AN INVESTIGATION OF THE EFFECT OF TESTING ACCOMMODATION CONDITION (EXTENDED TIME) ON THE PERFORMANCE OF DEAF AND HEARING STUDENTS ON A STANDARDIZED MATHEMATICS TEST

by

FAWZY AHMED EBRAHIM-SAID

(Under the Direction of Stephen Olejnik)

ABSTRACT

Despite the fact that creative thinking abilities and cognitive abilities are well-researched topics with nondisabled persons of different ages, there have been no attempts to study several creative thinking abilities and reasoning abilities of deaf children in a cohesive conceptualization, nor to compare these abilities of deaf children to those of hearing children. In this context then, the purpose of this study was to examine the relationship between creative thinking abilities and reasoning abilities for deaf and hearing children. Two instruments were used in the study: The Torrance Tests of Creative Thinking-Figural, Form A and the Matrix Analogies Test-Expanded Form. Two groups of participants were chosen: Deaf children (n=210) and hearing children (n=200). Both groups were chosen based on specific criteria. Correlational research was chosen to conduct the investigation in this study. Analyses of the data were done using canonical correlation analyses to estimate the relationship between the six creative thinking abilities and the four reasoning abilities of both deaf and hearing children. Multivariate analysis of
variance (MANOVA) was used to estimate the differences between deaf and hearing children in the four reasoning abilities and the differences between deaf and hearing children in the six creative thinking abilities. Results of the study revealed that there are no differences between deaf and hearing children in the four reasoning abilities. The canonical correlation analysis revealed that deaf and hearing children differ in only one variable (abstraction of titles) of creative thinking abilities. On the other hand, teachers showed stronger beliefs that testing accommodations provided to students with deafness are fair and that these scores are comparable to scores obtained by nondisabled students without accommodations. These results are discussed within a validity framework and future research is outlined on extended time as an accommodation.

INDEX WORDS: Testing Accommodations, Extended Time, Validity of Testing Accommodations, Deaf students, Hearing Students at Risk in Mathematics, Hearing Students at or above Grade Level.
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DOCTOR OF EDUCATION

ATHENS, GEORGIA

2005
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DEDICATION

This dissertation is dedicated to my wonderful wife, Zaineb, without whom this would have been very difficult, and to all my family, whose constant support will always be appreciated.
ACKNOWLEDGEMENTS

I believe that the completion of this doctoral degree is not the result of the efforts of only one person. Without the support, encouragement, and determination of many significant people in my life.

First and foremost, I would like to thank my wife for being with me in all times and hardships I passed through. She postponed the completion of her undergraduate study to come with me here to support and encourage me. Our marriage, thus far, has been forged in my doctoral degree and the completion of this degree reflects her efforts as well as mine.

This degree is also the result of my family praying to God for me all the time. Although, I am farway from them, their hearts are with me all the time. My entire family provides me with emotional and financial support since my parents passed away. They started me on a track that has led me to this point in time, and I am thankful to God to have a family who always insist I am smart and should be successful.

There have been many dedicated professors in my life. I am pleased to have Dr. Steve Olejnik as a major advisor. He has provided me with support, encouragement, and knowledge.

Dr. Bonnie Cramond is a great scholar and a very nice person. There is no means by which I might ever repay her efforts since I know her. I have benefited greatly by her generosity and her genius.
I gratefully acknowledge Dr. Lautenschlager for his support. He always reviews all my writing in a timely fashion and gives me sincere patience and advice.

I gratefully acknowledge Dr. Deborah Bandalos for high aspirations, productivity, understanding, and high expectation.

Finally, I send a special acknowledgement to my mentor, Dr. Stephen Olejnik. whose personality and teaching style fascinate me. He provided me with great help and advice throughout my work on this dissertation.
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CHAPTER 1
INTRODUCTION

Superior intellectual ability is found among children with physical, sensory, language, learning and emotional disabilities (Williamson, 1995). High intellectual ability can be advantageous in helping a child to compensate for his disability. Safford (1978, p.27) emphasized that disabled individuals use their intellectual proficiency in unique ways to achieve social, academic, and occupational success.

Because of the severity of some disability conditions and past inequalities of educational opportunity accorded individuals with disabilities, special abilities and talents among these children have often gone unrecognized and undeveloped. History tells us those persons with both gifts and disabilities, when given the opportunity to develop their potentials, can make a significant impact on society. For example, the contributions of Ludwig van Beethoven, Franklin Roosevelt, Helen Keller, Vincent van Gogh, Albert Einstein, and Thomas Edison stand as inspiring examples of the greatness that can be achieved by a severely disabled person.

The current study focuses on a deaf population. Easterbrooks (1987,pp. 189-192) distinguished among three categories of the deaf population:

1. Deaf I (Communicating orally): This group has 65-dB loss or greater in the better ear, may have lost hearing in preschool years, usually begin wearing hearing aids early, Fair
vocabulary, can indicate needs, usually have been in infant and/or preschool programs, parents usually involved in child’s program.

2. Deaf II: This group has 65-dB loss or greater in better ear, are actually two subgroups: (a) hearing parents- have developed a gesture system, home sign system, or rudimentary sign language system sufficient for making their needs known, some have developed excellent language. (b) Deaf parents- Have developed a sign system, probably ASL, due to good models, language may be excellent but differs from the structure of English, have received some preschool experiences, either formally through clinics and other programs or informally from adult models, parents often involved in child’s program.

3. Deaf III (Little to no language): This group has 65-dB or greater in the better ear, may have received aids or never assimilated them to daily routine, communication forms are rudimentary and very different in forms from normal early utterances, few useful words, may not have received any preschool services.

In general, children who are deaf or hard of hearing receive fewer special programs based on their abilities than programs based on disabilities (Laughton, 1988). In schools for deaf children, educational objectives and goals tend to focus on remediation or “normalization” related to the different aspects of their disability. Consequently, deaf children have been less likely than their hearing peers to be screened, identified, and served by special programs to assess and develop their creativity (Whitmore & Maker, 1985, p.123). Failure to identify and serve deaf children with creative thinking abilities is an indictment against the society and a problem that should not be tolerated (Johnson, Karnes, & Carr, 1997). Failure to identify and nurture
creativity among the deaf is unfair to them and to society. Moreover, failing to actualize one’s potential creates a breeding ground for frustration and poor mental health. So, it is imperative to develop services to identify and nurture the potential of children who are creative and who also happen to be deaf.

Several researchers have provided evidence for the relationship between giftedness and creative performance. Guilford (1968) believed that creativity is an important element of true giftedness. Renzulli (1986) viewed creativity as a specific subcomponent of giftedness. Creativity becomes an attribute that can influence the type of giftedness expressed, such as school related giftedness or creative-product giftedness. Sternberg and Lubart (1993) found that creatively gifted individuals excel in the intellectual processes of problem definition, selective encoding, selective combination, and selective comparison skills, and that these aspects comprise divergent thinking and generative thinking. Some other researchers believe there is an apparent overlap in the cognitive skills for both academic giftedness and creative giftedness, and this overlap explains the high correlation between measure of divergent thinking ability and the achievement or intelligence measures which are used to identify giftedness (Hall, 1985; Runco, 1986; Runco, 1993; Runco & Albert, 1986).

There are many factors that contribute to one’s creativity. Feldman (1999) reported that an adequate analysis of creativity involves at least six dimensions: cognitive processes, social/emotional processes, family aspects, education and preparation, characteristics of the domain and field, and historical forces and events. Most research of creative thinking abilities has focused on hearing children; significant factors that may
My career goals are to investigate these factors and their relationships with creativity in deaf children. There are many cognitive abilities that relate to their creative thinking abilities. The current research focuses on reasoning abilities for two reasons: first, there are some standardized nonverbal instruments to assess reasoning abilities. The instructions of these instruments can be delivered to the deaf children by using sign language and this provides valid assessment of the reasoning abilities of deaf children. Second, intervention programs to develop reasoning abilities could provide stable improvements in the reasoning abilities of the children. The goal of the research was to investigate the relationship between reasoning abilities and creative thinking abilities by using nonverbal instruments to evaluate the abilities in deaf children and to examine the relationship between the findings for this group and a hearing group. The Torrance Tests of Creative Thinking-Figural, Form A and the Matrix Analogies Test were administered for a group of deaf students whose ages range between 8 and 11 years, and whose unaided sensorineural hearing loss for three pure tone frequencies (500, 1000, 2000 Hz) is 90 dB HTL or greater in the better ear. The deaf students’ performance was compared with a group of hearing students. Both groups were homogenous with regard to school grade level, socio-economic status, and time of enrolling at school.

Cognition and Creativity

The current study focuses on investigating the relationship between reasoning abilities and creative thinking abilities of deaf children and comparing the results with those from hearing children. The study focuses on the cognitive approach, specifically the
Guilford Structure of Intellect (SI) Model, as a theoretical background to explain such relationship.

_Cognitive Approach to Study Creativity_

Many psychologists discussed the relationship between creative thinking ability and cognitive ability. Guilford (1950, p.25) considered convergent and divergent thinking operations as major components of creative thinking. He explained that the two operations require that the thinker produce information, when given other information. Divergent thinking includes the abilities that are most significant in creative thinking and invention.

According to Guilford (1967), commonly used intelligence tests measure convergent forms of thinking. However, creativity involves divergent thought processes, which account for 30 of the 150 factors of intelligence described by the structure of intellect model. Guilford was able to procedurally identify over 100 out of 150 factors through factor analysis.

Within creative cognition approach, many types of creative behavior are characterized as instances of conceptual expansion that push the boundaries of a conceptual domain by envisioning and bringing to fruition novel exemplars of such domains (Ward, Saunders, & Dodds, 1999). For example, when a composer writes a new symphony, or a student draws a unique picture, their creative products can be seen as instances of conceptual expansions.

Because the products of many creative persons are outgrowths of the concepts that have come before, they can be expected to share some important properties with previous

The creative cognition approach tends to concentrate much attention on what is old or familiar within each individual to understand the dimensions and properties of the new creative products (Ward, 1994, 1995). So, by examining what creative new ideas have in common with their predecessors, the creative cognition approach can provide insights into the way in which individuals use their existing knowledge to invent some new creative products.

Cropley (1999) added another perspective to the creative cognition approach. He emphasized the processes involved in producing effective novelty, as well as the control mechanisms that regulate novelty production, and the structures that result. He explained that effective novelty can be produced at lower levels of cognitive development, but children’s creativity is likely to differ qualitatively from that of adults. Croply emphasized that novel structures should be meaningful and practiced to be effective.

Based on the creative cognition approach, a variety of cognitive skills have been targeted as major factors in shaping creativity. These include problem-finding abilities, idea generation skills, communication skills, spatial abilities, and information organization tendencies (Amabile, 1996; Eysenck, 1994, 1995; Gardner, 1992; Schooler & Melcher, 1995). Other researchers investigated the relationship between certain cognitive skills and specific creative abilities. Schooler and Melcher (1995) indicated that cognitive skills are differentially related to solving different types of verbal-analytic and graphic-perceptual problems. More specifically, skill to avoid mental sets (an ability to be
original in thinking despite situational constraints) has a stronger relationship with performance on nonverbal-perceptually based problems than with verbal-analytic problems.

Although there is a great deal of research of the creative cognition approach, there is almost no research available to explain the relationship between creative thinking abilities and reasoning abilities of deaf population.

Creativity and Cognition in Deaf Populations

The relationship between cognitive ability and creative thinking ability of deaf children has been overlooked in educational research. Studies of cognitive ability in deaf individuals have focused on a wide range of issues, including the relationship between sign language and spoken language (Anderson & Reilly, 2002; Stokoe, 2001b), factors in memory span and memory coding (Flaherty, 2001; Fletcher-Flinn & Snelson, 1997), and reading ability (Hanson & Fowler, 1987; Byrne, 1993; Cossu, Rossini & Marshall 1993). However, the relationship between cognitive ability and creativity in the deaf population has not received enough attention from researchers in either psychology or education (Marschark & West, 1985; Marschark & Clark, 1987).

Cognition and Deafness

Three perspectives seek to explain the relationship between cognitive ability and deafness. The first viewpoint focuses on explaining that the lack of language in deaf people leads to intellectual abilities that fall far below those of hearing people (Moores, 1978, p.79; Conrad, 1979, p.112; Watts, 1979; Quigley & Paul, 1984, p.72). This view created an organismic shift, a biologically inspired change in a person’s orientation
towards the world. While rejecting the view that this leaves the deaf person with no symbolic world, no reasoning or rationality, this viewpoint became a theoretical view that has not been supported by empirical research.

The second view was articulated by Myklebust (1964, pp.42-49) when he proposed that the cognition of deaf and hearing people was different in some important aspects. Lacking access to sounds, deaf individuals exist in a more isolated world than their hearing peers. The hearing individual is exposed to simultaneous experiences of vision and hearing. For instance, many hearing children may concentrate on their own actions and their effects on the surrounding environment, and they are open to intrusions from the sounds of others. On the other hand, deaf individuals are excluded from such sounds and live in a world necessarily more centered on the self and the effects of their own activities. Myklebust concluded that the cognitive ability of deaf individuals is, therefore, more concrete and less abstract than that of hearing people.

