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A STUDY OF THE RELATIONSHIPS AMONG RUBELLA SYNDROME, ACADEMIC ACHIEVEMENT AND COGNITIVE PERFORMANCE OF DEAF STUDENTS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Robyn Denise Fillman, M.A.

* * * * *

The Ohio State University

1999

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College of Education
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Robyn Denise Fillman
1999
Dedicated to the late Sarah Ward, to Angelita Green and to all of the children who face a lifetime of obstacles as a result of rubella.
ACKNOWLEDGMENTS

I would like to extend my gratitude to my advisor Dr. Peter V. Paul for his unwavering patience and guidance through the many misfortunes that impeded my progress toward the completion of this dissertation. I wish to thank the other members of my doctoral committee, Drs. Marjorie E. Ward and Donald L. Haefele for their support and assistance.

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CHAPTER 1

INTRODUCTION

Sensory impairments can have profound effects on a child's cognitive development. Hearing impairment is no exception to this phenomenon—factors affecting language acquisition, cognition, and school performance have been researched extensively. However, since the majority of the research has been conducted by educators and psychologists, the implications of prenatal physiologic influences have frequently been ignored. It is this writer's intention to examine the influence of a particular etiology, congenital rubella syndrome, on the cognitive and academic performance of deaf students, that is, students with severe to profound hearing losses.

Intelligence Testing of Deaf Individuals

Numerous studies have utilized the Weschler Intelligence Scales for Children-Revised (WISC-R) (Weschler, 1974) to measure intelligence in both deaf (individuals with a hearing loss greater than 80dB PTA in the better ear) and hearing subjects. Such studies have frequently documented lags in performance of deaf students when compared to their
hearing peers, particularly in the areas of language and reading (Jensema, 1975; Moores, 1987; Myklebust, 1964; Paul & Jackson, 1993; Pintner, Eisenson & Stanton, 1941). Although other instruments have been employed to examine intelligence in deaf individuals, such as the Hiskey-Nebraska Test of Learning Aptitude (H-NTLA) (Hiskey, 1966) and the Leiter International Performance Scale (Leiter, 1979), the WISC-R has been the most frequently used because it has yielded the most normative data on both deaf and hearing groups and subsequently strengthens validity when comparisons are made between the groups (Braden, 1989). Deaf subjects are generally administered the Performance Scale of the WISC-R whereas the Verbal Scale is omitted. Although some investigators have found that there was no difference in performance on intelligence tests when the preferred mode of communication (e.g. American Sign Language) was used (Hirshoren, Hurley & Kavale, 1977, 1979), others have concentrated on utilizing nonverbal probes of intelligence to examine the effects of deafness in the cognitive domain (Furth, 1964; Rosenstein, 1961; Vernon, 1967). However, when examiners proficient in the use of ASL administered the Performance Scale of the WISC-R, the deaf subjects did not perform as well as the hearing subjects,
particularly on the Picture Arrangement and Coding Subtests (Watson, Sullivan, Teare, & Thompson, 1986).

Achievement Testing of Deaf Individuals

A wide range of achievement tests have been used to obtain information about academic achievement in the general school population. Normative data for the *Stanford Achievement Test (SAT)* have been collected from a large population of deaf students, so this instrument tends to be the most frequently cited when reporting academic achievement in this group (Ries, 1973). When comparisons are made between the performances of deaf and hearing students, the findings have been consistent, regardless of the instrument used (Hirshoren, Hurley & Hunt, 1977; Hirshoren, Hurley & Kavale, 1979; Jensema, 1975; Musgrove & Counts, 1975; Salvia & Ysseldyke, 1978). The achievement level of deaf students lags behind age-matched hearing counterparts, and the lag increases with age. Performance on the Language section is significantly lower for deaf students.

Differences Between Deaf and Hearing Subjects
Various factors such as home environment, school programming, and etiology have been offered to account for differences in both intelligence and achievement testing of deaf and hearing students. Although the achievement of hearing impaired students with mild-to-moderate hearing loss lags about 2 years on the average behind hearing peers, the gap significantly widens when a hearing loss of 50dB or greater is present (David, Shepard, Stelmachowicz, & Gorga, 1981; Kodman, 1963; Quigley & Thomure, 1968). Academic placement (residential, day school, self-contained public school, fully-integrated public school) and educational programming (oral, Total Communication or American Sign Language) also have significant effects on the performance of deaf students on standardized achievement tests, particularly on the Language section. Integrated students tend to achieve at grade level compared to the achievement of those attending special classes (Allen & Osborn, 1984; Jensema, 1975; Ross, 1986; Ross, Brackett, & Maxon, 1982). Understandably, students who are accustomed to using the English language would be more proficient on tests utilizing that language as a measure of language proficiency than students whose primary language is American Sign Language (ASL) (Moores, 1987, Quigley & Paul, 1986, Rosenstein, 1961;
Vernon, 1967). In addition, it should be noted that integration is not the sole factor accounting for variation in achievement; the quality of instruction, curricula, and teacher training and expectations have a significant impact on student progress as well (Paul & Quigley, 1990).

The probability of English language competence also increases when the hearing impairment has been acquired during the postlinguistic period, generally after the age of two years. Children who have a prelinguistic hearing loss (i.e., prior to the age of two years), particularly when combined with profound hearing impairment, experience significant impact on their acquisition of primary language and secondary language skills evaluated by achievement tests (King & Quigley, 1985; Paul & Quigley, 1994).

Explanations for Differences Among Deaf Students

There have been few studies undertaken to evaluate the influence of type of hearing impairment (sensorineural, conductive, central, or mixed) on intelligence and academic performance of deaf students (Jensema, 1975; Moores, 1987). Presumably, this lack of inquiry is due to the medical correctability of conductive hearing loss, and the rarity of
central and mixed hearing loss in the profoundly hearing impaired school-aged population.

Research studies have examined various facets of family and home environment and their impact on the language and achievement levels of deaf children. Variables such as parental acceptance, communication modes, and frequency of social interaction have been implicated in the superior performance of deaf children of deaf parents on tests of intelligence and academic achievement (Balow & Brill, 1975; Kusche, Greenberg & Garfield, 1983; Quigley & Frisina, 1961; Ray, 1982; Sisco & Anderson, 1980; Stuckless & Birch, 1966). However, some researchers have explained this difference to be the result of intrinsic differences between American Sign Language and English in the speed of information processing; that is, performance intelligence tests reward those who are facile in a visual/manual language because they are able to respond faster and to encode information faster than those who are dependent upon aural/oral modalities (Braden, 1987). Although there is a dearth of research on the effects of socioeconomic status on language and reading development in the deaf, research on both hearing and deaf children has indicated that it is a related rather than a causative factor (Alexander, 1979; Allen, 1986; Quigley & Paul, 1986).
Several studies have shown that deaf children of deaf parents have superior scores on the WISC-R when compared to age-matched deaf counterparts (Brill, 1969; Kusche, Greenberg & Garfield, 1983). Although several hypotheses including genetics, parental acceptance, and exposure to language at an early age have been offered to explain the better performance of the genetically deaf group (Paul & Jackson, 1993; Paul & Quigley, 1990, 1994), there have been no studies that have considered the etiologies causing the hearing impairment of the deaf group with hearing parents. The possible variable of an infectious etiology that may have caused central nervous system effects, which may have contributed to the lower language and achievement scores of the deaf children of hearing parents, has not previously been considered. Such individuals would not only be deprived of the potentially positive effects that elevate the intelligence and achievement scores of the genetically deaf group, but they would also have experienced the deleterious effects of a systemic neurologic disease.

Etiologies of Deafness and Congenital Rubella Syndrome

Vernon (1968) stated that the lack of etiologic information has resulted in an inability to prevent further
cases of deafness, a lack of knowledge available to researchers about the deaf population, a paucity of information leading to differential diagnoses concerning central nervous system effects in individuals, and resulting programming deficiencies. The single largest cause of deafness reported by most studies is etiology unknown (Beauchaine & Gorga, 1991; Hudgins, 1973; O’Hare, Grigor, & Cowan, 1993; Ries, 1973). Inquiry into the cause of deafness has historically relied upon anecdotal reports from parents rather than systematic serological and/or physical examination of the child. Until the development of sensitive immunologic tests and electrophysiologic equipment, the medical technology has not been available to pinpoint the etiology of a student’s hearing impairment and concomitant disabilities. Consequently, many cases of deafness have been attributed to genetic causes instead of infectious causes.

The rubella virus has frequently been ignored as the causative factor for many cases of deafness that have subsequently been misidentified as genetic or cause unknown. The relationship of the rubella virus (possibly the most common nongenetic cause of deafness) to congenital deafness was not described until 1944 (Bordley, Brookhauser, Hardy,
Bordley et al. (1967) found that, of 47 deaf children with positive virus cultures, 15 had not reported a previous history for rubella infection. A lack of a clear history of maternal infection with rubella is understandable when considering that most cases of childhood deafness are not uncovered until after two years of age, and by that time the pre- and perinatal history is not as easily recalled and the conventional tests for rubella infection are no longer accurate (Williams, Shannon, Leguire, & Fillman, 1993; Waxham & Wolinsky, 1984). Because the first trimester of pregnancy is often a time of fatigue and stress, a mild case of rubella at that time might readily be attributed to a normal pregnancy.

Rubella is an acute, mild viral disease in the adult. Epidemics occur in six to ten year cycles, with major epidemics approximately every ten to twenty years (Rubella and the Eye Specialist, Winter 1970-1971). Since the last major epidemic in 1967, an attenuated live vaccine was developed and rapidly introduced. The consistent use of this vaccine has greatly reduced the incidence of rubella, yet it still remains a threat to certain populations (Orenstein, Bart, Hinman, Preblud, Greaves, Doster, Stetler, & Sirotkin, 1984). Although the American Academy of
Pediatrics recommends that children be vaccinated after 15 months of age and again at the age of 12 years (Gardner & Shaffner, 1993), many children remain unvaccinated due to lack of regular health care and its costs. In addition, the live vaccine was administered before the age of 15 months for the first few years after its inception. Physicians now know that administration of vaccines are most effective after the age of 15 months when the normal immune system matures.

Although the attenuated live vaccine is very effective in producing antibody resistance to disease, it is not as effective as immunity developed as a result of actually having the disease. Reinfection in previously immune individuals has occurred (Horstman, Leibhaber, LeBouvier, Rosenberg, & Halstead, 1970). In addition, 1-2% of the population never develop titer antibodies in response to inoculation. Although most studies have identified the effects of rubella to be congenital and non-progressive in nature, immunologists have now been able to identify persistent viral infection into the third decade of life in deaf subjects with ocular manifestations of congenital rubella syndrome (Williams, Shannon, Leguire & Fillman, 1993).
The threat of rubella is particularly possible with the immigration of large populations from countries where routine vaccination is not the norm. Consequently, it is estimated that 5-20% of women of childbearing age are still susceptible to rubella infection (Schoenbaum, 1985). Checking the titers of women before pregnancy is not a viable option; almost 50% of the pregnancies in the United States are unplanned.

