EVALUATING PSYCHOMETRIC PROPERTIES OF AN EXISTING FUNCTIONAL COMMUNICATION ASSESSMENT FOR DEAF INDIVIDUALS

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DISSERTATION

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ABSTRACT

There are a lack of psychometrically sound and non-invasive assessments to determine individuals' strongest communication modality that researchers and practitioners can utilize within the deaf population. Researchers continue to have problems investigating effective communication modality for individuals with hearing loss to establish baselines for language usages. A communication assessment may provide better understanding of a deaf individual's best receptive and expressive language skills. The purpose of the study is to create psychometric properties of one communication assessment designed by the Alabama Department of Mental Health. Williams and Crump (2019) designed the *Communication Skills Assessment* (CSA) to measure functional communication of deaf individuals in order to develop effective communication strategies during real time settings. The CSA is included in routine mental health screenings across the states of Alabama and South Carolina to develop effective communication access within mental health care because treatment is language-based. Rasch analysis was used to evaluate the psychometric properties for six out of eight domains in the CSA. A further analysis of etiology was conducted to measure the potential impact of expressive and receptive skills. Results suggested etiology difference was detected in certain communication skill level which may offer insight for potential complications that prevent efficacy in receptive or expressive communication. Suggestions are also provided for additional research to fill in the gaps with communication assessment for deaf individuals.

DEDICATION

To Brean, Alanah, and Alexis Schafer, my better half and the two beautiful souls who have undertaken this journey with me by their side. They have observed each grey strand materialize during this academic journey. Through all this undue hardship, they keep me going.

To Wayne and Barbara Schafer, my parents, and my foundation. They ignored experts in deaf education that believed I was not capable of academic achievement at a young age. They ignored all those medical, educational, and clinical professional apologies of "I'm sorry, your son is deaf, and he may not amount to much" to create a visual language foundation for my success. It is through their persistence in recognizing the need for receptive and expressive language skills, I stand where I am today.

Words cannot express how much I love you all. I am because you are.

LIST OF ABBREVIATIONS AND SYMBOLS

ACL	Allen Cognitive Level Scale
ASL	American Sign Language
ASL-DT	American Sign Language Discrimination Test
ASLPA	American Sign Language Proficiency Assessment
BAS-II	British Ability Scales
CDC	Centers for Disease Control
CERF-R	Clinical Evaluation of Risk Functioning Scale-Revised
CSA	Communication Skills Assessment – Alabama Department of Mental Health
CTT	Classical Test Theory
D/HH	Deaf and/or Hard of Hearing
IDEA	Individuals with Disabilities Education Act
IRT	Item Response Theory
MFR	Multi-Facet Rasch Model
NVIQ	Nonverbal Intelligence Quotient
PC	Partial Credit
PPVT	Peabody Picture Vocabulary Test
PRT	Primary Reading Test
SLPI	Sign Language Proficiency Interview

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Little did I know the road would lead me to Alabama to make sense of the intricacies involved in dealing with confluence of deafness, language deprivation, trauma, and mental illness to broaden the world's view about Deaf people. One can only hope a modicum offer of cultural and linguistic diversity in the body of knowledge will be entrusted to University of Alabama's School Psychology program. Last but not least, I would like to thank Stephen Hamerdinger who took a chance on this yahoo to blaze a trail all his own.

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CHAPTER I

INTRODUCTION

In order to break down barriers that inhibit communication for students with hearing loss in education settings, there is a need for an effective communication assessment. A communication assessment will assess a continuum of communication methods. An effective communication assessment should take into consideration differential communication modalities for students who have hearing loss (Borgna et al., 2010; Cormier et al., 2012; Hall, 2017; Jeanes et al., 2000; Leigh, 1999a; Luckner & Muir, 2001; Lukomski, 2002; Marschark et al., 2010; Mayer, 2007; Reed, et al., 2008; Siegel, 2002; Smith, et al., 2015; Yoshinaga-Itano & Sedey, 2000).

In the field of deaf education, language planning is critical. Sigel (2002) reported that developing a plan is a complicated task for educational team members who have limited or no exposure with hearing loss. The current practical framework to address language planning for deaf and/or hard of hearing (D/HH) students is to evaluate expressive and receptive language ability based on spoken and listening language outcomes. These traditional approaches to assessment have heavy standards that compare a deaf individual's skill set to a comparable normative group (Hall, et al., 2017). Predictions on language outcomes are generalized and more likely to lead to failure in diagnosis and treatment for the deaf (Hall, 2017).

With hearing loss, there is a need to consider the culture of people who use their eyes, not their ears, as a predominant form to gain access and develop language (Hall, 2017; Humphries et al., 2016). For these students, measuring communication production using a visual medium may produce more accurate results compared to non-visual communication assessments (Bochner et al., 2016; Krouse & Braden, 2011). This assessment should be constructed in a simple enough format to reduce potential complications related to the administration of the instrument, as well as in the interpretation and use of the assessment results (Lukomski, 2002).

Using the ears as the sole source of information input for deaf students is more likely to result in deprivation of information (Gulati, 2018; Hall, 2017). As a result, education must include a visual experience. Educators and researchers continue to focus on a medical pathological model within the disability framework with a focus to restore a communication deficit (Hall, 2017). Given this model, deaf education still struggles to promote an effective educational platform to accelerate deaf students. There are certain cognitive differences that affect language and learning when it comes to understanding the senses. In order to do this, there is a need to compare various communication strengths and weaknesses across the communication spectrum.

The process of learning is more likely to be enhanced for deaf students using a visual modality of sign language (Borgna et al., 2010). In education, approximately 40% of schools in United States that contributed to the Gallaudet Research Institute (GRI) Survey (N=14,742) reported using some form of sign language as a communication mode primarily used to teach students (GRI, 2011). The remaining educational placements appear to determine effectiveness based on speech and hearing for their educational setting. The goal to restore spoken language ties and capture or amplify residual hearing into the medical model for assimilation to the dominant culture (Hall, 2017).