Based on Myklebust’s view, most of the previous investigations of deaf individuals cognitive ability have indicated their rigidity, concrete thinking, lack of imagination, and deficiency in abstract and divergent thinking (Oleron, 1953; Singer & Lenhan, 1976). The validity of these studies is questioned because they used instruments that are verbally structured to assess cognitive abilities. Because of recognized verbal differences, such instruments are not appropriate for use with deaf populations. Results in studies that force deaf children to rely on verbal communication may confuse the children’s misunderstanding of the directions with cognitive failure. If attempts to test deaf children’s understanding expose them to language demands they cannot meet, then
failures on their part may be the result of the failure to establish mutual communication between the deaf children and the hearing assessors rather than evidence of cognitive deficits.

A third view was proposed by Furth (1966, pp. 36-51). He adopted Piaget’s theory of human development and argued that cognitive ability of hearing and deaf people and their developmental patterns are essentially similar. He proposed that babies show evidence of mental activity and some forms of thinking before they learn to speak. Therefore, they exhibit cognition without language. Children usually begin to talk in the second year of life, and this comes after many months of development during which they come to understand verbal concepts. Piaget’s investigations revealed many situations in which children fail to understand the meaning of what adults are saying. Children understand the world and make sense of what adults do and say according to their developmental levels. The nature of their understanding may be different from that of adults because their views of the world are naturally and fundamentally different.

The proposed study is based on the views of Piaget and Furth that language is not the foundation for thought. Because cognitive development precedes linguistic understanding, we can conclude that the comprehension of language is based on cognition. Hence, deaf children, even if they lack facility with language, can be expected to develop the same nonverbal cognitive ability as their hearing peers (Bloom, 2001; Brown, 1991). Deaf children use Sign Language to compensate for the lack of speech. Most deaf children use Sign Language to communicate their thoughts and ideas to other deaf and hearing individuals. Wood (1991) pointed out that, whereas deaf adults may
come to think in signs rather than in words, the operations that govern their thinking are the same as those found in the hearing adult’s thinking.

Based on Furth’s view of the effects of deafness on cognitive ability, some studies were conducted to assess the cognitive ability of deaf individuals. Meadow (1980, p.212) found that cognitive performance of deaf learners is similar to their hearing peers, although their actual performance in several cognitive categories (e.g. anticipation of images, rule inferences) might differ from hearing learners. Considering the language deficiency among deaf children, Martin (1989) tested the cognitive skills of deaf and hard-of-hearing children by asking them to generate responses to selected visual problems. He found that deaf learners depend on visual spatial perception and processing, and they are good at simultaneous visual processing. Also, Bond (1987) found that when language demands are reduced, the cognitive development of young deaf children is comparable to that of hearing children of the same age.

Chovan (1972) demonstrated that deaf middle school and high school students are more likely than hearing students to use visual strategies for cognitive tasks. Further, deaf students showed faster reaction times on visual tasks.

Recently, Al-Hilawani (2000) concluded that deaf and hard-of-hearing students are as competent as hearing students in cognitive problem solving situations that focus on visual stimuli. Craig and Gordon (1989) reported that cognitive task performance (memorization, abstract matching) among deaf learners was below average for the verbal and sequential skills associated with the left hemisphere, but more importantly,
performance was above average for visual and spatial skills associated with the right hemisphere.

*Creativity in Deaf Populations*

For many years, the preponderance of literature concerning the education of the deaf has centered on their disability and the communication deficits imposed by it (Gamble, 1985). In general, research in creativity of deaf populations is still minimal. More efforts are needed to investigate whether the creative thinking abilities are similar in deaf and hearing individuals.

Although the Departments of Education in some countries have started providing significant services to gifted creative students regarding screening, assessment, and placement in special programs, gifted creative deaf students have not receive such services. However, one sub-population of gifted children has largely been overlooked both in the teaching requirements and in educational research. Gifted deaf children have not received educational services to develop their strengths. Instead, they have ostensibly been educated in the routine fashion dictated by the focus on the deficit needs of the majority of deaf students.

Internationally, most of the studies conducted on the creativity of deaf children have focused on assessing the creative ability of deaf students or comparing the creative ability of hearing children with deaf children. These studies found that there are no significant differences in creative thinking between deaf students and hearing peers. A review of literature in dissertation abstracts revealed that there is no recent published dissertations investigated the creative thinking abilities of deaf children especially over
large sample of children. So, there is still a need to investigate more components of creative thinking ability of deaf individuals and compare them to hearing individuals.

Horrocks and Pang (1968) found that deaf students scored approximately the same as hearing students on the Torrance Tests of Creative Thinking—Figural, although they scored higher on elaboration. Marscharark and West (1985) investigated the language flexibility and creativity of deaf students by having them generate stories to experimenter-supplied themes. The students showed considerable use of creative language devices when evaluated in sign rather than spoken language. Deaf students produced traditional types of figurative, nonverbal constructions at a rate equal to their hearing age-mates and surpassed them in four other categories of nonliteral expressions. Everhart and Marschark (1988) examined the linguistic flexibility of deaf and hearing children by examining the relative frequencies of their nonliteral construction in stories written and signed by the deaf or written and spoken by the hearing children. The study found that hearing students used more nonliteral constructions in their written stories than did their deaf peers who used very few. However, deaf students used more nonliteral construction in their signed stories than their hearing peers did in their spoken stories.

**Significance of This Study**

**The Theoretical Significance**

The goal of this study was to assess the relationship between creative thinking abilities and reasoning abilities of deaf and hearing children. There were 210 deaf children who participated in the study. There is no comparable number of deaf children participated in any of the previous studies. The current study represents the first study
that used Torrance Tests of Creative Thinking- Figural, Form A and Matrix Analogies Test- Expanded Form. The deaf children who participated in this study are considered a representative sample of deaf children for the age group 8-11 years. Consequently, the findings of this study can advance the current knowledge concerning the nature of the cognitive ability and creative thinking abilities of deaf children, and overcome misconceptions about deaf populations that make reference to their rigidity, concreteness, lack of imagination and deficiencies in abstract and divergent thinking.

The Practical Significance

The findings of this study can provide information that may assist us in identifying highly creative (deaf and hearing) children for enrollment in some gifted programs in their schools, in order to fully develop their mental abilities; provide directions to assist teachers and trainers in developing and delivering appropriate forms of assessment to deaf children; enable teachers, special education counselors, and other educators to obtain information about the strengths of deaf children’s thinking.

Research Questions

The purpose of the current study is to examine the relationship between the creative ability and reasoning abilities of a group of deaf children, and compare them with a group of hearing children.

The following questions were addressed:

1. What is the relationship between six creative thinking abilities and four reasoning abilities of deaf children?
2. What is the relationship between six creative thinking abilities and four reasoning abilities of hearing children?

3. Is there a significant difference between deaf children and hearing children in the six creative thinking abilities?

4. Is there a significant difference between deaf children and hearing children in the four reasoning thinking abilities?

Definitions of Terms

For the purpose of a common understanding of the terms that appear in this proposal, a definition of terms, as they apply to the current research, has been included:

Creativity

Torrance (1998) refers to the creative thinking as a component of five abilities. These abilities are fluency, originality, abstractness of titles, elaboration, and resistance to premature closure. Fluency refers to the number of ideas a person expresses through interpretable responses that use the stimulus in a meaningful manner. Originality refers to the infrequency and unusualness of the response. Abstractness of titles refers to the ability to produce good titles involves the thinking processes of synthesis and organization. In scoring elaboration, credit is given for each pertinent detail (idea, piece of information, etc.) added to the original stimulus figure, its boundaries, and/or its surrounding space. Resistance to premature closure refers to the ability of a creative person to keep open and delay closure long enough to make the mental leap that makes possible original ideas. This is measured by the individual’s tendency to close the incomplete figures immediately with straight or curved lines or not.
Cognition and Cognitive Thinking

Cropley (1999) distinguished between cognition and the thinking processes that use cognition. He defined cognition as concerned with the ways people obtain, organize, process, store, and use information. Thinking is a process through which symbols are constructed, revised, linked to other symbols, reorganized, and applied to abstract or concrete situations. It involves processes such as exploring, recognizing, organizing, coding, and structures (internal representations of the external world) such as patterns, categories, networks, and systems that result from the processes.

Deafness

Individuals with Disabilities Education Act “IDEA”(1997) has defined deafness as a hearing impairment that is so severe that a child is impaired in processing linguistic information through hearing, with or without amplification, that adversely affects educational performance. The terms mild, moderate, severe, and profound are often used to provide more specific information about severity of audiometrically assessed hearing loss. Profound hearing loss is considered deafness audiometrically. Cultural deafness entails different criteria such as mild severity of hearing loss and/or parents who are deaf.
CHAPTER 2
REVIEW OF LITERATURE

The purpose of this chapter is twofold: First, to emphasize the need for measures that are suitable for assessing deaf individuals’ mental abilities, and, second, to explore some controversial findings in the literature regarding cognitive ability and creative thinking abilities of deaf individuals. To achieve these purposes, this chapter is divided into the following sections: Structure of Intellect (SI) Model as a theoretical background for the proposed research, assessment of deaf individuals’ abilities, cognitive research in the deaf population, the effect of sign language on cognitive functioning, the effect of language deficit on the creative performance of deaf individuals.

*Structure of Intellect (SI) Model*

Perhaps the largest single breakthrough in the cognitive approach to understanding creativity came from Guilford’s (1967, pp.6-11) Structure of Intellect Model. The Structure of Intellect (SI) Model postulates five content categories that interact with its five operation categories, and these, in turn, interact with its six product categories. The three sets of categories are:

1. The content categories include figural (the examinee must be acquainted with and use certain figural properties such as shape, color, texture, and size), symbolic (such as syllables, words, and numbers), semantic (the examinee must know the word meaning
and use it), and behavioral content. Guilford (1982) divided figural ability into visual and auditory components.

2. The operation categories include cognition (awareness, immediate discovery or rediscovery, or recognition of information in various forms; comprehension or understanding), memory (retention or storage, with some degree of availability, of information in the same form in which it was committed to storage and in connection with the same cues with which it was learned), divergent thinking (the thinker must do much searching, and often a number of answers are available), convergent thinking (the thinker must arrive at one correct answer, and the information given generally is sufficiently structured so that there is only one correct answer), and evaluation (involves decisions as to the goodness, suitability, or success of information, memories, and products of thoughts).

3. The product categories refer to the products of the operations. By applying various operations to the different kinds of materials, certain kinds of products can be arrived. In the area of cognition, we can discover or know units; for example, figures, word structures, and meaning. We can become aware of classes of units; of relations between units; and patterns of the units, that is, structures or systems. We also may apply extrapolations beyond the materials given, in the form of implications and predicting. Similar products pertain to the other major categories: memory, convergent thinking, divergent thinking, and evaluation. Figure 2.1 illustrates different components of the Structure of Intellect (SI) Model.
Guilford’s (1967) distinction between convergent and divergent thinking established the potential for the creative cognition approach to understand creativity.

Abilities that are assessed by the Torrance Tests of Creative Thinking, Figural and Matrix Analogies Test were generated from the Structure of Intellect (SI) Model.

Assessment of Deaf Individuals’ Abilities

Deaf children present with a number of special assessment needs. These needs require an accurate determination of cognitive, communicative and personal characteristics in order to plan instructional and other experiential activities to promote the child’s development. Vernon and Rabush (1980) noted several trends in the field of deaf education. These trends include greater enrollment in public school programs,
technological advances, and wider use of sign language. Johnson (1998) validated the previous trends with emphasis increased using American Sign Language as a primary communication mode. These trends are relevant in assessing this population. Drawing on current findings about the deaf population, several objectives can be identified that appear central to the psychological assessment of children with deafness.

One of the primary objectives in the assessment of the deaf child is to explore the factors that may account for the discrepancy between cognitive ability and performance. As Tomlinson-Keasey and Kelly (1978) have indicated, there is a paradoxical situation in which the measured nonverbal IQ of a deaf child is often within the normal range; whereas, achievement scores reflect substantial deficits when compared to hearing peers. A central purpose for the assessment of deaf children is the identification of characteristics associated with discrepancies between ability and effective learning and achievement.

A second major objective of assessment is to differentiate cognitive and linguistic competence. The distinction between these two domains is important, since tests that are verbal in nature or orientation are likely to measure the language problems rather than intellectual ability of deaf children (Sullivan & Vernon, 1979). Thus, in assessing a deaf child it is essential that every effort be made to select instruments and utilize administration procedures that limit the confounding effects of language competence in the measurement of cognitive skills.

Providing valid and comprehensive assessment of a child who is deaf or hard of hearing can be a complex and time consuming process because these children represent a
very heterogeneous group. They vary with regard to a full range of significant background and personal variables such as family size, parental education, socioeconomic status, minority group membership, intelligence, personality, and additional disabilities. However, a few also vary with regard to a number of factors related to the hearing loss itself such as degree and type of hearing loss, communication mode and language competence, hearing status of parents, and other factors (Mullen, 1999).

The United States of America was the first country that created laws that organized the assessment process for disabled individuals. According to these laws, tests and other evaluation materials used in the assessment process must be “validated for the specific purpose for which they are used” and are to be “administered by trained personnel in conformance with the instructions provided by their producers” (IDEA (1997) Section 300.532,2,C, pp. 132-133). The law mandated that the tests be:

Selected and administered so as best to ensure that when a test is administered to a child with impaired sensory, manual, or speaking skills, that the results accurately reflect the child’s aptitude or achievement level or whatever other factors the test purports to measure rather than reflecting the child’s impaired sensory, manual, or speaking skills (except when those skills are the factors which the test purports to measure (IDEA, 1997, Section 300.533, 2, E, pp. 123-124).