The virus can be recovered from 21 days before to 21 days after visible lesions appear. The infected infant can shed the virus from body mucosa up to two years after infection, and it can be found active in the lens capsule up to three years after birth. New methods of Enzyme-Linked Immunosorbent Assay (ELISA) and electron microscopy have identified that due to its relatively small particle size, its coating the cell with an impermeable lipid layer and by containing a single strand of RNA instead of nuclear DNA, it is relatively easy for the virus to escape unrecognized by the immune system (Waxham & Wolinsky, 1984). Rare incidents of rubella panencephalitis have been reported, suggesting that rubella may be present in its latent form throughout an individual's life.
Rubella can be a severe disease when contracted in utero. It has been reported that 3 infants in every 10,000 births have congenital rubella syndrome (CRS) (Fraser & Friedman, 1967; Kaplan, Cochi, Edmonds, Zell & Preblud, 1991). However, due to recent studies attempting to determine the etiology of hearing impairments previously believed to be either hereditary or of unknown origin, the incidence of this disease may be much higher. If contracted prior to four weeks, 85% will show effects; if contracted between 5-9 weeks, 50% will exhibit the syndrome; and when contracted between 13-20 weeks gestation 10% will show effects of the virus (Vernon, Grieve, & Shaver, 1980). The child can seem normal at birth, with effects appearing up to five years of age. Growth retardation is common, although the trilogy of heart defects, deafness, and cataracts is considered to be the classic sign of the disease (Orenstein, Bart, Bart, Sirotkin, & Hinman, 1986). The hearing impairment can range from mild to profound, and as is the case of many hearing impaired children, is not diagnosed until language is found to be delayed around 18-25 months of age (Northern & Downs, 1991). This is often too late to conduct traditional serological studies in order to
determine the culprit in the child's developmental
difficulties.

Cardiovascular involvement is the leading cause of
death in these children, and has been reported to be found
in up to 50% of those affected. They can also have
anencephaly, microcephaly, and other neurological sequelae
(Pike, Jan, & Wong, 1989). Genitourinary effects can occur,
including cryptorchidism, hypospadia, and kidney
abnormalities (Vernon & Hicks, 1980).

Over 50% of these individuals will have ocular
involvement (Boniuk & Zimmerman, 1967). Microphthalmia
and/or cataracts occur in over 40%. Corneal clouding is not
uncommon. The disease is usually bilateral, but is
occasionally uniocular. The cataract tends to be nuclear and
the lens shape can be affected. The disease can affect the
nasolacrimal system and the iris, and the glaucoma that
occurs generally arises from incomplete anterior segment and
angle development. Late onset glaucoma can also be found
(Cooper, 1969). The retina is frequently involved, which is
more marked in the macular region and has a typical "salt
and pepper" appearance which is a manifestation of retinal
pigment epithelium atrophy (Kresky & Nauheim, 1967). Optic
atrophy can often occur in the absence of glaucoma and often causes nystagmus (Woodruff, 1986). Clinical diagnosis can be made even if a complete history is not available based upon the aforementioned signs (Leguire, Fillman, Fishman, Bremer, & Rogers, 1992). It can be a relief to parents who do not know the etiology of their child's impairment, but who may choose not to bear additional children if heredity might play a role. It is important that rubella be diagnosed and treated as soon as possible, often requiring medical intervention for cataracts, glaucoma, strabismus, and refractive errors or educational intervention to facilitate adaptation to a visual impairment (Fillman, Leguire, Rogers, Bremer, & Fellows, 1987). All hearing impaired children for whom the etiology of their deafness is unknown or questionable should be carefully examined by an ophthalmologist upon entry into school, ideally as soon as the hearing impairment is discovered.

Rubella syndrome causes a wide variation in physical and systemic effects, depending upon when and to what degree the fetus was exposed to the virus in utero (Boniuk & Zimmerman, 1967; Chess et al. 1971; Sever, et al., 1985). As no state in this country currently has mandated
requirements for ophthalmologic examinations before deaf students enter a school program for the hearing impaired, it is questionable whether all children who may be affected with congenital rubella syndrome have been identified. Since the inception of the rubella vaccine in 1970 and due to the apparent decrease in numbers of persons born with rubella syndrome, the medical system and educators have become complacent about the numbers of children who may be affected by this syndrome; consequently, little research has been conducted in recent years concerning its affect on cognition and academic achievement (Orenstein et al. 1984).

A number of studies cited in medical literature have reported systemic effects of prenatal infections including deterioration of medical status, and there have been many anecdotal reports by educators that students with congenital rubella syndrome exhibit late-onset behavioral abnormalities (Sever, South, & Shaver, 1985; O'Dea & Mayhall, 1988; Van Dijk, 1993). If congenital rubella syndrome is consistent with other congenital infectious syndromes, it seems likely that such effects would be apparent in performances on cognitive and academic tasks (Chess, Korn & Fernandez, 1991; Hanshaw, Sheiner, Moxley, Gaev, Abel & Sheiner, 1976; Rantala, Uhari, Uhari, Saukkonen & Sorri, 1991). There
should be measurable differences in intellectual functioning between a group of deaf individuals with rubella syndrome, individuals who are deaf due to other etiologies, and age-matched hearing counterparts. In addition, the first group's performance should deteriorate over time and the latter two groups' performance should remain stable if the anecdotal reports of late effects are true.

Rational and Purpose of Present Study

A number of studies have shown inferior performance of deaf students on intelligence tests and measures of academic achievement when compared to hearing students, particularly in the areas of reading and language skills (Allen, 1986; Hirshoren, Hurley & Hunt, 1977; Hirshoren, Hurley & Kavale, 1979; Jensema, 1975; Moores, 1987, 1996; Musgrove & Counts, 1975; Quigley & Paul, 1986; Salvia & Ysseldyke, 1978). Speculation on the reasons for these differences have included the influences of genetics, academic placement, educational programming, and even cognitive differences between the deaf and hearing populations. Past experiences in the medical field have led this investigator to conjecture that perhaps there are unknown physiological variables that affect intelligence and academic performance
that have not yet been identified. Students with infectious causes for their deafness may have subtle neurological effects that result in differences in cognitive development and in the acquisition of academic skills compared to non-affected deaf peers. Although there is little research to confirm this suspicion in the deaf population, investigators have identified systemic neurologic damage in the hearing population that has a life-long impact on both physical and cognitive development (Hanshaw, Sheiner, Moxley, Gaev, Abel, & Sheuner, 1976; Sever, Sout & Shaver, 1985; Rantala, Uhari, Uhari, Saukkonen, & Sorri, 1991; O’Dea & Mayhall, 1988; Van Dijk, 1993).

Studies have also shown that deaf students of deaf parents perform better on standardized achievement tests than deaf students with multiple causes of deafness and hearing parents (Braden, 1987; Brill, 1969; Conrad, & Weiscrantz, 1981; Kusche, Greenberg & Garfield, 1983; Messerly, & Aram, 1980; Ray & Ulissi, 1982; Sisco & Anderson, 1980). Braden (1987) postulated that the deaf children of deaf parents processed information at a faster speed than their deaf peers with hearing parents, although it has not yet been demonstrated how the former acquire these superior skills. Some investigators have hypothesized
that deaf children of deaf parents are able to provide a more emotionally and socially stable environment for their deaf children (Levine, 1981; Meadow, 1980). Deaf parents are able to communicate with their deaf children, resulting in superior language competence when compared to deaf counterparts with hearing parents (Greenberg & Marvin, 1983). There has been some evidence to show that attachment in mother/child dyads is better developed in deaf child/deaf mother environments, again possibly as a result of communication difficulties and subsequent confusion in differentiating social cues (Schlesinger & Meadow, 1972). In general, the positive social adjustment that results in higher academic achievement is more likely to occur in an environment with effective communication between parent and child (Levine, 1981; Meadow, 1969; Meadow, Greenberg & Erting, 1983). Mindel and Vernon (1971) reported that a hearing mother’s inability to communicate with her deaf child may be compounded by depression about the hearing loss, resulting in a further lack of responsivity to her child. In situations where hearing parents have access to professional assistance in communication skills and family dynamics strategies, this situation can be ameliorated (Paul & Jackson, 1993).
Few studies have explored infectious influences as an explanation for the differences in performance between deaf children of deaf parents and deaf children of hearing parents. Although the previously mentioned variables may indeed significantly impact the performance of deaf children of deaf parents, there may be a synergistic effect of several variables resulting in a greater lag for some deaf children of hearing parents. In addition to difficulties in communication, attachment, and social delays, perhaps the subtle neurologic effects of congenital infectious disease also impact deaf children's academic achievement.

The present investigation was conducted to further identify the influences that one infectious etiology, congenital rubella, has on the intelligence and academic achievement of deaf students. The primary purpose of the study was to compare the performance of students identified with CRS on standardized tests of intelligence and achievement with age-matched nonaffected peers. A secondary aim was to examine subtle effects on the subtests of the WISC-R and on the Language and Mathematics subtests of the SAT.

If children affected with CRS can be identified by a complete ophthalmoscopic examination, and if in fact they
are at risk for specific delays in cognitive and academic functioning, it may be possible to adjust school programming to more appropriately serve their needs. If such individuals demonstrate difficulties in rote memorization, the curricula could be adjusted to utilize teaching strategies that emphasize a multisensory approach to provide concrete bases for higher-order cognitive development. Some students with CRS may have significantly lower scores on WISC-R subtests and subsequently qualify for services for learning disabilities. If this population of students shows consistently lower scores attributable to short-term memory processing in certain areas such as reading, programming may be developed to address specific needs, for example, selection of a whole language approach, a phonics approach, or a combination of both.

Research Design

Variables

The independent variable will be etiology (presence or absence of ocular rubella). This is a dichotomous categorical variable with nominal level scaling.

The dependent variables of the Performance WISC-R, the sub-scales of the Performance WISC-R, the full-scale SAT and
the subtests of the SAT are categorical with continuous level scaling.

Hypotheses

\( H_1 \): The CRS group’s mean scores on the Performance Quotient of the WISC-R will be lower than the mean scores of the nonCRS deaf group. This would be consistent with previous studies finding the neurologic effects of congenital infectious disease reflected in lower intelligence test mean scores (Hanshaw, Sheiner, Moxley, Gaev, Abel & Sheuner, 1976; Rantala, Uhari, Uhari, Saukkonen, & Sorri, 1991).

