaired students were developed in 1983 in conjunction with the norming of the Stanford using a national sample of the hearing impaired. While no test, answer sheet, or teacher instruction manual has been altered in any way during the norming processes, it has been strongly recommended that hearing impaired students take two short screening tests in reading and mathematics. This would help determine the appropriate level of SAT to administer from the various subtests contained in the six different difficulty levels of the SAT battery.

Second, the Center for Assessment and Demographic Studies (CADS) at Gallaudet University, after ten years' experience with the sixth edition of the SAT, considers some subtests to be appropriate for most hearing impaired students, since they are tied neither to curricula or auditory experience. The recommended subtests did not include environment and sciences. Consequently, the American-oriented items such as Environment and Sciences were not included in the subtests administered.

The third reason for selecting the SAT-HI for this study is that the recommended subtests include Reading Comprehension, Spelling/Decoding, and Mathematics Computation. These subtests are similar to subtests of specific academic skills that have been related with the CAS tasks in previous studies.

Independent Variables:

1. Age

Both deaf and hearing subjects were selected on the basis of age. Selection based on IQ scores was not considered because of the difficulty in matching deaf and hearing subjects on all three variables of IQ, academic attainment, and chronological age. The study as a result matched the subjects on two age sets, a younger and an older group of deaf and hearing subjects. In doing so, consideration was given to recent research evidence suggesting that the CAS cognitive functions in the younger and older subjects differ (Naglieri & Das, 1987; Snart, Das, & Barriault, 1987; Zwiebel, 1989). By including the younger and older age groups, a more valid picture underlying cognitive structure of the two groups may emerge.

2. Hearing Condition

The decision to use deaf and hearing groups was guided by the objective of this study, which is to investigate whether the CAS tasks can be used with the deaf as well as the hearing. Additionally, it will be interested to know if the performance of the deaf will differ from the performance of the hearing in the CAS tasks.

Hypotheses

On the basis of the previous discussion, the hypotheses to be investigated in this study include the following:

Performance on CAS Attention Tasks

Hypothesis 1

Because Attention Deficits or other neuropsychological dysfunctions have not been shown to be part of the profile of the deaf (Wolff, Radecke, Kammerer, & Gardner, 1989), it is hypothesized that there will be no significant difference between the deaf and hearing in Expressive and Receptive Attention CAS tasks.

Performance on Simultaneous and Successive CAS tasks

Hypothesis 2

2.1. If there is a verbal factor affecting simultaneous and successive processing ability of deaf subjects, then it is hypothesized that the deaf will achieve lower scores than the hearing on verbal simultaneous and successive processing tasks.

2.2. Alternatively, the deaf will achieve comparable scores with the hearing on nonverbal simultaneous and successive tasks.

2.3. If there is a specific processing deficit in successive processing due to loss of auditory experience in the deaf, then it is hypothesized that the deaf will achieve lower scores than hearing subjects in successive but not in simultaneous tasks.

Performance on Planning CAS tasks

Hypothesis 3

Deaf subjects will perform more poorly than hearing subjects in CAS Planning tasks.

Relationship between CAS tasks and Academic achievement

Hypothesis 4

The CAS tasks will predict academic-related skills in reading and mathematics of hearing subjects only but not for deaf subjects. This will be so if the CAS does not differ from Standard Psychometric IQ-type tests. However, if the CAS differs from Standard Psychometric IQ-type tests, then the relationship between scores on the subtest of the CAS tasks and specific academic skills in the SAT/SAT-HI will be established for hearing as well as deaf subjects.

Chapter V

Methodology

Subjects

Subjects selected for this study include the deaf and hearing. The difficulties in getting deaf subjects in Western [illegible] provincial schools for the deaf is a serious factor that limited the [illegible]. This is because the majority of deaf students attending these schools [illegible] handicapping conditions that significantly affect test performance. Another reason is that the degree of hearing loss in decibels (dB) varies among these deaf subjects which again made it difficult to obtain a larger pool of subjects who have similar hearing loss. The description of each group will be presented below.

The Deaf

After screening the population of deaf students who meet the required criteria, 28 males and 24 females attending the Sir Robert Williams School for the Deaf, Saskatoon, Saskatchewan, The Manitoba School for the Deaf, Winnipeg, and The Jericho Hill School for the Deaf, Vancouver, British Columbia participated in the study. All deaf subjects' audiograms showed a bilateral hearing loss ranging from severe to profound as defined by the American National Standard Institute (ANSI) (1969) and the International Standard Organization (ISO) (1964). Nine of these students attended special classes for the deaf, three were in a complete mainstreaming program, while two others were mainstreamed on a part -time basis. Subjects not in the residential programs maintained contact with the residential school students through socialization activities in sports, basic computer literacy, or other extra curricular activities. These non-residential deaf students were also fluent in the use of American Sign Language (ASL). Deaf students were further subdivided into two groups on the basis of age. The younger group ranged in age from 9 years to 10.5 years with a mean average age of 9.9 yrs. The older group ranged in age from 12 years to 15.4 years with a mean age of 13.7 years. Apart from the hearing loss reported for deaf subjects, no other handicapping conditions that could affect academic performance were identified among subjects. All deaf subjects used for this study covered the spectrum of socio-economic background and comprised a wide range of academic attainment.

The Hearing Subjects

Hearing subjects consisted of 36 males and 28 females students attending the D. S. Mackenzie Junior High School and the McKee Elementary School located in Edmonton, Alberta. The hearing students were also subdivided into two age groups. The younger group ranged in age from 8.7 years to 10.2 years with a mean average age of 9.4 yrs. The older group ranged in age from 12.7 years to 15.7 years with a mean average age of 13.7 yrs. The hearing subjects had no other handicapping conditions that could significantly affect academic performance. They also covered the spectrum of socio-economic background and comprised a wide range of academic attainment.

Instruments

Instruments used for this study include eight CAS tasks of Attention, Planning, Simultaneous and Successive Processing, in addition to The Stanford Achievement Test batteries (SAT). Each of the CAS tasks will be described below:

Expressive Attention

Description

The form of Stroop Color and Word Test (Stroop, 1935) was used. Initially this test was thought to measure cognitive flexibility and the ability of subject to shift perceptual set to conform to changing demands (Lezak, 1983). However, in the Das et al. (1975, 1979) Information Integration Model, it was used as a measure of Selective Attention. The test consists of three stimulus pages. The first consists of the words, red, green, yellow, and blue printed in black ink. The second consists of a series of rectangles printed in the colors red, yellow, green, and blue. The third, termed the "incongruent ink color names" consists of the same words printed on item one and item two. According to Wolff, Radecke, Kammerer, and Gardner (1989), this condition creates interference by requiring suppression of a natural tendency to read linguistic text. The competition of the color and the printed word provides the examiner an opportunity to assess the child's ability to focus attention on the critical variable, in this case, the color the word is printed in, and not the word itself.

Modification for Deaf subjects

Presentation of tasks to deaf subjects is through Total Communication which involves signing and speaking. The instruction "Read all the words Blue, Green, Red and Yellow" in Expressive Attention was replaced with common terms familiar to deaf students, such as "read" is replaced by the sign language word "Sign"

Scoring

1. There is a 3-minute time limit per item.
2. A correct check mark is placed in the box below the word if the child responds

correctly and a wrong check mark in the box below the word if the child responds incorrectly.

3. The number of check marks (correct responses) is added within each item and the total is entered in the space provided.
4. The time taken to complete each item is recorded.
5. If the child exceeds the time limit, record 3:01 on the Record Form.

Receptive Attention

Description

This is a marker test for Receptive Attention which appears in the Das and Naglieri (1989) CAS try out. The tasks required the subjects to find and underline pairs of pictures or pairs of letters that are the same on the basis of physical or a category/name match. For ages 5-7 years, subjects must underline picture pairs that match on the basis of physical appearance or on category match. For age 8 years and above, the child must underline pairs of letters that have the same Physical Match and the same Name Match.

Modification for the Deaf

All items were presented using Total Communication modality.

Scoring

Record the time taken to complete each item. If the child exceeds the time limit, record 2:01 on the Record Form.

Word Series

Description

This is a marker test for verbal successive processing which appears in the Das & Naglieri (1989) CAS try out. For this task, the examiner first says or signs names of common objects like "Book, Car, Key, Shoe, etc." The subject's task is to repeat a series of such names in the same order that the examiner says or signs them. The number of words per trial varies from two words to nine words in each series.

Modification for the Deaf

Total Communication is used through out the administration. The instruction for Word Series "I am going to say some words, listen carefully" was replaced with common terms familiar with deaf students, such as "say" was replaced by the sign language word for "sign" and "listen" was replaced by the sign word "watch". The examiner maintained perceptual eye contact with the subjects during the course o. the presentation, and would drop hands when the presentation was complete instead of looking down when reading the words or reducing voice, or looking up when the item presentation is complete as instructed in the manual.

Scoring

1. Record responses on the Record Form as follows: If the child says the correct word in the correct order, put a check mark in the box below the word. If the child says an incorrect word, write that word in the box under the correct word. If the child omits the last word(s), place a dash mark (-) in the box below the correct word. If the child adds words to the end of an item, write those words to the right of the last word.

2. Score Pass (1) for perfect recall; otherwise score Fail (0)

Color Ordering

Description

This is a marker test for nonverbal successive processing which appears in the Das & Naglieri (1989) CAS try out. The task required the child to turn color chips (one each of blue, white, olive yellow, black, gray, and orange) in the specific order demonstrated by the examiner. The chips were placed on a card in front of the child, and were always arranged in the sequence indicated on the card. Additional chips were added as the item difficulty increases.

Modification for the Deaf

All item were presented in a Total Communication .

Scoring

1. Self-corrections are permitted.
2. Record responses on the Record Form as follows:

   If correct, place a correct check mark in the box under the color.

   If incorrect, indicate the color turned.

   If the final color of a sequence is left out, insert (-) in the box

   If the child adds colors to the end of the series, write them at the end of the line.
3. Score Pass (1) or Fail (0). To receive a passing score on an item, the child must repeat the entire sequences exactly.

Simultaneous Verbal

Description

This is a verbal simultaneous processing task which appears in the Das & Naglieri (1989) CAS try out. It assesses the child's appreciation of logicalgrammatical relationships. In the tasks, the examiner describes a picture and then exposes the picture which has six options. The subject is then asked to choose which of the pictures correctly answers the questions. Either a verbal or a nonverbal response is accepted.

Modification for the deaf

In this tasks, words in the sentences that could easily reveal the answer were finger spelled instead of signing the exact word. For example, in the sentence such as "which picture shows the ball under the table?" and "which picture shows the triangle above the circle?", the words "under" and "above" were finger spelled, rather than put in sign words which could have provided a cue to the answer.

Scoring

1. Record the time taken to complete each item.
2. If the child exceeds the time limit, record 1.31 on the Record Form.
3. Record the child's response to each item, and score each as Pass (1) or Fail (0).

Figure memory

Description

Figure memory is a test of simultaneous nonverbal processing tasks derived from Graham and Kendall's (1960) original test of Memory For Design (MFD). This task requires the subjects to draw a geometric design that was exposed for five seconds when it is embedded within a more complex design. The task is made difficult by having more complex standards and response diagrams that contain additional lines and shapes embedded around the shape to be produced from memory. In the Naglieri and Das (1989) try out, each stimulus figure is exposed for 5 seconds and the child is then instructed to outline the stimulus figure within the more complex design presented on the response page.

Modification for the Deaf

Instruction for all items were presented in Total Communication.

Scoring

Score each item as Pass (1) or Fail (0). To receive a passing score on an item, the child's outline must be accurate and complete.

Planned Connections

Description

This test which also appears in the Das & Naglieri (1989) CAS try out is a nonverbal version of the verbal planning composition demonstrated to have a high loading on the factor identified by Ashman (1980) as Planning. There are two kinds of items in this subtest; those that include numbers only, and those that include numbers and letters. While the first items involve connecting the boxes that have numbers only, the second items involve connecting the boxes that have numbers and letters (1-A-2-B-3-C, etc.). For all the tasks, the subjects are required to use a regular pencil, and connect series of numbered boxes in correct numerical sequences as quickly as possible. The two items vary in the requirement of what is to be connected in the boxes.

Observed Strategies

During the administration of each Planning subtest, it is recommended that the examiner observe and record in the "Obs" column of the Record Form, the strategy or strategies the subject appears to be using. Place a check mark in the box(es) to indicate the particular strategies used. These strategies in the Record Form include whether or not the subjects engage in the following:

1. Repetition of alphabet/number series out aloud.
2. Repetition of alphabet/number series to self.
3. Remember last number or letter.
4. Looked back at last number or letter.

Reported Strategies

With the last item still exposed, say: Tell me how you did these (point to the page just completed by the child). If necessary, say: What way did you figure out to do these? Further clarification of the question in a brief manner is permitted provided no examples are given. Place a check mark in the box(es) to indicate the particular strategies used.

Scoring

1. Record the time taken to complete each item.
2. If the child exceeds the time limit, record 1:01 for Items 7, and 3:01 for Items 8-10.

Crack the Code.

Description

Crack the Code is a task similar to a strategy game, Master Mind, used in Das and Heemsbergen (1983). The subject is asked to determine the correct sequence of Colored Chips when given a limited amount of information. Chips of various colors are laid out in a predetermined sequences and the child is instructed to determine the correct sequence of the chips. During the trial, the child is told how many chips are in the correct position after each trial. As many as two trials are given for the three-chips items and as many as three trials are given for the four-chip items to help the child determine the correct sequence of the chips.

Observed and Reported Strategies

Record any observed behavior or any reported strategies similar with that of Planned connection tasks noted earlier.