A core feature of deafness stems from barriers in acquiring information. There are medical professionals that continue to discourage sign language as a primary language in early intervention (Hall, 2017). One possibility identified by Suppala (2001) is that information about the history of American Sign Language (ASL) is lacking a paper trail; ASL cannot be transcribed effectively. It is a language without a writing system. Documenting the history of a visual language like ASL is difficult utilizing written materials save a few images using early inventions of film, camera, or relying on the written word trying to visualize an unwritten language. This is much harder when the medical and educational industry follows a paper-based trail for evidence. At the time of this research, the only way to analyze the history of ASL is to review preserved film. Lane and colleagues (2000) combed archival records and newspapers to identify the emergence of one of the first American organizations for the deaf that utilize sign language. This occurred during the 1800's in New England. The writers recognized the founders of American deaf education that opened the first permanent school during that time in 1817 in Hartford, CT. As a result, there is a little over 200 years of possible information on educating deaf students.

To complicate matters, ASL received validation approximately sixty years ago. Suppala (2001) credits William Stokoe whose research in the early 1960's validates that ASL is a grammatical language of its own with a linguistic structure and has its own culture. When considering the history of language, 60 years is still relatively young for linguistic treatment in ASL and language rights of deaf people. Stokoe was able to bring linguistic evidence to recognize ASL as an appropriate language.

Considering the presence of sign language as a communication modality, the lack of culturally informed and psychometrically sound communication assessments for students with hearing loss continues to be a concern (Krouse & Braden, 2011; Vernon, 2005; Vernon & Ottinger, 1981). It was a concern for the state of Alabama to the degree that they approved a state administrative code (Administrative Code, 2010) requiring the use of a communication assessment in its community mental health center standards. The Office of Deaf Services inside the Department of Mental Health has participated in the development, training, and assessment for the *Communication Skills Assessment* (CSA; Williams & Crump, 2019).

Williams and Crump (2019) collaborated to improve on Greg Long's work (Long & Alvares, 1995) from Illinois designed for matching communication skills required for successful employment and the abilities of a deaf worker. Long & Alvares (1995) surveyed over 1,700 professionals to find out that deaf workers were unable to obtain or maintain employment due to communicating ineffectively. At that time, vocational evaluators were using the Peabody Picture Vocabulary Test (PPVT) as the primary communication assessment (Abraham & Stoker, 1998, as cited in Long & Alvares, 1995). Using the PPVT is highly suspect when it comes to identifying a communication gap (Carrigan & Coppola, 2020). Examiners often assume deaf students have sufficient skill for the purpose of PPVT. The PPVT relies on a developed vocabulary bank of knowledge and does not account for diversity within language acquisition. Individuals with limited access to a visual language are more likely to have a fund of information deficit (Pollard & Barnett, 2009) and will develop alternative methods to communicate. Measuring an individual's receptive (hearing) vocabulary for verbal aptitude is not effective for deaf individuals who have a wide variability in communication modalities (Henner et al., 2018). In 2012 at a breakout national conference designed for deaf social services and behavioral health, Williams and Crump shared a vision to merge Mr. Long's work with their own to create an assessment and procedures to measure communication (Williams & Crump, 2018) to account for the wide variability in communication. To do that, they shared their development of a Communication Skills Assessment (CSA) to measure functional communication for deaf adolescents and adults with mental illness. This instrument is included in routine mental health screenings with the goal of monitoring communication access within mental health care because treatment is language-based. However, there is a lack of information regarding its reliability and validity to support the interpretation and use of the CSA as a measure. This research intends to fill the gap by developing psychometric properties for the CSA.

There are few validated measures within the field of deafness focused on communication apart from spoken and listening outcomes. In those measures, researchers are often left with the following options of 1) use general design measures and propose limitation within communication assessment; 2) tweak the original design with adept wording of caution; or 3) develop new measures by undertaking a significant research of their own. After recognizing that current language assessments were not effective in assisting providers with a general awareness of effective communication for the deaf mental health population, Williams and Crump (2019) selected option three and developed their own communication skills assessment towards cultural and linguistic relevance. They developed their own communication skill assessment using Greg Long's initial work (Long & Alvares, 1995) developing a communication skill assessment to educate employers about motivated deaf workers who may not have optimal communication in all modalities.

Considering state administrative code for Alabama and earlier work in achieving optimal employment outcomes for deaf individuals, this research explored the possibility of utilizing the communication skill assessment to be used in school settings (Cuculick & Kelly, 2003; Krouse & Braden, 2011; Kyle & Harris, 2006; Marschark et al., 2015). In order to reduce a reactive approach (i.e., not responding to a student's communication needs until after a student has failed) in addressing students with hearing loss who are failing in the school, the goal is to improve identification of the student's strongest mode of communication. Utilizing a communication assessment that identifies strengths and weaknesses while permitting a demonstration of communication skill has potential.

The state of Alabama has implemented a useful method for evaluating individuals' communication preferences when working with individuals who have mental illness, as an alternative to traditional models of language assessments. To date, there is no psychometric evidence to support the interpretation and use of functional communication assessments provided by the Alabama Department of Mental Health. The purpose of this study is to evaluate the psychometric properties of this existing communication assessment to provide evidence to inform the interpretation and use of the CSA as a measure of functional communication for students with hearing loss.

Statement of Problem

Individuals with hearing loss provide a unique challenge for practitioners in a variety of settings, including mental health and educational settings (Barker et al., 2009; Glickman, 2007; Lukomski, 2002). For the purpose of this research, the term "deaf and/or hard of hearing" will be identified as D/HH to reflect individuals that may have language differences and a range of heterogeneity affiliated with hearing loss (Crump & Hamerdiner, 2017) . The consensus in the community that utilizes speech and hearing appears to be that, if an individual can speak, has residual hearing, or can lipread, then no further actions are needed to improve outcomes for individuals who have hearing loss (Hall, 2017; McCullough & Duchesneau, 2016; Siegel, 2002). Hearing loss impacts individuals' ability to function in many environments, including school settings (Borgna et al., 2010; Cuculick & Kelly, 2003; Leigh, 1999a; Lukomski, 2002; Powers, 2003). Importantly, loss of hearing may result in language delays (Hall, 2017). Such delays affect individuals' ability to process information. In order to reduce risk, communication assessment documenting an individual's best expressive and/or receptive language skills across various communication modalities is recommended.