\( H_2 \): The CRS group’s mean scores on the subscales of the WISC-R will be different than the mean scores of the nonCRS deaf group.

\( H_3 \): The WISC-R scores of the subjects will predict the etiology of the profound hearing impairment of the nonCRS and CRS groups.

\( H_4 \): The CRS group’s raw score means on the SAT will be lower than the raw score means of the nonCRS deaf group. This finding would be consistent with lower academic achievement of students with other congenital infectious syndromes (Hanshaw, Sheiner, Moxley, Gaev, Abel & Sheuner,
1976; Rantala, Uhari, Uhari, Saukkonen & Sorri, 1991).

H₅: The CRS group’s raw score means on the Reading Recognition, Language and Mathematics sections of the SAT will be different than the raw score means of the nonCRS deaf group. If neurologic deficits are present, they would most likely affect all areas of academic performance.

H₆: The SAT scores of the subjects will predict the etiology of the profound hearing impairment of the nonCRS and CRS groups.
CHAPTER 2

REVIEW OF THE LITERATURE

The primary focus of this study is to explore the hypothesis that the presence of subclinical Congenital Rubella Syndrome (CRS) is an additional factor to other variables traditionally accepted as contributing to deaf students' generally poor school performance when compared to that of their hearing peers. In particular, some of the factors previously studied have been school programming, academic placement, and the hearing status of parents (Allen & Osborn, 1984; Braden, 1987; Brill, 1969; Conrad, & Weiscrantz, 1981; Jensema, 1975; Kusche, Greenberg & Garfield, 1983; Messerly, & Aram, 1980; Ray & Ulissi, 1982; Ross, 1986; Ross, Brackett, & Maxon, 1982; Sisco & Anderson, 1980). Despite the observations of some teachers that rubella has long-range behavioral effects in some affected students which can worsen with time, few studies have used medical examination and analysis of school records to
confirm their suspicions. This study evaluated CRS as a variable in the performance of deaf students on the WISC-R Performance Scale and the Stanford Achievement Test (SAT), and further examined any effects of the corresponding subscales of these instruments.

Intelligence Testing of Hearing and Deaf Subjects

Although numerous instruments have been employed for obtaining information about intellectual functioning, the Weschler Intelligence Scale for Children-Revised (WISC-R) is the most commonly utilized for both the hearing and deaf populations (Levine, 1974). The WISC-R is comprised of two Scales: the Performance Scale which purportedly measures nonverbal cognitive abilities, and the Verbal Scale, a measure of language abilities. The Subtests of the Performance Scale are Picture Completion, Coding, Picture Arrangement, Block Design, and Object Assembly. The Subscales of the Verbal Scale are Information, Similarities, Arithmetic, Vocabulary, Comprehension, and Digit Span.

Because adequate performance on the Verbal Scale of the WISC-R is strongly dependent upon knowledge of the English language, it is generally deleted from the battery of intelligence tests administered to deaf children who
communicate using American Sign Language (ASL) and those with limited knowledge of the English language. For these groups the Performance Scales are utilized. Although there has been some controversy about the validity of the results when obtained from deaf children, it has been generally agreed that their performance on the Performance Scales differ very little from their hearing peers; however, some studies have reported lower intelligence scores for the deaf subjects. Hirshoren, Hurley, and Hunt (1977) tested fifty-nine prelingually deaf children with both the Hiskey-Nebraska Test of Learning Aptitude (HNTLA) and the WISC-R Performance Scale and found the scores of the WISC-R Performance Scale were comparable to scores of the HNTLA. In this study, the mean Performance IQ was 88.07, significantly lower than the mean of 100 for hearing children.

Sisco and Anderson (1978) standardized the WISC-R on a sample of 1,228 deaf children. All of the subjects were congenitally or prelingually deaf and had hearing losses of 70dB PTA or greater in the better ear. The mean WISC-R Performance IQ was 95.7, as compared to 100 for hearing children. Studies that have controlled for language differences through adaptation of the instrument and by
utilizing examiners who are proficient in the use of ASL have found no significant differences on tests of intelligence between deaf students and age-related hearing subjects. Watson, Sullivan, Teare and Thompson (1986) administered the Peformance Scale of the WISC-R utilizing an interpreter and obtained mean IQ scores (99.6) even closer to the mean for hearing subjects.

Although most researchers agree that deaf students possess Performance Intelligence Quotients that are in the normal range, some investigators have found subtle differences on various subtests of the WISC-R. Notably, Sisco and Anderson's (1978) normative study of 1,228 deaf subjects showed that the greatest differences in deaf children's performance relative to hearing children were in the Coding and Picture Arrangement subtests. Performance improves on the Picture Arrangement subtests by age 12 for deaf children, although by this age performance on the Coding subtests remains below that of hearing children. They conjectured that deaf students do not have access to the same educational and environmental experiences as hearing children, and consequently do not develop Coding skills to the same level as their hearing peers.
Some studies have shown that variability in performance in the hearing population has been attributed to socioeconomic and cultural differences (Mercer, 1971). Phelps and Ensor (1987) compared the Performance Scale scores of 60 female and 65 male hearing-impaired children on the WISC-R to 60 female and 65 male age-matched hearing subjects. They found a significant difference in the Coding subtest, with females outperforming males. The deaf females possessed significantly better visual motor coordination and speed, whereas the deaf males demonstrated better spatial analysis and synthesis skills.

Many studies have shown that deaf children of deaf parents consistently have higher mean IQ scores than other deaf children. Brill (1969) considered that early language acquisition explained the higher Performance IQs of this group. Ray (1982) noted a significant variation within the subtests of deaf subjects of hearing parents. The subjects were particularly weak in picture arrangement and coding with relative strength in object assembly. Sisco and Anderson (1980) suggested that parenting style may contribute to the differences. Kusche, Greenberg, and Garfield (1983) expressed the hypothesis that because parenting styles and language experiences cannot account
entirely for the superior intelligence scores, perhaps there is a genetic component involved.

Achievement Testing of Deaf Subjects

The Stanford Achievement Test (SAT) is the most commonly used standardized assessment in a special education program for hearing impaired students (DiFrancesca, 1972; Trybus, White, & Karchmer, 1977; Allen, 1986). It has been standardized on approximately 10,000 hearing impaired students across the country, with a wide range of distributions including sex, age, race, degree of hearing impairment, and region (Allen & Karchmer, 1983; Allen, 1986). It also contains a prescreening section to ascertain a child’s initial testing level. The SAT reports achievement in the following academic areas: Vocabulary, Reading, Reading Comprehension, Word Study Skills, Mathematics Concepts, Mathematics Computation, Mathematics Application, Spelling, Language, Social Science, and Science.

Virtually all studies have concluded that the academic achievement levels in deaf students are not commensurate with the levels of their hearing counterparts, particularly in the areas of language, where poor English language skills are a primary factor. The reading scores on adapted
instruments do not differ significantly from non-adapted measures (King & Quigley, 1985; Allen, 1986). DiFrancesca (1972) reported that in a study utilizing the SAT with approximately 17,000 deaf students between the 6 and 21 years old, the average growth was only 0.2 grade levels per year of schooling on the Paragraph subtest (measuring comprehension). Additionally, the median reading level of the twenty-year-olds was at the 4.5 grade level equivalent.

In a study comparing academic skills utilizing the Woodcock Reading Mastery Test (WRMT-WI), Peabody Individual Achievement Test (PIAT-RC) and SAT, Kroese, Lotz, Puffer, and Osberger (1986) examined performance on word identification and passage comprehension subtests. The highest score achieved was that for a fourth-grade student with normal hearing, although the age range for the deaf group was 7.5-20 years.

In general, SAT results reveal that 18- to 19-year old deaf students do not read much better than 9- or 10-year old hearing students. Furthermore, the tests showed an annual growth rate of only 0.3 reading grade levels per year with a leveling off in the third or fourth grades (Furth, 1966). In addition, general achievement batteries have been shown to overestimate the reading ability of hearing-impaired
students (Davey, LaSasso & McReady, 1983). Consequently, the true reading levels of deaf students may be even lower than the levels previously reported on the SAT-HI.

**WISC-R and Achievement**

Intelligence tests have traditionally been used to determine educational placement and in some circumstances to predict academic achievement (Salvia & Ysseldyke, 1981, 1992). Nevertheless, when the ability of the WISC-R to predict academic achievement was evaluated, only 25-30% of the variance in achievement scores of hearing subjects could be attributed to their performance on the intelligence test (Matazzaro, 1972; Zimmerman & Woo Sam, 1972).

In an attempt to document the validity of utilizing intelligence tests for predicting the academic aptitude of deaf children, researchers have attempted to demonstrate a correlation between both the WISC-R and standardized achievement tests and actual school performance (Sisco & Anderson, 1980). It should be emphasized that severe to profound deafness is generally accepted to be a hearing loss of greater than 80dB Pure Tone Average (PTA) in the better aided ear across the frequencies of 500, 1,000 and 2,000 Hz. Few studies report the specific ranges and means of hearing loss for their subjects, preferring to utilize the term deaf
to indicate severe-to-profound hearing impairment.

Braden (1989) stated that, despite the popularity of nonverbal IQ tests for psychoeducational assessment of deaf children, criterion-related validity is lacking and the WISC-R PS is not a powerful predictor of deaf children's achievement levels. Conversely, he also noted academic achievement may be an inappropriate criterion of judging nonverbal IQs because academic achievement is negatively affected by hearing loss and nonverbal IQs reflect different processes than are reflected in achievement scores. His first study (N=33) correlated WISC-R PIQs with SAT grade equivalents and age-based percentiles, and showed that the WISC-R PS is not a powerful predictor of deaf children's academic achievement. Conversely, the second study (N=64) correlated nonverbal IQ from many tests with SAT-HI scores and provided evidence that academic achievement is not an appropriate predictor of nonverbal IQ since nonverbal IQ reflects different cognitive processes.

Watson (1982) examined the relationship between nonverbal intelligence and English language ability in 25 deaf children between the ages of six and 20 years. Audiological data were not reported. When analyzing the relationship between nonverbal language and English
language, the subtests which require verbal memory were consistently the best predictors of language performance. Osberger (1986) also investigated the influence of language on the learning skills of profoundly hearing-impaired students. Multivariate analysis of areas of language (receptive and expressive), academic skills (reading, spelling, mathematics) and related learning (visual perception and short-term memory) revealed that expressive language skill level was the major determining factor to academic achievement, and visual processing skills also contributed significantly. She found that hearing level, speech intelligibility, and short-term memory for linguistic material contributed relatively little to academic achievement.