Hendershot (1998) noted that the definition of disability should be changed to reflect the mandate of the Americans With Disabilities Act that deems a disability as an interaction
between the individual with impairment and the environment rather than a deficit of the individual. Accordingly, the past two decades have witnessed a paradigm shift in the conceptualization and assessment of disability. Rawlings, Karchmer, Decaro, and Allen (1999) explained that this shift provided a movement away from categorical definition of the disability to a framework in which functional abilities of the individual are described in the context of a particular social environment (e.g., the work place or the classroom). Functional assessment, in the light of the new paradigm, is very useful and can identify not only the impaired abilities, but also other abilities and areas that need to be developed.

Problems in Assessing Deaf Individuals’ Abilities

Salvia and Ysseldyke (1991, pp. 108-123) have reported that children who are difficult to assess are whose with the greatest need for help. Unless the teacher can accurately describe their abilities and design programs appropriately for them, they are unlikely to improve. When children are placed in an evaluation setting because they encounter academic or behavioral problems, evaluators and assessors usually concentrate on the child’s problems. They rarely concentrate on assessing and developing the child’s strengths. Salvia and Ysseldyke (1991) raised some important issues that challenge the assessment process of handicapped individuals in general, and deaf children in particular:

Most commercially available standardized tests were developed for use with hearing children. Some problems arise when educators and professionals attempt to modify these tests for use with disabled children. Some commonly used modifications used in assessing deaf children are stimulus demands (e.g., signing or pantomiming) and
eliminating time requirements. Unfortunately, these modifications make norm-referenced interpretation of the scores obtained invalid conditions under which assessments were made may differ.

Examiners of deaf children often apply tests based on a normed sample of students who are younger than the test takers. This assessment may provide incorrect results because norm-referenced interpretations are unjustified when the age of the children in the norm group and the age of the person being tested are not the same.

The children tested may differ significantly in acculturation, background, and experience from those for whom the test was developed. In this case, the test should not be used. When children are tested using a standardized device and compared to a set of norms to get an index of their relative standing, the researcher can not always assume that the children assessed are similar to those on whom the test was standardized (personal characteristics and testing environment of the reference groups may differ significantly from the group that are being tested).

Some assessors employ developmental tools designed for special populations other than the children with whom they are working. The rationale is that such tests reflect some acknowledgement of a lack of sensory ability or behavioral adequacy.

There is a lack of professional diagnosticians who are able to communicate with deaf individuals. A deaf child may use one or more of several different communication languages or modalities (e.g. speech and listening, cued speech, or a form of sign languages).
Some assessment measures may not have a sufficient number of items to adequately describe skills in a particular area. Thus, it may seriously affect a child’s score and not provide enough information on which to design remedial programs.

A child’s performance on an isolated task presented by a stranger will rarely be comparable to that child’s performance in a classroom during a familiar activity. Moody (1990) found that performance of deaf children on achievement tests differ significantly when a different teacher accustomed to test them. Performance may vary with the evaluator’s competence understanding his/her sign language.

*Clinical Cognitive Assessment of Deaf Individuals’ Abilities*

A new approach has appeared to reduce the effects of previous problems which arise when using psychometric instruments. Clinical cognitive assessment was mainly developed to assess cognitive and other mental abilities of deaf people. It is mainly a series of structured interviews that focus on cognitive functioning of deaf people. Clinical cognitive assessment in social service contexts helps to determine eligibility for service and admission for special educational programs (Sattler, 1992). For example, deaf children who have cognitive disabilities may qualify for additional services that are not available to deaf children without cognitive disabilities. Also, clinical assessment of cognitive abilities of the deaf may be performed to help deaf people better understand their abilities and characteristics (Sattler, 1992).

Braden (2001) divided the methods of clinical cognitive assessment of deaf children into the following four categories: First, clinicians may draw inferences about a person’s cognitive abilities from informal observations during assessment sessions.
Atypical behavior such as persistence on doing the same actions, smelling materials, or lack of responsiveness to context changes may suggest limited cognitive abilities. Atypical behavior such as insight, use of sophisticated vocabulary, or uncommon knowledge about many topics may indicate advanced cognitive abilities.

Second, clinicians often interview a person seeking services to obtain a broad estimate of the person’s cognitive abilities. These interviews are termed mental status exams and either follows a formal protocol or is composed of an informal set of questions and procedures. Mental status exams often include questions to measure people’s ability to orient themselves in time, space, and social settings.

Third, clinicians may use assessment devices whose parameters are not formally described. Clinicians may assess a client’s ability to solve certain kinds of problems or respond to various items. The clinicians may then teach the client some strategies for responding to these items, and test the client again to determine whether the client learned and applied these strategies.

Fourth, formal tests of cognitive abilities are the most evolved and studied tool in the clinician’s repertoire. In this assessment, clinicians seek to isolate problems of cognitive functions from problems associated with deafness.

Although the clinical assessment of a deaf individual’s cognitive ability can provide a clear, authentic picture about cognitive ability, there are some challenges: First, there are few professional clinicians who possess sufficient experience in the field of clinical assessment and who have mastered one or more of the communication styles suitable for use with deaf individuals (e.g., American Sign Language). Second, clinical
assessment must be applied on an individual basis. It is a time-consuming process, and, therefore difficult to use in school settings. Third, most deaf people experience substantial language deficits because they are isolated from consistent exposure to oral language. It is ethical for professional clinicians to be able to discriminate between language deficits and cognitive deficits.

A review of literature revealed that psychometric assessment is continuing to be the predominant style in assessing cognitive and mental abilities of deaf individuals. Some recommendations have been suggested to reduce the effects of psychometric assessment in deaf populations. According to Mullen (1999), the primary challenge in assessing cognitive ability in a child with a significant hearing loss is differentiating linguistic competence from other areas of cognitive functioning. Tests that are verbal in nature require a child either to comprehend directions or to provide a verbal response; this may give the examiner useful information regarding verbal skill development, but confounds the assessment of the child’s thinking and reasoning abilities. Nonverbal instruments are highly recommended to reduce the language demands on deaf individuals.

Cole and Cole (1989) emphasized the need to validate most of the nonverbal instruments that are used with deaf individuals. So, researchers should make an effort to compute validity and reliability coefficients for the tests they will use, over a large number of deaf subjects, to make sure these instruments measure deaf individuals’ abilities adequately.
Research in Cognition of Deaf Individuals

Piaget (1983) proposed that knowledge is not derived from sensation or perceptions, nor is knowledge gained from information provided by others. He also argued that individuals construct knowledge initially out of their own motor activity. Piaget contended that knowledge begins with actions. Acquiring knowledge depends on doing rather than passively observing.

Although we know that observational learning does occur, it seems that actions are clearly a strong basis for gaining perceptual knowledge. Oleron (1953) proposed that, for deaf individuals, actions sometimes seem even more important than perceptual information.

Early research that has focused on specific aspects of cognitive development of the deaf, such as conservation, classification, and concept learning, has yielded contradictory and confusing results. For example, a variety of studies have examined the acquisition of simple single and multidimensional concepts. These studies involved nonverbal stimuli (e.g. picture matching) and responses and used transfer tasks in which concepts were mastered by discovery, or trial and error learning. The nonverbal tasks were intended to avoid deaf children’s linguistic deficiencies while the transfer tasks allowed investigators to ensure that a child understood a task before they moved on to more complex test phases of the experiment (Braden, 1985; Marschark, 1993; Marschark, & Clark, 1987).

Oleron (1953) had 15-year old deaf adolescents sort a set of 27 stimulus cards that differed in color, number, and shape representations. The goal was to have the subjects successively sort the cards on each of the three dimensions. Oleron found that only 6 of
his 24 deaf subjects could perform the task. When the researcher gave feedback, only 15 of 24 of the deaf subjects performed the task successfully. Oleron concluded that deaf children think concretely, in terms of objects and attributes, rather than in terms of classes and item similarities and differences. It seems that this study may have underestimated the abilities of deaf 15-year-olds because it did not address the language demands during the instructions and feedback to the deaf adolescents. In addition, Oleron did not include a control group of hearing adolescents as a comparison group.

Furth (1961) had deaf and hearing children, 7 to 12 years of age, learn the concepts of sameness, symmetry and opposition. In the sameness task, children saw sets of four circles, each circle containing two simple figures. The task required only choosing the circle in which the two figures were the same. On the symmetry task, children were shown pairs of geometric figures, one of which was symmetrical and one of which was not. The task was to choose the symmetrical one. In the opposition task, children were first shown a randomized subset of four wooden disks varying in diameter. If the experimenter pointed to the smallest, the child had to point to the largest, and vice versa. Once the child had acquired the opposition concept, there was a transfer task in which similar trails were given on the dimensions of volume, length, number, brightness, position on a circle, or sandpaper texture, from the smoothest to roughest. In the sameness and symmetry tasks, Furth found no reliable difference between the deaf and hearing children. However, the deaf children performed less well than the hearing at all ages on the opposition task. Furth explained this advantage of hearing children over the deaf accused because opposition is most often encountered in verbal contexts. Irrelevant
stimulus dimensions distract deaf children. Furth concluded that the problem might not be that deaf children are unable to form concepts or categories, but that the dimensions on which they are to form them are not as obvious as they might be for the hearing children. This misdirection could result either from the lack of verbal mediation (similar objects get the same category name) or from the lack of experiential diversity in which such concepts might be acquired.

Ljubesic (1986) examined the structure of cognitive ability of deaf individuals by assessing variables of visual stimuli, verbal stimuli, verbal understanding and expression, and short-term memory. She found that nonverbal cognitive ability has a similar psychological construct in deaf children and children with no impairment for every language deficit level. Also, she found that deaf children apply the same cognitive processes as children with no hearing impairment on nonverbal tests. To provide valid results concerning the general level of cognitive abilities of deaf children, educators should use tools that are suitable for their disability (nonverbal measures rather than verbal measures).

Effect of Sign Language on Cognitive Functioning

Like other languages, sign language is a fully-fledged system composed of sublexical structures: hand configurations, place of articulation, and movement (Bellugi & Klima, 1978). Stokoe (1960) explained that sign language has rules that specify the ways in which the signs are linked to each other in space so as to express well-organized sentences. Stokoe (2001a) emphasized that a sign language environment for deaf children
is as important to their cognitive development as a spoken language environment is for hearing children.

There are numerous studies that tested the effects of sign language on the cognition of deaf individuals. Everhart and Marchark (1997) and Marchark, West, Nall, and Everhart (1986) asked four deaf students to create a story about pre assigned topics and to sign their stories to the experimenter. They found that using American Sign Language as a basic communication style increases the nonverbal creative thinking abilities of 4th grade deaf children especially when the children are fluent in using ASL.

Deaf children acquire American Sign Language movements for space and time by learning how to apply these expressions to a prior knowledge they may have about space and time. This learning leads to better representation of spatial cognition (Bellugi, Grady, Lillo-Martin, and O’Grady, 1990; Parasnis, Samar, Bettger, and Sathe 1996. Courtin (1997) found that using American Sign Language increased the flexible thinking of deaf children when they solve daily life problems especially when they deal with one another. Ronnberg, Soderfeldt, and Risberg (1998) found that American Sign Language increases the ability of deaf children to maintain information in working memory in way that allows them to rehearse it in later times..

When the assessors reduce the demands of language and depend on nonverbal instruments to assess the mental abilities of deaf children in general and cognitive ability in particular, deaf individuals show no differences from hearing individuals (Everhart & Marschark, 1997). Some studies have found that there are no major differences in the range or quality of cognitive ability between deaf and hearing individuals (Braden, 1984,
Zweibel, 1991). Pinhas (1991) examined the constructive processing of skilled deaf and hearing readers. He concluded that although the deaf students did not exhibit the characteristics of the constructive reader, their patterns of cognitive processing might not indicate an actual deficiency in inferential processing. The deaf students were as effective in inferences as were hearing students, but the deaf students did exhibit differences in cognitive functioning, possibly as a result of their adaptive strategies such as functional fixedness and strategic learning. Eagney (1983) found that intellectual ability was the only significant contributor to variance on the cognitive tasks. It was concluded that enough of linguistic ability was accounted for by intellectual ability to prevent linguistic ability from contributing significantly to variance on the cognitive tasks for the deaf children.

The use of American Sign Language and other communication aids, such as lipreading, is important in assessing cognitive abilities of deaf individuals because it is a way of making sure that they fully understand the purpose and instruction of the testing.

_Effect of Language Deficit on Creative Performance of Deaf Individuals_

There are controversial findings as to whether deaf individuals possess the same creative thinking abilities as their hearing peers. Some investigators have cited that deaf children’s poor performance on several nonverbal tests of cognitive and creative thinking is evidence of their conceptual concreteness and rigidity (Templin, 1950; Oleron, 1953; Myklebust, 1964; Singer & Lenahan, 1976).