Currently, there is a lack of a psychometrically sound and non-invasive assessments that researchers and practitioners can use to determine individuals' strongest communication modality for use within the deaf population. In order to advance further in this development for the state of Alabama, there is a need to evaluate the adequacy of a current instrument provided in the state of Alabama (Crump & Hamerdinger, 2017) for individuals with hearing loss who receive mental health services.

Current communication assessments often lead to a lack of understanding of student communication needs in school. Instead, most research is geared towards identifying accommodations, providing sensitivity, and resources. Likewise, a review of previous research (Black & Glickman, 2006; Bochner et al., 2016; Caccamise & Samar, 2009; Maller et al., 1999) indicates that current communication assessments are not designed to measure a student's preferred communication modality. By evaluating the psychometric properties of the Alabama Department of Mental Health Communication Assessment for deaf individuals (Crump & Hamerdinger, 2017), the goal of this study is to use the results from an existing functional communication assessment instrument to provide guidance for further development of a psychometrically sound measurement instrument to evaluate functional communication among students with hearing loss.

Purpose

The purpose of this study is to evaluate the psychometric properties of the Communication Skills Assessment (CSA) as a measure of functional communication among students with hearing loss. The study begins with an overview of psychometric measurements and the measurement of communication within the field of deafness. A brief description of the current communication assessment and the methods is provided. Issues and problems related to use and validation of methods are discussed. Ultimately, the results from this study may guide future researchers and practitioners in evaluating functional communication among students with hearing loss in general, and especially among students without fluent language skills in any modality. This evaluation of the current CSA from the Office of Deaf Services inside the Alabama Department of Mental Health will hopefully facilitate future professionals' ability to identify individual' strengths in several communication modalities in order to improve a variety of educational outcomes for students with hearing loss.

Research Questions

The following research questions guided the design and analysis for this study:

1. What are the psychometric properties of the Communication Skills Assessment (CSA) related to reliability, validity, and fairness?
2. To what extent are there differences in the difficulty of the domains included in the CSA?
3. To what extent does the CSA reveal differences in functional communication among individuals with different etiologies of deafness?
4. Are there certain etiologies for which individuals demonstrate strengths and weaknesses in receptive or expressive skills?

Null Hypotheses

1. There will be no differences across the domains included in the Communication Skills Assessment.

2. There will be no differences among the etiologies in the Communication Skills Assessment.

Assumptions of the Study

1. It is possible to measure functional communication among individuals who are deaf or hard of hearing.
2. Psychometric analyses will provide insight into the quality of the CSA.
3. Psychometric analyses will provide insight toward areas for improvement in measuring functional communication.

Limitations of the Study

1. The study has limited generalizability due to narrow population and specific assessment.
2. The study is limited to deaf individuals who conducted a Communication Skills Assessment at a regional mental health center.
3. The study is limited to a localized geographical area in one state in the southeastern region of the United States and the results may not be generalizable to other populations.
4. The information used in this study relies on a rater-mediated assessment, which may be affected by rater effects.

CHAPTER II

REVIEW OF RELATED LITERATURE

In the field of school psychology, accurate investigation of proficiency in visible communication methods for students with hearing loss requires psychometrically sound instruments that are reliable, valid, and fair (AERA, APA, & NCME, 2014). Without such instruments, it may not be possible to obtain awareness of a student's strongest communication method. To date, communication assessments for students who are deaf and/or hard of hearing that do not include spoken or listening outcomes (D/HH) are limited and under-researched (Black & Glickman, 2006; Bochner et al, 2016; Caccamise & Samar, 2009; Maller et al., 1999). Professionals have long pathologized the characteristics of students with hearing loss (Crump & Hamerdinger, 2017; Ebert & Heckerling, 1995; Gulati & Glickman, 2003; Hall, 2017; McCullough & Duchesneau, 2016; Vernon, 2005). Pathology considers deafness as a medical concept instead of acknowledging deafness as a cultural and linguistic representation. Investigating the relationship between acceptance and integration of language is crucial to improving academic outcomes inside an educational setting (Borgna et al., 2010; Cormier et al., 2012; Hrastinski & Wilbur, 2016).

Henner et al., (2018) identified that analyzing the data of expressive sign language cannot develop through means-based statistics. They identified that it is difficult to separate a child's delay in language stemmed from biological conditions or language deprivation given that research cannot account for the possible linguistic varieties through sign language. Additionally, Henner et al. recognized that there are few (if any) assessments with a large enough D/HH population to create a norming sample among this low incidence population. As a result of this inadequacy, there is a continued history of framing D/HH children as inferior with a deficit in receptive/manual communication skills instead of considering how wide the communication variables are in data collection.

If researchers are able to identify the modality of communication in which students are most proficient, then the focus can be shifted towards achievement (Allen, 1986; Qi & Mitchell, 2011). Far too many children are entering school without a communication plan which creates a form of variable access to language. These same children are more likely to attend classrooms to where there are no professionals fluent in a visual language modality. It is this researcher's hope to validate a communication skills assessment to help determine a child's communication modality as soon as possible so that a communication plan may be in place for the Individual Education Plan (Siegel, 2002). Evaluating the psychometric properties of a language assessment (Williams & Crump, 2019) may strengthen functional communication for students with hearing loss, especially if we can utilize this type of assessment to monitor production-based and receptive-based skills within language acquisition (Henner et al. 2018).