Modification for the Deaf

All items were presented in Total Communication modality; however, Crack the Code sample instructions were modified as follows:

"Look at this page. You see there is a black circle here and a blue one here, but these colors are not in the correct places." You are to figure out which color goes where. "Put these here in the correct order".

On the initial try out, every part of the above instructions appear clear except when the sentence, "Put these here in the correct order" is signed. Deaf students will ask back, "You mean I should reverse the order in the correct places?" Other deaf subjects simply ask, "Reverse Right ?" As a result, when the request "Put these here in the correct order" is signed and subjects looked perplexed in the sample section, the examiner would add "reverse the order in the correct places."

Scoring

1. Record the time taken to complete each item.
2. Score each item as 1 if the correct answer is reached or 0 if the answer is incorrect.

Stanford Achievement Test (SAT)

The Stanford Achievement Test, Seventh Edition, was published in 1982. It contains six difficulty levels with corresponding grade levels for use with hearing children. The levels and grades include the following:

Level	Grade
Primary 1	1.5-2.9
Primary 2	2.5 -3.9
Primary 3	3.5 -4.9
Intermediate 1	4.5-7.9
Intermediate 2	5.5-7.9
Advanced	7.0 -9.9

The following subtests were used since they are neither tied to curricula or auditory experience as recommended in the 1982 adapted guideline by the Gallaudet University Center for Assessment and Demographic studies.

1. Reading Comprehension , All levels.
2. Math Computation, All levels.
3. Spelling, all levels
4. Math Applications, administered on the level of screening test.

Procedure

Permission to conduct the study within the Edmonton Public School System was obtained from the Edmonton Public School Board through the Cooperative Activities program of the University of Alberta, following the Department of Educational Psychology's Ethics Review committee approval.

The principals of the two schools (Mckee Elementary School and D. S. Mackenzie Junior High School) were then approached following the approval. A parental consent letter (see appendix) including a short description of the research and its implications was sent out to parents/guardians. Only students with an approved parent/guardian consent form were allowed to participate in the study.

These procedures differ some what from the three Western Canadian provincial deaf schools that include The Jericho Hill School for the Deaf, B.C, Vancouver, The Sir Robert William School for the Deaf, Saskatoon, Saskatchewan and the Manitoba School for the Deaf, Winnipeg, Manitoba. Request to conduct this study following the Ethics Review committees' approval was made directly to respective principals outlining the research objectives and implications. Following the approval from the school principals, a consent letter including a short description of the research and its implication was sent out to parents or guardians. It is only those students whose parents' or guardian gave consent that were allowed to participate in the study.

For the hearing regular school students, a hearing research assistant familiar and knowledgeable in the administration of the CAS was hired to administer all tasks. For the deaf subjects, the author who is familiar with Sign Language, used the manual coded language form to administer the CAS individually.

Conditions and duration of testing

All CAS tasks were administered individually in one and a half hours to deaf and hearing subjects in the following order:

1. Crack the Code
2. Planned Connections
3. Simultaneous Verbal
4. Figure Memory
5. Word Series
6. Colour Ordering
7. Expressive Attention

8. Receptive Attention

The location was a quiet room with adequate lighting and ventilation. The examiner and the child were seated comfortably at a table, while the examiner positioned himself in a manner that permitted full view of the child's responses and test taking conditions. The examiners made sure that adequate rapport was initiated and maintained throughout the testing session. The younger children were told initially about the nature of the test and were further told that some of the tasks are easy, whereas others were more difficult . The older children were provided with a brief explanation of the nature of the test and the purpose. Both groups were encouraged to do their best on all items.

The Stanford Achievement Test (SAT) was administered to hearing students in a group setting within two weeks following CAS tasks test. All hearing students were assigned to the SAT level on the basis of grade. For the hearing sample, Primary 2 was administered to elementary grade 4 and Intermediate 2 was similarly administered to the junior high school grade 8. Administration of the SAT follows the procedure outline in the administrative manual through an active cooperation of the researcher, the classroom teacher and the school principal.

The procedure for administering the SAT-HI to deaf students differed from that of the regular hearing school students. First, some deaf students had taken the SAT-HI just five or six months prior to the period of data collection. In that case, results of such tests were obtained from the student's file and retained.

Other deaf students who did not take the SAT-HI test at all or who had taken the SAT-HI within the past 9 to 12 months were administered the screening mathematics and reading test to determine their appropriate placement level. For deaf students who had taken this test before, and their screening tests results did not suggest that their present level of test placement differed from their earlier level, then the earlier SAT-HI test results were taken from the school files and retained.

However, if their screening results indicated that their present level SAT-HI placement differed from the earlier level, then they rewrote the SAT-HI level tests. On the basis of this consideration, 20 subjects that made up about 37 percent of all deaf subjects, were not administered the SAT-HI. Their original scores were retained.

The second reason for using different procedures with deaf subjects is that the SAT-HI did not consider subjects' age or grade. Instead, subjects were assigned a possible level on the basis of performance on the screening tests.
Deaf subjects were as a result, regrouped on the basis of SAT-HI level scores, rather than their original age grouping. Each groups of deaf students who were administered the SAT-HI took the test two days after the CAS tasks, through the assistance of either a regular classroom teacher, an interpreter or a deaf signer. All test administrators were familiar with the American Sign Language. The procedure outlined in the administrative manual as it effects deaf subjects by the office of Gallaudet University Demographic Studies (ODS) in the 1982 adaptive manual was followed.

Chapter VI

Results

The Nature of Statistical Analysis

The data analysis procedure was shaped by the subject groups and the nature of the research questions and hypotheses. Initially, a 2X2 Multivariate Analysis of Variance (MANOVA) was used to test the overall statistical significance differences between the deaf and hearing subjects' performance on Attention, Simultaneous, and Planning CAS tasks. The University of Alberta variation of the SPSSx MANOVA gives multivariate and univariate results. The advantage of the MANOVA procedure is its ability to reveal the two main effects (age and hearing conditions) separately and the interaction effects between age and condition where applicable. Since the comparison is between four groups of subjects, the MANOVA can guard against a type 1 error which is a good possibility. This would be preferred to a simple four group comparison on CAS tasks. A type 1 error involves accepting marginal differences between the groups as true differences when in fact the differences may not be significant using MANOVA, which is more rigorous than a one way ANOVA. Other statistical tests used include the Pearson Product Moment Correlations (r)and the Multiple Regression Analysis. The Pearson (r) should establish possible relationship between CAS tasks and SAT/SAT-HI, while the Multiple Regression Analysis would determine the amount of variance in SAT/SAT-HI criterion variable that is predictable from one subtest or combined subtest of CAS tasks used as a predictor variable.

The organization of this chapter will be presented under three headings.

The first section will present the descriptive statistics for Attention, Simultaneous, and Planning CAS tasks. The second section will summarize the results of the Multivariate Analysis of Variance (MANOVA) and the Univariate Analysis of Variance (ANOVA) for the performance of the deaf and hearing groups in Attention, Simultaneous, Successive, and Planning CAS tasks. The third section will detail the results of the relationship between the CAS tasks and the subtests of academic skills. This section will also present the results of and a discussion about which CAS tasks act as potential best predictors of academic subskills.

Section 1

Descriptive Statistics

The mean and standard deviation for the Stroop test used as a measure of Expressive Attention for the four groups is shown in Table 1. The mean and standard deviation were computed separately for the Stroop Word, Color, and combined Color and Word. The means for the combined Stroop Word scores range from 38.95 to 39.98 with standard deviations ranging from .15 to 2.41. For the Stroop Color, the mean scores range from 39.43 to 39.95 with standard deviations ranging from 1.60 to 4.43. The mean scores for the combined Stroop Color and Word range from 37.10 to 39.30 with standard deviations ranging from .22 to 2.69. Given that the maximum raw scores expected for the Stroop Word, Color, and Color-Word combined was 40, the mean score differences among the four groups is minimal. The presentation of the mean raw scores for the Stroop tasks is followed with the means and standard deviations of time taken in seconds to complete each of the Stroop tasks. As shown also in Table 1, the mean of time in seconds taken to complete the Stroop Word tasks ranges from 16.40 seconds to

TABLE 1

Means and Standard Deviations of Stroop Tests for Younger Deaf, Younger Hearing, Older Deaf, and Older Hearing Samples

Variable	(N=21) Younger Deaf		(N = 20) Younger Hearing		(N =43) Older Deaf		(N=30) Older Hearing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stroop Word Correct Score	39.10	2.41	38.95	.22	39.87	.51	39.98	.15
Stroop Word Score in secs.	34.00	6.16	22.45	4.86	32.33	12.76	16.40	2.75
Strrop Color Correct Score	39.95	.22	39.50	2.69	39.43	1.57	39.91	.37
Stroop Color Score in secs	44.76	9.57	36.00	10.69	38.97	14.00	26.02	9.68
Stroop Color-Word Correct Score	37.10	4.43	37.90	2.69	38.97	1.99	39.30	1.60
Stroop Color-Word Score in secs	78.91	25.04	69.80	20.19	59.03	16.07	45.14	9.11

34 seconds with standard deviation ranging from 2.75 seconds to 12.76 seconds. For the Stroop Color, the mean of time seconds range from 26.02 seconds to 44.76 seconds with standard deviation ranging from 9.57 seconds to 14 seconds.
The mean in seconds required to complete the combined Color and Word Stroop tasks range from 45.14 seconds to 78.91 seconds with standard deviation ranging from 9.11 seconds to 25.04 seconds. The observed variation in the means and standard deviation of time in seconds required to complete the Stroop Expressive Attention tasks for the four groups will be used for further statistical analysis. In Table 2, the mean and standard deviation for the two Posner tasks used as a measure of Receptive Attention are recorded. Initially, this involved the computation of the means and standard deviation of raw scores for Physical Match and Name Match for the four groups. The mean and standard deviation of raw scores for Physical Match and Name Match are first computed. In the Physical Match tasks, the means range from 43.24 to 48.07 with standard deviations ranging from 2.11 to 6.02. For the Name Match tasks, the means and standard deviations range from 23.45 to 32.58 with standard deviation ranging from 5.17 to 5.99. The next step was the computation of the means and standard deviations of time taken in seconds to complete the Physical Match and Name Match tasks separately for each of the four groups. The mean times required to complete the Physical Match tasks range from 93.05 seconds to 118.86 seconds for the four groups, with standard deviations ranging from 3.76 seconds to 13.32 seconds. For the Name Match tasks, the mean times required vary from 119.42 seconds to 121 seconds with standard deviations ranging from zero seconds to 7.79 seconds. This step was followed by the presentation of the means and standard deviations of the ratio for

TABLE 2

Means and Standard Deviations of Posner Test for Younger Deaf, Younger Hearing, Older Deaf, and Older Hearing Sample

	(N =21) Younger Deaf		(N =20) Younger Hearing		(N =30) Older Deaf		(N =43) Older Hearing	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Phy.Match Correct Score	43.24	6.02	43.85	4.84	47.33	3.08	48.07	2.11
Phy. Match Time in secs.	118.86	3.76	111.05	12.58	103.73	13.32	93.05	12.78
Phy. Match Ratio	.37	.06	.40	.09	.46	.10	.47	.08
Name Match Correct Score	26.29	5.55	23.45	5.17	31.57	5.23	32.58	5.99
Name Match Time in secs	121.00	.00	121.00	.00	120.70	7.79	119.42	6.62
Name Match Ratio	.22	.05	.19	.04	.26	.05	.27	.05

Receptive Attention Physical Match and Receptive Attention Name Match, respectively. These ratios were obtained by dividing the raw score by the time in seconds: As shown in Table 2, the means for the Physical Match ratio for the four groups range from .37 to .47 with standard deviation ranging from .06 to .10. For the Name Match ratio, the mean ranges from .19 to .27 with standard deviations ranging from .04 to .05. The means and standard deviations ratio for Physical Match and Name Match appear too low. Since further statistical analysis will be based on the mean ratio for the Physical Match and Name Match, it is expected too that the means error squared should be similarly low (see Table 10). In Table 3, the means and standard deviations for the two simultaneous processing tasks involving Simultaneous Verbal and Figure Memory and two successive processing tasks that include Word Series and Color Ordering are reported. The mean scores for the four groups in Simultaneous Verbal range from 11.29 to 17.77 with standard deviations ranging from 2.18 to 3.85. The means for Figure Memory range from 8.95 to 13.91, with standard deviations ranging from 2.15 to 4.05. For Word Series, the mean scores range from 6.07 to 11.44, with standard deviations ranging from 2.37 to 2.87, while the means for Color Ordering range from 9.60 to 13, with standard deviations ranging from 2.21 to 3.22. The means and standard deviations for the Planning tasks are given in Table 4. This includes Crack the Code tasks and the two Planned Connection tasks. For Crack the Code items, the means and standard deviations of raw scores were first computed; the means ranged from .95 to 2.79 and the standard deviations ranged from 1.05 to 1.52. Considering that the maximum score is 6, it would appear from the distribution of scores for the Crack the Code that the tasks were too difficult for all subjects to handle. Nevertheless,

TABLE 3

Means and Standard Deviations of four Simultaneous-Successive Tests scores for Younger Deaf, Younger Hearing, Older Deaf, and Older Hearing Samples

Variable	(N =21) Younger Deaf		(N = 20) Younger Hearing		(N = 30) Older Deaf		(N = 43) Older Hearing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Simultaneous Verbal	11.29	3.74	15.65	2.18	12.00	3.85	17.77	2.79
Figure Memory	11.29	3.47	8.95	2.65	12.43	4.03	13.91	4.05
Word Series	6.67	2.54	9.50	2.50	6.07	2.37	11.44	2.87
Color Ordering	10.71	2.74	9.60	2.21	11.53	3.22	13.00	2.27