In most Middle East countries, before using Sign Language as a formal communication method in schools for the deaf, most deaf students received little direct or
indirect linguistic instruction. The lack of availability of effective communication style reduces the diversity of deaf students’ linguistic and nonlinguistic creative experiences (Liben, 1978; Watts, 1979; Hoffmeister, 1990; Holt, 1994).

Cornelius and Hornett (1990) reported that at a certain level of linguistic deficiency, deaf children are limited in providing the anticipated quantity and diversity of their imaginary play compared to their hearing peers. Singer and Lenahan (1976) attempted to tap the imaginative abilities of deaf children by examining their daydreams, play, and fantasy reports. They obtained language samples of 20 profoundly deaf students using structured interviews and elicited story productions. Their reports indicated that the deaf children demonstrated less creativity and imagination than hearing peers. Also, they reported “the deaf children tended to use past and present time frames, for the most part, the fantasies were very ordinary, and these children usually related experiences that they had encountered rather than experiences they wished to encounter” (Singer & Lenahan, 1976, p.47). Silver (1977) concluded that deaf children lag behind hearing children in terms of abstract thinking, imaginary play, and originality in the verbal domain. However, she also argued that deaf children do not lag behind hearing peers when using nonverbal instruments to assess these capacities. Also, Johnson and Khatena (1975) found that deaf children scored significantly lower than their hearing peers on Torrance Tests of Creative Thinking-Verbal. Deaf children signed to the experimenter their responses while the hearing children wrote their responses.

On the other hand, some investigators have observed that deaf individuals performed as well as their hearing peers and sometimes exceeded them on some creative
tasks. Kaltsounis (1970) compared the creative thinking abilities of deaf students and hearing students by using Torrance Tests of Creative Thinking—Figural. He found that deaf subjects surpassed their hearing age-mates on measures of nonverbal fluency and originality; whereas, the hearing subjects were superior in nonverbal flexibility. Performance differences of the deaf subjects were especially large in the fourth and fifth grade samples compared to the sixth grade sample. Marschark and West (1985) examined creative story productions signed and spoken by four severely to profoundly deaf and four hearing 12 to 15 year old students. They videotaped the children while they were telling stories on two experimenter-supplied fantasy themes. The most important finding was the use of several creative language constructions by deaf as well as hearing subjects. Marschark and West also found that their deaf subjects produced novel and figurative constructions just as often as their hearing age-mates in the frequency of using gesture, pantomime, nonliteral linguistic modifications, and linguistic inventions. Marschark and West suggested that deaf school children are not necessarily tied to concrete, literal language when sign language is available as a communication mode.

Laughton (1988) compared a traditional approach to art education with a curriculum designed to develop creative abilities of deaf students. Twenty eight profoundly deaf children between 8 and 10 years of age were exposed to one of the two curricula for 12 weeks during their regularly scheduled art classes. Pretest and posttest scores on the Torrance Tests of Creative Thinking—Figural were the dependent measures. Data analyses indicated significant improvement in two of the creativity measures (flexibility and originality) by the group exposed to the creative thinking curriculum.
The findings of previous research suggest that deaf children might perform creatively when using nonverbal instruments.

Summary

Deaf individuals have a well-documented deficit understanding and producing spoken language. On the other hand, the extent to which this deficit in language development affects their cognitive ability and creative thinking is still open to more investigation—especially over a large sample of deaf individuals from culturally diverse populations. There are some studies that have shown that hearing individuals exceed deaf individuals in performance on several types of cognitive tasks (Rozanova, 1966; Ehrlich and Bramaud du Boucheron, 1974; Ross 1996). Such studies did not demonstrate clearly whether these differences would remain or disappear when adequate controls for the language deficit were used. If these differences persist after using sign language and nonverbal instruments, we could conclude that deafness may represent not only a language deficit, but also a deficit in cognitive ability. On the other hand, if the differences disappear after controlling for language deficit, then we could conclude that deaf individuals are similar to the hearing in cognitive functioning.

Additional research is needed to explore creative thinking abilities of deaf children. The literature review had provided only a limited number of studies. There is a severe lack of updated findings regarding the nature of creative thinking abilities with regard to deaf individuals. The area of nonlinguistic creativity in deaf children, including fluency, originality, play, art, and cognitive flexibility needs more investigation to answer the question of how deaf individuals express their creativity, the role of language, and if
they are similar to hearing individuals in creative expression. This information will assist educators to create more suitable assessment instruments to identify creative deaf students and design more valid programs to nurture creativity in deaf students.

The previous discussion demonstrates that the cognitive abilities and creative thinking abilities of deaf children need more investigation. Nonverbal instruments should be used to assess these both types of abilities. If the nonverbal instruments are not originally developed to be used with the deaf, these instruments should be validated in deaf populations especially over a large sample of deaf individuals.
CHAPTER 3

METHOD

The purpose of the current study was to investigate the relationship between reasoning abilities and creative thinking abilities exhibited by deaf and hearing children. This chapter presents the methods that were used in conducting the study, and includes a description of the subjects, the assessment instruments that were used, and the procedures that were followed.

Participants

Deaf Students

A group of 210 deaf children was selected based on the following criteria:

- Unaided sensorineural pure tone average hearing loss for three frequencies (500, 1000, 2000 Hz) of 90 dB HTL or greater in the better ear.
- The hearing loss of deaf children ranged from 90 to 131 dB HTL (with a mean of 110 and standard deviation of 5.8).
- Ninety-five of deaf children have deaf parents (both father and mother), 28 have deaf father, 17 have deaf mother, and 70 have hearing parents (both father and mother).
- Deaf children are screened at the beginning of each academic year for the level of hearing loss.
- Pre-lingual onset of hearing loss at birth or prior to age 2 years.
- No other diagnosed disabilities.
- The children do not use any hearing aids.
- Chronological age between 8 and 11.
- Identified as deaf by the age of 6 and enrolled at deaf schools at the same age.
- Enrolled in the third grade in the Schools for the Deaf.
- Children spent two years practicing sign language (start at age 6). So it is assumed that the deaf children participated in this study have the same proficiency level of using sign language.
- Use sign language as the primary communication mode.

According to Special Education Laws, while deaf students must study the regular curriculum for hearing students, they can take two academic years to do one academic year of work for the hearing. For example, deaf students study the regular first grade curriculum in two academic years instead of one. Accordingly, deaf students spend 10 years finishing the elementary school before they move to the middle school.

**Hearing Students**

A group of 200 hearing children was selected based on the following criteria:

- They were enrolled in third grade in regular schools.
- Chronological age between 8 and 11.
- They enrolled in school at age 6.
- The hearing children were selected from the largest regular elementary schools from the same areas.
- These children were chosen on the basis of convenience sampling.
Research Design

Correlational research was chosen to conduct the investigation in this study because it allows a researcher to look for and describe relationships that may exist among naturally occurring phenomena without trying in any way to alter these phenomena (Fraenkel & Wallen, 2000, pp.359-363). Thus, a Correlational research design was chosen for this study because its goal was to identify the relationship between components of selected reasoning abilities and creative thinking abilities. No attempt was made to affect the presentation of these abilities by the participants in this study.

Instruments

Matrix Analogies Test- Expanded Form

Naglieri (1985) designed the Matrix Analogies Test- Expanded Form (MAT-EF) to assess nonverbal reasoning abilities of children (ages 5 to 17 year old). The test constructed to reduce the influence of impaired color vision by using the colors blue, yellow, black, and white. The MAT-EF was used in this research for three reasons: first, it provides important information about the range of individual abilities in the examination of intellectual strengths and weaknesses; second, it requires no reading and the directions are very simple making it suitable for those with limited language skills such as deaf people; and third, it provides norms for both hearing and deaf individuals in.

The MAT-EF has 64 items and was designed to provide an individually administered assessment of nonverbal reasoning ability that allows individuals to either point to or say aloud the number for his/her answer. The MAT-EF uses 64 abstract designs printed one per page to provide norms for a large, representative sample of
individuals, ages 5 to 17 years living in the United States. These designs require minimal motor involvement and minimal verbal comprehension requirements.

There are four groups of items in the MAT-EF: Pattern Completion, Reasoning by Analogy, Serial Reasoning, and Spatial Visualization. Each group consists of 16 items:

**Pattern Completion**

This subtest requires that students choose one of the options that accurately complete a pattern. These items require the individual to examine the directions and shapes in the diagram presented to determine which option fits the pattern and belongs on the question mark. The correct option should continue the pattern without interruption in a manner similar to that found in the rest of the diagram. These items are made more difficult when they require completion of a pattern which does not have contiguous parts.

**Reasoning by Analogy**

This subtest of items requires that the examinee investigate how the change(s) in one figure is (are) analogous to the change(s) in another. These items require the individual to analyze a matrix on the basis of specific variables (i.e. shape, size, shading) and determine how changes in two or more variables converge to result in a new figure. Complexity is achieved in this item group through increasing the number of changing variables in the item matrix.

**Serial Reasoning**

This subtest of items requires the student to discover the order in which items appear throughout a matrix. The boxes in the items included in this group have a specific order in which they appear and the student has to decide which option completes the
matrix according to the specific order. Complexity is achieved in these items through sequencing more than one variable in the matrix.

Spatial Visualization

This subtest of items requires the student to imagine how a figure would look when two or more components are combined. Difficulty is achieved in this item group by requiring manipulation of many figures at one time. (See Appendix A for a sample of the group items)

Directions for Administration

The administrator provided an item example from each item group to the deaf and hearing children. He used sign language to give the instructions for the deaf children. For a full description of the administration directions, see Appendix B.

The MAT-EF Reliability and Validity

Naglieri (1985) used internal consistency and test-retest procedures to assess the reliability of the MAT-EF. Internal consistency coefficients were calculated using the Cronbach alpha. For each age group, alpha coefficients were computed for the total MAT-EF, and for each of the four item groups using raw scores. The coefficients for the total MAT-EF ranged according to the group age from 0.88 to 0.93. The stability of the MAT-EF over time was studied by administering the test two times to a sample of 65 fifth grade students with an interval of four weeks between administrations. The correlations between pretest and posttest standard scores were consistently high for the MAT-EF total score and for the four items groups .91, .87, .86, .92.
One method that can be used to assess the construct validity of a test such as the MAT-EF is an analysis of developmental changes in mean scores. Because the ability to solve MAT-EF items is expected to increase with age, increase in mean test scores with age provide evidence of construct validity. Means and standard deviations of the raw scores at one year age intervals for the MAT-EF reveal a clear increase in raw score means by age group and this provides evidence for age differentiation. Also, the MAT-EF item groups by one-year age intervals revealed steady increases in the mean scores for each item group. These findings provide evidence for age differentiation of the MAT-EF item group scores. Also, to further investigate the construct validity of the MAT-EF, (Naglieri, 1985) performed factor analysis using the individual sample. The purposes of this analysis were to examine the factor structure of the MAT-EF when all item groups were administered to the same subjects, to gather information on the correlation among the noted factors, and to obtain each item loading on the first un-rotated factor. The factor analysis revealed that the four item groups of MAT-EF were designed to measure a single construct: Nonverbal reasoning ability.

Reliability and Validity of the MAT-EF in the Current Study

According to Fraenkel and Wallen (2000, p.176), reliability refers to the consistency of the scores obtained, how consistent they are for each individual from one administration of an instrument to another and from one set of items to another. The two basic considerations in assessing reliability are time and content. We can take samplings of test performance over time to check on stability reliability, and over content by using different forms of the test to check on equivalence. Test-retest reliability and
internal consistency reliability of scores of the MAT-EF were computed for the group of deaf children participating in this study.

According to Fraenkel and Wallen (2000, p.181), validity refers to the appropriateness, meaningfulness, and usefulness of the specific inferences made from test scores. Test validity involves three concerns: first, one wants to know that a test is measuring what it is supposed to measure; second, one wants to know as fully as possible what the score obtained from the test means; and third, one wants to know how an individual’s score on a test relates to other observable facts about the individual (Wolf, 1982). To evaluate the construct validity of MAT-EF, a factor analysis was performed. Also, concurrent validity coefficients were estimated by correlating the total scores of the MAT-EF for the deaf sample with the total score of the Iowa Test of Basic Skills for for the deaf sample. The Iowa Test of Basic Skills was designed to assess nonverbal cognitive abilities for individuals (age 5 to 14) and consists of four subscales: Nonverbal reasoning, analogies, sequences, and visualization.

_Torrance Tests of Creative Thinking-Figural, Form A_

The Torrance Tests of Creative Thinking (TTCT) were first published by E. Paul Torrance and his associates in 1966. The tests have been normed four times since in 1974, 1984, 1990, and 1998. There are two forms (A and B) of the TTCT-Verbal and two forms (A and B) of the TTCT-Figural. This study used only the TTCT- Figural (form A). The TTCT- Figural has much to support its use (e.g., Cropley, 2000). It has been translated into over 35 languages (Miller, 2002). The TTCT-Figural is the most widely used test of creativity (Colangelo & Davis, 1997), and has been used in more research.
than any other creativity test (Lissitz & Willhoft, 1985). The standard administration and scoring procedures (Davis & Rimm, 1994) as well as the development and evaluation (Colangelo & Davis, 1997) have made the TTCT especially useful for identifying gifted and talented students. The TTCT-Figural has had 25 years of extensive development and evaluation (Miller, 2002). It has large norming samples, valuable longitudinal validations, and high predictive validity for a very wide age range (Cropley, 2000).