Demographics

Over 90% of children who are deaf will be born to parents who are hearing (Mitchell & Karchmer, 2004). Gallaudet Research Institute (GRI; 2011) reports that 72% of these parents do not sign. This indicates that the majority of parents do not have any type of shared language with their children. With parents who do not have the experience of hearing loss or willingness to learn sign, this continues to present a barrier that slows down acquisition of language for a student with hearing loss. Recent trends indicate that nearly 90% of deaf children are educated in a mainstream setting (Cogen & Cokely, 2015; GRI, 2011). The evidence points toward adults who have very little experience as someone with hearing loss making major decisions for language and academic outcomes without the child's input (Gulati, 2014; Hall, 2017; McCullough & Duchesneau, 2016; Siegel, 2002; Vernon, 2005).

Isolation within the Mainstream Environment

The Individuals with Disabilities Education Act (IDEA, 2004) pushes for inclusion via the least restrictive environment. IDEA promotes students who are D/HH to be educated within a classroom of students of normal hearing. This form of inclusion may involve an assortment of services, but these services are provided within the context of a regular classroom. According to Siegel (2002), this current standard of inclusion within disability education is missing one fundamental aspect, the child's right to communication and language. The practice of including D/HH children in regular classrooms is a form of mainstreaming. In this environment, a child with hearing loss is more likely to be isolated (Hall, 2017), have reduced or zero direct instruction (Marschark et al., 2008) or not be able to engage in their strongest language with their peers (Reed, et al., 2008). Mainstreaming is not inclusion as the population of students who are D/HH is equally or more culturally/linguistically diverse than the general student population (Marschark, et al., 2008; Traxler, 2000).

There is a fundamental right for all students to come into school with language (Siegel, 2002). Fifty years ago, approximately 80% of students with hearing loss were educated in residential schools designed for shared experiences through disability and language (GAO, 2011; Marschark et al., 2015). By 2011, this trend has reversed and approximately 85% of students with hearing loss spend their school days isolated from other people who have little to no barriers to accessing language in general education environment. (Cogen & Cokely, 2015; GAO, 2011). Instead of integration among shared discourse, these students are now mainstreamed across educational environments and facing isolation, not inclusion (GRI, 2011; Mitchell & Karchmer, 2006). As a result, these students are more likely not exposed early enough to visual language or long enough to acquire language. They are also more likely to be not successful in acquiring language and may present little to no language proficiency of any kind.

In one of the earliest studies using observation of students who are D/HH, Heider and Heider (1941) pointed out that the most debilitating thing about deafness continues to not be the disability but the negative and devaluing attitude of people who are unaware of differential ability. Instead of acknowledging that something is missing, Heider and Heider identified that deaf children produced different thought structures than hearing children. People assumed that deafness and hearing loss was a disability that contributed to low intelligence (Vernon, 2005). More recently, there has been a shift in the research towards recognizing language deprivation, trauma, and the human right for language access (Gulati, 2018; Hall, 2017; Siegel, 2002). The first psychological trauma someone with hearing loss experiences is not often related to the inability to hear, instead it is deprivation to full access to language in a form of linguistic discrimination by society (McCullough & Duchesneau, 2016).

Gallaudet Research Institute (GRI, 2011) reported that 57% of D/HH students received special education services in the mainstream setting, 23% in a self-contained classroom, and 12% were in a resource room. What the raw data from GRI do not convey is that isolation in the mainstream increases the risk of trauma (Anderson et al., 2016; McCullough & Duchesneau, 2016). By the virtue of being in a hearing environment, the majority of those students will face a communication barrier (Mccullough & Duchesneau, 2016). The consequences of late exposure to language creates an academic deficit (Hall, 2016). The teachers are more likely to have no experience working with students who have hearing loss and will more likely struggle in providing quality information for the student to acquire (Marschark et al., 2008).

Gallaudet Research Institute (GRI, 2011) appears to have conducted the largest national survey on students and hearing loss. They reported as little as 8% (N=37,828) of the students included in their sample received regular access to a visual language in the home. Considering this survey, from birth until the student enters school, the majority are deprived of fluent conversational language at home prior to entering school. Hall (2016) recognized that from birth until the age of five, there is a critical window to acquire language. This time sensitive period for students face deprivation when professionals and parents do not provide a visual language foundation (Hall, 2017).

For D/HH students, cognitive skills that require a solid first language foundation are more likely to be underdeveloped (Bochner et al., 2016; Hall, 2017). Upon arriving to an educational setting, the communication barrier becomes more complicated when cognitive sophistication (Smith et al., 2015) is required to gain access to a visual modality utilizing educational interpreters for a communication medium. Literacy, memory organization, and number manipulation becomes severely delayed (Humphries et al., 2016).

Additional Risk Factors

Apart from the isolation, there is the risk of genetic factors complicating deafness and potential for diagnostic complications increasing the delay in language development. According to the Centers for Disease Control (CDC; 2009), the average age of autism diagnosis in children with normal hearing was approximately 48 months, whereas the average autism diagnosis in children with hearing loss was delayed by more than a year-and-a-half at the age of 66.5 months. Szymanski et al. (2012) went a step further and disseminated Gallaudet Research Institute Data

(2010) to substantiate reports that deaf students are more likely to have higher rates of autism. Szymanski et al. (2012) indicate that some of the current characteristics of autism may be misunderstood within D/HH culture. The researchers reported that poor language development is one possible factor in cognitive impairment. Hall (2017) proposed that the inflated rates may be related to language deprivation, a phenomenon where children with hearing loss are more likely withheld from establishing a visual language foundation. Penicaud et al. (2013) theorized that aphasias and similar impairments may emerge when linguistic information is disorganized due to hearing loss. Mayberry et al. (2011) suggested that underdeveloped language has similar outcomes as those who were on the autism spectrum. Szymanski and colleagues (2012) stated that one in 59 students with hearing loss compared to one in 110 students with no hearing loss will have a diagnosis of autism. Because of the increased diagnosis of autism and deafness observed in Szymanski's research and the ideas reported by Hall (2017), Penicaud et al. (2013), and Mayberry et al. (2011), there is potential to reduce the gap by developing an assessment to identify a deaf child's strongest language.