TABLE 4

Means and Standard Deviations of Planning Tests for the Younger Deaf, Younger Hearing, Older Deaf, and Older Hearing Samples

	(N =21) Younger Deaf		(N = 20) Younger Hearing		(N =30) Older Deaf		(N = 43) Older Hearing	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Crack the Code	.95	1.28	1.60	1.05	1.33	1.42	2.79	1.52
Plan Con. Numbers Score	40.19	2.14	40.95	.22	40.77	.50	40.84	.62
Plan Con. Numbers time in secs	96.91	24.38	66.95	19.21	68.97	20.99	43.02	10.40
Plan Con. Num & Letters Score	37.05	8.26	41.55	.10	38.63	6.50	41.00	2.88
Plan Con. Num & Letters Time in secs.	177.05	65.57	138.70	45.10	116.40	38.06	80.77	23.94

the data seems to yield a very good estimate of variance compared to the means. The mean raw scores for the Planned Connection Numbers range from 40.19 to 40.95 with standard deviation ranges from .22 to 2.14; the raw scores for the Planned Connection Numbers and Letters range from 37.05 to 41.55 with standard deviations ranging from .10 to 8.26. Since the maximum scores for Planned Connection Number is 41 and the maximum score for Planned Connection Numbers and Letters is 42, the means and standard deviations distribution for the four groups' performance in these tasks do not appear to show much difference. The next step is to present the means and standard deviations of time taken in seconds to complete the two Planned Connection tasks. As shown in Table 4, the mean scores of time in seconds taken to complete the Planned Connection Number tasks range from 43.02 seconds to 96.91 seconds, with standard deviation ranging from .22 seconds to 2.14 seconds. For Planned Connection Numbers and Letters, the mean scores of time taken in seconds range from 80.77 seconds to 177.05 seconds, with standard deviations ranging from 23.94 seconds to 65.57 seconds. As a result of this larger variation in the means and standard deviations of time required to complete the two Planned Connection tasks, further statistical analysis will be based on the mean and standard deviation of the required time.

Section II

MANOVA and Univariate Statistics

The mean for Expressive Attention time, Receptive Attention Ratio, Simultaneous and Successive scores, Crack the Code raw scores, and time scores for the Planned Connection tasks for the four groups were compared using a 2X2 MANOVA. The results as reported in Table 5, indicate a significant main effect for age based on

Table 5

Summary of 2X2 MANOVA Showing Effects of Age(A), Hearing Conditions (B) and Interaction (AXB) on All CAS Tasks Based on Wilk's Lambda Value

Source	DF	F	P
Age (A)	12	7.478	<.001
Hearing Condition (B)	12	23.347	<.001
Interactions (AXB)	12	1.86	< .05
Error	99		

Wilks Lambda test of significance (F= 7.478, P<.001) and a significant conditions effect for (F= 23.347, P<.001). The interaction effect was also significant (F=1.86, P< .05). The significant main effect suggests that there exist certain degrees of differences between the two age groups (younger and older) and the two hearing conditions (deaf and hearing) in performance on the CAS tasks. The significant interaction also suggests that the effects of age and hearing conditions on performance with respect to CAS tasks taken jointly at a younger age re not necessarily the same at the older age level. In order to understand on ... of the CAS tasks the subjects showed performance differences and at what level, the univariate "F" statistics of the same MANOVA were examined separately for the Attention, Simultaneous, Successive, and Planning tasks. The subsequent section presents these results.

<u>CAS Attention Tasks</u>

This section considers the results for the Stroop tests used as a measure of Expressive Attention and the Posner tests used as a measure of Receptive Attention, respectively. The univariate "F" statistics presented in Table 6 suggest a significant main effect for age in the Stroop Word time (F=6.81, P< .01), Stroop Color time (F=13.02, P<.01) and Stroop Color-Word time (F= 45.26, P<. 01). There was also a significant main effect for hearing conditions in the Stroop Word time (F=86.27, P<.01), Stroop Color time (F=24.67, P< .01) and Stroop Color-Word time (F=12.07, P< .01). The interaction effects for the Stroop Word time, Stroop Color time and combined Stroop Color-Word time were not significant. The group mean performance on the three Expressive Stroop Attention tasks depicted graphically in Figures 3a, 3b and 3c provide a clear meaning for the significant

Table 6

A Summary of Univariate " F " Statistics Showing the Effects of Age (A), Hearing Conditions (B) and Interaction (AxB) on the Stroop Test

	Stroop Word Time			Stroop Color Time			Stroop Color-Word Time		
Source	DF	MS	F Ratio	DF	MS	F Ratio	DF	MS	F Ratio
Age (A)	1	386.61	6.81**	1	1613.11	13.02**	1	12859.82	45.26**
Hearing Conditions (B)	1	4899.80	86.27**	1	3055.10	24.67**	1	3429.99	12.07**
Interactions (AxB)	1	124.86	2.20	1	113.39	<1	1	148.73	<1
Error	110	56.80		110	123.91		110	284.16	

*P < .05
** P < .01

Figure 3a Means of Stroop Word for the four groups

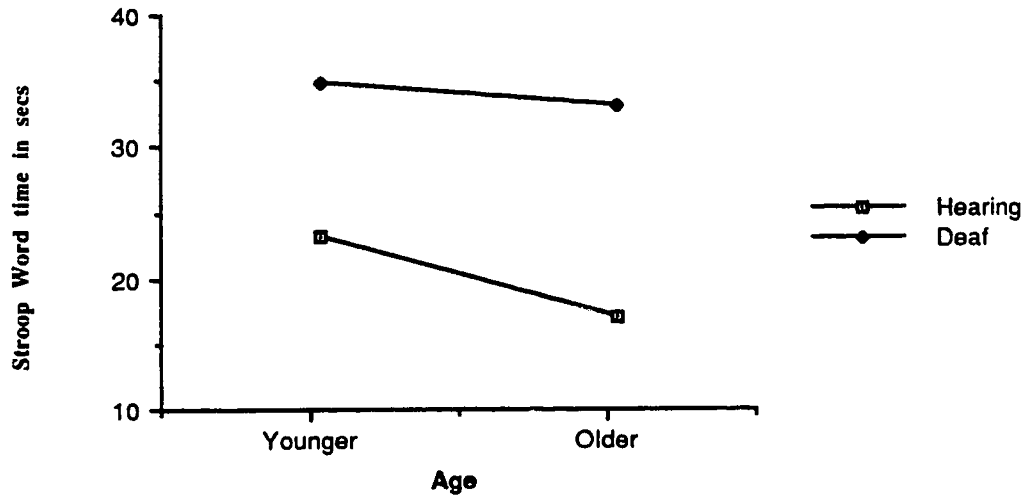


Figure 3b Means of Stroop Color for the four groups

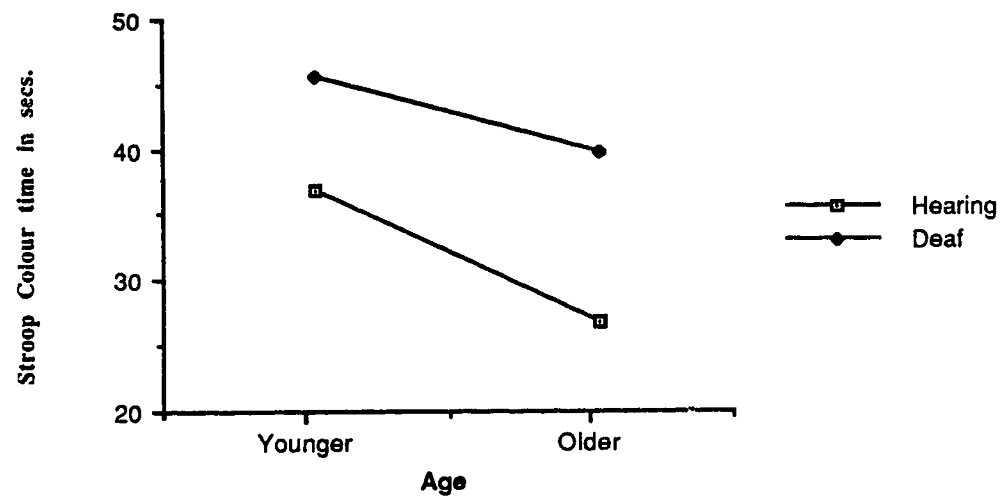
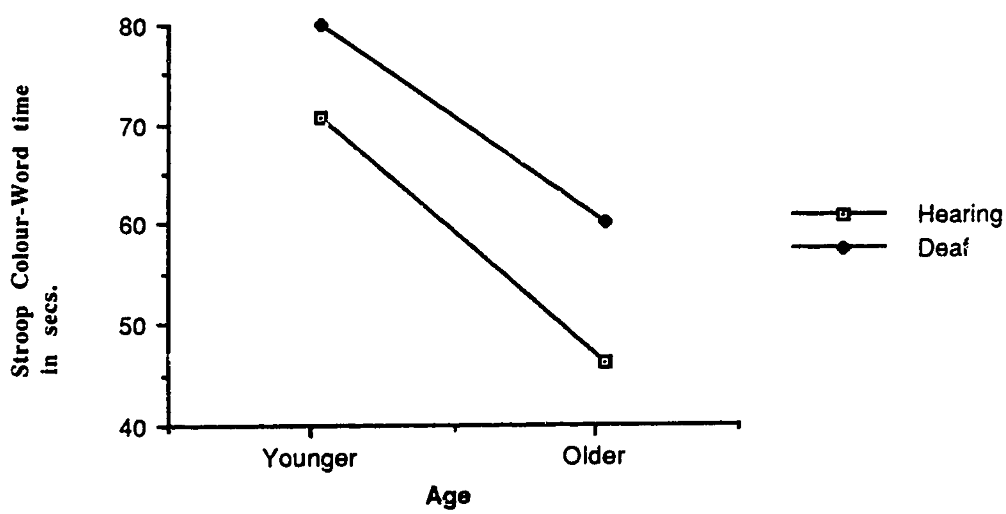


Figure 3c Means of Stroop Color-Word for the four groups



main age and hearing condition effects. In all three tasks, the rate of naming by hearing groups was faster than the rate of signing by deaf groups. Whether this difference was due to greater susceptibility of signing to interlingual interference as opposed to the intended intralingual interference was examined by performing a One Way Analysis of Variance (ANOVA) for the four groups. Interlingual interference is an important factor to consider here because the deaf subjects were expected to give a sign language response to an English stimulus. This implies that two languages are involved for the deaf groups as compared with one language for the hearing groups. Before performing the ANOVA, the interference ratio was first computed using the formula I = CW-(CxW)/(C+W) derived from Golden (1978) and Wolff, Radecke, Kammerer and Gardner (1989). C stands for the raw scores for Color time, W stands for the raw score for Word time, and CW stands for the raw score for Color-Word time. The formula index has been found to be theoretically invariant as a function of overall motor speed. This was interpreted to mean that higher scores reflected less susceptibility to interference while lower scores reflected the opposite. For this present sample, it will be assumed that higher scores by deaf subjects compared with hearing subjects of similar age reflect the factor of intralingual interference; otherwise the reverse should be true.

Table 7 presents the means and standard deviations of the interference measure for the four groups. The table also shows the results of the ANOVA "F" statistics comparing the group mean score on interference ratio. The results reveal a significant interference effect ($F=15.31$, $P<.001$) for the four groups. Multiple comparisons using the Scheffe (1959) method were utilized to determine the specific differences between each of the four groups. The results in Table 8

Table 7

Summary of Analysis of Variance (ANOVA) on Stroop Interference Ratio*

Groups	Sample size	Mean	SD	DF	MS(between)	MS(error)	F ratio
Younger Hearing	20	56.10	17.86				
Older Hearing	43	35.29	8.30	3,110	3815.95	249.32	15.31***
Younger Deaf	21	59.74	23.75				
Older Deaf	30	41.51	15.75				

*Intereference=(Color & Word) - (Color x Word)/(Color + Word)
***P < .001

Table 8

Scheffe Multiple Comparison for all Groups

Groups Compared	Level of Significance
Younger hearing versus older hearing	$P < .05$
Younger hearing versus younger deaf	NS
Younger hearing versus older deaf	$P < .05$
Older hearing versus younger deaf	$P < .05$
Older hearing versus older deaf	NS
Younger deaf versus older deaf	$P < .05$

indicate significant differences across the two ages ($p<.05$) but not across hearing conditions. In other words, the younger the subjects, whether the subject is deaf or hearing, the greater the susceptibility to interference. The hearing conditions were not a factor since no significant differences were found between the younger deaf and the younger hearing or the older deaf and the older hearing ($P> .05$) in a measure of interference.

The results of the Posner tasks used as a measure of Receptive Attention are given in Table 9. There was a significant main effect for the two age groups (old and young) in the Physical Match tasks ($F=55.06$, $P< .001$) and Name Match tasks ($F=44.20$, $P< .001$). The main effect for hearing conditions was significant only for the Physical Match tasks ($F=10.97$, $P< .001$), but not for the Name Match tasks. The interaction effects for both Physical Match and Name Match were not significant. To facilitate interpretation, the mean performance comparing the four groups in Physical Match and Name Match are depicted graphically in Figures 4a and 4b. The means suggest that there were no differences in performance between deaf and hearing subjects of similar age groups.