Bonham (1963) attempted to determine the predictive value of individual and group achievement tests when used to evaluate deaf children. Etiology of deafness and hearing loss were not stated. The group appeared to be 3 years overage for their actual grade placement based on Metropolitan Achievement Test scores. This study revealed that the Leiter Mental Age grade placement score is the single best predictor of success in the language arts area, and the Knox Cube raw score is the single best predictor of
success in the development of word recognition skills and oral language in deaf children in the elementary grades. Complete evaluation data should include the Leiter, Knox Cube, and WISC-R Performance Scales in order to obtain information about academic aptitude in both the verbal and performance aspects of school achievement.

Explanations for Differences in Intelligence and Achievement

Several studies have indicated that deaf children of deaf parents have superior performance on intelligence tests and achieve higher levels of academic achievement than their deaf peers of hearing parents. Supporting many researchers' findings that deaf children of deaf parents have superior intelligence scores and academic achievement when compared to deaf children of hearing parents, children who are deaf due to a genetic etiology show better academic achievement than those who are deaf due to other causes (Jensema, 1975).

Some research has attempted to determine the extent of the effects that heredity and environment have on these differences between deaf children of deaf parents and deaf children of hearing parents (Mindel & Vernon, 1971). Deaf children of deaf parents are less likely to be affected by
additional disabilities than those who are deaf as a result of other etiologies. However, this variable has been difficult to control for comparison with infectious etiologies, as such diagnoses are difficult to make retrospectively.

Sisco and Anderson (1980) found consistently higher scores in the deaf children/deaf parents group (dc/dp), on the WISC-R Performance Test when compared to a standardized sample of hearing peers. These investigators postulated that the differences could be attributed to a better home environment in the dc/dp group, implying that they experience better parental acceptance, less isolation, and an environment more amenable to the development of language skills than the deaf children/hearing parents (dc/hp) group.

Kusche, Greenberg, and Garfield (1983) assessed the difference in intelligence and achievement of deaf adolescents from three family constellations: 19 deaf children with deaf parents matched to 19 controls with hearing parents and hearing siblings, and 20 deaf children with deaf siblings and hearing parents matched to 20 deaf controls with hearing parents and hearing siblings. It is assumed that the subjects were severely-to-profoundly hearing impaired. Subjects were matched on 16 variables to
control for extraneous factors. Dependent variables included nonverbal intelligence, vocabulary achievement, reading comprehension, language achievement, and sign communication mode (e.g., signed system or American Sign Language). The results revealed that the impact and interaction of the relationships of heredity and environment are more complicated than previously indicated. Genetic etiology as a cause of deafness (e.g. dc/dp or deaf child/deaf sibling) was a strong predictor for nonverbal intelligence. However, in the area of academic achievement the dc/dp dyad was clearly superior to its control group of dc/hp, particularly in the area of language competence. The researchers concluded that a rich language environment interacts with the advantages of a genetic etiology to boost performance in academic achievement.

Braden (1987) explained the difference in the mean IQ between the deaf child/deaf parent dyad and deaf child/hearing parent dyad with the hypothesis that the scores were affected by differences in speed of information processing. He conjectured that the dc/dp are able to execute the responses more quickly because their parents have had to compensate for deficits in strategy skills. In comparison with their hearing peers, he explains that,
whereas they have equal or superior information processing skills due to academic programs that emphasize rote learning, these programs do not encourage the development of higher-order cognitive skills. Consequently, in comparison to hearing peers even the dc/dp do not perform comparatively on tests of intelligence and achievement.

Etiologies of Deafness

Jensema (1974) has reported on causes of hearing impairment among 25,000 children enrolled in elementary and secondary programs for the hearing impaired nationally in the 1972-1973 school year. The five major identified causes of deafness in the United States are heredity, maternal rubella, Rh incompatibility, meningitis, and prematurity. The percentage that each of these etiologies contributes to the entire picture is difficult to determine. Various studies have reported the cause of deafness to be unknown in 13% to 32% of the subjects reported (Caccamise & Johnson, 1988; Jensema, 1974; Stockwell, 1967). It is questionable that hereditary deafness is as common as has been thought. In recessively inherited disease, there is no previous family history of the disorder, and it is, therefore, sometimes not possible to rule out other etiologies.
Conversely, some parents readily attribute congenital deafness to infection or injury and do not consider heredity to be a possible contributory factor (Ries, 1973).

During non-epidemic years, according to Vernon and Hicks (1980), the overall incidence of childhood deafness in the United States directly related to maternal rubella is 12.5%. The incidence of hearing impairment in children with maternal rubella varies from 73% (Chess, Fernandez & Korn, 1978) to 58% born deaf and blind (Orenstein, Bart, Bart, Sirotkin, & Hinman, 1986). Among children born between 1964 and 1965, the number whose cause of hearing impairment was reported as unknown also rose significantly, probably due to many instances of undiagnosed rubella syndrome (Trybus, Karchmer, Kerstetter & Hicks, 1980).

Other investigators have found that despite the introduction of the attenuated live virus vaccine in 1970 and an aggressive vaccination program, rubella is still contacted prenatally, albeit in a decreased frequency. Between 2 to 4% of individuals vaccinated against rubella do not have complete immunity to the virus (Northrup, Gardner & Geittman, 1972). Prenatal infection is known to cause multiple systemic and neurological effects, many of which can be permanent or to cause late-onset effects.
Incidence of Eye Disease in the Deaf

Numerous studies have documented a high incidence of vision problems in students with hearing impairment. Stockwell (1967) reported that 58% of a group of 103 profoundly hearing impaired children had an ocular abnormality. The etiology of the hearing loss was unknown in 13% of this group. She reported the ophthalmologic findings that were part of routine examinations of 960 deaf children at the Pennsylvania School for the the Deaf over a ten-year period. Although there was an increased incidence in eye disease in general compared with a normal pediatric population, which is consistent with the incidence found by other investigators, it is interesting to note that she does not report any individuals with evidence of rubella syndrome. It is possible that since this study was undertaken before the advent of electrophysiologic testing, which is the most effective tool in the discrimination of retinal diseases (Walters, 1978), some cases of rubella retinopathy were misdiagnosed as retinitis pigmentosa. Similar screening programs (Caccamise & Johnson, 1978; English, 1978; Fillman, Leguire, Rogers, Bremer, & Fellows, 1987; Quinsland, Isaeff & Niswonger, 1981) have described
similar results in the incidence of eye disease in the deaf, ranging from 48% to 63% of hearing impaired school-aged subjects.

Whereas the incidence of overt rubella syndrome has declined since the 1960s in deaf individuals, congenital rubella syndrome (CRS) is still often present. In a study of 505 hearing-impaired and deaf students utilizing a combination of electrophysiology and dilated eye examinations conducted at Children’s Hospital Eye Clinic, Columbus, Ohio, 48.7% were found to have significant eye abnormalities (Leguire, Fishman, Fillman, Bremer, & Rogers, 1992; Rogers, Fillman, Bremer, & Leguire, 1988). Of note was the high incidence of rubella-consistent abnormalities, including microphthalmia, glaucoma, cataracts, optic atrophy and rubella retinopathy. The incidence of rubella consistent retinopathy in the severe to profound hearing impaired students (>80dB PTA loss in the better ear) was 13.4% compared to 6.1% (20-80dB PTA loss in the better ear) in the hearing impaired population (Leguire, Fishman, Fillman, Bremer, & Rogers, 1992; Rogers, Fillman, Bremer, & Leguire, 1988).

Johnson and Whitehead (1989) found a similar incidence of eye problems and CRS in a study of college-aged subjects
with hearing impairment. Two hundred forty-two students at the National Technical Institute of the Deaf (NTID) had complete eye examinations at the Eye and Ear Clinic in Rochester, New York. The incidence of eye disease in this group was 51%. Of the 242 students, 104 were known to be hearing impaired as a direct result of maternal rubella (38.8%).

Rubella and Ocular Pathology

Rubella syndrome is notorious for the concomitant occurrence of hearing impairment and ocular abnormalities. The relationships among cataracts, deafness, and cardiovascular abnormalities were first described in 1941 by Gregg. Although the most common finding is nuclear cataract, the retinal disease of rubella can be quite distinctive in appearance without affecting visual acuity. Rubella retinopathy tends to cause a mottled, blotchy appearance to the retina, and it tends to cause more dense accumulations in the macular area. Dilated indirect ophthalmoscopy aids the physician in distinguishing this disease from end-stage retinitis pigmentosa. In the peripheral retina, it is often described as salt and pepper retinopathy, as compared to the bone spiculing of retinitis...
pigmentosa in Usher syndrome, a recessive genetic disease in the deaf individuals (Kresky & Nauheim, 1967; Krill, 1967). The diagnosis of rubella syndrome can be confirmed through the use of the electroretinogram, which measures retinal function, and the presence of other ocular abnormalities commonly associated with rubella, such as the aforementioned nuclear cataracts, microphthalmia, glaucoma, and strabismus (Walters, 1978). Eye pathology reflects infection in utero in the first trimester (Krill, 1967).

Intelligence, Achievement, and Congenital Rubella Syndrome

Some studies have implicated prenatally acquired viral infection with lower intelligence and academic achievement (Chess, Korn, & Fernandez, 1991; Hanshaw, Scheiner, Moxley, Gaev, Abel, & Scheiner, 1976). Forty-four of 53 children with IgM antibody directed against cytomegalovirus (CMV) had a mean IQ of 102.5, whereas in age-matched controls the IQ mean was 111.7 (Rantala, Uhari, Saukkonen, & Sorri, 1991). The predicted school failure rate, based on IQ, neurologic, behavioral and auditory test data, was 2.7 times that of matched socioeconomic controls and eight times that of randomly selected controls. Subclinical CMV infection can adversely affect CNS development. Cytomegalovirus is also known to have similar systemic effects as the rubella virus.
such as growth retardation, hearing impairment, and retinal abnormalities. Encephalitis with varicella as the etiology has been known to cause ataxia, seizures, and most commonly, optic atrophy. One study indicated a significant decrease in mean school achievement scores in a group of school-aged children previously infected with viral encephalitis when compared to a non-affected control group (Rantal, Uhari, Saukkonen, & Sorri, 1991).

Some investigators have not identified statistical differences in achievement between students with CRS and other deaf students. The incidence of additional impairments among 8,000 or more children born with hearing impaired as a result of the 1963-1965 rubella epidemic led Stuckless and Walter, (1980) to question the number likely to qualify for post-secondary education. Among students born between 1954 and 1963 who enrolled at NTID at the Rochester Institute of Technology, 8% have been identified as hearing impaired from rubella, but for those born in 1964, the percentage jumps to 45%.