There continues to be an intersection between the hearing population and how results are interpreted differently with the deaf population (Barker et al., 2009; Kyle & Harris, 2006; Marschark et al., 2008; McCullough & Duchesneau, 2016; Richardson et al., 2000). Existing recommendations from research on deaf communication may present a challenge when their own research is difficult to reproduce for future testing. Gaps in knowledge surrounding effective communication practices continue to be present. Research indicates that there is a chance for higher rate of misunderstanding made by professionals who do not have direct communication with the deaf student (Glickman, 2007; Luckner & Bowen, 2006; Marschark et al., 2008; Parasnis et al., 2003). With the higher rate of misunderstanding, literacy, and the ability to process written information becomes difficult to measure. Hall (2017) stated a form of systematic exclusion remains which prevents students from inferring further to determine deeper meaning when they are not able to exchange language in a productive manner. For example, medical school does not address language development for deaf people. Medical professionals continue to promote technology to address the physical deficit. This same medical model describes how an invasive medical procedure cannot guarantee success for hearing. Community sources are more likely to not be knowledgeable about language, cognition, or brain development of deaf children. Professionals who encourage speaking or listening strategies often prefer the child to not learn sign language until after they struggle with meeting speaking/listening milestones (Hall, 2017). Normal abled hearing babies are encouraged to learn baby signs along with their parents as early as possible while medical professionals continue to discourage the same visual intervention of baby signs with deaf babies. Professionals have stated claims that it is more critical to train speech and hearing and that visual sign languages may delay this educational process in acquiring language (Hall, 2017). This researcher has not found a case where learning sign language is harmful.

Considering this delay in processing linguistic information, language disorder is a possibility (Hall, 2017). Gulati (2018) was able to identify only five cases of severe language deprivation among the hearing nondisabled population in the past three centuries. Gulati stated that when language deprivation occurs in a hearing society, these cases receive a lot of attention in the scientific community. However, Gulati reported that language deprivation occurs on a daily basis with people who have hearing loss and there is little to no scientific attention. Without access to information in a visual modality, psycholinguistic errors are more likely to manifest early (Thacker, 1994; Trumbetta et al., 2001). Additionally, deaf children have been found to have greater rates of neurocognitive deficits that impact functional language development (Landsberger et al., 2014). Grammar rules differentiate between the two languages of English and American Sign Language.

Nearly every activity in life is mediated through language. It is unfortunate that education enables poor language outcomes for students with hearing loss. The well-intended efforts of educational staff and professionals produces unintended outcomes. These grammar rules may become confused in narration when a deaf individual tosses in several different English words or concepts into their own form of a sign language attempting to demonstrate their own level of comprehension (Hall et al., 2016). Gaps in social understanding are more likely to influence reasoning in expressive production for these deaf children who faced linguistic neglect (Cuculick & Kelly, 2003). Professionals do not realize the daily implications of language deprivation and have a challenging time even understanding the concept of something they cannot observe (Gulati, 2018).

Edwards & Crocker (2008) suggested an approach for adolescents with hearing loss. The use of metaphors, role play, and/or imagery is a challenge when connecting personal experience. Language requires a child to be aware of their emotions and put them into words. This means a child must be able to access and communicate their thoughts. With a language delay or lack of prior learning experience, a child may not be able to narrate their story or exchange information in plain language.

Language Development

The earliest source of literature regarding intelligence tests for students with hearing loss appears to have occurred in 1915 (Vernon, 2005). To this day, evaluators continue to combine verbal and nonverbal ability on many assessments to measure intelligence for D/HH students.

When a D/HH student is unable to speak or produce any measurable spoken language or auditory listening outcomes, their intelligence would more likely score within the intellectually disabled range. Vernon (2005) has identified that language development is not related to cognitive functioning. It became clear that the focus is not a loss of intelligence. Instead, it is the absence of language. D/HH students, as compared to their hearing peers, are more likely to be deprived of language.

With the recent requirement of newborn hearing screening loss (Hall, 2017), medical professionals are able to identify hearing loss within days of birth. Medical professionals must consider how this form of reporting of a hearing screening failure may be misconstrued as bias (Humphries et al., 2016) as they are more than likely to apologize to the parents instead of inviting a promising future. These same professionals are not able to promise that assistive devices such as hearing aids and surgical procedures such as cochlear implants will provide a positive language outcome (Hall, 2017; Hyde et al., 2010). In a brief advising medical experts, Humphries et al. (2016) encouraged medical professionals to acknowledge their bias towards hearing ability and report that cochlear implants do not guarantee 100% success in attempts at remediating hearing loss and acquiring spoken language acquisition. Humphries and colleagues (2016) also emphasized the need to acquire any foundational language to communicate, and that it is not necessarily a spoken modality that is important. There is a need to consider a visual language foundation since this is accessible for all sighted deaf children while spoken language may or may not become accessible for these same deaf children (Hall, 2017; Humphries et al., 2016).

With hearing loss, measuring orthography may be relevant (Stone et al., 2015). By relying on a visual structure of English words being spelled out, the use of sound or attempts to replicate the sound may serve as a tool to be measured. Writing specific letters that form words and drawing visual symbols that represent pictures may serve as a better additive than visual language which requires additional knowledge to process to produce clarity (Mayer, 2007). The implementation design was two-fold: word-level and sentence-level. In making a connection, the author recognizes the need to decode English by making a connection between word-level and sentence-level comprehension. With identifying one word at a time, we focus on reading whereas creating productive vocabulary comes with identifying sentences. With this strategy comes the ability to develop sentence comprehension. In a cross-sectional design, Kyle and Harris (2006) reported disparity in predicting spelling words and reading sentences for deaf children. Their research indicated that deaf children are more likely to develop phonological awareness while learning to read instead of being a precondition to begin reading. If a child can internalize their thought process to develop some type of language, then the challenge will be measuring the word-level items through a form of communication assessment.