Table 9

A Summary of Univariate "F" Statistics Showing the Effects of Age (A), Hearing Conditions (B) and Interaction (AxB) on the Posner Test

	Physical Match Ratio			Name Match Ratio		
Source	DF	MS(error)	F Ratio	DF	MS(error)	F Ratio
Age (A)	1	.33	55.06***	1	.10	44.20***
Hearing Conditions (B)	1	.07	10.97***	1	.001	<1
Interactions (AxB)	1	.003	<1	1	.01	3.10
Error	110	.006		110	.002	

*P < .05
**P < .01
***P < .001

Figure 4a Means of CAS Posner Receptive tasks for the four groups

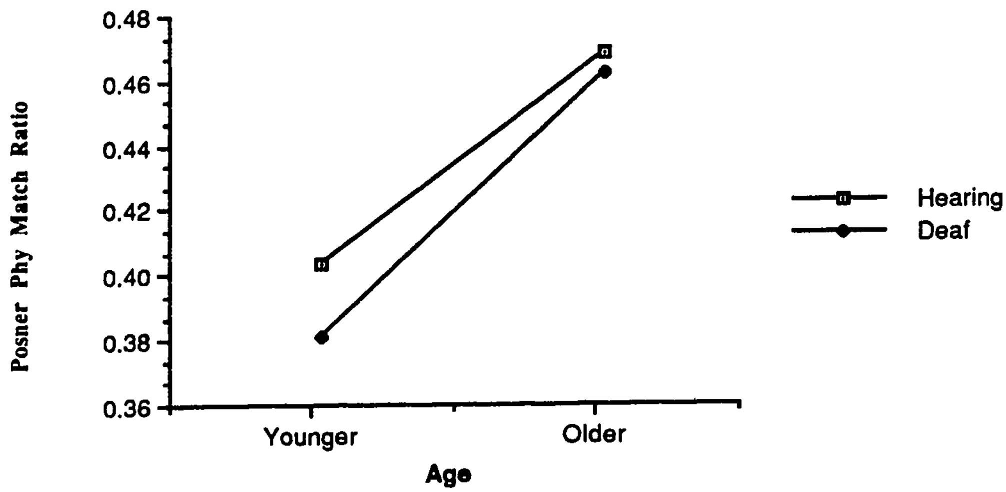
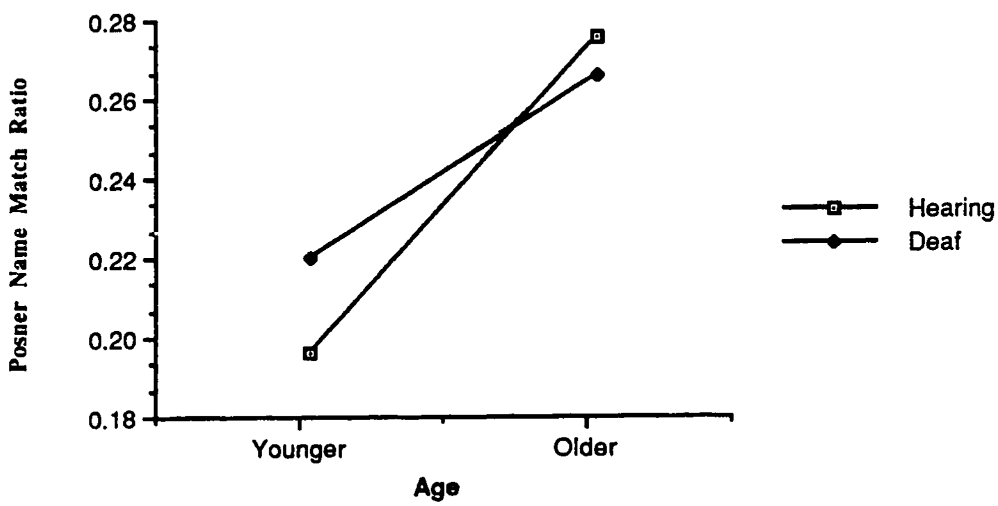


Figure 4b Means of CAS Name Match for the four groups



In conclusion, these results have shown that the rate of naming Expressive Attention tasks by hearing groups is faster than the rate of signing by the deaf groups. Furthermore, the younger the subjects, the greater the susceptibility to interference effects in naming or signing the Stroop Expressive Attention tasks. The results failed to reveal the effects of intralingual interference in the Stroop tasks even though deaf subjects gave a sign language response to an English stimulus.

For the Receptive Attention, there appear to be no differences between the deaf and hearing groups of similar age. If the only observed differences between the deaf and hearing groups' performances in Attention tasks can be assigned to the rapid rate of using spoken language as opposed to the reduced rate of using sign language in the Stroop Expressive Attention tasks, then it can be concluded that Attention or neuropsychological deficits cannot be considered part of the present deaf groups: In that sense Hypothesis 1, stating that there will be no significant differences between the deaf and hearing in the CAS Attention tasks is as a result supported.

CAS Simultaneous and Successive Tasks

There were two simultaneous tasks which included Simultaneous Verbal, a verbal task, and Figure Memory, a nonverbal task. Word Series, a verbal task, and Color Ordering, a nonverbal task, made up the successive processing tasks.

The univariate "F" statistics testing the significant differences between group means for each of these tasks are shown in Table 10. The first test to consider is the Simultaneous Verbal, which shows a significant main effect for age ($F=5.07$, $P< .05$) and hearing conditions ($F=64.89$, $P< .001$). The interaction effect was not significant. The significant main effects for age and hearing conditions was in This

Table 10

A Summary of Univariate "F" Statistics Showing the Effects of Age (A), Hearing Conditions (B) and Interaction (AxB) on Simultaneous & Successive Tests

	Simultaneous Tests						Successive Tests					
	Simultaneous Verbal			Figure Memory			Word Series			Color Ordering		
Source	DF	MS	F Ratio	DF	MS	F Ratio	DF	MS	F Ratio	DF	MS	F Ratio
Age (A)	1	51.99	5.07*	1	241.66	17.33***	1	11.68	1.70	1	115.43	16.70***
Hearing Conditions (B)	1	665.67	64.89***	1	4.82	<1	1	436.94	63.73***	1	0.80	<1
Interactions (AxB)	1	12.77	1.25	1	94.10	6.75**	1	41.90	6.11*	1	43.20	6.25**
Error	110	10.26		110	13.95		110	6.86		110	6.91	

* F < .05
** P < .01
*** P < .001

favor of the hearing groups, as can be seen from Table 3. Overall, the means show that the younger and older hearing groups scored higher than the younger and older deaf groups in the Simultaneous Verbal tasks.

The second test, Figure Memory, revealed a significant main effect for age (F=17.33, P< .001) but not for hearing conditions. The interaction effects were significant (F=6.75, P< .01). The mean performance of the four groups in Figure Memory tasks is depicted graphically in Figure 5a. It is apparent from this figure that at the younger level, the performance of the deaf is superior to the hearing groups. This trend is reversed at the older level since the hearing groups were instead found to be ahead of the deaf groups.

The third test, Word Series, also shows a significant main effect for hearing conditions (F=63.73, P< .001) but not a significant main effect for age. The interaction effects were significant (F=6.11, P< .05). The mean performance comparing the four groups is represented graphically in Figure 5b. The figure suggests that the performance of the hearing groups is better than that of the deaf groups. The difference in performance in favor of the hearing groups as shown in this figure, is far greater at the older age than at the younger age.

The final CAS test to consider under this section is the Color Ordering, which also revealed a significant main effect for age (F=16.70, P<.001) but not a significant main effect for hearing conditions. The interaction effect is, however, significant (F=6.25, P< .01); the mean performance for the four groups is depicted graphically in Figure 5c. This figure suggests that the performance of the younger deaf is better than the performance of the younger hearing. At the older level, the

Figure 5a. Means of CAS Figure Memory tasks for the four groups

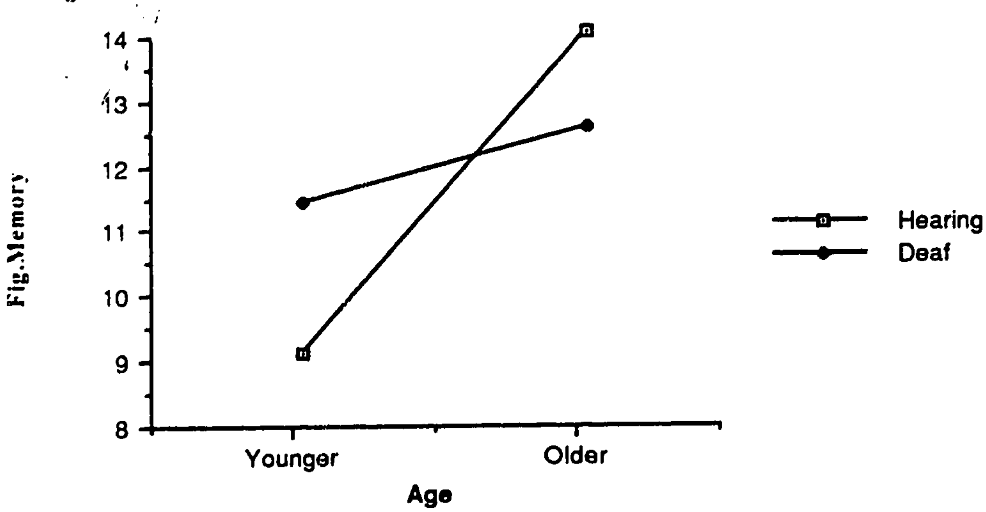


Figure 5b Means of CAS Word Series Tasks for the four groups.

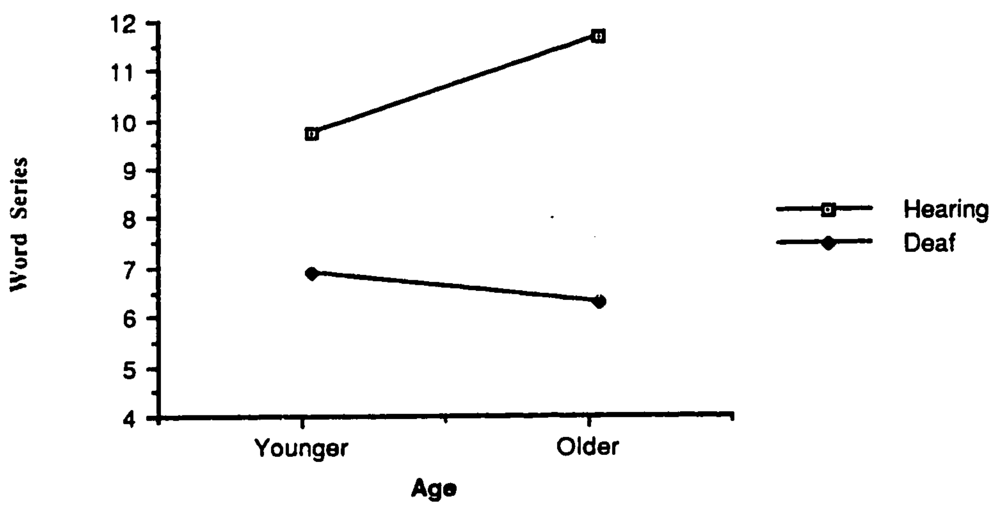
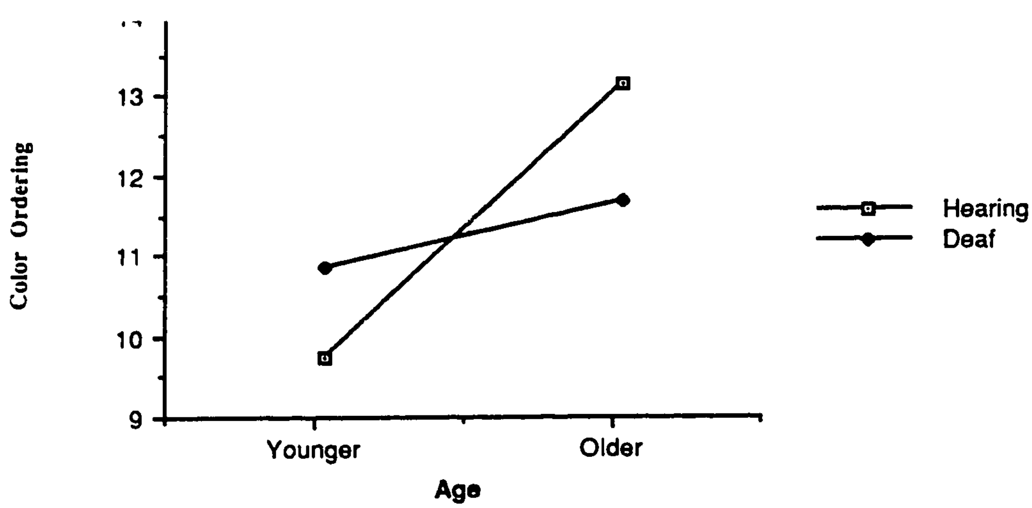


Figure 5c Means of CAS Color Ordering tasks for the four groups.



trends are reversed and the older hearing groups are found instead to perform better than the older deaf groups.

In conclusion, the results of the simultaneous and successive processing tests considered together did illustrate that where a verbal task becomes a factor, the deaf perform poorly compared to the hearing at the younger and older age level. Hypothesis 2.1, stating that the deaf will achieve lower scores compared to the hearing in the verbal simultaneous and successive tasks, is as a result supported. When the nonverbal task is used as a measure of the simultaneous and successive processing, the younger deaf groups maintained relative advantage over the younger hearing groups and they did equal or better. Hypothesis 2.2 stating, that the deaf will achieve comparable scores with the hearing on a nonverbal simultaneous and successive task, is therefore supported for the younger deaf groups.