The TTCT-Figural are unbiased in terms of gender, race, and for persons who have various language, socioeconomic status, and cultural backgrounds (Torrance, 1974; Cramond, 1993). The scores can also be useful for counseling purposes (e.g., Cropley & Cropley, 2000).

Each form of the test consists of three activities; each designed to tap somewhat different aspects of creative functioning. Following is a brief description of the activities included in the TTCT-Figural, Form A.

Activity 1: Picture construction consists of a single curved shape.

Activity 2: Picture Completion consists of ten incomplete linear figures.

Activity 3: Lines, in Figural Form A, consists of three pages of sets of parallel lines. For sample items of these activities and directions for administration, see Appendices C and D.

These three activities provide scores for five norm-referenced creative thinking abilities and 13 criterion-referenced abilities. Norm Referenced Creative Thinking Abilities are fluency, originality, abstraction of titles, elaboration, and resistance to premature closure. Fluency refers to the number of ideas a person expresses through
interpretable responses that use the stimulus in a meaningful manner. Originality refers to
the infrequency and unusualness of the response. Abstractness of titles refers to the
ability to produce good titles involves the thinking processes of synthesis and
organization. In scoring elaboration, credit is given for each pertinent detail (idea, piece
of information, etc.) added to the original stimulus figure, its boundaries, and/or its
surrounding space. Resistance to premature closure refers to the ability of a creative
person to keep open and delay closure long enough to make the mental leap that makes
possible original ideas. This is measured by the individual’s tendency to close the
incomplete figures immediately with straight or curved lines or not (Torrance, 1998). In
scoring for the criterion-referenced creative thinking strengths, any genuine appearance
of a strength is indicated by a plus sign (+). If the strength appears three or more times,
this is indicated by two plus signs (++) . These creative strengths include: emotional
expressiveness (in drawings, title), storytelling articulateness (context, environment),
movement or action (running, dancing, flying, falling, etc.), expressiveness of titles,
synthesis of incomplete figures (combination of 2 or more), synthesis of lines
(combination of 2 or more), unusual visualization (above, below, at angle, etc.), internal
visualization (inside, cross section, etc.), extending or breaking boundaries, humor (in
titles, captions, drawings, etc.), richness of imagery (variety, vividness, strength, etc.),
colorfulness of imagery (exactingness, earthiness, etc.), and fantasy (figures in myths,
fables, fairly tales, science fiction, etc.).
Reliability and Validity of the TTCT-Figural, Form A in the Current Study

Although the Torrance Tests of Creative Thinking- Figural, Form A is widely used, it has not used with deaf children especially with a large sample of the deaf children. So, I computed new reliability and validity coefficients for this instrument. The test-retest method was used to estimate a reliability coefficient for the TTCT-Figural, Form A. Three certified raters participated in scoring the TTCT-Figural, Form A, so interrater reliability was calculated. Pearson correlation coefficients were computed to examine the concurrent validity of the TTCT-Figural, Form A. The WISC-III was used to estimate the concurrent validity of the TTCT- Figural- Form A. The WISC-III consists of 28 incomplete obscured figures. These figures are divided in each group and they provide estimate for fluency, originality, elaboration, and flexibility.

Data Analysis

Data for this study were collected from deaf and hearing children chosen from the largest schools in the south east of the United States. Analyses of this data were done using the canonical correlation analysis to answer question 1 and 2, regarding the estimation of the relationship between the six creative thinking abilities and the four reasoning abilities of both deaf and hearing children. Multivariate analysis of variance (MANOVA) was used to answer question 3 and 4, regarding the differences between deaf and hearing children in the four reasoning abilities and the differences between deaf and hearing children in the six creative thinking abilities.
Procedures

1. Prior to data collection, human subjects approval was obtained to administer the instruments used in the study.

2. Approvals were obtained from the division of special education, school district superintendents, and school principals to use school records to select the children participating in the study and administer the instruments.

3. Consent forms and information sheets were sent to parents of the deaf and hearing children who meet the criteria (see Appendices E and F). Dr. Mark Engles, a colleague at College of Education, was responsible for selecting the children according to the criteria mentioned earlier, and sending the consents to the parents.

4. Ninety five deaf and 80 hearing children were chosen from Area A, 60 deaf and 60 hearing children were chosen from Area B, and 55 deaf and 60 hearing children were chosen from Area 3.

5. ASL translation was done for the instruction of the Matrix Analogous Test- Expanded Form.

6. Administrator Training: I conducted 3 video-conferences with each test administrator to clarify administration procedures. Dr. George Cohens, who administered the MAT-EF, has expertise in administering several cognitive ability instruments to elementary school children. Dr. Engles is a sign language interpreter. Mrs. Black was responsible for administering the TTCT-Figural, Form A to deaf and hearing children. Mrs. Black is certified to administer and score the TTCT. Mrs. Black is currently a teacher for deaf children and studying for her Master degree in deaf education.
7. Administration started on October 10, 2003 and finished on December 25, 2003. The children took classes from 7:30 AM until 11 AM. After 11 AM, the children had their lunch and participated in activity time (soccer, volleyball, painting, music, etc.) until 4 PM. The administration of the instruments took place during the activity time, so there was no interruption to the academic schedule. The administration first took place in Area 1, then Area 2, and finally in Area 3. The two administrators alternated the administration of the tests between the two schools, deaf and hearing, so that some children were administered the creativity test one week and the reasoning ability test the next, and another group were tested in the reverse order.

8. The MAT-EF was administered individually. Dr. Engles was able to administer the MAT-EF to 8 children a day. The TTCT-Figural, Form A was administered in groups (5 children in each group). Mrs. Black was able to administer the TTCT-Figural, Form A to 2 groups a day.

9. After each administration session, candy, pencils, and notebooks were given to the children.

10. The scoring started during Christmas and ended by the end of January 2004. Three raters participated in the scoring of TTCT-Figural, Form A. Three graduate students trained in the Torrance Center scored the TTCT-Figural, Form A.
CHAPTER 4

RESULTS

This chapter highlights the major findings related to the research questions outlined in the first chapter and listed below. Analyses for this study were done in two stages. In the first stage, canonical correlation analyses were conducted to answer questions 1 and 2. In the second stage, multivariate analyses of variance were conducted to answer questions 3 and 4.

Research Questions

1. What is the relationship between the six creative thinking abilities and the four reasoning abilities of deaf children?
2. What is the relationship between the six creative thinking abilities and the four reasoning abilities of hearing children?
3. Is there a significant difference between deaf children and hearing children in the six creative thinking abilities?
4. Is there a significant difference between deaf children and hearing children in the four reasoning thinking abilities?

Before I discuss my findings related to the 4 questions posed, I will first discuss the steps I took to validate the two instruments used in this study for deaf children.
Reliability and Validity Analysis of the MAT-EF

Internal Consistency Reliability

Internal consistency coefficients were calculated using Cronbach’s alpha. Coefficients were computed for the total MAT-EF scores, and for each of the four item groups using raw scores for the deaf sample. The coefficients for internal consistency of the total MAT-EF scores are presented in Table 4.1 along with the mean raw scores and standard deviations.

Table 4.1
The MAT-EF Total Raw Score Means, Standard Deviations, and Internal Consistency Coefficients (coefficient alpha)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>25</td>
<td>29.41</td>
<td>7.23</td>
<td>.87</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>37.01</td>
<td>11.91</td>
<td>.91</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>39.62</td>
<td>9.82</td>
<td>.89</td>
</tr>
<tr>
<td>11</td>
<td>52</td>
<td>40.92</td>
<td>11.28</td>
<td>.93</td>
</tr>
</tbody>
</table>

These coefficients ranging from .87 (age 8) to .93 (age 11) provide evidence of high internal consistency for the MAT-EF with the deaf sample.

For each age group, the internal consistency coefficients for each of the MAT-EF item groups are presented in Tables 4.2, 4.3, 4.4, and 4.5 along with the raw score means and standard deviations.
Table 4.2

The MAT-EF Item Group 1 Raw Score Means, Standard Deviations, and Internal Consistency Coefficients (coefficient alpha)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>25</td>
<td>11.08</td>
<td>3.81</td>
<td>.85</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>12.03</td>
<td>3.01</td>
<td>.83</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>13.14</td>
<td>2.51</td>
<td>.79</td>
</tr>
<tr>
<td>11</td>
<td>52</td>
<td>14.00</td>
<td>2.52</td>
<td>.81</td>
</tr>
</tbody>
</table>

Table 4.3

The MAT-EF Item Group 2 Raw Score Means, Standard Deviations, and Internal Consistency Coefficients (coefficient alpha)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>25</td>
<td>7.82</td>
<td>3.14</td>
<td>.79</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>9.93</td>
<td>3.52</td>
<td>.81</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>11.01</td>
<td>2.89</td>
<td>.83</td>
</tr>
<tr>
<td>11</td>
<td>52</td>
<td>10.54</td>
<td>2.93</td>
<td>.78</td>
</tr>
</tbody>
</table>

Table 4.4

The MAT-EF Item Group 3 Raw Score Means, Standard Deviations, and Internal Consistency Coefficients (coefficient alpha)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>25</td>
<td>8.10</td>
<td>4.6</td>
<td>.88</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>10.62</td>
<td>4.3</td>
<td>.82</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>11.14</td>
<td>4.1</td>
<td>.87</td>
</tr>
<tr>
<td>11</td>
<td>52</td>
<td>11.52</td>
<td>3.7</td>
<td>.86</td>
</tr>
</tbody>
</table>
Table 4.5

The MAT-EF Item Group 4 Raw Score Means, Standard Deviations, and Internal Consistency Coefficients (coefficient alpha)

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>25</td>
<td>3.11</td>
<td>3.7</td>
<td>.88</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
<td>4.63</td>
<td>4.1</td>
<td>.86</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>5.92</td>
<td>4.3</td>
<td>.87</td>
</tr>
<tr>
<td>11</td>
<td>52</td>
<td>5.94</td>
<td>4.8</td>
<td>.81</td>
</tr>
</tbody>
</table>

The coefficients for the four item groups are in a high range. These coefficients provide evidence that the MAT-EF item groups have good internal consistency.

*Test-Retest Reliability*

The stability of the MAT-EF over time was studied by administering the test two times to a sample of 58 deaf children (age 11) with an interval of 6 weeks between the two administrations. Table 4.6 represents the test-retest correlations and the pretest and posttest mean scores and standard deviations for the total scores of MAT-EF and item groups.

Table 4.6

Means, Standard Deviations, and Test-Retest Reliability Coefficients of the MAT-EF

<table>
<thead>
<tr>
<th></th>
<th>Pretest mean</th>
<th>Posttest Mean</th>
<th>Pretest S.D.</th>
<th>Posttest S.D.</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Test</td>
<td>49.51</td>
<td>60.81</td>
<td>10.1</td>
<td>12.2</td>
<td>.81</td>
</tr>
<tr>
<td>Item Group 1</td>
<td>11.22</td>
<td>14.50</td>
<td>2.9</td>
<td>3.1</td>
<td>.68</td>
</tr>
<tr>
<td>Item Group 2</td>
<td>10.13</td>
<td>15.11</td>
<td>2.3</td>
<td>3.2</td>
<td>.63</td>
</tr>
<tr>
<td>Item Group 3</td>
<td>13.22</td>
<td>15.32</td>
<td>2.6</td>
<td>2.9</td>
<td>.72</td>
</tr>
<tr>
<td>Item Group 4</td>
<td>14.01</td>
<td>15.91</td>
<td>3.1</td>
<td>3.6</td>
<td>.67</td>
</tr>
</tbody>
</table>
These results support the evidence that the MAT-EF has good test-retest reliability over a 6 weeks interval.

*Construct Validity*

To evaluate the construct validity of MAT-EF, item factor analysis was performed. Scores of 200 deaf children were analyzed to determine the factor structure of the instrument. Results of factor analysis revealed three interpretable factors. Each of these factors had eigenvalues greater than 1.0 and the three accounted for 65% of the variance in the item scores. Table 4.7 presents the factor pattern matrix (standardized regression coefficients) for the three factor oblique rotation (promax) for the deaf children.