Considering the interaction between working memory and the time spent translating language, Alamargot et al. (2018) conducted an assessment of orthography using French written language involving hearing students with typical development (*M*=15.32 years) and deaf students (*M*=15.18 years) and cross referenced these students using the Wechsler Intelligence Scales for Children, Third Edition (WISC-III). The students were matched with the same sex and approximately the same chronological age. Using a digitized tablet and Eye/Pen software, they recorded the positioning and strength of the pen tip being pressed onto the tablet, and the time it took to complete the writing assignment. There was no significant difference between the deaf and hearing students using recall of letters. However, fluency of letters had a significant effect, $F(1,28) = 7.40$, $MSE = 267,479$, $p< 0.015$, $n^2_p = .21$. When considering the length of time between deaf students (*M* = 1148 ms/letter) and hearing students (*M* = 784 ms/letter), deaf students require more time to produce alphabet letters (+ 577 ms per letter on average). Additionally, the researchers identified that deaf students would produce shorter texts. Average text production was 31.80 (*SD*=14.90) words for a deaf student when compared to 95.13 (*SD*=47.14) words for a hearing student. Text characteristics, lexical fluency during text compression and spelling accuracy combined to the percentage of total words written. This research indicates that although deaf students are able to identify and recall letters of the alphabet, more time is needed for writing composition and deaf students are more likely to produce narrower text information. Additionally, the researchers discussed the possibility that auditory deficit may deprive students of some fine motor control in writing.

Yoshinaga-Itano (2003) explored early intervention over a period of ten years for language development. It was found that the earlier a child is able to secure services, the stronger a relationship can be made between cognitive development and language outcomes. Prior to implementation of the newborn hearing screening test, children with hearing loss were detected around the age of 20 months. This delay may have affected the critical acquisition period of language. In another research study, Yoshinaga-Itano and Sedey (2000) found that a child with hearing loss acquired approximately 25%-50% less words than a student with no hearing loss. The child with no hearing loss would acquire approximately 300 words around the age of two and reach an estimated 500 words within the next year. The child with hearing loss would acquire approximately 300 words around the age of three to four years old and would reach an estimated 500 words sometime around the age of five to six years old. Additionally, achievement is noticeably lower among children with hearing loss as a large discrepancy between acquired languages within the two groups was identified (Yoshinaga-Itano & Sedey, 2000).

Considering language development, another study (Jeanes et al., 2000), monitored pragmatic skills. Students with no hearing loss would ask for clarification up to 86% of the time. Students who had hearing loss and oral speaking skills would ask 65% of the time to gain clarity. The students who were deaf would only ask 52% of the time. Results of the study indicated that the students with hearing loss were more likely to not follow up to clarify the information.

A lack of a strong language foundation within communication is more likely to create additional challenges that may affect mental health (Cerulli et al., 2015; Hall, 2017; Hamerdinger & Schafer, 2016; Pollard & Barnett, 2009). Students who are D/HH may carry an emotional load with turning information into a conversation (McCullough & Duchesneau, 2016). Impaired modulation of attention (Barker et al, 2009), poor mental tracking (Hall & Bavelier, 2011), cognitive slippage (Borgna et al., 2010), and failure to generate ideas (Luckner & Muir, 2001) are some areas that could be explored further to reduce mental health concerns. Youth with hearing loss are more likely to be victimized and encounter severe abuse based upon power differential experienced between themselves and youth with no hearing loss (Titus, 2010). Additionally, hearing parents were more likely to choose physical discipline when dealing with deaf children than hearing children (Barker et al., 2009; Knutson et al., 2004).

The majority of deaf individuals are faced with minimal language skills (Leigh, 1999b) and are more likely to use behavior as their primary form of communication (Barker et al., 2009). This behavior becomes an observable form of communication. Barker et al. (2009) conducted a study to replicate previous findings predicting that deaf and hearing children under the age of five years old are more likely to produce behavior as a primary form of communication. Children with hearing loss experience language deficits and display increased observable challenging behavior. Individuals who are D/HH and diagnosed with behavior problems are more likely to demonstrate a form of language disorder when compared to D/HH individuals who do not have behavior disturbance (Black & Glickman, 2006). Isolating language from behavior problems may prove difficult (Hall, 2017). Sustained attention inside an academic setting is an important part of behavioral regulation (Barker et al, 2009; Parasnis et al., 2003).

Students are often placed in an environment where they are expected to understand the basic knowledge spoken by an educator and then translate this information into a functional linguistic experience (Kyle & Harris, 2006; Powers, 2003; Reed et al., 2008). The student may have to interpret the information incorrectly with their pre-existing false knowledge (Smith, et al., 2015). Complications which become time consuming and lack convenience for the student with hearing loss. Given all these factors, D/HH students are more likely to take on additional burdens while navigating the complexity of a learning climate designed by administrators and professionals who do not have a shared live experience (Leigh, 1999a).

Studies (Marschark, 1997; Marschark, 2001; Vaccari & Marschark, 1997) have shown that identifying hearing loss early and introducing visual language early (e.g. baby signs) to establish communication will lead to the best chances for success. This researcher has yet to find an article of how sign language is harmful. Introduction of a visual language early can be combined with various tools (e.g. cochlear implant, hearing aids, speech therapy) to create a "bi-modal" form of instruction. Geers (2006) did investigate the use of spoken language while a child develops his cognition but found that even with tools, the use of trying to be language accurate with an electronic system (even cochlear implant) that reproduces sound does not necessarily improve language. Even with spoken and listening outcomes, it is unclear how much of the success rate can be attributed to academic potential or social integration ability. What we do know is that students who are deaf face insurmountable odds to advance in an educational setting when the evidence for spoken and listening outcomes still relies on "it depends". In order to reduce that gap, there is a need to develop language as early as possible. A Communication Skills Assessment may have the ability to assess a child's strongest communication modality so that we may build their language.

Interpersonal Barriers in Language

How can an educator or administrator appropriately observe the student's behavior (Barker, et al., 2005), the content being delivered (Hall, 2017), or the instructional intervention (Yoshinaga-Itano, 2003) when they are unable to decipher sign language themselves? This may further be masked by the transmission of information promoted by the educational interpreter (Marschark et al, 2010; Smith, et al., 2015).