Unlike the younger deaf groups, a different picture emerged for the older deaf groups in nonverbal simultaneous and successive processing tasks. Firstly, when the older deaf group is compared with the older hearing group in performance on the verbal simultaneous and successive processing tasks, they are found to be backward. Secondly, when the simultaneous and successive processing tasks involve the nonverbal simultaneous and successive tasks, a further backward performance of the older deaf groups compared with the older hearing groups is demonstrated. Hypothesis 2.2, stating that the deaf will achieve comparable scores with the hearing on a nonverbal simultaneous and successive task, can be said to receive partial support at the younger age level but not at the older age level. The overall results indicate also that where deaf subjects did poorer than hearing subjects, it was not limited to successive tasks alone. Additionally, where deaf subjects were shown to perform better than hearing subjects, it was also not limited to simultaneous processing tasks alone. The younger deaf, for instance, were not only found to be backward in verbal successive tasks, but were found also to be backward in verbal simultaneous tasks as well. Similarly, the same younger deaf subjects were not only better in nonverbal simultaneous tasks but were better in the nonverbal successive tasks. The older deaf groups were not only backward in all the verbal and nonverbal successive processing tasks, but were found to be backward also in verbal and nonverbal simultaneous processing tasks. Hypothesis 2.3, stating that the deaf will achieve lower scores than hearing in successive but not in simultaneous tasks, is not supported. The discussion section will relate these results with other similar studies pertaining to this topic.

CAS Planning Tasks

The results of the CAS tasks used to measure planning will be presented under this section. The Planned Connection tasks include Crack the Code, Planned Connection Numbers, and Planned Connection Number and Letters. The univariate "F" statistics comparing the four groups' mean performance in these tasks are shown in Table 11. For Crack the Code, the main effect for age was significant ($F=8.41$, $P<.01$). The main effect for hearing conditions was also significant ($F=15.10$, $P<.001$). The interaction effect was not significant. The mean performance for the four groups depicted graphically in Figure 6a reveals that the significant main effect for age and hearing conditions was in favor of the hearing groups. At both the younger and older age, the hearing group performed better than the deaf group.

Table 11

A Summary of Univariate "F" Statistics Showing the Effects of Age (A), Hearing Conditions (B) and Interaction (AxB) on Planning Tasks

Source	Crack the Code			Plan. Con. No.-Time			Plan. Con. No. & Letter-Time		
	DF	MS	F Ratio	DF	MS	F Ratio	DF	MS	F Ratio
Age (A)	1	16.02	8.41**	1	17443.70	52.98***	1	91183.60	53.32***
Hearing Conditions (B)	1	28.73	15.10***	1	20262.26	61.54***	1	35491.41	20.75***
Interactions (AxB)	1	4.25	2.23	1	104.35	<1	1	47.80	<1
Error	110	1.90		110	329.26		110	1710.12	

*P < .05
**P < .01
***P < .001

Figure 6a Means of Crack the Code for four groups.

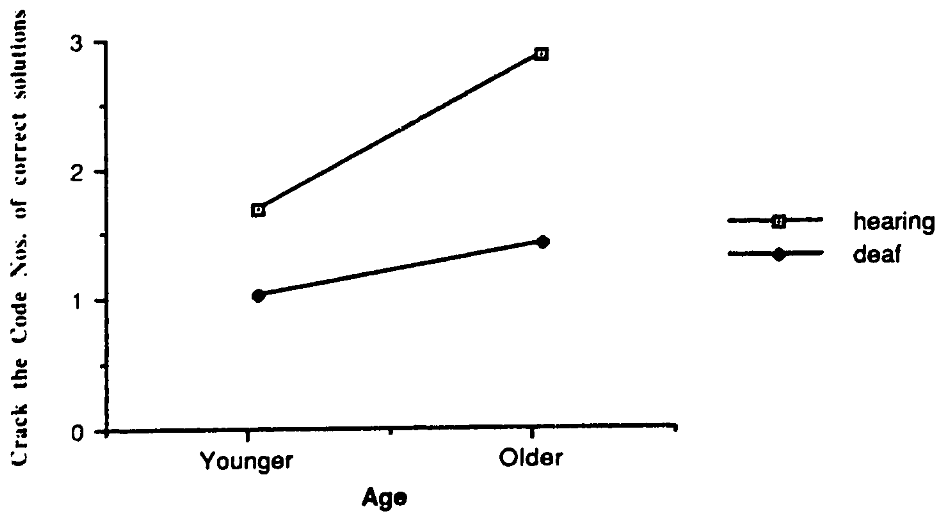


Figure 6b Means of CAS Plan Nos.tasks for the four groups

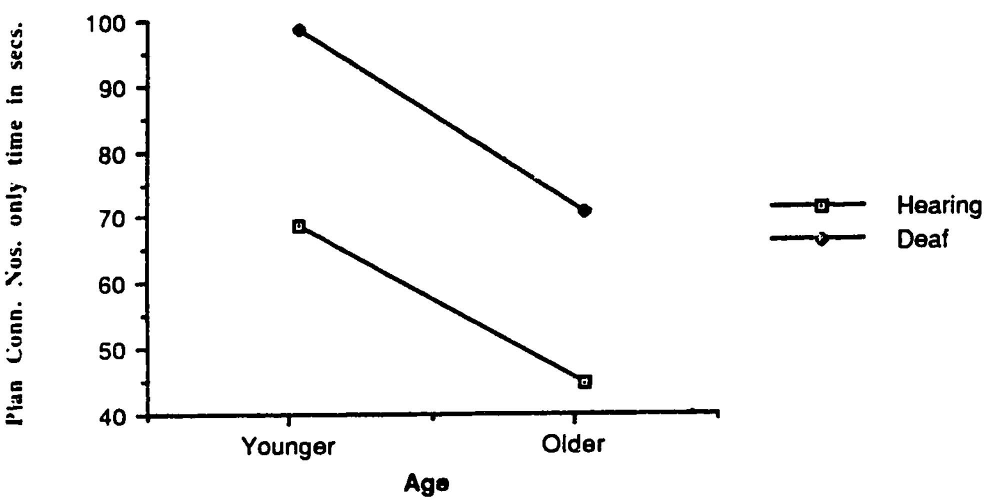
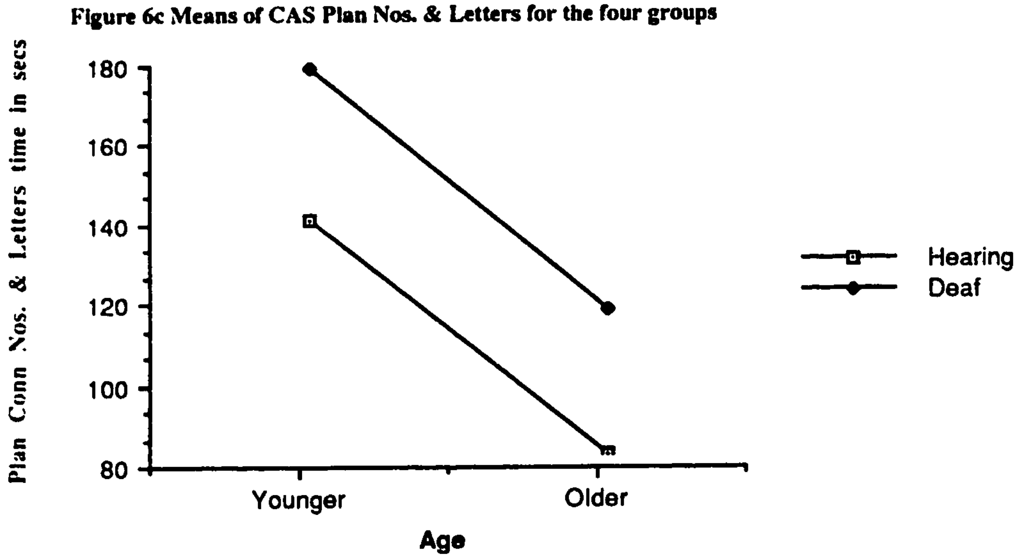


Figure 6c Means of CAS Plan Nos. & Letters for the four groups



The Planned Connection Numbers result also demonstrates a significant main effect for age (F=52.98, P<.001) and a significant hearing condition effect (F=61.54, P< .001), but not a significant interaction effect. Similar results were observed for the Planned Connection Numbers & Letters. The main effect for age was significant (F=53.32, P<.001), and the hearing conditions effect was also significant (F=20.75, P<.001); however, the interaction effect was not significant. The significant age and hearing condition effects interpreted from the mean performance graphs shown in Figure 6b and 6c indicate that the younger and older hearing groups take less time than the younger and older deaf groups on the Planned Connection tasks. This implies that the hearing groups are better than the deaf groups, if performance were judged in terms of the lesser time taken to complete the two Planned Connection tasks.

In conclusion, the results show that in all the CAS tasks used as a measure of Planning, the hearing group did better than the deaf group; therefore Hypothesis 3, stating that deaf subjects will perform poorly compared to the hearing subjects in CAS Planning tasks is as a result supported.

Qualitative Analysis of Planned Connection Tasks

In the try-out manual version of the CAS, Das & Naglieri (1989) recommend checklist strategies required for the Planned Connection tasks. These strategies include the following:

1. Repetition of alphabet/number series out aloud
2. Repetition of alphabet/number series to self
3. Remember last number or letter
4. Looked back at last number or letter

5. Scanned page for next numbers or letters

These strategies were checked for all the four groups involving the younger deaf, younger hearing, older deaf, and older hearing respectively. The outcome suggests that those found utilizing the listed strategies (deaf and hearing alike) completed the Planned Connection tasks in less time and with accuracy. Instead of repeating the alphabet/number series out loud or to one's self typical of the hearing groups, the deaf groups signed this out to themselves.

As would be expected, less than ten percent of deaf groups apply the stated strategies whether young or old. For the hearing groups, while over seventy percent of the older groups were using the stated strategies less than ten percent of the younger groups were found doing the same.

Qualitative Analysis of performance on Crack the Code

In Crack the Code, only a limited amount of information is available for subjects to determine the correct sequence of color chips. Following a sample trial, various color chips are laid out in a predetermined sequence with instructions for subjects to determine the correct order.

When deaf groups are compared with hearing groups, it is obvious from quantitative data results that the hearing groups are far ahead of the deaf groups. The recorded observation regarding the deaf and hearing groups' pattern of responses and behavioral characteristics may provide data for further exploration.

Performance of the hearing groups.

Over 70 percent of the hearing groups were found giving the following response or displaying such behavioral characteristics:

1. When the color chips were laid down following instructions, they would quickly scan through the available colors with many declaring the exact numbers of the color chips.

2. They would scan through the whole page and cross-check the previous order of color chips in rows and columns using mental calculation or through verbal gestures.

3. In response to the examiner's question "Tell me how you did these or what way did you figure out to do these" recommended by Naglieri and Das's (1989) try-out manual under the evaluation of the subject's strategies in Planning CAS tasks, a general summary of their pattern of responses include,

"I recognized the missing color chips in the final series by using my knowledge of the previous order of color chips and knowing specifically that one of the previous color chips is missing from the columns or rows of the present order of chips."

4. They were very confident in selecting the appropriate color chips to place in the missing row/columns from the available arrays of color chips.

Performance of the deaf groups

The patterns of response and behavioral characteristics for over 70 percent of the deaf groups include the following:

(a) Visual attractiveness

The majority of the deaf groups, young and old alike, were more concerned about the visual attractiveness of the color chips. They determined the correct sequences of color chips to select by noting how similar the color chips appeared in rows and columns.

(b) Doubtful in Judgement

Unlike the hearing groups, the younger and older deaf groups appeared doubtful in their judgement concerning the selection of the appropriate color chips. The nature of the phrases they were found muttering indicate such uncertainty. Example of such phrases include, "I don't care," "I don't know," "Stupid me,"and "I fuck it up again."

(c) Eager to please the examiner

Another unique characteristic observed among the deaf groups was their inclined tendency to please the examiner. Once they finished arranging the color chips to their satisfaction, they would turn to the examiner to ask questions such as, "I finish before time - right?," "What more time do I have left?," "I got the arrangement right?," and "How many more do I have left to complete?"

In response to the examiner's question such as, "Tell me how you did these," or "What way did you figure out to do these?" as recommended by the Naglieri and Das's (1989) try-out manual under strategies check lists for subject's performance on Planning tasks, the majority of the deaf subjects responded, "I don't know," or questioned the examiner: "Why ask?"

In conclusion, this qualitative data analysis result comparing the deaf and hearing groups' performance in CAS planning tasks may suggest two things. The first is that the present deaf subjects expected the examiner to help them complete the tasks as illustrated from their primary concern of satisfying the examiner instead of looking inwardly to negotiate a solution to the problems. The second is that they were apparently not using the necessary cues to solve the CAS Crack the Code problems did not go beyond superficial analysis to an in-depth analysis typical with the majority of the hearing groups. The discussion section will attempt to relate the qualitative data results with other similar observations and suggest possible implications.

Section III

CAS Tasks and Academic Achievement

In order to examine the possible relationship between the CAS tasks and subtests of the SAT/SAT-HI batteries, the original CAS tasks was retained. The SAT and SAT-HI raw scores were then converted to percentile rank using a separate conversion scale for hearing and deaf groups. The means and standard deviations for the SAT and SAT-HI are reported in Table 12 for all groups. The Pearson product moment correlation (r) was performed to examine the possible relationship between the CAS task scores and the SAT/SAT-HI academic achievement subtests scores for the deaf and hearing groups.

Tables 13-16 present the results of the correlation for the younger deaf, younger hearing, older deaf, and older hearing groups, respectively. The significant correlations are marked with an asterisk. Hypothesis 4 could be said to receive support to a certain extent, since some CAS tasks were found to relate with certain SAT/SAT-HI subtests for all groups. The results must, however, be interpreted with caution because of the small number of subjects for each group.