Table 4.7

Factor Loadings for the Three Factor Oblique Rotation (Promax) for Deaf Children

<table>
<thead>
<tr>
<th>Item Group</th>
<th>Item #</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern</td>
<td>1</td>
<td>5</td>
<td>78</td>
<td>7</td>
<td>60</td>
</tr>
<tr>
<td>Completion</td>
<td>2</td>
<td>14</td>
<td>71</td>
<td>6</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>9</td>
<td>79</td>
<td>4</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-2</td>
<td>79</td>
<td>-4</td>
<td>58</td>
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<tr>
<td></td>
<td>5</td>
<td>10</td>
<td>78</td>
<td>8</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
<td>84</td>
<td>4</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>6</td>
<td>45</td>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>-12</td>
<td>56</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>3</td>
<td>85</td>
<td>4</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>3</td>
<td>31</td>
<td>-2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>-2</td>
<td>39</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>12</td>
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<td>77</td>
<td>5</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>18</td>
<td>28</td>
<td>-13</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>23</td>
<td>48</td>
<td>5</td>
<td>45</td>
</tr>
</tbody>
</table>
Table 4.7 (continued)

<table>
<thead>
<tr>
<th>Item Group</th>
<th>Item #</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasoning by Analogy</td>
<td>1</td>
<td>60</td>
<td>47</td>
<td>-68</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>57</td>
<td>30</td>
<td>-4</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>54</td>
<td>15</td>
<td>6</td>
<td>44</td>
</tr>
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<td></td>
<td>4</td>
<td>43</td>
<td>37</td>
<td>4</td>
<td>48</td>
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<td></td>
<td>5</td>
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<td>22</td>
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<td>37</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>16</td>
<td>26</td>
<td>13</td>
<td>21</td>
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<tr>
<td></td>
<td>7</td>
<td>10</td>
<td>21</td>
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<td></td>
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<td>8</td>
<td>43</td>
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<td>46</td>
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<tr>
<td></td>
<td>11</td>
<td>38</td>
<td>41</td>
<td>-5</td>
<td>49</td>
</tr>
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<td></td>
<td>12</td>
<td>26</td>
<td>6</td>
<td>13</td>
<td>13</td>
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<tr>
<td></td>
<td>13</td>
<td>49</td>
<td>18</td>
<td>4</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>17</td>
<td>24</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>28</td>
<td>27</td>
<td>-5</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>47</td>
<td>-3</td>
<td>-8</td>
<td>18</td>
</tr>
<tr>
<td>Serial Reasoning</td>
<td>1</td>
<td>74</td>
<td>7</td>
<td>1</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>59</td>
<td>15</td>
<td>-2</td>
<td>46</td>
</tr>
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<td></td>
<td>3</td>
<td>41</td>
<td>1</td>
<td>8</td>
<td>41</td>
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<td></td>
<td>4</td>
<td>79</td>
<td>2</td>
<td>7</td>
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<td></td>
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<td>68</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>8</td>
<td>41</td>
<td>4</td>
<td>-3</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>52</td>
<td>-6</td>
<td>1</td>
<td>27</td>
</tr>
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<td></td>
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<td>7</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>62</td>
<td>-10</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Spatial Visualization</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>48</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>31</td>
<td>22</td>
<td>36</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7</td>
<td>27</td>
<td>44</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>23</td>
<td>-4</td>
<td>72</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>61</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>37</td>
<td>-7</td>
<td>42</td>
<td>36</td>
</tr>
</tbody>
</table>
The results of the factor analysis indicated that all 16 items for Serial Reasoning loaded on the first rotated factor. Eight of the 9 other items loaded on this factor were from The Reasoning by Analogy group. Fourteen of the 18 items loading on the second rotated factor were from The Pattern Completion group. All 10 items loading on the third rotated factor were from Spatial Visualization group. The fourth factor oblique rotation revealed that the fourth rotated factor was uninterpretable. Results from the factor analysis provided evidence that the four item groups of the MAT-EF were designed to measure a single construct: Nonverbal Reasoning Ability.

**Concurrent Validity**

In addition to construct validity, concurrent validity coefficients were estimated by correlating scores on each of the four subscales of MAT-EF with four subscales of the Iowa Test of Basic Skills. Correlations were .71 (p=.023), .79 (p=.032), .82 (p=.041) and .87 (p=.046). All the correlation coefficients were statistically significant (p<.05). These coefficients provided evidence of concurrent validity of the MAT-EF on deaf children.

**Reliability and Validity Analysis of the TTCT-Figural, Form A**

**Reliability of the TTCT-Figural, Form A**

The test and retest scores were compared to examine the stability of the Torrance Tests of Creative Thinking-Figural, Form A, scores over time. Table 4.8 reports a series of statistics for the children who had retested for both raw and standard composite and total scores. Pearson product moment correlation coefficients (r) were calculated to examine the relationship between the test and retest scores and are reported in Table 4.8
along with the levels of significance. Using Cohen’s classification of correlation
coefficients (Cohen, 1988. p. 123), all raw coefficients were significant and large,
ranging from .76 to .91. All standard score coefficients were significant and large ranging
from .64 to .92.

Table 4.8

Test-Retest Reliability Coefficients of the TTCT-Figural, Form A for Raw and Standard
Scores

<table>
<thead>
<tr>
<th>TTCT-F</th>
<th>Raw scores</th>
<th>Standard Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
</tr>
<tr>
<td>Fluency</td>
<td>.77 .023</td>
<td>12.5 .034 .59</td>
</tr>
<tr>
<td>Originality</td>
<td>.79 .031</td>
<td>14.4 .048 .63</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.87 .039</td>
<td>20.7 .049 .73</td>
</tr>
<tr>
<td>Abstractness of</td>
<td>.76 .022</td>
<td>9.12 .024 .25</td>
</tr>
<tr>
<td>Titles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to</td>
<td>.81 .034</td>
<td>15.2 .046 .85</td>
</tr>
<tr>
<td>Premature Closure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>.91 .046</td>
<td>12.9 .041 .55</td>
</tr>
</tbody>
</table>

Differences between the test and retest scores were analyzed by calculating a t test
of means for paired samples. The paired samples t test evaluates whether the mean
difference between the test and retest scores is significantly different from zero. The
results of the t tests and levels of significance are reported in Table 4.8 for the raw and
standard scores. These results indicate that the mean retest raw scores were significantly
greater than the mean initial test raw scores for all composite and total scores for the
TTCT-Figural, Form A. In contrast, there were no significant differences between the standard scores from test to retest.

The $d$ statistic was computed as the effect size index by dividing the mean of paired differences by the average of the two standard deviations. As $d$ diverges from 0, the effect size becomes larger. The effect sizes for differences between raw scores range from .25 to .85. Regardless of sign, $d$ values of .25 represent a small effect size, but $d$ values of .73 and .85 represent large effect sizes (Cohen, 1988). In contrast, the effect sizes of the differences in standard scores can even be classified as small (ranging from .00 to .09), indicating that there were not appreciable differences in standard scores from test to retest. These results indicated that the TTCT-Figural, Form A detects growth over short periods, based on changes in raw scores from test to retest. Moreover, these results show that the TTCT-Figural, Form A produced relatively stable rankings of children, even when these children showed significant improvement over a short period of time, based on the strong correlations of the raw and standard scores from test to retest. The test-retest data provided evidence of high stability for the TTCT-Figural, Form A over a two month retest interval.

*Interrater Reliability of the TTCT-Figural, Form A*

Interrater reliability of the TTCT-Figural, Form A was calculated by comparing the scores for pairs of three certified independent raters (graduate students at The University of Georgia). Estimates of interrater reliability were obtained by calculating generalizability ($g$) coefficients between each pair of raters. The $g$ coefficient is a measure of the source and magnitude of variance accounted for by the participants and
the rater (McWilliam & Ware, 1994). The g coefficient was chosen as a measure of reliability because it provides an index of whether the scores discriminate among children with varying creative thinking abilities, and not among coders, and considers multiple sources of error variance. I scored the majority of the samples used in this study after being stringently trained in the Torrance Center and receiving a scoring certificate, and therefore, was considered the expert (rater 1) for comparison with the other raters. The g coefficients are shown in Table 4.9.

Table 4.9

Generalizability (g) Coefficients of the TTCT-Figural, Form A

<table>
<thead>
<tr>
<th>Rater</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>.92</td>
<td>.89</td>
</tr>
<tr>
<td>Originality</td>
<td>.89</td>
<td>.90</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.74</td>
<td>.79</td>
</tr>
<tr>
<td>Abstractness of titles</td>
<td>.91</td>
<td>.95</td>
</tr>
<tr>
<td>Resistance to Premature Closure</td>
<td>.89</td>
<td>.93</td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>.97</td>
<td>.98</td>
</tr>
<tr>
<td>Total Scores</td>
<td>.95</td>
<td>.97</td>
</tr>
</tbody>
</table>

As the g coefficient approaches 1, the variance accounted for by the children is large in comparison with the variance accounted for by raters (Bakeman & Gottman, 1997). The g coefficients that are in range of at least .5 to .7 are considered acceptable for demonstrating interrater reliability (Mitchell, 1979). The g coefficients in Table 4.9
indicate that the TTCT-Figural, Form A raters exhibit high interrater reliability for all the subtests and very high interrater reliability for the total scores.

*Validity of the TTCT-Figural, Form A*

A correlation analysis was conducted to examine the concurrent validity of the TTCT-Figural, Form A. The WISC III was used as a criterion measure. The Pearson product moment correlation coefficient (r) between the two measures and their squared value (r^2) are presented in Tables 4.10, 4.11, 4.12 and 4.13. The correlation coefficient is an index of the strength of the relationship ranging in value from –1.0 to +1.0, with values closer to +1 indicating stronger linear relationships.

Table 4.10

Pearson Correlation Coefficients between the TTCT-Figural, Form A and the WISC III

<table>
<thead>
<tr>
<th>Torrance Tests of Creative Thinking- Figural</th>
<th>WISC III</th>
<th>r</th>
<th>p</th>
<th>r^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td></td>
<td>.85</td>
<td>.049</td>
<td>.72</td>
</tr>
<tr>
<td>Originality</td>
<td></td>
<td>.58</td>
<td>.037</td>
<td>.34</td>
</tr>
<tr>
<td>Elaboration</td>
<td></td>
<td>.66</td>
<td>.041</td>
<td>.44</td>
</tr>
<tr>
<td>Abstractness of Titles</td>
<td></td>
<td>.57</td>
<td>.034</td>
<td>.32</td>
</tr>
<tr>
<td>Resistance to Premature Closure</td>
<td></td>
<td>.47</td>
<td>.029</td>
<td>.22</td>
</tr>
<tr>
<td>Creative Strengths</td>
<td></td>
<td>.69</td>
<td>.044</td>
<td>.48</td>
</tr>
</tbody>
</table>

Table 4.11

Pearson Correlation Coefficients between the TTCT-Figural, Form A and the WISC III

<table>
<thead>
<tr>
<th>Torrance Tests of Creative Thinking- Figural</th>
<th>WISC III</th>
<th>r</th>
<th>p</th>
<th>r^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td></td>
<td>.58</td>
<td>.037</td>
<td>.34</td>
</tr>
<tr>
<td>Originality</td>
<td></td>
<td>.75</td>
<td>.045</td>
<td>.57</td>
</tr>
</tbody>
</table>
Table 4.12

Pearson Correlation Coefficients between the TTCT-Figural, Form A and the WISC III

<table>
<thead>
<tr>
<th>Torrance Tests of Creative Thinking- Figural</th>
<th>WISC III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
</tr>
<tr>
<td>Fluency</td>
<td>.66</td>
</tr>
<tr>
<td>Originality</td>
<td>.56</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.86</td>
</tr>
<tr>
<td>Abstractness of titles</td>
<td>.72</td>
</tr>
<tr>
<td>Resistance to Premature Closure</td>
<td>.74</td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>.52</td>
</tr>
</tbody>
</table>

Table 4.13

Pearson Correlation Coefficients between the TTCT-Figural, Form A and the WISC III

<table>
<thead>
<tr>
<th>Torrance Tests of Creative Thinking- Figural</th>
<th>WISC III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
</tr>
<tr>
<td>Fluency</td>
<td>.82</td>
</tr>
<tr>
<td>Resistance to Premature Closure</td>
<td>.81</td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>.73</td>
</tr>
</tbody>
</table>

Canonical Correlation Analyses

I conducted canonical correlation analyses to identify a combination of creative thinking abilities that might be correlated with a combination of reasoning abilities by using SAS. Canonical correlation analysis is used to examine the relationship between two sets of variables when each set contains more than one variable (Thompson, 1984).
In the current study, I treated the six dimensions of creative thinking abilities as one set of variables, and used the four reasoning abilities as the other multivariate profile. Deaf and hearing children’s scores on both instruments met the basic distributional assumptions underlying multivariate analyses.

The number of canonical functions (i.e., factors) that can be generated for a given data set is equal to the number of variables in the smaller of the two variable sets. TTCT-F has six dimensions and MAT-EF has four dimensions, therefore, four canonical function coefficients were generated.

A structure coefficient is the correlation between scores on a given variable and scores on the canonical composite (i.e., latent variable) in the set to which the variable belongs (Thompson, 1984). Thus, structure coefficients indicate the extent to which each variable is related to the canonical function for the variable set. Structure coefficients are essentially bivariate correlations that range in value from −1.0 to +1.0 inclusive. The square of the structure coefficient is the proportion of variance that the original variable shares linearly with the canonical variate.

The canonical correlation analysis was conducted to answer the first question regarding the relationship between the six creative thinking abilities and the four reasoning abilities of deaf children. The canonical correlation analysis revealed that four canonical correlations were statistically significant (p < .05). However, when the first pair of canonical functions was excluded, the remaining three pairs canonical functions combined were not statistically significant. Similarly, with the removal of the first and
second canonical functions, the remaining canonical functions combined were not statistically significant.

Further removal of canonical functions also produced statistically nonsignificant results. Together, the results suggest that the first canonical function was statistically significant but all the subsequent canonical functions were not statistically significant. However, because the calculated probabilities are sensitive to sample size, particular attention should be paid to the educational (practical) significance of the obtained results (Thompson, 1980). The educational significance of canonical correlations typically is assessed by examining their size (Thompson, 1984). The canonical correlation indicates how much variance the two sets of weighted original variables share with each other (Thompson, 1988). In the current study, the first canonical correlation ($R_{c1} = .789$) was judged to be educationally significant, contributing 62% (i.e., $R_{c12}$) of the shared variance. Thus the focus was based on explaining the first canonical correlation. Table 4.14 presents the canonical correlation analysis relating six creative thinking abilities and four reasoning abilities for the deaf children.