When an educator is able to communicate directly with a student, there is no translation needed. When an interpreter enters the picture, this becomes a form of mediated instruction as the educator and student are unable to speak to each other directly. What makes mediated instruction a challenge is that there is a time lag between spoken modality, the interpreter, and then the student with hearing loss (Smith, et al., 2015). Cokely (1986) reviewed the lag time experienced with interpreters using simultaneous interpreting. Interpreters who had a two second lag time were likely to have up to 140 differences between what is said and what is demonstrated in an eight-minute interpretation whereas interpreters who took a six second lag time had approximately 20 miscues. Because of lag time and miscues, Marschark et al. (2008) proposed that quality instruction with direct deaf to deaf instruction may be stronger. Marschark et al. conducted four experiments inside a university with a critical mass of deaf students and instructors alongside peers without disability. The location provided several different testing environments exploring the method of communication transmission ranging from deaf, oral deaf, hearing students and deaf or hearing professors. Signing and Spoken modalities were used. Analysis of this design indicated that quality of information exchange is a relevant factor for improving academic success. The research also strongly encouraged future researchers to study individual differences of students with hearing loss. Based on their findings, there is a need to focus adjusting information delivery to accommodate the individual deaf students in their strongest language. Of concern is that students with hearing loss are more likely to come into the classroom with less content knowledge than their hearing counterparts. Due to deficits in content knowledge experienced by students with hearing loss, developing reliability in a communication assessment is critical to optimizing learning outcomes within language development.

In a study of forty students across four different regional schools for the deaf using ASL, Goldin-Meadow et al. (2012) found that students with hearing loss were capable of learning math through a visio-spatial modality. Regression analysis indicated that students are capable of producing gestures to organize mathematical concepts using handshapes. The finding indicated that using sign language can reinforce learning across different educational contexts for deaf students.

Even with early identification, there is hope for parents who claim they cannot become fluent in visual language. Enns and Price (2013) indicated that parents of young deaf children who are learning sign language do not need to achieve mastery of language for their children to benefit from early exposure to sign language. In contrast, Hrastinski and Wilbur (2016) compared two standardized measurements (Measures of Academic Progress and Stanford Achievement Test for Hearing Impaired) to five predictors (education, hearing devices, secondary disability, proficiency in ASL, and home language). The findings suggested a focus on having a successful deaf education involves promoting skilled ASL fluency.

Cultural and linguistic differences are more likely to be misconstrued when educational decisions are based on norms established by hearing non-disabled students. Prior to 1960, evaluating students with hearing loss focused on intelligence and personality. These intelligence tests would often use verbal assessments and score them without acknowledging the student's hearing loss. Vernon and Ottinger (1981) reported a need to focus on verbal direction, measuring expressive content, recognizing the exception not the rule, and suggested the need for psychologists to tread cautiously in their understanding that a difficulty in communication is not the same as a lack of intelligence. Measuring intelligence requires a great deal of adaptation. Vernon and Ottinger (1981) suggested that the art is in the interpretation of the results. However, validation of results becomes difficult. Current trends of evaluation have grown to include cognitive, visual motor, achievement, and socio-emotional measurements for students with hearing loss (Vernon, 2005) which makes measurement more difficult if an examiner is not familiar with how administering a test may alter intended outcomes. There is a need to reduce bias when testing linguistically diverse students.

Educational interpreters are hired to deliver information that often cannot be assessed by a teacher or administrator who do not use sign language (Marschark et al., 2008). Wolbers et al. (2012) measured language in the classroom using an interpreted classroom with one interpreter. When the interpreter was asked to provide information as close as possible to what was spoken in the classroom, Wolbers et al. estimated a third of the information was accurately interpreted. Further, Wolbers et al. discovered that when the interpreter chose to revise the content messages, nearly 90% of the spoken language was not interpreted. Using this same divergent model, over 80% of the deaf student's expressive delivery content was not shared with the teacher. Thus, interpreters are more likely to make educational decisions on language outside the scope of the classroom and these decisions may affect the teacher's instructional service delivery at the expense of the deaf child. Wolbers et al. pointed out that interpreters make executive decisions on the rest of the information in the classroom by editing, eliminating information, or elaborating (stepping outside the role of substituting language by teaching instead of interpreting). The child's academic success may be contingent on what information the interpreter shares.

Apart from the complication in having interpreters decide what information is shared inside an academic setting, a factor analysis (Richardson et al., 2000) reported that 149 deaf students had difficulty in their approach of selecting big picture material that have a significant impact on their academic success. Using the Approaches to Study Inventory tool, Richardson et al. confirmed that deaf students are more likely to adopt a critical approach to studying if they are provided content in an accessible format.

The power of a voice adds a social context to learning that may devalue the meaning of a student's life during the quality of language exchange (McCullough & Duchesneau, 2016). Leigh (1999a) conducted a qualitative study with educated people with hearing loss about the attitude of inclusion in education. Of special interest is the identification of communication difficulties to create an identity. Siegel (2002) pointed out that inclusion in the educational setting requires awareness of a student's preferred communication to formulate an action plan inside schools.

Increased achievement results (Kyle & Harris, 2006) appear to rely on degree of hearing loss, lip-reading skill, and productive vocabulary. Lip-reading, a potential tool that requires reading speech on the lips, appears to have some accuracy and may serve as a bridge to potential language but cannot function as a stand-alone tool to improve academic success. Approximately 30% of the information can be read on the lips with intensive practicing (Barnett, 2002; Ebert & Heckerling, 1995).

An alternative to signing or lip-reading is fingerspelling (Hall & Bavelier, 2011; Stone et al., 2015). Fingerspelling uses manual handshapes to identify one letter in the alphabet. Fingerspelling may offer some resolution to increase reading fluency. Stone et al., (2015) conducted a regression analysis across four assessment batteries to propose more fingerspelling in an educational environment. Results were promising for the use of fingerspelling as a communication modality that is visual and manual to strengthen orthography in reading English print. The concern becomes the ability to develop working memory that can decipher serial spanning capacity of fingerspelling (Hall & Bavelier, 2011). An additional challenge is that delayed manipulation of information appears to be only effective for students with no hearing loss in a classroom setting (Borgna et al., 2014). Delaying information while assigning another task appears to remove all working memory content for D/HH students.