As can be observed in the correlation tables, the number of CAS tasks found to relate with one subtest of academic achievement varies for each groups. Consequently, in order to determine the amount of variance in the SAT/SAT-HI

TABLE 12

and Standard Deviations of Achievement Tests for Younger Deaf, Younger Hearing, Older Deaf, and Older Hearing Sample in Percentile

	(N = 21) Younger Deaf		(N =20) Younger Hearing		(N =30) Older Deaf		(N =43) Older Hearing	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
:omprehension	53.10	25.52	65.25	20.16	56.03	27.40	70.63	25.77
ding	68.29	25.33	65.05	28.92	63.83	14.98*	-	-
	54.52	30.60	68.40	28.08	55.97	26.80	63.23	25.96
of Numbers	51.38	22.74	80.45	18.58	45.67	30.83	86.40	15.90
ıputation	38.86	25.17	75.95	23.32	39.67	29.91	62.63	28.93
lications	51.19	26.90	71.10	21.76	51.48	32.66	79.00	21.17

Table 13

Pearson Product Moment Correlations Between CAS Tasks and SAT-HI for Younger Deaf Group (N = 21)

asks	Standford Achievement Test (SAT - HI)			
	Reading Comprehension	Spelling	Mathematics Computation	Mathematics Application
ive Word	.03	-.01	.07	-.17
ive Color	.27	.05	-.06	.17
ive Color-Word	-.16	-.47*	-.15	.13
/e Physical Match	.01	.23	.28	.08
/e Name Match	-.06	.29	.01	-.06
ıeous Verbal	.74***	.58**	.60**	.41*
/lemory	.39*	.22	.50**	-.20
eries	.41*	.10	.25	.41*
rdering	.31	.42*	.30	.30
ıe Code	.07	.20	-.18	-.01
ımbers	.11	.10	.14	.02
ımbers & Letters	-.07	-.14	-.22	-.12

)5
.01
: . 001

Table 14

Pearson Product Moment Correlations Between CAS Tasks and SAT for Younger Hearing Groups (N =20)

ısks	Subtests of Standford Achievement Test			
	Reading Comprehension	Spelling	Mathematics Computation	Mathematics Application
ive Word	-.60**	-.59**	-.45*	-.60**
ive Color	-.44*	-.44**	-.42*	-.49**
ive Color-Word	-.48*	-.55**	-.43*	-.47*
/e Physical Match	.41*	.57**	.55**	.47*
/e Name Match	.47*	.62**	.69**	.57**
neous Verbal	.22	.26	.34	.28
Memory	.29	.34	.29	.14
eries	.42*	.54**	.23	.30
rdering	.39*	.38**	.40*	.28
ıe Code	-.03	-.11	.06	.13
ımbers	.22	.37*	-.35	-.33
ımbers & Letters	-.23	-.56*	-.39*	-.34

)5

. 01

: . 001

Table 15

Pearson Product Moment Correlations Between CAS Tasks and SAT-HI for Older Deaf Group (N =30)

Tasks	Subtests of Standford Achievement Tests (SAT -HI)			
	Reading Comprehension	Spelling	Mathematics Computation	Mathematics Application
sive Word	-.30*	-.35*	-.40**	-.46**
sive Color	-.30*	-.37*	-.36*	-.35*
sive Color-Word	-.29	-.43**	-.21	-.35*
ive Physical Match	.43**	.11	.31*	.28
ive Name Match	.34*	.25	.29	.31
ineous Verbal	.45**	.37*	-.15	.44*
Series	.45**	.46**	.42*	.36**
Memory	.05	-.10	.06	.03
Ordering	.58***	.23	.60***	.50**
he Code	.35*	-.03	.41**	.43*
umbers	.60***	-.44**	-.29*	-.45**
umbers & Letters	-.70***	-.39**	-.64***	-.70***

05
. 01
< . 001

Table 16

Pearson Product Moment Correlations Between CAS tasks and SAT for the Older Hearing Group (N =43)

sks	Subtests of Standford Achievement Tests			
	Reading Comprehension	Spelling	Mathematics Computation	Mathematics Application
ive Word	-.37**	-.34*	-.05	-.24*
ive Color	-.05	.04	.16	.06
ive Color-Word	-.25	-.22	-.03	-.11
ve Physical Match	.35**	.22	.16	.22
ve Name Match	.34**	.42***	.30*	.33*
neous Verbal	.38**	.36**	.10	.42**
Memory	.31*	.25**	.21	.42**
rdering	-.07	.02	-.03	.20
eries	.44**	.32*	.20	.29*
he Code	.18	.26	.29*	.23
umbers	-.05	-.06	-.04	-.04
umbers & Letters	-.07	-.21	-.27*	-.27*

05
. 01
< . 001

tasks used as a predictor variable, the Multiple Regression Analysis was performed separately for each group. The step for the Multiple Regression Analysis required a continuous inclusion of the predictor variables for each criterion variable until improvement in the regression sum of squares at a given step was no longer significant.

Table 18 presents the results of the regression analysis for the younger deaf group following the intercorrelations shown in Table 17. As this table will indicate, Reading Comprehension is best predicted by Simultaneous Verbal, accounting for 55% of the variance ($P < .001$). Expressive Attention Color and Expressive Attention Word were entered as the second and third best predictors of Reading Comprehension variance. However, only .09 increment ($P < .01$) was added by Expressive Attention Color, while Expressive Attention Word added just .10 increment ($P < .01$) to the total variance predicted. Simultaneous Verbal was another significant variable entered as the best and only predictor of spelling subtests accounting for 34% of the variance ($P < .001$).

In Math Computation and Math Application, Simultaneous Verbal was also the first variable entered as the best predictor, accounting for 36% of the variance ($P < .01$) for Math Computation and 17% of variance ($P < .05$) for Mathematics Application. Figure Memory was the second variable entered as the best predictor of Math Computation, but only a negligible .11 increment, ($P < .05$) was added to the total 47% of the variance accounted.

For the younger hearing groups, the results of the Multiple Regression Analysis are shown in Table 20. In Reading Comprehension, only the Expressive Attention Word was entered as the best predictor, accounting for 36% of the variance

Table 17

Intercorrelations of Cognitive Assessment System (CAS) Tasks for Younger Deaf Group (N = 21)

	CC	SV	FM	WS	CO	PN	PNL	EW	EC	ECW	RPM	RNM
he Code (CC)	1.00											
ıneous Verbal (SV)	-.08	1.00										
Memory (FM)	-.19	.34	1.00									
;eries (WS)	.01	.48	.21	1.00								
)rdering (CO)	-.03	.46	.35	.50	1.00							
ɔnn Numbers (PN)	-.05	-.10	-.29	-.50	-.40	1.00						
onn Numbers & Letters (PNL)	-.13	-.20	-.21	-.59	-.63	.71	1.00					
ive Word (EW)	-.16	.20	-.34	-.20	-.27	.48	.27	1.00				
sive Color (EC)	.11	-.02	-.23	-.21	-.61	.54	.47	.51	1.00			
sive Color -Word (ECW)	-.03	-.27	-.23	-.17	-.36	.34	.29	.28	.47	1.00		
ive Physical Match (RPM)	-.10	.32	.36	.14	.43	-.31	-.30	-.14	-.41	-.48	1.00	
ive Name Match (RNM)	.24	.29	.04	.20	.39	-.45	-.35	-.12	-.52	-.64	.56	1.00

Table 18

Summary of Weighted Regression Analysis for Younger Deaf Group (N =21)

ble	Beta weight	Multiple R	R	R Increment
ling Comprehension				
ltaneous Verbal	.83	.74	.55	.55**
essive Color	.49	.80	.64	.09*
essive Word	-.38	.86	.74	.10*
ling				
ltaneous Verbal	.58	.58	.34	.34**
hematics Computation				
ltaneous Verbal	.48	.60	.36	.36**
re Memory	.34	.68	.47	.11*
hematics Application				
ltaneous Verbal	.46	.41	.17	.17*

< .05

< .01

P < .001.

Table 19

Intercorrelations of Cognitive Assessment System (CAS) tasks for Younger Hearing Group (N =20).

	CC	SV	FM	WS	CO	PN	PNL	EW	EC	ECW	RPM	RNM
t the Code (CC)	1.00											
ltaneous Verbal (SV)	.30	1.00										
e Memory (FM)	.22	.64	1.00									
Series (WS)	.18	.20	.21	1.00								
Ordering (CO)	.13	.56	.36	.11	1.00							
Conn Numbers (PN)	-.28	-.44	-.51	-.19	-.64	1.00						
Conn Numbers & Letters (PNL)	-.44	-.53	-.44	-.17	-.52	.62	1.00					
essive Word (EW)	.05	-.03	-.07	-.24	-.18	.35	.44	1.00				
esive Color (EC)	.01	-.18	-.09	-.13	-.28	.16	.41	.66	1.00			
essive Color-Word (ECW)	-.02	-.04	-.17	-.18	-.39	.48	.48	.70	.78	1.00		
ptive Physical Match (RPM)	.22	.50	.60	.19	.43	-.73	-.71	-.45	-.48	-.71	1.00	
ptive Name Match (RNM)	.12	.30	.34	.44	.50	-.62	-.53	-.45	-.56	-.67	.68	1.00

Table 20

Summary of Weighted Regression Analysis for Younger Hearing Group (N = 20)

able	Beta Weight	Multiple R	R	R increment
ding Comprehension				
ressive Word	-.60	.60	.36	.36*
lling				
eptive Name Match	.62	.62	.38	.38***
thematics Computation				
eptive Name Match	.69	.69	.48	.48***
thematics Applications				
ressive Word	-.60	.60	.36	.36**

< .05

? < .01

P < .001

(P<.05). Receptive Attention Name Match was also the only significant variable entered as the best predictor of Spelling and Math Computation. Receptive Attention Name Match accounted for 38% of the variance (P<.001) in Spelling and 48% of the variance (P<.001) in Math Computation. Expressive Attention Word was again entered as the best predictor of Math Application, accounting for 36% of the variance (P<.01). This result for the younger hearing groups must be interpreted with considerable caution because of higher intercorrelations found between Receptive Attention Name Match and Simultaneous Verbal, Figure Memory, Planned Connection Numbers, PlannedConnection Numbers and Letters, and the Expressive Attention Color-Word combined that appear in Table 19.

Table 22 presents the results of the Multiple Regression Analysis for the older deaf group following the intercorrelations in Table 21. For this group, two factors were entered as best predictors of Reading Comprehension. The first was Planned Connection Numbers and Letters which predicted 50% of the variance (P< .01). This was followed by Simultaneous Verbal which added .15 increment (P< .01) to the total 65% of variance predicted. Spelling was best predicted by Word Series, accounting for 21% of the variance (P<.05) and then by Planned Connection Numbers which added .15 increment (P<.05) to the total 36% of variance predicted. The Planned Connection Numbers and Letters was entered also as the first best predictor of Math Computation and Math Applications. It accounted for 41% of the Math Computation variance (P<.01) and 49% of the Math Application variance (P<.01), respectively. The second best predictor of Math Computation was Color Ordering, which added .11 increment (P<.01). For Mathematics

Table 21

Intercorrelations of Cognitive Assessment System (CAS) Tasks for the Older Deaf group (N =30)

	CC	SV	FM	WS	CO	PN	PNL	EW	EC	ECW	RPM	RNM
ck the Code (CC)	1.00											
ıultaneous Verbal (SV)	-.03	1.00										
ıre Memory (FM)	.09	-.15	1.00									
rd Series (WS)	-.24	.54	.07	1.00								
or Ordering (CO)	.37	.40	.13	.59	1.00							
ı Conn. Nos. (PN)	-.23	-.21	-.13	-.12	-.20	1.00						
ı Conn. Nos.& Letters (PNL)	-.51	-.10	-.03	-.17	-.48	.45	1.00					
ıressive Word (EW)	-.04	.02	.21	-.20	-.30	.11	.46	1.00				
ıressive Color (EC)	-.05	-.00	.04	-.22	-.26	.19	.48	.85	1.00			
ıressive Color-Word (ECW)	.05	-.18	-.40	-.37	-.17	.32	.31	.14	.39	1.00		
:eptive Physical Match (RPM)	.27	-.03	.33	.04	.31	-.45	-.47	-.27	-.37	-.52	1.00	
:eptive Name Match (RNM)	.02	.11	.26	.32	.23	-.35	-.34	-.10	-.27	-.53	.66	1.00

Table 22

Summary of Weighted Regression Analysis for Older Deaf Group (N = 30)

	Beta weight	Multiple R	R	R Increment
prehension				
: Letters	-.67	.71	.50	.50**
erbal	.38	.80	.65	.15**
	.41	.46	.21	.21**
nly	-.39	.60	.36	.15**
Computation				
k Letters	-.46	.64	.41	.41**
	.38	.72	.52	.11**
Application				
k Letters	-.67	.70	.49	.49**
erbal	.39	.80	.64	.15**

Application, the second best predictor was Simultaneous Verbal which also increased the total variance predicted by .15 increment (P<.01)

The results of the Multiple Regression Analysis for the older hearing groups are shown in Table 24, following intercorrelations in Table 23. Table 24 shows that Reading Comprehension is best predicted by two factors. The first variable entered was Word Series, accounting for 20% of the variance (P<.001). The next variable was Receptive Attention Name Match which added .16 increment (P<.01) to the total 36% of variance predicted. In Spelling subtests, Receptive Attention Name Match was the first variable entered followed by Word Series. While Receptive Attention Name Match predicted 17% of the variance (P<.001), Word Series increased the total variance predicted to 33% by .16 increment (P<.01). For Math Computation subtests Receptive Attention Name Match was again entered as the only best predictor accounting for a negligible 9% of variance predicted (P<.05). Three factors were entered as the best predictor of Math Application subtests. The first is Figure Memory, accounting for 18% of the variance (P<.01); Simultaneous Verbal added .9 increment (P<.01), followed by Receptive Attention Name Match which added .07 increment (P<.01).