Table 4.14
Canonical Correlation Analysis Relating Six Creative Thinking Abilities and Four Reasoning Abilities of Deaf Children

<table>
<thead>
<tr>
<th>First Canonical Function</th>
<th>Canonical Correlation</th>
<th>Adjusted Canonical Correlation</th>
<th>Canonical R2</th>
<th>F Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.789</td>
<td>.773</td>
<td>.623</td>
<td>29.32</td>
<td>0.043</td>
</tr>
</tbody>
</table>
Canonical loading is used explain this canonical function. Table 4.15 contains the canonical loadings for the two sets of variables for the first canonical function.

Table 4.15
Canonical Loadings of the First Pair of Canonical Functions in Deaf Children

<table>
<thead>
<tr>
<th>Variables</th>
<th>Canonical Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern Completion</td>
<td>.69</td>
</tr>
<tr>
<td>Reasoning by Analogy</td>
<td>.88</td>
</tr>
<tr>
<td>Serial Reasoning</td>
<td>.71</td>
</tr>
<tr>
<td>Spatial Visualization</td>
<td>.72</td>
</tr>
<tr>
<td>Fluency</td>
<td>.56</td>
</tr>
<tr>
<td>Originality</td>
<td>.28</td>
</tr>
<tr>
<td>Elaboration</td>
<td>-.43</td>
</tr>
<tr>
<td>Abstractness of Titles</td>
<td>.88</td>
</tr>
<tr>
<td>Resistance to Premature</td>
<td>-.29</td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>-.17</td>
</tr>
</tbody>
</table>

This table indicates that abstractness of titles has the highest loading .88, resulting in the shared variance with reasoning abilities. The reasoning variables do not have a quiet different pattern, with loading ranging from .685 to .876.

Because standardized function coefficients typically are highly affected by the collinearity of the variables in a given set (Thompson, 1984), I also interpreted structure coefficients. The coefficients are particularly useful for assessing the nature of the relationships between two sets of variables. These structure coefficients revealed that all six dimensions of creative thinking abilities made important contributions to the first canonical variate.
According to Thompson (1984), variables with small structure coefficients, but standardized coefficients that are large in absolute value magnitude indicate that they are suppressor variables in the canonical correlation model. Suppressor variables are those that assist in the prediction of dependent variables because of their correlation with other set of variables (Tabachnick & Fidell, 1996). In the current study, the abstractness of titles serves as a suppressor variable. A variance of 68.5% of in the pattern completion variable, 87.6 % of the variance in the reasoning by analogy variable, 71.4% of the variance in the serial reasoning variable, and 71.5% of the variance in the spatial visualization variable is explained by the abstractness of titles variable (creative thinking set). This canonical function has been labeled “Abstractness of titles in creative thinking”.

The canonical correlation analysis was conducted to answer the second question regarding the relationship between the six creative thinking abilities and the four reasoning abilities of hearing children. The analysis revealed that only one pair of canonical correlation should be considered. For the hearing children sample, the first canonical correlation (Rc1 = .723) was judged to be educationally significant, contributing 52% (i.e., Rc12) of the shared variance. Table 4.16 presents the canonical correlation analysis relating six creative thing abilities and four reasoning abilities for the hearing children.
Table 4.16
Canonical Correlation Analysis Relating Six Creative Thinking Abilities and Four Reasoning Abilities of Hearing Children

<table>
<thead>
<tr>
<th>Canonical Function</th>
<th>Canonical Correlation</th>
<th>Adjusted Canonical Correlation</th>
<th>Canonical R²</th>
<th>F Statistics</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.723</td>
<td>.711</td>
<td>.523</td>
<td>27.97</td>
<td>0.041</td>
</tr>
</tbody>
</table>

Canonical loadings are used to explain this canonical function. Table 4.17 contains the canonical loadings for the two sets of variables for the first canonical function for the hearing children.

Table 4.17
Canonical Loadings of the First Canonical Function in Hearing Children

<table>
<thead>
<tr>
<th>Variables</th>
<th>Canonical Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern Completion</td>
<td>.46</td>
</tr>
<tr>
<td>Reasoning by Analogy</td>
<td>.81</td>
</tr>
<tr>
<td>Serial Reasoning</td>
<td>.61</td>
</tr>
<tr>
<td>Spatial Visualization</td>
<td>.31</td>
</tr>
<tr>
<td>Fluency</td>
<td>.46</td>
</tr>
<tr>
<td>Originality</td>
<td>.42</td>
</tr>
<tr>
<td>Elaboration</td>
<td>-.43</td>
</tr>
<tr>
<td>Abstraction of Titles</td>
<td>-.91</td>
</tr>
<tr>
<td>Resistance to Premature</td>
<td>-.32</td>
</tr>
<tr>
<td>Closure</td>
<td></td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>-.17</td>
</tr>
</tbody>
</table>

This table indicates that only abstractness of titles has a loading of .91, resulting in the shared variance with reasoning abilities. The value of the canonical loading refers to the shared variance between the suppressor variable and canonical function variables.

Table 4.17 shows that 46.1% of the variance in the pattern completion variable, 81% of
the variance in the reasoning by analogy variable, 61.2% of the variance in the serial reasoning variable, and 31.3% of the variance in the spatial visualization variable is explained by the abstractness of titles variable (creative thinking set). For this group of children, the canonical function includes only two variables with large canonical loadings (reasoning by analogy and serial reasoning). Also, abstraction of titles appeared to serve as a suppressor variable and assist in the identification of the canonical function. This canonical function has been labeled “Visual Reasoning”. Abstractness of titles reflects a language element and it seemed to affect the nonverbal cognitive performance of the deaf children.

From the previous analyses, we could conclude that abstractness of titles was the dominant variable that was responsible for the identification of the canonical function in both hearing and deaf samples. Although, the canonical function for the deaf sample includes all the four variables of reasoning abilities, the canonical function for the hearing sample includes only two variables (reasoning by analogy and serial reasoning) of the reasoning ability variables. The abstractness of titles’ canonical loading is larger for the hearing children (.91) than for the deaf sample (.881). This result indicated that the abstractness of titles variable is more powerful and has greater effect on the cognitive performance of hearing children than for deaf children in nonverbal context. This reflects the effects of the language deficit in the deaf children and the nature of the instruments used in this study.
Means and standard deviations for the MAT-EF and TTCT-F scores for each group (deaf and hearing) are shown in Table 4.18.

Table 4.18
Means and Standard Deviations of Raw Scores for Deaf and Hearing Children

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deaf (n=210)</td>
<td>Hearing (n=200)</td>
</tr>
<tr>
<td>TTCT-F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>12.99</td>
<td>14.25</td>
</tr>
<tr>
<td>Originality</td>
<td>11.78</td>
<td>13.78</td>
</tr>
<tr>
<td>Elaboration</td>
<td>11.10</td>
<td>12.68</td>
</tr>
<tr>
<td>Abstractness of Titles</td>
<td>14.40</td>
<td>18.40</td>
</tr>
<tr>
<td>Resistance to Premature</td>
<td>15.06</td>
<td>15.39</td>
</tr>
<tr>
<td>Closure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>12.85</td>
<td>13.09</td>
</tr>
<tr>
<td>MAT-EF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pattern Completion</td>
<td>11.20</td>
<td>12.26</td>
</tr>
<tr>
<td>Reasoning by Analogy</td>
<td>11.29</td>
<td>12.23</td>
</tr>
<tr>
<td>Serial Reasoning</td>
<td>11.68</td>
<td>12.25</td>
</tr>
<tr>
<td>Spatial Visualization</td>
<td>14.40</td>
<td>12.41</td>
</tr>
</tbody>
</table>

In order to answer the third question, regarding the expected differences between deaf and hearing children in creative thinking abilities, Multivariate analysis of variance (MANOVA) was carried out by using SPSS 11.0. MANOVA is used to simultaneously compare mean differences on the two sets of scores on the outcome variables (Anderson, 2003).
The test statistics employed are Wilks lambda, Pillai’s criterion, Hotelling’s trace, and Roy’s largest root. Table 4.19 details the multivariate statistics are statistically significant.

Table 4.19
Multivariate Test Statistics Comparing Deaf and Hearing Children on Creative Thinking Abilities

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value</th>
<th>Approximate F Statistics</th>
<th>Significant of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilks lambda</td>
<td>.17185</td>
<td>2.7635</td>
<td>.030</td>
</tr>
<tr>
<td>Pillai’s trace</td>
<td>.18835</td>
<td>2.8123</td>
<td>.031</td>
</tr>
<tr>
<td>Hotelling’s trace</td>
<td>.85049</td>
<td>2.705</td>
<td>.027</td>
</tr>
<tr>
<td>Roy’s largest root</td>
<td>.13522</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The MANOVA revealed a significant overall effect (Wilks lambda = .17, p < .05). Both tau squared ($\tau^2$) and zeta squared ($\zeta^2$) were computed as indices of effect size. Tau squared ($\tau^2$) was equal to .74 and zeta squared ($\zeta^2$) was equal to .76. The discriminant function that results from the descriptive discriminant analysis may be used to calculate a discriminant score for each child. The discriminant scores are then correlated with each variable. These resulting correlations are referred to as structure coefficients. In the current study, these structure coefficients were based upon the total sums of squares and cross-product matrices. Structure coefficients greater than .3 are considered to be meaningful. Table 4.20 represents the structure coefficients for creative thinking abilities.
Table 4.20

Structure Coefficients for Creative Thinking Abilities

<table>
<thead>
<tr>
<th>Variable</th>
<th>Structure Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluency</td>
<td>-.55</td>
</tr>
<tr>
<td>Originality</td>
<td>-.07</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.21</td>
</tr>
<tr>
<td>Abstractness of Titles</td>
<td>.83</td>
</tr>
<tr>
<td>Resistance to Premature Closure</td>
<td>.28</td>
</tr>
<tr>
<td>Creative Strengths</td>
<td>.23</td>
</tr>
</tbody>
</table>

The results from the MANOVA indicate that deaf children are different from hearing children in creative thinking abilities with respect to the abstractness of title variable. Tuckey HSD tests revealed that the hearing children scored significantly (p < .05) higher than the deaf children in fluency, originality and abstractness of titles. However, there were no significant differences between the deaf and hearing children in elaboration, resistance to premature closure, and creative strength (p < .05) in all cases.

To answer question 4, regarding the expected differences between deaf and hearing children in reasoning abilities, a MANOVA was carried out. This found a nonsignificant overall effect (Wilks lambda = .959, p > .05). Both tau squared (τ²) and zeta squared (ζ²) were computed as indices of effect size. Tau squared (τ²) was equal to .08 and zeta squared (ζ²) was equal to .11. These results provide evidence that there are no differences between deaf and hearing children in nonverbal reasoning abilities.

When comparing the means of the deaf and hearing children, the hearing children scored higher than the deaf children in pattern completion, reasoning by analogy, and serial
reasoning. However, deaf children scored higher than the hearing children in spatial visualization.
CHAPTER 5

DISCUSSION

Despite the fact that creative thinking abilities and cognitive abilities are well-researched topics with nondisabled persons of different ages, there have been no attempts to study several creative thinking abilities and reasoning abilities of deaf children in a cohesive conceptualization, nor to compare these abilities of deaf children to those of hearing children. In this context then, the purpose of this study was to examine the relationship between creative thinking abilities and reasoning abilities for deaf and hearing children. Results from this study will be discussed in reference to the questions stated in chapter one and the literature reviewed in chapter two.

A secondary purpose of this study was to test the reliability and validity of the Torrance Tests of Creative Thinking-Figural (Form A) and the Matrix Analogous Test-Expanded Form on deaf populations.

Internal consistency and test-retest analyses revealed high reliability coefficients for the Matrix Analogies Test-Expanded Form. These results support the evidence that the MAT-EF has good reliability coefficients in deaf populations. To evaluate the validity of the MAT-EF, two analyses were conducted to determine construct validity and concurrent validity. A useful way of conducting validity studies is analyzing the latent construct of the instrument. I used item factor analysis to analyze the MAT-EF scores in the deaf population in order to understand the test’s latent construct and to confirm its
validity. Results from the factor analysis provide evidence that the four item groups of the MAT-EF were designed to measure a single construct: Nonverbal reasoning ability. Further research is needed to establish appropriate interpretations for the meaningfulness and validity of these item groups and the meaningfulness of differences in item group scores for the deaf children. The concurrent validity of the MAT-EF is supported by strong correlations between the MAT-EF and the Iowa Test of Basic Skills (range from .71 to .87). The latter test has been validated over hearing and deaf children and is used as a screening and identification instrument for different ages. The current study used the total scores of the MAT-EF for the deaf children and correlated them to the total scores of the Iowa Test of Basic Skills.