These percentages are almost identical to figures reported earlier among students enrolled in post elementary/secondary programs for hearing-impaired students (Stuckless, Parker, & Morasse, 1980). These students at
NTID are indistinguishable as a group from students whose hearing impairment is from other causes. The investigators compared 30 rubella students to 34 non-rubella students on the same two subtests of the Differential Aptitude Tests (DAT) (abstract reasoning and spatial relations) and eight communication measures (writing, reading, speech intelligibility, manual recognition, simultaneous recognition, auditory discrimination, speechreading with sound, and speechreading without sound) and found similar means and standard deviations for both groups. They concluded that the prognosis for postsecondary education is favorable for many rubella students graduating from secondary programs in 1983, 1984, and 1985. The instructors and counselors have observed no differences between their rubella and non-rubella students across a wide range of educational, psychological, and communication variables.

Medical histories revealed a higher incidence of congenital vision and cardiovascular disorders among the NTID rubella students than among their hearing-impaired and normal hearing peers, but these appeared to present no continuing problems to the rubella students enrolled at NTID as adults (Stuckless, 1980). They have slightly better auditory discrimination and speech intelligibility scores.
than do their hearing-impaired classmates, due possibly to more residual hearing above the speech range than students who become hearing impaired from other causes (Vernon & Hicks, 1980). However, these students reflect the subpopulation of students with congenital rubella syndrome, who apparently did not suffer significant diffuse central nervous system effects.

Need for Present Study

Although there have been many studies that have identified subtle variations on the Performance Scale and subtests of the WISC-R, most have attributed the deficiencies to lack of competence in English on the part of the deaf subjects and/or a lack of proficiency in the use of American Sign Language by the examiners (Sisco & Anderson, 1978; Watson, Sullivan, Teare & Thompson, 1986). Other researchers have postulated that early language experiences, parenting styles, and even genetics contribute to higher intelligence and achievement scores for deaf children of deaf parents (Allen & Osborn, 1984; Braden, 1987; Brill, 1969; Conrad, & Weiscrantz, 1981; Jensema, 1975; Kusche, Greenberg & Garfield, 1983; Messerly, & Aram, 1980; Ray & Ulissi, 1982; Ross, Brackett, & Maxon, 1982; Ross, 1986;
Sisco & Anderson, 1980). To this investigator's knowledge, there have been no studies that have examined physiological (e.g. infectious) reasons for differences in performance on both the Performance Scale and composite subtests of the WISC-R.

Despite the well-known neurologic effects of CRS, few studies have attempted empirically to document anecdotal reports of decreased achievement in these individuals. One reason may be that because the effects are not always readily apparent the etiology for the child's hearing impairment is rarely identified. However, it is possible to identify rubella as the culprit through utilization of retinal examination combined with confirmation of elevation of rubella titers on ELISA and latex agglutination analysis (Williams, Shannon, Leguire, & Fillman, 1993).

The purpose of the proposed study was to analyze the effects that congenital rubella syndrome may have on the non-verbal scales of the Weschler Intelligence Scale for Children-Revised (WISC-R) and on the Stanford Achievement Test (SAT). In order to ascertain if rubella has specific effects (e.g. behavioral, attention deficits, memory, etc.), the performance of the CRS group on subscales of the
WISC-R was compared with the performance of age-matched hearing and deaf subjects.

If infectious etiologies are found to contribute to differences in intelligence and achievement among deaf students, it is hoped that a more diligent effort will be made to utilize state-of-the-art medical techniques to diagnose subclinical rubella syndrome. Consequently, the identification of individuals who exhibit delayed manifestations of CRS can be expedited. In addition, when the causes for lower academic achievement are elucidated, specific programming interventions may be developed. Finally, it has been this writer’s experience that parents of any child with a disability experience relief when the cause of their child’s disability is identified, particularly if they are considering another pregnancy.
CHAPTER 3

METHODOLOGY

Purpose of Study

The purpose of the study is to investigate the effects of Congenital Rubella Syndrome (CRS) on the performance of deaf students on the Weschler Intelligence Scale for Children-Revised (WISC-R) and the Stanford Achievement Test (SAT). These data are compared to those of age-matched non-affected deaf students. This investigation explored the following research questions:

1. Is there a difference in intelligence between the nonCRS group and the CRS group as measured by the Performance Scale Score of the WISC-R?
2. Do WISC-R Subscale Scores of the Performance Scale vary according to the presence or absence of CRS?
3. Can the etiology of a student’s hearing impairment (nonCRS or CRS) be differentiated based on the individual subscale scores of the Performance Scales of the WISC-R?
4. Is there a difference in academic achievement between the nonCRS group and the CRS group as measured by the Full-Scale Score of the SAT?

5. Do SAT Subscale Scores vary according to the presence or absence of CRS?

6. Can the etiology of a student’s hearing impairment (nonCRS or CRS) be differentiated based on the individual subscale scores of the SAT?

Variables

The independent variable is etiology (presence or absence of ocular rubella). This is a dichotomous categorical variable with nominal level scaling.

The dependent variables of the full-scale WISC-R, the sub-scales of the WISC-R, the full-scale SAT and the subtests of the SAT, are continuous with interval level scaling.

Participants

Participants in the study consisted of deaf students who attended day and residential school programs for the deaf in Ohio between the years 1984 and 1994, and who were between the ages of 13 and 21 years old (i.e., dates of birth ranging from 1964-1984) at the time of administration of the WISC-R and the SAT. Gender and racial distribution reflect
the typical student population. The following criteria for selection of participants were:

1. A congenital bilateral hearing loss of at least 80dB Pure Tone Average (PTA) in the better unaided ear. PTA is obtained by averaging the hearing loss in decibels across the frequencies of 500Hz, 1,000Hz, and 2,000Hz.

2. Participation in a screening program for Usher syndrome (an autosomal recessive disease resulting in sensorineural hearing impairment and retinitis pigmentosa), and receiving a dilated ophthalmologic examination. Only subjects with ocular pathologies other than rubella-consistent anomalies with no loss of measurable functional vision or normal ocular status (other than refractive error) were included.

3. The presence of no other physical disabilities other than hearing impairment, including visual impairment of less than 20/70 visual acuity in the better eye with correction or a visual field defect of less than 40 degrees. Although these criteria are less stringent than those for legal blindness, they represent the criteria for possible supplemental services for visually impaired in the public school system.
4. Age between 6 years old through 16 years old at time of eye examination as well as intelligence and achievement testing. The most recently administered tests were used for analysis.

5. Enrollment in an academic school program for deaf students in Ohio. Students enrolled in classes for multihandicapped, learning disabilities, severe behavior disorders, or the developmentally delayed were excluded.

6. Participation in an academic program which includes testing utilizing the WISC-R and the SAT for assessment purposes.

7. Consent obtained from either parent or guardian if the subject is under the age of eighteen, or consent given by participants over the age of eighteen.

8. Subjects with an immediate family member who is deaf and who uses American Sign Language as his or her primary mode of communication were not be included.

The sample frame was composed of 138 subjects who participated in the initial ten-year eye screening study, and for whom WISC-R scores, SAT scores, or both were available. The two groups that comprised the sampling were:
(a) NonCRS sample- 59 deaf students with no identified ocular abnormalities other than refractive errors or strabismus 

(b) CRS sample- 25 deaf students with ocular evidence of congenital rubella syndrome such as microphthalmia (underdeveloped eyeball), nuclear polar cataract (opacity of the lens of the eye), and/or rubella retinopathy (mottled or salt and pepper appearance of the macular retina).

Instrumentation

WISC-R

Selection of the WISC-R was based on the findings of previous studies by Hirschoren, Hurley, and Kavale (1977,1979), who demonstrated concurrent validity between the Performance scale of the WISC-R and the Hiskey-Nebraska Test of Learning Aptitude, a test frequently used to measure non-verbal intelligence in deaf individuals. Braden (1985) has conducted extensive research comparing the aforementioned measurements, and reported similar results on concurrent validity. Consequently, the WISC-R has been the most commonly used test of non-verbal intelligence in the deaf population in recent years (Braden, 1984, 1985; Graham

The WISC-R is one of the most widely used individually administered standard measures of general intelligence (Weschler, 1974). The WISC-R provides a measure of verbal, performance, and full-scale Intelligence for 6- to 16-year-old children. The average reliability of the Performance Scale is .90, with subtest reliability coefficients ranging from .62 to .92 (Weschler, 1974).

The participants in the present study were administered only the Performance Scale which consists of the following 5 subtests:

**Picture Completion** This is a 26-item performance subtest in which the subject is required to identify a missing part or component in a picture of a common object or familiar scene. The subject obtains a score of 1 for each item identified within 20 seconds of display. The subtest is discontinued after 4 consecutive failures.

**Picture Arrangement** In this 12-item subtest, the subject is given three to five cards and is asked to arrange them so that they tell a sensible story. The first four items have a 45-second time limit, and the subject can receive 0, 1, or 2 points, the latter being given when the
test is completed without assistance from the examiner. The final eight items have time limits of 45 to 90 seconds, and bonus points up to 5 are awarded with completion under the optimum time limits. The subtest is discontinued after three consecutive failures.

Block Design  This is an 11-item performance test in which subjects are provided plastic blocks and are to copy or match pictures of designs in a booklet. Items 1 to 4 have a time limit of 45 seconds, items 5 to 8 have a time limit of 75 seconds, and items 9 to 11 have a time limit of 120 seconds. Items 1 to 3 are scored 0, 1, or 2; bonus points from 1 to 7 may be obtained on items 4 to 11 if completed within a designated optimum time limit. Testing is discontinued after two consecutive failures.

Object Assembly  This test contains 4 items. The subject assembles pieces of a puzzle to form familiar objects in time periods ranging from 120 seconds to 180 seconds. This is not a matching task; the subject must have previous knowledge of the object and possess the ability to identify and reconstruct it by its component parts. Each puzzle is composed of six to eight pieces. Partial scores for partially correct solutions are possible. The time limits are between 120 to 180 seconds. Completion of the
puzzles in less than the predetermined optimum time results in bonus points added to the subtest score. All items are administered regardless of number of failures.

Coding Form B of this test, for children eight years of age and older, contains symbols which are matched with the digits 1 to 9. For example, children are required to match a circle to the number 1, a square to the number 2, and so on. Each correct response receives a score of 1. Ninety-three digits appear above empty boxes that the child is required to fill in with the appropriate code within 93 seconds.