Table 23

Intercorrelation of Cognitive Assessment System (CAS) Tasks for Older Hearing Group (N=43)

	CC	SV	FM	WS	CO	PN	PNL	EW	EC	ECW	RPM	RNM
a (CC)	1.00											
Verbal (SV)	.08	1.00										
y (FM)	.19	.30	1.00									
WS)	.12	.18	.28	1.00								
ı (CO)	.37	.09	.07	.26	1.00							
nners (PN)	.10	.01	-.25	-.19	.09	1.00						
mbers & Letters (PNL)	-.09	-.13	-.19	-.14	-.14	.29	1.00					
ord (EW)	-.11	-.27	.09	-.30	-.05	.06	-.15	1.00				
lor (EC)	.22	.01	-.14	.03	.08	.17	-.02	.08	1.00			
lor Word (ECW)	-.15	-.05	-.09	-.04	-.03	.07	.05	.43	.34	1.00		
sical Match (RPM)	.09	.16	.11	-.02	-.11	-.29	-.11	-.31	-.25	-.36	1.00	
ne Match (RNM)	.27	.14	.08	-.14	-.09	-.22	-.28	-.30	-.10	-.47	.67	1.00

Table 24

Summary of Weighted Regression Analysis for Older Hearing Group (N =43)

	Beta Weight	Multiple R	R	R Increment
omprehension				
	.50	.44	.20	.20***
me Match	.41	.60	.36	.16***
ame Match	.48	.42	.17	.17***
	.39	.57	.33	.16**
s Computation				
me Match	.33	.30	.09	.09*
s Application				
ry	.31	.42	.18	.18*
Verbal	.29	.52	.27	.09*
me Match	.26	.57	.34	.07*

In conclusion, the overall results of the Multiple Regression Analysis will require extensive caution in interpretation because of the small number of subjects in each group and the many CAS tasks used as predictor variables. Nevertheless, since the CAS tasks could still predict certain academic subtest variance despite the small number of subjects in each group, this gives further support to Hypothesis 4.

Chapter VII

Discussion

Introduction

The discussion section will be presented under four headings. The first section is Attention, the second is Simultaneous and Successive processing, the third is on Planning, and the fourth is a discussion on the relationship between the CAS tasks and academic achievement.

Attention

The two CAS tasks of Attention involving the Stroop test and the Posner test will be discussed under this section. Hypothesis 1 is supported in the sense that no significant differences were observed between the performance of the deaf and hearing subjects in the Stroop Expressive Attention tests and the Posner Receptive Attention tests. This was expected because of the theoretical assumption underlying the construction of the Stroop tests (Stroop, 1935) and the Physical Match versus Name Match tasks of Posner (Posner & Boies, 1971; Proctor, 1981). Even though the Stroop and Posner tasks differ, it would appear that there is uniformity in the theoretical assumption of why these tests should be used as measures of Attention. The Stroop test, for instance, is comprised of word reading, color naming, and the naming of the color of ink in which the words are written (otherwise termed the incongruent ink color of color names). The word reading or color naming aspects of the Stroop test may not be the most difficult; the combined color-word should be more difficult since it is expected that interference will occur in attention because subjects are required to suppress reading the words to say the colors instead (see normal subjects should be able to suppress the urge to read the word instead of the colors. Individuals with underlying cognitive difficulties such as the Learning Disabled (LD), Mental Retarded (MR), or those with behavioral disorders should find it hard to suppress the urge to read the word instead of the colors.

In the Posner Physical Match task, subjects are requested to detect letter pairs which are identical; both letters are in the upper case. In contrast, in the Name Match tasks, subjects are to detect identical letter pairs presented in upper and lower cases. Proctor (1981) noted that the physical code which is accessed through the use of both perceptual and memory systems arrives at the output faster than the name code. Assuming, then, that the Posner Physical Match task is faster than name match task, because "subjects could respond on the basis of visual information alone and respond before the letter names are available" (Posner & Snyder, 1975, p. 72), we are led to believe that the Physical Match is the less difficult while the Name Match task is more difficult. In that case, the Name Match task should discriminate between normal subjects and subjects suspected of such cognitive deficits as LD, MR or behavioral disorders.

In line with the Wolff, Radecke, Kammerer & Gardner (1989) study, where the Stroop Color and Word tests were administered to deaf and hearing subjects, the outcome of the present study suggests that the Stroop responses cannot be signed as rapidly as they can be spoken. The interference measure has also been used to differentiate the Reading Disabled (RD) from average readers (Lazarus, Ludwig, & Aberson, 1984). The RD's were shown to be two years behind the average readers in Color-Word naming speed. The present results fail to show any significant interference. Instead, the interference differences observed were between the younger deaf and older deaf or the younger hearing and older hearing. The significant Multiple Comparison results using the Scheffe test shown in Table 8 support the above.

The performance of the deaf subjects compared with the performance of the hearing subjects in the Posner Physical Match task reveal no significant differences between deaf and hearing subjects of similar age. The Posner Name Match task also failed to reveal any significant difference between deaf and hearing subjects of similar age. This is so despite the fact that from the theoretical perspective, the Posner Name Match task should be more difficult since it involves a name code.

In conclusion, because the Stroop test (used as a measure of Expressive Attention) and the Posner test (used as a measure of Receptive Attention) have failed to show performance differences between the present deaf and hearing groups, the implication is that attention deficit underlying probable neuropsychological dysfunction may not be considered a profile of the present deaf groups.

Simultaneous -Successive Processing

For the younger subjects, Hypothesis 2.1 is supported because results reveal that the deaf subjects' poor performance in simultaneous and successive tasks is a factor of the verbal contents of these tasks. When similar tasks are presented nonverbally, younger deaf subjects were at an advantage and performed better, supporting Hypothesis 2.2. This finding agrees with earlier studies which suggest that the poor performance of the deaf in sequential processing tasks is a factor of the nature of the experimental tasks used, the linguistic contents of these tasks, and the manner or method of presentation. When these factors are controlled, no significant differences are observed between deaf and hearing subjects (Anooshian & Bryan, 1979; McDaniel, 1980 ; McGurk & Saqi, 1985). Hypotheses 2.3 is not supported for the younger deaf subjects because, other than the verbal factor influencing the poor performance of the younger deaf subjects in both simultaneous and successive tasks, there is no evidence to suggest that the deaf subjects could be poor in successive processing tasks because of specific cognitive processing deficits. It also can not be established that the same deaf subjects did better only in simultaneous and successive tasks because of specific cognitive processing preference. Since Kaufman and Kaufman (1983) have equated simultaneous processing with spatial order and successive processing with temporal order; this result is in conflict with the research of O'Connor and Hermelin regarding this topic. O'Connor and Hermelin (1973) observed that while hearing subjects tend to recall the digits in their temporal order, deaf subjects tend to recall the digits in their spatial order. In a recognition task, O'Connor and Hermelin also observed similar patterns of temporal order recall for their hearing subjects and spatial order recall for deaf subjects. In a recall test, deaf subjects showed improvement when the stimuli were presented spatially and not sequentially (Hermelin & O'Connor, 1975). However, like this present study, a replication study of the O'Connor and Hermelin research, by Beck, Beck, and Gironella (1977), failed to support the hearing subjects' preference for temporal processing or the deaf subjects' tendency to choose spatial processing. A study by Das (1983) relevant to the same topic has simultaneous and successive tasks that were verbal and nonverbal as did the present study; therefore the verbal factors as such were not evident in these studies.

The performance of the younger deaf subjects differed markedly from the performance of the older deaf group. The older deaf group compared to the older hearing subjects continued to be backward whether the simultaneous and successive tasks were verbal or nonverbal. It is not clear why this is the case, but some studies cite maturational lag factors as influencing cognitive processing (see Altom & Weil, 1977; Freeman, 1975; Klapper & Birch, 1971; Zwiebel, 1989). All these studies suggest that younger hearing or deaf children may lag in cognitive processing test but that the lag is often not evident at the older age level. Once again these studies receive no support from the present deaf group. Indeed if the maturational lag were a possible factor, the performance of the present younger deaf subjects compared to the younger hearing subjects in CAS tasks could have been more backward than the performance of the older deaf subjects when compared to the older hearing subjects.

In conclusion, the question of the age factor as it relates to the simultaneous and successive processing ability of the deaf may have to be interpreted differently base on this result. It would appear that there is an age-specific period when the simultaneous and successive processing ability of the deaf will be similar to the simultaneous and successive processing ability of the hearing subjects in nonverbal tasks. This age may peak at an average of 9.9 years or so, corresponding with the age of the younger deaf subjects used for this study. Beyond this age, roughly at about 13.7 years (corresponding also with the average age of the older deaf subjects used for this study), the possibility of the simultaneous and successive processing ability of the deaf being similar to the simultaneous and successive processing ability of the hearing subjects in verbal or nonverbal tasks may be very slight.

CAS Planning Tasks

Hypothesis 3 is supported in the sense that deaf subjects were found to perform poorly compared to hearing subjects in the CAS planning tasks. According to Das (1988), planning emerges as a unique function of human cognitive activity and is probably the last function to evolve. It is the most obvious one that is totally influenced by social-cultural factors, and it is that part of cognition which has a transactional relationship with activity as well as with consciousness. The similarities between the CAS planning and higher order cognitive skills is very striking.

In an attempt to explain what higher order cognitive skills are, Rodda and Grove (1985) provide the following definition: "By 'higher' skills we mean thinking, reasoning, problem solving, and concept formation: cognitive skills that may draw on 'lower level' resources but that fall into the broad category of 'intelligent behavior' (p. 180).

If one is to equate the CAS planning with higher order cognitive skills, then there is evidence to suggest that as cognitive function moves from representational processes to higher enactive, iconic, and symbolic modes, the likelihood of deaf subjects completing such tasks as well as their hearing counterparts diminishes (Cumming & Rodda, 1985). Other studies illustrate this point. The study by Furth (1961), using deaf and hearing subjects, employed three experimental tasks: the certain characteristics; the second was the symmetry task, which required subjects to select a figure possessing symmetry; the third was the apposition task which required the subjects to pick the opposite size (smaller or larger) of the one specified by the examiner. Results indicated that the deaf and hearing subjects between 7 and 12 years of age performed equally well on the sameness and symmetry tests. The deaf subjects' performance on the opposition tasks as compared to the performance of the hearing groups was somewhat backward. As already pointed out, other studies using the Piagetian tasks have shown that in higher order cognitive tasks such as classification, concept formulation, conservation of liquids, sequential memory, and transitive thought, marked negative differences with the deaf persisted (see Quigley & Kretschmer, 1982). In a related study, Arnold and Walter (1979, cited in Rodda & Grove, 1985) found 19-year-old deaf students to be significantly inferior to hearing controls on tests of abstract and mechanical reasoning as well in verbal reasoning, even though an earlier study reported by Arnold (1978) (in which subjects had to mentally rotate complex stimuli through either 90 degrees or 180 degrees), found that the deaf 15-year-olds to outperformed the hearing subjects. All these studies appear to have supported substantially the present results of the backward performance of the deaf in the CAS higher order planning tasks. The quantitative data results obtained from this study have also added a new view to the retarded performance of the deaf on higher order cognitive tasks. The results reveal that the majority of the deaf group as compared to the hearing group, were not using the recommended checklist of strategies needed to complete the CAS Planned Connection tasks. Furthermore, in the second CAS Planning task involving Crack the Code, the majority of the deaf group appear not to be negotiating possible approaches to solving the problems. The same deaf groups did not take advantage of the available cues that would have provided solutions to the Crack the Code problems.

It is somewhat difficult from this study to pinpoint concisely why deaf subjects may be backward in the CAS higher order Planning tasks. Evidence from Furth (1974) suggests that the poor performance of the deaf in whatever level of cognitive tasks is principally a factor of experiential and linguistic deficit and must not be taken lightly. Moreover, a similar view which includes environmental deprivation was advanced succinctly by Keane (1981) for disrupting the mediational learning process that is typical of the Feuerstein model of higher level cognitive function.

The lack of using strategies for the planning tasks by the majority of the deaf group and their failure to take advantage of necessary cues needed to complete the CAS higher order Planning tasks, noted in the qualitative result, is similar to what previous studies have reported.

For example, Martin's (1984) observation is worth quoting here:

> Teachers who work with hearing impaired adolescents frequently express deep concern and frustration about some of their students' serious deficiencies in problem solving skills, as evidenced in both classroom and written work. The concern often relates to difficulty in manipulating more than one variable, conceptualizing what a text book or journal author is saying, forming conclusions, dealing with hypothetical data, and spatial reasoning. (p. 235)

In the light of the present results, linguistic poverty and experiential-deaf in advanced cognitive functioning cannot go unchallenged at this moment. The present results which support Martin's observation may lead us to conclude that the cause of the deficit in cognitive functioning of the deaf at the higher level is primarily an absence of systematic strategic behavior and a failure on the part of the deaf to put necessary effort into negotiating a solution to the CAS planning problems or an inability to recognize available cues needed to complete the higher order planning tasks. This symptom is likely aggravated by linguistic and experiential/environmental factors as deaf subjects get older.