Reliability of the Torrance Tests of Creative Thinking-Figural, Form A has been established through the test-retest method by using Pearson product moment correlation coefficient. The analysis provided evidence of high stability for the TTCT-Figural over a two-month retest interval. Because of the large number of children who participated in the study, three certified independent raters have scored the TTCT-Figural. Thus, estimates of intrarater reliability were conducted between each pair. The analysis revealed high intrarater reliability coefficients for the entire subtest (.92, .89, .74, .91, .89, .97) and very high for the total scores of the TTCT-Figural (.95). To establish evidence about the concurrent validity of the TTCT-Figural on the deaf children, Pearson correlation coefficients between the TTCT-Figural, Form A and the WISC III subscales (fluency, originality, elaboration, and flexibility). The results revealed moderate to strong
correlations between the two instruments and this reflects concurrent validity of the TTCT-Figural in deaf population.

The canonical correlation analyses revealed one significant dimension in both deaf and hearing children. This dimension links between the abstraction of titles and the four reasoning abilities’ parables in the deaf sample, and two reasoning variables (analogy by reasoning and serial reasoning) in the hearing sample.

Although the abstraction of titles seemed to be more powerful in the hearing sample (.91) than in the deaf children sample (.88), this variable affected the cognitive performance of deaf children more than the performance of hearing children. The results of the canonical analysis indicated that deaf children differed in only one of the creative thinking abilities investigated. The current findings do not support some of the previous research (Oleron, 1953; Singer & Lenhan, 1976; Moores, 1978; Conrad, 1979; Watts, 1979; Quigley & Paul, 1984) that indicated the rigidity, concreteness, and lack of divergent thinking among deaf individuals.

Most of the previous investigations in creative thinking abilities of deaf children used the Torrance Tests of Creative Thinking- Figural with the old method of scoring which included providing scores for flexibility, fluency, originality, and elaboration. The old scoring method did not provide scores for the abstraction of titles variable.

The current findings agreed with Laughton (1976) in finding no differences in originality and elaboration, however, the latter study found that the deaf and hearing children differed only on fluency. The current findings also agreed with Horrocks and Pang (1968) that deaf students scored approximately the same as hearing students in
fluency and originality. However, Horrocks and Pang also found that deaf children scored higher in elaboration.

The findings of the multivariate analysis of variance revealed that there are no differences between deaf and hearing children in reasoning abilities. This result supports the finding of Martin (1989) that deaf learners depend on visual spatial perception and processing, and they are good at simultaneous visual processing. Also, this result supports some other previous research which indicated that the cognitive development of young deaf children is comparable to that of hearing children of the same age (Chovan, 1972; Meadow, 1980; Bond, 1987; Martin, 1989; Craig and Gordon, 1989; Al-Hilawani, 2000). In addition, these results enhance Furth’s viewpoint that the cognitive ability of hearing and deaf people and their developmental patterns are essentially similar.

The findings of the multivariate analysis of variance revealed that there are some similarities and differences between the deaf and hearing samples regarding creative thinking abilities. Both groups are different only in the abstraction of titles variable, and they are similar in the other five variables of creative thinking abilities.

The difference in the abstraction of titles variable between deaf and hearing children raise the issue of the effect of a language deficit in deaf children on the cognitive and creative performance. Earlier research, which examined deaf children's language abilities, had concluded that they were concrete and literal in their language abilities, and, by extension, concrete and literal in their cognitive abilities (e.g. Blackwell, Engen, Fischgrund & Zarcadoolas, 1978). Everhart & Marschark (1988), however, showed that,
when evaluated in sign language rather than English, deaf students showed language flexibility and creativity equal to or superior to that of hearing students of the same age.

Most obviously, deaf children, as a group, are more heterogeneous than hearing students. Beyond variability that may be directly related to their hearing losses, and beyond the normal variability found among children, deaf children frequently have different experiences, different language backgrounds, and perhaps different cognitive skills. This does not mean that deaf students are in any way deficient (Marschark, 2003).

Sign language was not used in the schools for the deaf until the mid-1990s, and recognition of the implications of that fact did not reach psychological research until the early 2000s. Even in the U.S., much of the early research concerning the cognitive development of deaf children was presumed to be examining cognitive growth in the absence of language (e.g. Furth, 1966). Other investigations involved tasks that either required comprehension of the vernacular (e.g. English) in order to understand written instructions, or demanded a history of reading in order to have the knowledge necessary to perform according to normative standards.

Stokoe & Marschark (1999) noted that in the case of children acquiring their first language, the language used by adults around the child could affect the child’s cognitive development and make cognitive and cultural environmental connections. The underlying conceptual system is unlikely to be language-specific or even specific to a particular mode of language; although particular concepts may well vary in their availability or ease of communication in one language (or language mode) or another. It thus seems safe to assume that the more directly communication—whether by gesture, spoken language, or
sign language—maps onto the world, the easier it will be to comprehend the cognitive tasks.

*Implications*

In this study, multiple facets of creative thinking of deaf children became apparent. The TTCT-F provides valuable information to the teachers of the deaf who can thereby foster their students’ creative thinking by integrating humor, thinking, feeling, intuition and physical sensing into their instruction. By constantly adjusting their program through detailed observations over time, teachers can show different learners how to use their strengths to improve academic and social performance.

Assessment of creativity or creative potential is generally acknowledged as a key component in the definition of giftedness in addition to general intelligence and specific academic achievements. When an assessment confirms that a student is creative/deaf, this study suggests that programming should take into account those areas in which creative aspects resemble both those of the creative and deaf. Like those who are creative hearing children, children who are creative/deaf require enriching and stimulating cognitive experiences where they can use their problem solving abilities, independent research skills, initiative, ability to elaborate and to express both their sense of humor and feelings.

Based on the findings of the current study, there exists a need to improve assessment procedures used to assess creative thinking abilities and reasoning abilities of deaf learners. With these needs in mind, I sought to provide some ideas to improve the assessment instrument that is currently used and the assessment process for deaf children.
Accordingly, assessment objectives must focus on specific, higher order cognitive skills. I believe that this is important in guiding the development of instruments that ensures that deaf learners have various opportunities to express their abilities at advanced levels.

Also, assessment of creativity in deaf children should include: tests of divergent thinking; attitude and interest inventories; personality inventories; biographical inventories; rating by teachers, peers, and supervisors; judgment of products; and self-reported creative activities and achievements.

**Limitations**

There are a few limitations that should be considered in this study.

1. No attempt was made to determine if any of the participants (deaf and hearing) had training in reasoning or in creative thinking.

2. Hearing children were selected on the basis of convenience sampling procedures. From my viewpoint, it would be more beneficial if these children were selected by random sampling procedures.

3. No attempt was made to investigate the language variability among the deaf children. Further investigation will be made on the same sample of deaf children concerning the language variable and its relation to reasoning and creative thinking abilities.

4. The participants of the study were deaf and hearing children. If each group were divided into subgroups based on the age of the participants, it might reveal more significant underlying constructs that could provide more insights about the relationship between reasoning abilities and creative thinking abilities.
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Appendix A

Sample Items of the Matrix Analogous Test-Expanded Form

Item group 1: Pattern Completion

Item group 2: Reasoning by Analogy
Item Group 3: Serial Reasoning

Item Group 4: Spatial Visualization
Appendix B

Directions for Administering the MAT-EF

The administrator provided some examples to the deaf and hearing children. He used sign language to give the instructions for the deaf children. Following is some directions for the administration.

Item Group 1: Pattern Completion

Item 1-1

Examiner begins the assessment session by signing: Look at this page (point to the page containing items 1-1). There is a piece missing in this picture (point to the question mark). Which one of these (point to options 1 to 5 in a sweeping motion) goes here (point to the question mark)? The examiner may either point to the option chosen or sign its number.

If correct:

The examiner signs: Yes, that the right one because it is all yellow. Now do this one. Turn to item 1-2.

If incorrect:

The examiner signs: You should have picked this one because it is all yellow. Now do this one. Turn to item 1-2.

Item 1-2

Examiner signs: There is a piece missing in this picture (point to the question mark). Which one of these (point to options 1 to 5 in a sweeping motion) goes here (point to the question mark)? The child may either point to the option chosen or sign its number.
If correct:

The examiner signs: Yes, that is the right one because it has lines going this way (point to option 4 and move your finger in the direction of the diagonal lines). Now do this one.

Turn to item 1-3.

If incorrect:

The examiner signs: You should have picked this one (point to option 4) because it has lines going this way (move your finger in the direction of the diagonal lines). Now do this one. Turn to item 1-3.

Items 1-3 through 1-16

The remaining items in this Item Group are administered by signing: Now do this one, with no further help. The examiner may stop signing “Now do this one” when the directions are no longer necessary. Whenever necessary the examiner may say “There is a piece missing in this picture. Which one of these goes here?” or a portion of this direction.

Item Group 2: Reasoning by Analogy

Item 2-1

Examiner signs: There is a piece missing in this picture (point to the question mark). Which one of these (point to options 1 to 6 in a sweeping motion) goes here (point to the question mark)? The child may either point to the option chosen or sign its number.

If correct:

The examiner signs: Yes, that is the right one because the arrows are all pointing the same way. Now do this one. Turn to item 2-2.
If incorrect:

The examiner signs: You should have picked this one (point to option 3). The examiner should point to the three boxes in the matrix and signs: The arrows are all pointing the same way here, so this one (point to option 3) is correct because it points this way. Now do this one. Turn to item 2-2. No feedback is given for any of the remaining items on the rest of the test.

All Remaining Items in All Item Groups

Only if necessary, the examiner signs: There is a piece missing in this picture (pointing to the question mark). Which one of these (point to options 1 to 6 in a sweeping motion) goes here (point to the questions mark)? No feedback or explanation for any of the remaining items is given. The child may either point to the option chosen or sign its number.
Appendix C

Sample Items of the Torrance Tests of Creative Thinking - Figural, Form A

Activity 1

Activity 2

Activity 3
Appendix D

Directions for Administering the TTCT-Figural, Form A

The test consists of three activities; each designed to tap somewhat different aspects of creative functioning:

Activity 1: Picture construction, has three instructions:

a. On the opposite page is a curved shape. Think of a picture or an object which you can draw with this shape as a part.

b. Try to think of a picture that no one else will think of. Keep adding new ideas to your first idea to make it tell an interesting and exciting a story.

c. When you have completed your picture, think up a name or title for it and write it at the bottom of the page in the space provided. Make your title as clever and unusual as possible. Use it to help tell your story.

Activity 2: Picture Completion, consists of ten incomplete figures with the following instructions:

Add lines to the incomplete figures on this and the next page, you can sketch some interesting objects or pictures. Try to think of some pictures or objects that no one else will imagine. Try to make it tell as complete and as interesting a story as you can by adding to and building up your first idea. Make up an interesting title for each of your drawings and write it at the bottom of each block next to the number of the figure.

Activity 3: Lines, in Figural Form A, consists of three pages of sets of parallel lines. The instructions are as follows:
In ten minutes see how many objects or pictures you can make from the pairs of straight lines below and on the next two pages. The pairs of straight lines should be the main part of whatever you make. With pencil or crayon add lines to the pairs of lines to complete your picture. You can place marks between the lines, on the lines, and outside the lines-wherever you want to in order to make your picture. Try to think of things that no one else will think of. Make as many different pictures or objects as you can and put as many ideas as you can in each one. Make them tell as complete and as interesting a story as you can. Add names or titles in the spaces provided.
Appendix E

Consent Form for Participation in the Study of Fawzy A. Ebrahim

Dear Parents:

I’m Fawzy Ebrahim, a doctoral student at University of Georgia, Athens, Georgia. I’m contacting you regarding getting your permission to involve your son/daughter in a study looking at the relationship between cognitive ability and creative thinking ability in deaf and normal hearing children. I’m conducting this study for my doctoral dissertation. I’m aiming to recruit 200-250 from deaf children (Female/Male) and the same from normal hearing children aged 8-10 year old.

I’m going to test your son/daughter by using two tests:

Torrance Tests of Creative Thinking- Figural, Form A. This test measures the nonverbal aspects of the creative thinking abilities. The testing time for this instrument is about 40 minutes.

Matrix Analogies Test. This test measures four cognitive abilities (pattern completion, reasoning by analogy, serial reasoning, and spatial visualization). The testing time for this instrument varies from 35 minutes to 55 minutes.

The two tests will be administered at two different times.

The study will be conducted during the school day. All the information you provide will be confidential. Your son/daughter’s participation is voluntary.

General findings of this research will be useful to improve the curriculum designs for the deaf. If you are interested in this study, please fill out the attached information sheet and send it to me by June 10, 2003.
If you have any questions, please feel free to contact me by email at febrahim@arches.uga.edu.

I truly appreciate your consideration to participate and I’m looking forward to hearing from you as soon as possible.

Best Wishes,

Fawzy Ebrahim
Dept. of Educational Psychology,
College of Education,
University of Georgia,
Athens, GA 30602
Appendix F

Information Sheet

Your son/daughter’s name: ............................................................

Your son/daughter’s age: ............................................................

Your educational level (circle one):

- No-education
- Middle school
- High school
- College

Mother’s educational level (circle one)

- No-education
- Middle school
- High school
- College

Father’s current job:......................................................................

Mother’s current job:......................................................................

Is the mother/ father deaf?  No               Yes                     If yes, who ..............

How many deaf children do you have?

What is the gender of your child?  Male               Female

Authorization for Participation

My son/daughter can participate in the study conducted by Mr. Fawzy Ebrahim titled

(.................................................................................................).

Please contact me by calling me at ( .................) or writing to me at my address (..........................)

.................................................................................................

Signature of the child’s father/mother       Today’s date