SAT

The SAT was selected because it is one of the few achievement tests for which there are norms for deaf individuals (Allen, 1986; Rosenstein, 1960, 1961; Sisco & Anderson, 1978). It is a means of testing reading and language performance, and additional areas of cognitive performance which are not available on the WISC-R (Allen & Osborn, 1984; Allen, White, & Karchmer, 1983; Kelly, 1995). The SAT is administered to students in Grades 1.5 to 9.9. Extensive normative data are available. Although the Standard Achievement Test Series contain a total of ten
levels that overlap adjacent grades, in this study they will be combined into three academic levels: Primary (tests 1, 2, and 3; grade levels 1.5-4.9), Intermediate (tests 1 & 2; grade levels 4.5-7.9), and Advanced (grade levels 7.0-9.9).

Although reliability coefficients averaged .90 for the total subtest score, they tend to be somewhat higher for older students (Advanced test) than for younger students (Primary tests) (Gardener, Rudman, Karlsen, Merwin, 1982). Although the ability of either test to estimate school performance cannot be determined with precision, for the purposes of this study, the subjects' SAT scores were used to compare school achievement with previously ascertained norms of the deaf school-aged population (Allen, 1986; Rosenstein, 1960, 1961; Sisco & Anderson, 1978).

The SAT has eight test levels that have been vertically equated so that scores are reported on a single scale for each subtest. These “scaled scores” allow comparisons of scores from different test levels and permit evaluation of changes in achievement over a period of time. Each test level was designed to measure curriculum content commonly taught to both deaf and hearing students in the United States.
The basic skills areas tested are language and mathematics. The question format is multiple choice, and there are time limits for the completion of each section. Mathematics subtest of the SAT emphasizes three skill areas at all six levels.

**Language Skills**

**Reading Comprehension** Proficiency in comprehension of a variety of reading materials is evaluated using textual reading, functional reading, recreational reading, literal comprehension, and inferential comprehension.

**Spelling** This subtest evaluates knowledge of sight words (words that cannot be decoded using phonics), phonic principles (using a knowledge of letter sounds to decode words), and structural principles (analysis utilizing word parts).

**Language** This test evaluates proficiency in the use of the English language for communication through an understanding of conventions (grammar and punctuation) language sensitivity (e.g., figures of speech), and reference skills (using the dictionary, index, and encyclopedia).

**Mathematics**

**Concepts of Number** This subtest measures understanding
of whole numbers and place value, fractions, operations (addition, subtraction, multiplication, and division) and properties (e.g., the commutative principle of addition means that the sum is the same regardless of the order of the addends).

Mathematics Computation This subtest evaluates competency in addition, subtraction, multiplication, and division with whole numbers.

Mathematics Applications This test evaluates competency in applying a knowledge of operations and principles to problem solving, geometry and measurement, and graphs and charts.

Data Collection

Medical and ophthalmological data were obtained from records of students who participated in the Children's Hospital Usher syndrome screening program. Academic and demographic data were collected from school files at the students' school program, for example, date of birth, race, gender, etc.

Data Management

The intelligence and achievement tests were scored by the school psychologist. After the WISC-R was administered,
the subject's raw scores were computed and recorded on a record form. Each raw score was converted to a scaled score with a mean of 10 and a standard deviation of 3. For example, a total non-verbal WISC-R intelligence quotient consisting of ten mean scores of 10 would result in a Full-Scale score of 100. In this study, means and standard deviations were recorded for both the CRS group and the non-CRS group, and for both groups together.

Standard scores were computed for the total SAT and for the subtests of the SAT. In addition, SAT means and standard deviations were computed for both the CRS group and the non-CRS group, and for both groups together.

The data file consisted of the following: age of subject at time of administration of intelligence and achievement tests, CRS status, WISC-R full-scale scores and sub-scale raw scores, and SAT total test and subtest standard-scores. WISC-R subscale scores and SAT subtest scores were not available for all subjects—numbers obtained are indicated on the appropriate tables.

Data Analysis

Research questions one and four were answered via the two-tailed t-test on the Performance scale of the WISC-R and the full-scale SAT to determine any significant differences
between the CRS and non-CRS groups at alpha level of significance of .05. A point biserial correlation coefficient was computed and used as a measure of effect size. The resulting correlation coefficient was the index of the relationship between the independent variable of CRS status (a dichotomous variable) and the performance on both the full-scale WISC-R and SAT.

Research questions two and five were answered using a multivariate analysis of variance, which assesses the main effects and interactions of nonCRS and CRS status. Scheffe's post hoc contrast method was used to investigate specific group differences when indicated by resulting mean group differences. Eta will be computed and used as a measure of effect size. This correlation ratio assumes a nonlinear relationship between two variables. Use of the Pearson r could underestimate the relationship between two variables if a nonlinear relationship exists.

Research questions three and six were answered using a multivariate analysis, and then were analyzed by a discriminant analysis. In this analysis, the etiologic status of the subjects (CRS versus non-CRS) is the dependent variable whereas subscale scores on the WISC-R and the SAT-HI are the independent variables. Discriminant analysis has
two purposes: to describe major differences among the groups in the MANOVA and to classify subjects into groups on the basis of a battery of measurements, in this case performance on the WISC-R subscales. When used along with the MANOVA, discriminant analysis has the added benefit of interpretation through the use of uncorrelated variables (Stevens, 1992). Measures of association were included with each of the previous tests, where appropriate. The research utilized the Statistical Package for the Social Sciences (SPSS; Norusis, 1990).

Power Analysis

Power is a function of alpha, sample size, and effect size (Stevens, 1992). Alpha level will be fixed at .05. The sample size was limited to the availability of data obtainable in the archives of the educational facilities attended by the subjects. An attempt was made to obtain the academic data of at least 80% of the CRS and the non-CRS groups. The effect size used r from the point biserial correlations for the t-tests, and eta from the MANOVA. Power estimates were also calculated from the SPSS results.
Statistical Analysis

Research Question One

Was there a difference in intelligence between the nonCRS group and the CRS group as measured by the Performance Scale Score of the WISC-R? The independent variable was etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling. The dependent variable was the full-scale WISC-R, which is continuous with interval scaling. This hypothesis was tested using a two-tailed t-test. A point biserial correlation coefficient was also be computed and used as a measure of effect size.

Research Question Two

Did WISC-R Subscale Scores vary according to the presence or absence of CRS? The independent variable was etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling. The dependent variables were the subscales of the WISC-R Subscales (Picture Completion, Picture Arrangement, Block Design, Object Assembly, and Coding), which are continuous with interval scaling. A multivariate analysis of variance
(MANOVA) tested the main effects of the CRS status. Scheffe’s post hoc contrast method was used to investigate specific group differences if indicated by resulting mean group differences. Eta was computed and used as a measure of effect size.

Research Question Three

Could the etiology of a student’s hearing impairment (CRS or non-CRS) be differentiated based on the individual subscale scores of the WISC-R? Discriminant analysis was used to compare the independent variables of the subscales of the WISC-R (Picture Completion, Picture Arrangement, Block Design, Object Assembly, and Coding), which are continuous with interval scaling. The dependent variable was etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling.

Research Question Four

Was there a difference in academic achievement between the nonCRS group and the CRS group as measured by the Full-Scale Score of the SAT? The independent variable was etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling. The dependent variable was the full-scale SAT, which is continuous with interval scaling. This hypothesis was
tested using a two-tailed t-test. A point biserial correlation coefficient was computed and used as a measure of effect size.

Research Question Five

Did SAT Subtest Scores vary according to the presence or absence of CRS? The independent variable was etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling. The dependent variables were the subtests of the SAT (Reading Comprehension, Spelling, Language, Concepts of Number, Mathematics Computation and Mathematics Applications), which are continuous with interval scaling. A multivariate analysis of variance (MANOVA) was computed to test the main effects of nonCRS and CRS status. Scheffe’s post hoc contrast method was used to investigate specific group differences, if indicated by resulting mean group differences. Eta was be computed and used as a measure of effect size.

Research Question Six

Could the etiology of a student’s hearing impairment (CRS or non-CRS) be differentiated based on the subtest scores of the SAT? Discriminant analysis was computed to compare the independent variables of the subtests of the SAT
(Reading Comprehension, Spelling, Language, Concepts of Number, Mathematics Computation and Mathematics Applications), which are continuous with interval scaling, with the dependent variable of etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling.

Research Design

This was a comparative, correlational study using an ex post facto descriptive design. The independent variable was etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling. The dependent variables were the WISC-R subscales and Performance scales scores and the SAT subtests and total SAT scores, which are continuous with interval scaling.

Limitations

Internal Validity Power of the research design was maintained within acceptable limits and the number of the sample sizes that could be obtained from the sample frame of all the participants in the initial Usher syndrome study were adequate; consequently, threats to internal validity were limited. This correlational study was an ex post facto design; while causality may be inferred, control of
confounding variables that may contribute to the effects on the independent variables were limited.

**External Validity** Due to the complexity of the medical diagnostics used to identify subjects with congenital rubella syndrome, the ability to generalize the results of this study to other geographic locations would be difficult.

**Statistical Conclusion Validity** Low statistical power did not result as adequate sample sizes were obtained and suitable statistical tests were selected.
CHAPTER 4

RESULTS

Research Design

This is a comparative, correlational study using an ex post facto descriptive design. The independent variable is etiology (presence or absence of ocular rubella), a dichotomous categorical variable with nominal scaling. The dependent variables are the WISC-R subscales and Performance scales scores and the SAT subtests and total SAT scores, which are continuous with interval scaling.