Cognitive Assessment System (CAS) and Academic Achievement.

The Deaf Subjects

The patterns of the Pearson Product Moment Correlations (r) between the CAS tasks and Academic Achievement for the younger and older deaf groups shown in Table 13 and Table 15 were not repeated in the Multiple Regression Analysis shown in Table 18 for the younger deaf and in Table 22 for the older deaf groups. Unlike the Simultaneous Verbal which best predicted Reading Comprehension, Spelling, Math Computation, and Math Application for the younger deaf groups, the Plan Connection task was the best predictor of Reading Comprehension, Math Computation, and Math Application variance for the older deaf groups. The Spelling variance was also best predicted by the Successive Word Series for the older deaf instead of the Simultaneous Verbal that was the best predictor for the younger deaf groups. The Simultaneous Verbal task which was the best predictor of Reading Comprehension, Spelling, Math Computation, and Math Application variance for the younger deaf groups is inconsistent with the Ulissi, Brice, and

Gibbins (1989) study where the nonverbal simultaneous processing scale of the K-ABC was found to correlate significantly with the Reading and Mathematic Scores of their deaf subjects. However, it must be emphasized that both Ulissi et al.(1989) study and the present study agree on the significant role of simultaneous processing in predicting the academic skills of the deaf. The differences is as such in the nonverbal simultaneous and the verbal simultaneous. The Planning factors shown as the best predictor of Math Computation of the older deaf group conform to the Garafolo (1983) study, where Mathematic Computation was found to have the highest loading on Planning factors for grade 5 students. The prediction of the Reading Comprehension and Math Application variance by the Planning and the Simultaneous Verbal tasks is also in agreement with the Naglieri and Das (1987) study where Planning and simultaneous tasks were found to relate to Reading and Math achievement of both the younger grade 2 and the older grade 6 and 10 students. Additionally, the successive Word Series which emerged as the best predictor of Spelling variance for the older deaf groups supports Das and Mensink's (1989) study, where the successive tasks also related significantly with the Spelling subtest.

For the older deaf group, the Planned Connection tasks which acted as the best predictors of all academic scores (except for Successive Word Series, which best predicted Spelling variance) appear to be in line with earlier studies. However, whether the prediction of academic skills by the Simultaneous Verbal for the younger deaf subjects is due to the small number of younger deaf subjects used for the Multiple Regression Analysis or the considerable influence of verbal cognitive tasks which tend to overshadow the role of nonverbal cognitive tasks in predicting academic skills (see Fraser, 1987), will require further investigation.

The Hearing Groups

When the results of the older hearing groups are compared with the results of the younger hearing groups, there is a similarity in that Receptive Attention tasks come out as the best predictors of Spelling and Math Computation variance for both groups. This further confirms the need, as recommended by Naglieri and Das (1987), to include Attention tasks in cognitive assessment.

The difference between the younger and older hearing groups is that although the Math Application variance is best predicted by simultaneous Figure Memory and Reading Comprehension by successive Word Series for the older hearing groups, the Expressive Attention Word came out instead as the best predictor of Reading Comprehension and Mathematic Application variance for the younger hearing groups.

It was expected that the Planning factors should have better predicted Reading Comprehension and Mathematic Computation of the older hearing groups, as previous research tends to indicate; but the reverse appears true for this present older hearing group. The successive Word Series which best predicts Reading Comprehension variance and the two simultaneous processing tasks which also predict Mathematic Application variance nonetheless conform with other studies which have observed similar relationships (e.g., Das & Mensink, 1989; Kirby & Das, 1977; Naglieri & Das, 1987).

While the pattern of Academic subtest variance predicted by the CAS tasks for similar studies, the higher intercorrelations between the Receptive Attention and other relevant CAS tasks as previously pointed out may explain such unusual patterns of prediction for the younger hearing groups.

For the older hearing groups, such higher intercorrelation seen for the younger hearing is not observed. It appears also that the total variance of Academic subtests predicted by the CAS tasks for the older hearing as compared to the variance of the remaining groups may be considered too low. It is plausible to assume that, unlike the remaining groups, the SAT Academic achievement may not be considered appropriate for the older hearing groups. The use of the SAT, designed for an American population but used with the Canadian population has been criticized by French (1987).

Unlike the results for the older hearing groups, the patterns of the CAS tasks which best predict the Academic subtests variance for the older deaf groups conform with expectations. This is so despite the backward performance of the older deaf as compared with the older hearing groups in the CAS tasks. The reason could be that the deaf groups were tested in appropriate SAT-HI based on their initial screening. The SAT-HI requires that deaf subjects be given a screening test to determine at which level they can be tested. Because of this, they were not assigned randomly to the SAT level on the basis of grade typical with the hearing groups. In essence, therefore, the deaf groups' performance on the CAS tasks correspond fairly with the level of the SAT-HI that they were administered following the screening.

In conclusion, unlike the negative relationship found between nonverbal reported in research literature (Jensema & Trybus, 1978; Myklebust, 1964; Quigley & Kretschemer, 1982; Servatka, Hessou, & Graham, 1984; Wrighstone, Aranow & Muskowitz, 1963), the CAS tasks used in this study predicted significantly specific academic areas in Reading Comprehension, Spelling, Math Computation and Math Application for the deaf. However, because of the small number of subjects used for this study, the results will require replication in studies using larger samples. Of significance is the emergence of attentional factors which relate significantly with academic subtests of both deaf and hearing groups.

Chapter VIII

Limitations and Implication for Future Research

Evaluation and Limitations

CAS Tasks

The first limitation of this study was that the CAS tasks were used on a trial basis in conjunction with similar ongoing research studies (see Naglieri & Das, 1989). Consequently, these tasks have not yet been normed or standardized for the deaf, the hearing, or other populations. Norming studies will be required for the CAS tasks battery. The use of the CAS in this present study should therefore be considered an initial contribution to the norming and validity of the CAS for the deaf population .

SAT-HI

The use of the SAT/SAT-HI with the Canadian population has been criticized because the test is designed for the American population and not for Canadians (French, 1987). It is quite possible that such an observation might explain the failure of the CAS to make significant prediction of SAT achievement scores for the older hearing groups. For the Canadian deaf population at the moment, the SAT-HI may be the only appropriately normed and standardized achievement test currently available across North America. However, because not all SAT/SAT-HI subtests were considered appropriate to be included in this investigation (as pointed in the methodology section), the use of the SAT/SAT-HI as a measure of a full range of academic achievement for the present deaf and hearing samples is limited.

Subjects

Although the available hearing subjects were small in number, they were selected from the Edmonton public school system, which represents a broad spectrum of individuals from different socio-economic backgrounds. The deaf subjects were also few in numbers. They attended three different western Canadian residential schools for the deaf. They had a profound bilateral hearing loss. The study, however, could not control for other relevant factors such as family background or the hearing status of parents. One or a combination of these factors has been reported to influence test results.

Design and Data Analysis

The design and data analysis was shaped by the limited subjects available. Earlier investigators such as Das and Mensink (1989), or Kirby and Das (1977) did utilize the median split method prior to the introduction of the MANOVA design. Such an approach could have provided a better picture of the structural relationship between all the CAS tasks. It could have clarified also the components of academic skills predicted for individuals with higher scores on CAS tasks as opposed to individuals with lower scores. However, because the present subjects were too few, statistics for a larger sample such as the factor analytical approach or the median-split method on the basis of subject scores on simultaneous and successive processing were not possible.

Implication for Future Research

Cognitive Specificity and Preference

The use of CAS verbal and nonverbal simultaneous and successive processing provides further insight into the existing knowledge pertinent to cognitive specificity and preference in the deaf population. There appears to be a verbal and age factor influencing deaf performance in the simultaneous and successive processing. It can be inferred from this study, that within certain ages (currently an average age of 9.9 years), deaf subjects do not differ from hearing subjects in simultaneous and successive cognitive processing, if these tasks are nonverbal. It is only when the simultaneous tasks are presented verbally that deaf subjects begin to experience difficulty. In contrast, at an average age of 13.7 years, it appears from this study that deaf subjects are inferior to hearing subjects in simultaneous and successive cognitive processing whether the tasks are verbal or nonverbal. The question this research was unable to answer is whether there is an age specific period in which simultaneous and successive processing ability of the deaf would equal that of hearing, or an age specific period where it differs. This question is important because as already mentioned in the review section, academic achievement of the deaf hardly exceeds grade 4-5 equivalent regardless of age or years of schooling (Trybus & Karchmer, 1977; Wrighstone, Aronow, & Moskowitz, 1963). Incidentally, a recurring plateau has been discovered in academic attainment of the deaf, specifically because reading scores of 13 and 14 year old deaf students as they reach grade three or four level, changes very little from the same scores obtained by 19 year old deaf students (see Quigley & Kretschmer, 1982). The importance placed on simultaneous processing tasks in predicting mathematical skills (see Das & Naglieri, 1987), and the sequential deficits associated with possible difficulties deaf persons experience in acquiring the syntax of English (Rodda & Grove, 1985, p. 205), have been discussed earlier. Therefore, future research should aim at identifying the specific age at which deaf subjects are equal to the hearing subjects in simultaneous and successive cognitive processing ability. Additionally, future studies should examine the relevance of nonverbal simultaneous and successive processing tasks and academic subskills as opposed to the verbal simultaneous and successive processing skills.

Higher Cognitive Skills

As already pointed out, there appears to be a substantial amount of literature suggesting that as cognitive tasks move from representational to higher enactive, iconic, and symbolic modes, deaf subjects consistently lag behind the hearing subjects. The deficit performance of the deaf subjects in CAS higher order planning tasks compared to hearing subjects, is in support of earlier research. Furth (1974) and Keane (1981) suggest that such cognitive deficits in the deaf may be primarily a factor of experiential and linguistic deficit, or "environmental deprivation" to use Keane's term. The present study has not completely ruled out the experiential/environmental and linguistic deficit factors, but has revealed additional factors that enhance performance in higher order cognitive tasks. These factors include a) absence of strategies, b) lack of effort on the part of the deaf subjects to negotiate a solution to the planning problems and, c) failure to take advantage of available cues needed to complete the higher order planning tasks. It will be significant if future research examines in detail the importance of these strategies or necessary cues in higher order cognitive tasks, and whether it will be possible to instruct deaf subjects to make necessary efforts in identifying them. This should enhance their performance in higher order cognitive tasks.

Cognition and School Achievement

The CAS successfully predicts components of academic skills of the deaf subjects at the younger and older age levels. Therefore, it can be concluded at this stage that the CAS is a step ahead of the traditional intellectual IQ instrument, and it better predicts specific academic skills of the deaf population than the K-ABC. It has to be emphasized here, that by using the CAS to predict academic success or difficulties will not provide a solution to other relevant factors affecting academic success or failure. Other issues involved with predicting academic success or failure will include the positive or negative effects of the teachers, instructional modality, the nature and contents of the academic tests used, the child's previous experience with testing, motivation or lack of motivation, the presence of additional handicapping conditions, and so on. It is important that future research using the CAS tasks to predict academic success or difficulties is aware of these additional factors that will likely bias the interpretation of results.

The Hearing Impaired

This study is based only on the prelingual deaf attending residential schools so generalization of results to all deaf groups is limited. In order to establish appropriate validity and reliability of the CAS tasks for the deaf population, a larger sample of deaf children is required. These samples should represent the diversity of the deaf population accounting for their educational background, socio-economic status, decibel (dB) of hearing loss, onset of hearing loss, family background, parental hearing status, and method of communication utilized. Outcome of such studies should be able to establish particular norms and standardization for the population defined as hearing impaired.

It is expected that as soon as the CAS instruments are available, and its considerable strength in intellectual and psychological evaluation and academic prediction is recognized, our current knowledge regarding cognition, assessment and processes which predict academic success or failure, will greatly improve.

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Appendix I

Department of Educational Psychology,

University of Alberta, Edmonton.

Canada. T6G 2G5.

Feb. 27th, 1989

Dear Parent,

I am a Ph.D candidate in Educational Psychology program at the University of Alberta, working with Professor, J. P. Das, my thesis supervisor. I am conducting a study on Academic skills, Attention, Planning, Simultaneous-Successive Cognitive processing and would need permission to test your child.

The study would require that either I or a colleague administer an individual Cognitive Assessment System (CAS) subtests which should take approximately one hour and half of each child.

Some subtests of the Stanford Achievement Test (SAT) which should take approximately two hours will be administered later in a group setting.

Information obtained from these tests could provide a more valid assessment picture of the cognitive competence of the students. The CAS could very well become an important addition to the already existing psychological tools use for evaluating school children.

This project has been approved by the University of Alberta research committee. I want to give you further assurance that the identity of your school upon completion of this study and you can access this report anytime or request a copy from the school.

In order to insure that I am operating in accordance with your understanding and consent would you please complete and return the attached consent form.

If you have any questions or concerns about this study, feel free to contact:

Professor J, P. Das (Director)
Developmental Disabilities Center,
Department of Educational Psychology,
University of Alberta, Edmonton.
Canada. T6G 2G5.
Phone (403) 432-5245

Yours truly,

Emmanuel Ojile, Ph.D Candidate

CONSENT FORM

I give permission ______________________________ (child's name) to participate in the study title: "Academic skills, attention, planning, simultaneous-successive cognitive processing". I understand that the Cognitive Assessment System (CAS) tests will be administered along with certain subtests of the Stanford Achievement Test. I further understand that the child's identity will be protected and no child's name will be used in the written research report, and that you as the parent/guardian can access the report of this study after completion.

Name:___________________________ Address: _______________

Date: ___________________________ _______________________

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Please return this form to the classroom teacher or to the principal's office.