The results were first analyzed for differences between the nonCRS (Congenital Rubella Syndrome) and the CRS groups utilizing Weschler Intelligence Scale (WISC-R) subscale scores and Performance Intelligence Quotient (PIQ) scores to see if the effects of rubella syndrome could account for deficits in intellectual development. The SAT subtest scores were then analyzed to see if congenital rubella infection can have long-term effects on academic achievement.
Demographics

Table 4.1 shows the demographics of the non-CRS and the CRS groups. The total group includes subjects for whom either WISC-R scores, SAT scores, or both were available. There are no significant differences in race between the groups, and race reflects the demographics of the state in which the study was conducted. There is a significant difference in the proportion of females to males. However, the incidence of CRS in each sex is approximately the same (females 19.5%, males 13.4%).
<table>
<thead>
<tr>
<th>Attribute</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonwhite</td>
<td>11</td>
<td>7.9</td>
</tr>
<tr>
<td>NonCRS</td>
<td>7</td>
<td>5.0</td>
</tr>
<tr>
<td>CRS</td>
<td>4</td>
<td>2.8</td>
</tr>
<tr>
<td>White</td>
<td>127</td>
<td>92.0</td>
</tr>
<tr>
<td>NonCRS</td>
<td>110</td>
<td>86.6</td>
</tr>
<tr>
<td>CRS</td>
<td>17</td>
<td>12.3</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>46</td>
<td>33.3</td>
</tr>
<tr>
<td>NonCRS</td>
<td>37</td>
<td>26.8</td>
</tr>
<tr>
<td>CRS</td>
<td>9</td>
<td>6.5</td>
</tr>
<tr>
<td>Male</td>
<td>92</td>
<td>66.6</td>
</tr>
<tr>
<td>NonCRS</td>
<td>80</td>
<td>57.9</td>
</tr>
<tr>
<td>CRS</td>
<td>12</td>
<td>8.6</td>
</tr>
<tr>
<td>Rubella</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NonCRS</td>
<td>117</td>
<td>84.7</td>
</tr>
<tr>
<td>CRS</td>
<td>21</td>
<td>15.2</td>
</tr>
<tr>
<td>School placement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day program</td>
<td>18</td>
<td>13.0</td>
</tr>
<tr>
<td>NonCRS</td>
<td>10</td>
<td>5.2</td>
</tr>
<tr>
<td>CRS</td>
<td>6</td>
<td>4.3</td>
</tr>
</tbody>
</table>
Table 4.1: Demographics of nonCRS and CRS groups

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>NonCRS</th>
<th>CRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>120</td>
<td>103</td>
<td>17</td>
</tr>
<tr>
<td>% nonCRS</td>
<td>86.9</td>
<td>74.6</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Note. N = 138; nonCRS = absence of Congenital Rubella Syndrome; CRS = Congenital Rubella Syndrome

Table 4.2 presents the means and standard deviations of the WISC-R subscale and Performance scale scores of the nonCRS and the CRS groups. The mean WISC-R Performance scale score of the nonCRS group was 95.28, and the CRS group, 90.24 WISC-R. Levene's Test for Equality of Variances (F = .693, sig. .407) assumed equal variances. Details of variable comparisons are shown on Table 4.3 which shows the results of the two-tailed t-tests for the WISC-R subscales and Performance scale scores. No significant differences between the nonCRS and CRS group scores on the Picture Completion, Picture Arrangement, Block Design, Object Assembly and Performance scale were revealed by the
independent samples t-test (p > .05). A significant
difference (.025) was demonstrated in the non-CRS group
means (8.29) and the CRS group means (6.81) on the Coding
subscale (p < .05).
<table>
<thead>
<tr>
<th>Subscales</th>
<th>Rubella Status</th>
<th>PC</th>
<th>PA</th>
<th>BD</th>
<th>OA</th>
<th>C</th>
<th>PIQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NonCRS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>58</td>
<td>58</td>
<td>58</td>
<td>58</td>
<td>58</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Mean</td>
<td>9.47</td>
<td>8.62</td>
<td>9.29</td>
<td>9.79</td>
<td>8.29</td>
<td>95.28</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.84</td>
<td>3.11</td>
<td>2.81</td>
<td>3.83</td>
<td>2.57</td>
<td>15.38</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Mean</td>
<td>8.57</td>
<td>8.81</td>
<td>8.33</td>
<td>9.38</td>
<td>6.81</td>
<td>90.24</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.11</td>
<td>3.70</td>
<td>3.79</td>
<td>2.92</td>
<td>2.89</td>
<td>17.03</td>
<td></td>
</tr>
</tbody>
</table>

Note. N = 79; PC = Picture Completion; PA = Picture Arrangement; BD = Block Design; OA = Object Assembly; C = Coding; PIQ = Performance Intelligence Quotient; nonCRS = absence of Congenital Rubella Syndrome; CRS = Congenital Rubella Syndrome

Table 4.2: Non-CRS and CRS means and standard deviations on WISC-R subscale and Performance scale scores
<table>
<thead>
<tr>
<th>Subscales</th>
<th>Sig.</th>
<th>Mean</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>-1.384</td>
<td>78</td>
<td>.170</td>
</tr>
<tr>
<td>PA</td>
<td>0.095</td>
<td>78</td>
<td>.924</td>
</tr>
<tr>
<td>BD</td>
<td>-1.298</td>
<td>78</td>
<td>.198</td>
</tr>
<tr>
<td>OA</td>
<td>-0.525</td>
<td>78</td>
<td>.601</td>
</tr>
<tr>
<td>C</td>
<td>-2.286</td>
<td>78</td>
<td>.025</td>
</tr>
<tr>
<td>PIQ</td>
<td>-1.453</td>
<td>109</td>
<td>.149</td>
</tr>
</tbody>
</table>

Note. N = 79; PC = Picture Completion; PA = Picture Arrangement; BD = Block Design; OA = Object Assembly; C = Coding; PIQ = Performance Intelligence Quotient; nonCRS = absence of Congenital Rubella Syndrome; CRS = Congenital Rubella Syndrome; p < .05.

Table 4.3: NonCRS and CRS two-tailed t-tests of WISC-R subscale and Performance scale scores

Table 4.4 shows a multivariate analysis of variance which tested the main effects of the CRS status utilizing
the WISC-R subscale scores. No significant effects in variable relationships between the nonCRS and CRS group WISC-R subscale scores on the Picture Completion, Picture Arrangement, Block Design, and Object Assembly were revealed. The use of Sheffe's post hoc contrast method was deferred, as the main effects of the variable relationships did not substantiate the significance necessary to warrant its use. Eta was computed and used as a measure of effect size, which was significant for the Coding subscale (eta = .582).
<table>
<thead>
<tr>
<th>Subscales</th>
<th>F</th>
<th>df</th>
<th>Sig.</th>
<th>squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>1.915</td>
<td>1</td>
<td>.170</td>
<td>.024</td>
</tr>
<tr>
<td>PA</td>
<td>.009</td>
<td>1</td>
<td>.924</td>
<td>.000</td>
</tr>
<tr>
<td>BD</td>
<td>1.684</td>
<td>1</td>
<td>.198</td>
<td>.021</td>
</tr>
<tr>
<td>OA</td>
<td>.276</td>
<td>1</td>
<td>.601</td>
<td>.004</td>
</tr>
<tr>
<td>C</td>
<td>5.225</td>
<td>1</td>
<td>.025</td>
<td>.063</td>
</tr>
<tr>
<td>PIQ</td>
<td>1.563</td>
<td>1</td>
<td>.215</td>
<td>.235</td>
</tr>
</tbody>
</table>

Note. N = 79; PC = Picture Completion; PA = Picture Arrangement; BD = Block Design; OA = Object Assembly; C = Coding; PIQ = Performance Intelligence Quotient; nonCRS = absence of Congenital Rubella Syndrome; CRS = Congenital Rubella Syndrome; p < .05.

Table 4.4: Multivariate analysis of variance of nonCRS and CRS WISC-R subscale and Performance scale scores

Discriminant analysis has two purposes: to describe major differences among the groups in the MANOVA and to classify subjects into groups on the basis of a battery of
measurements, in this case performance on the WISC-R subscales. When used along with the MANOVA, discriminant analysis has the added benefit of interpretation through the use of uncorrelated variables (Stevens, 1992). The results of the Predictive Discriminant Analysis of the WISC-R subscale and Performance scale scores shown in Table 4.5 revealed an overall hit/miss rate of .682. Consequently, 68.8% of the subjects can correctly be assigned to the nonCRS or the CRS group using the WISC-R and PIQ scores. Case classification as nonCRS was correct 69.5% of the time; only 66.7% of case classification as CRS group was correct.

First Canonical Discriminant Analysis resulted in an eigenvalue of .129; consequently, the Canonical Correlation was .338 (Table 4.6). Therefore, the estimate of the variance shared by the two linear combinations is 33.8%. These data do not support the ability of the WISC-R subscale and Performance scale scores to predict the etiology of profound hearing impairment (nonCRS or CRS).

Wilk's Lambda was computed to test any significant differences between the nonCRS and the CRS groups using each of the subscale and PIQ scale scores. As shown by Table 4.7, Wilk's Lambda was not significant at .886, p > .05. Consequently, the null hypothesis cannot be rejected.
Predicted Group Membership

<table>
<thead>
<tr>
<th>%</th>
<th>nonCRS</th>
<th>CRS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>nonCRS</td>
<td>96.6</td>
<td>3.4</td>
<td>100.0</td>
</tr>
<tr>
<td>CRS</td>
<td>77.2</td>
<td>23.8</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Note. N = 79; nonCRS = absence of Congenital Rubella Syndrome; CRS = Congenital Rubella Syndrome; p < .05.

Table 4.5: Predictive Discriminant Analysis of classification results for membership in non-CRS and CRS groups

<table>
<thead>
<tr>
<th>% of</th>
<th>Cumulative</th>
<th>Canonical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Eigenvalue</td>
<td>Variance</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>----------</td>
</tr>
<tr>
<td>1</td>
<td>0.126</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 4.6: Summary of Canonical Discriminant Function
Test of Function Wilks' Lambda Chi-square df Sig.

<table>
<thead>
<tr>
<th>Test of Function</th>
<th>Wilks' Lambda</th>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.888</td>
<td>8.812</td>
<td>6</td>
<td>.184</td>
</tr>
</tbody>
</table>

Note. p < .05.

Table 4.7: Wilks' Lambda- tests of equality of group means

Table 4.8 presents the means and standard deviations of the SAT subtests and total SAT scores of the nonCRS and the CRS groups. The mean total SAT score of the nonCRS group was 3676, and the CRS group, 3657. Levene’s Test of Equality of Variances (F = .590; sig. = .445) assumed equality of variance. Details of variable comparisons are shown on Table 4.9, which shows the results of the two-tailed t-tests for the SAT subtests and total SAT scores. No significant differences between the nonCRS and CRS group scores on the Language, Reading Comprehension, Spelling, Computation,
Concepts and Mathematics Applications subtests were revealed by the independent samples t-test (p > .05).

<table>
<thead>
<tr>
<th>Subtests</th>
<th>Rubella Status</th>
<th>LA</th>
<th>RC</th>
<th>SP</th>
<th>COM</th>
<th>CON</th>
<th>MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NonCRS</td>
<td>n</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>49</td>
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<tr>
<td></td>
<td>Mean</td>
<td>593</td>
<td>582</td>
<td>639</td>
<td>653</td>
<td>621</td>
<td>584</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>53.47</td>
<td>58.50</td>
<td>57.19</td>
<td>59.94</td>
<td>58.99</td>
<td>67.82</td>
</tr>
<tr>
<td>CRS</td>
<td>n</td>
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<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
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<td>54.24</td>
<td>44.05</td>
<td>76.99</td>
<td>43.63</td>
<td>63.02</td>
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</tbody>
</table>

Note. N = 68; LA = Language; RC = Reading Composition; SP = Spelling; COM = Computation; CON = Concepts; MA = Mathematics Applications; nonCRS = absence of Congenital Rubella Syndrome; CRS = Congenital Rubella Syndrome; p < .05.

Table 4.8: NonCRS and CRS means and standard deviations on SAT subtests and total SAT scores
The results of the two-tailed t-tests for the SAT subtests and total SAT scores are shown in Table 4.9. No significant differences between the nonCRS and CRS group scores on the Language, Reading Comprehension, Spelling, Concepts, Computation, Mathematics Applications or total SAT scores ($p < .05$).
<table>
<thead>
<tr>
<th>Subtests</th>
<th>t</th>
<th>df</th>
<th>(2-tailed)</th>
<th>Difference</th>
<th>Difference</th>
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<td>95</td>
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Note: N = 68; LA = Language; RC = Reading Comprehension; SP = Spelling; CON = Concepts; COM = Computation; MA = Mathematics Applications; TOSA = Total SAT; p < .05.

Table 4.9: NonCRS and CRS two-tailed t-tests on SAT subtests and total SAT scores
Table 4.10 shows a multivariate analysis of variance which tested the main effects of the CRS status utilizing the SAT subtests. No significant effects in variable relationships between the nonCRS and CRS group SAT subtest scores on the Language, Reading Comprehension, Spelling, Computation, Concepts and Mathematics Applications were revealed. The use of Sheffe’s post hoc contrast method was deferred, as the main effects of the variable relationships did not substantiate the significance necessary to warrant its use. Eta was computed and used as a measure of effect size, which was not significant for any of the subtests.
Subtest | F  | df | Sig.  | eta  \\
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Note: N = 68; RC = Reading Comprehension; SP = Spelling; LA = Language; MA = Mathematics Applications; CON = Concepts; COM = Computation; p < .05).

Table 4.10: Multivariate analysis of variance of nonCRS and CRS scores on SAT subtests

The results of the Predictive Discriminant Analysis of the SAT subtest and total SAT scores shown in Table 4.11 revealed an overall hit/miss rate of .750. Consequently, 75%
of the subjects can correctly be assigned to the nonCRS or the CRS group using the SAT subtest scores. Case classification as nonCRS was correct 95.9% of the time; only 21.7% of case classification as CRS group was correct. First Canonical Discriminant Analysis resulted in an eigenvalue of .094; consequently, the Canonical Correlation was .294 (Table 4.12). Therefore, the estimate of the variance shared by the two linear combinations is 29.4%. These data do not support the ability of the SAT subtests to reliably predict the etiology of profound hearing impairment (nonCRS or CRS).

Wilk's Lambda was computed to test any significant difference between the nonCRS and the CRS groups using each of the subtest scores. As shown by Table 4.13, Wilk's Lambda was not significant at .459, $p > .05$.

<table>
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<tr>
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<th>nonCRS</th>
<th>CRS</th>
<th>Total</th>
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<tr>
<td>nonCRS</td>
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<td>CRS</td>
<td>78.9</td>
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</table>

Table 4.11: Discriminant Analysis of classification results—predicted nonCRS or CRS group membership
Table 4.12: Summary of Canonical Discriminant Function

<table>
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<tr>
<th>Function</th>
<th>Eigenvalue</th>
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<th>%</th>
<th>Correlation</th>
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Note. P < .05.

Table 4.13: Wilks' Lambda of Discriminant Analysis of classification- predicted non-CRS and CRS group membership

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<th>Test of Function</th>
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An overview of the significant findings of the study and the implications is provided in Chapter 5.
CHAPTER 5

DISCUSSION

Although there have been many anecdotal reports that students with congenital rubella syndrome exhibit late-onset behavioral abnormalities (Sever, South, & Shaver, 1985; O’Dea & Mayhall, 1988; Van Dijk, 1993), the results of this study provide little evidence that the etiology of congenital rubella syndrome (CRS) has significant influence on the cognitive and academic performance of students with severe to profound hearing losses and ocular evidence of rubella with no functional visual impairment. While students with CRS experience the same impact on standardized tests of cognition and academic skills as their peers with deafness of other etiologies, they apparently do not experience the long-range deleterious effects of a prenatal systemic neurologic disease previously reported by other investigators, studying the effects of other congenital
Cognitive Performance

When examiners proficient in the use of American Sign Language (ASL) administered the Performance scale of the Wisc-R, the deaf subjects did not perform as well as the hearing subjects, particularly on the Picture Arrangement and Coding subtests (Watson, Sullivan, Teare, & Thompson, 1986). The Coding subscale of the WISC-R was the sole area in which there were significant differences in cognitive functioning between the students not affected by CRS and the students with CRS. However, this deficit did not result in significant differences between the two groups in any area of the SAT, an instrument that assesses academic achievement. The Coding subscale differs from the other subscales on the WISC-R in that it evaluates psychomotor functioning as opposed to higher cognitive functioning.

While other studies have found differences scores on Coding among various groups of deaf subjects, none of the explanations for such differences appear to apply to the groups in the present study. Sisco and Anderson (1978)
showed that the greatest differences in deaf children's performance relative to hearing children were in the Coding and Picture Arrangement subtests. They conjectured that deaf students do not have access to the same educational and environmental experiences as hearing children, and consequently do not develop Coding skills to the same level as their hearing peers. The nonCRS and CRS groups in this study were not in programs with hearing peers, and while some variation in teaching style and curricula can be expected, access to educational and environment experiences probably did not vary significantly as all of the subjects were profoundly hearing impaired.

Phelps and Ensor (1987) found a significant difference in the Coding subtest, with females outperforming males. T-tests performed as part of this study did not show any significant difference between the scores of the females and males on the Coding subscales.

Ray (1982) noted a significant variation within the subtests of deaf subjects of hearing parents. The subjects were particularly weak in picture arrangement and coding with relative strength in object assembly. The scores of both groups in this study support his findings, with the
performance of the CRS group in particular showing poor performance on the Coding subscales.

Academic Achievement

Some studies have found lags in academic performance of deaf students compared to their hearing peers, particularly in the areas of language and reading (Jensema, 1975; Moores, 1987; Myklebust, 1964; Paul & Jackson, 1993; Pintner, Eisenson & Stanton, 1941). The achievement level of deaf students lags behind age-matched hearing counterparts, particularly on the Language section of the SAT. The students with profound hearing impairment in this study achieved SAT scores consistent with the scores of other deaf students in other studies: that is, they were lower than those of age-matched hearing counterparts.

This study attempted to control for variables that have resulted in differences in performance on tests of intelligence and academic achievement of students with profound hearing impairment. Previous studies have indicated that the gap in academic achievement is the widest for students with a hearing loss of greater than 50dB (David, Shepard, Stelmachowicz, & Gorga, 1981; Kodman, 1963; Quigley & Thomure, 1968). Children who have a prelinguistic hearing
loss (i.e., prior to the age of two years), particularly when combined with profound hearing impairment, experience significant impact on their acquisition of primary language and secondary language skills evaluated by achievement tests (King & Quigley, 1985; Paul & Quigley, 1994). All students in this study had congenital profound hearing loss of greater than 80dB PTA in the aided better ear.

Integrated students tend to achieve at grade level compared to achievement of those attending special class (Allen & Osborn, 1984; Jensema, 1975; Ross, 1986; Ross, Brackett, & Maxon, 1982). The number of students affected by CRS in this study who attended either day programs or residential programs were approximately equal, and both programs provide instruction using manual communication as the primary mode of communication. Consequently, the opportunity for exposure to English language experience was the same for both groups and did not result in a difference in performance on either the WISC-R or the SAT.

Variables such as parental acceptance, communication modes and frequency of social interaction have been implicated in the superior performance of deaf children of deaf parents on tests of intelligence and academic achievement (Balow & Brill, 1975; Kusche, Greenberg &
Garfield, 1983; Quigley & Frisina, 1961; Ray, 1982; Sisco & Anderson, 1980; Stuckless & Birch, 1966). Consequently, students who were known to have immediate family members who used ASL as their primary mode of communication were excluded from the study.

Conclusions

The results of the WISC-R and the SAT scores of both groups of students are consistent with those in previous studies where normative data on the performance of profoundly hearing impaired students were collected. These results do not support anecdotal reports by teachers of lower academic functioning in rubella students. Although previous studies have found that individuals born with other prenatal infections such as cytomegalovirus and toxoplasmosis have lower intelligence tests scores than age-matched peers, rubella syndrome does not have the same impact on intelligence and is probably more tissue-specific (e.g. cochlea, retina) than systemic.

After careful examination of the findings in this study, it is difficult to identify any evidence that even partially supports the hypotheses and current popular belief of many educators of hearing impaired students with CRS that the syndrome causes subtle differences in learning in such children. The results of this study do not indicate that
any changes in school programming are necessary for students whose etiology for their hearing status is CRS. Subtle deficits on the Coding on the subscale are not reflected in the CRS groups scores on the SAT on any subtest.

Limitations of the study that may affect the validity or the generalizability of the results include the necessity to use data collected from subjects over a period of ten years. The incidence of CRS is low; consequently the collection of a sample size of significant numbers is not possible without collection of data over several years' time. Changes in teaching approaches and materials used certainly occurred. In order to obtain a large enough group of individuals with CRS over a more brief period of time, it would be necessary to collect data from several locations possibly in several states.

Suggestions For Further Research

Some recommendations for further research include the use of more recent measures of cognition and learning functioning in order to ascertain differences in cognitive functioning. Additionally, it might be interesting to pursue the anecdotal reports that children with CRS have cognitive and behavioral changes that occur over time, extending even into adulthood. Use of statistical regression techniques, instruments that measure behavioral changes or
a comparison of the incidence of mental health interventions required by the CRS and nonCRS groups might indicate differences that the present study did not uncover.

The most important implications of the present study and the study which originally identified the subjects in the CRS group, are the unexpectedly high incidence of not only significant eye problems in the hearing impaired student population but also the high incidence of congenital rubella syndrome that exists after the introduction of the attenuated live vaccine in 1970. Hopefully, the incidence of CRS will continue to decrease as vaccination at the age of 12 is now required and boosters of Measles/Mumps/Rubella (MMR) are encouraged throughout life. Required ophthalmologic examination of all children with any degree of hearing impairment should yield useful information about the etiology of the hearing loss that may enlighten parents as to the probability of other siblings being at risk. Since this population of students with one sensory impairment has a greater risk of secondary eye problems that can be corrected, it seems that regular thorough eye examinations are as vital as audiologic care.


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### APPENDIX A

#### Subject Age and WISC-R Scores

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Note: PC = Picture Completion; PA = Picture Arrangement; BD = Block Design; OA = Object Assembly; C = Coding
### APPENDIX B

Subject Ages and SAT scores

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Note: LA = Language; RC = Reading Comprehension; SP = Spelling; COM = Computation; CON = Concepts; MA = Mathematics Applications; TOSAT = Total SAT