Assessment of Communication

Several assessment instruments are currently used to evaluate functional communication. The American Sign Language Discrimination Test (ASL-DT; Bochner et al., 2016), American Sign Language Proficiency Instrument (ASLP; Maller et al., 1999), Sign Language Proficiency Interview (SLPI;C accamise & Samar, 2009), and Language Rating Scale (LRS; Black & Glickman, 2006) were reviewed. The State of Alabama currently requires the use of a communication assessment in its community mental health center standards (Crump & Hamerdinger, 2017). Specifically, the Office of Deaf Services inside the Department of Mental Health has participated in the provision of the *Communication Skills Assessment* (CSA; Williams & Crump, 2019), which was designed to measure functional communication. The CSA is included in routine mental health screenings with the goal of developing communication access within mental health care, because treatment is language-based.

Although the State of Alabama has implemented a method for evaluating individuals' communication preferences when addressing individuals who have mental illness, as an alternative to traditional models of language assessments, there is no psychometric evidence to support the interpretation and use of functional communication assessments provided by the Alabama Department of Mental Health (Crump & Hamerdinger, 2017; Williams & Crump, 2019).

Individuals with hearing loss provide a unique challenge for practitioners in a variety of settings, including mental health settings and educational settings (Barker et al., 2009; Cormier et al., 2012; Crump & Hamerdinger, 2017; Glickman, 2007; Gulati & Glickman, 2003; Hall, 2017; Landsberger et al., 2014; Lukomski, 2002; Marschark et al., 2015; Richardson et al., 2000). If the brain is not able to provide early visual language acquisition, then the relationship of language to cognition is not cultivated. This cascade effect of language development may lead to an unfortunate chain of events that could result in neurodevelopmental delays (Hall et al., 2017) for students with hearing loss if professionals are unable to identify strength in a communication modality as early as possible.

Educational team members often assume that deaf children enter school with basic language skills. However, hearing loss impacts the acquisition of content knowledge prior to entering school. Additionally, challenging behavior is often thought to stem from factors involving hearing loss. Hall et al. (2016) reported elevated scores in inhibition and working memory from deaf children who were introduced to visual language later in life when compared to deaf children who were exposed to sign language since birth. It was concluded that deprivation to accessible information is more likely liable for behavior rather than the inability to acquire speech or sound. Educational programming is not designed intuitively as the program attempts to teach a second language while the student is learning a first language at the same time (Lukomski, 2008, Marschark et al, 2008; McCullough & Duchesneau, 2016; Siegel, 2002).

Sign language is one of the few languages where the majority of language users are more than likely to develop late language as they gravitate towards a visual modality. This form of acculturative stress creates challenges for professionals to assess. The level of modifications needed for students with hearing loss will vary across individual subtests (Day et al., 2015). Norm-referenced assessments often do not consider sign language as a language option. There is a general lack of agreement on what should be assessed within a sample of students with hearing loss and how the assessments should be conducted. Mayer (2007) reported that there have been very little longitudinal studies regarding the age of onset for students with hearing loss, records of their emergent literacy, and when or if they achieve literacy skills at their grade level. Instead, researchers and practitioners are left with interventions and studies that only reflect a brief probe in the field of education. Several researchers (e.g., Hall & Bavelier, 2011; Krouse & Braden, 2011; Parasnis, et al., 2003; Vernon & Ottinger, 1981) strongly encourage modification to test administration to unlock the student's capacity to produce measurable outcomes.

Given the widespread changing demographics inside an educational setting reflected inside America's schools, academic achievement for students with hearing loss appears to be continually delayed. Gallaudet University Research Institute reviewed forty years of the Stanford Achievement Test (SAT) series using a cross-sectional design to explore academic achievement among students with hearing loss (Gallaudet Research Institute, 2004; Marschark et al., 2015; Qi & Mitchell, 2011; Traxler, 2000). Results revealed that students with hearing loss are more likely to be behind in academic performance when compared to grade-based norms established by the SAT (Qi & Mitchell, 2011). Research explored a longitudinal study with the Woodcock Johnson, Third Edition (WJ-III) exploring age-based norms and hearing loss was conducted by the Stanford Research Institute (Morere, 2013). Within the WJ-III Test of Achievement, the subtests Reading Fluency, Writing Fluency, and Academic Knowledge were selected. Within the WJ-III Test of Cognitive Abilities, the subtests Math Fluency was selected. While considering attrition rates, students with hearing loss were still reported to be behind the academic curve. Despite the two studies using different instruments (SAT and WJ-III) to report data on achievement measures, the studies complement each other in producing a sizable result showing that students with hearing loss are more likely to be academically delayed when compared to their hearing counterparts.

Krouse & Braden (2011) collected data from 128 D/HH students assessed using the Weschler Intelligence Scales for Children, Fourth Edition (WISC-IV). Deaf students were more likely to show lower verbal ability scores. Testing verbal skills in a population subset that does not acquire language verbally is more than likely to yield construct-irrelevant variance that threatens validity of testing. Krouse and Braden (2011) reported that internal consistency reliability for verbal measures is difficult to measure when considering the low incidence population of D/HH. Within the WISC-IV, the Perceptual Reasoning Index (PRI) and the Performance Intelligence Quotient (PIQ) may be able to measure how a deaf student can respond with little to zero language involved. The PRI invites the deaf student to organize and coordinate information in their head by identifying possible sequences or missing information. Whereas the PIQ requires actual physical handling of objects, manual dexterity, and the speed of responses in creating correct answers. When considering validity, the results of the perceptual reasoning task averaged lower than the mean sample of students without hearing loss. Due to this study, the researchers invited the question that the (PRI) may measure something other than the intended results for performance intelligence when considering D/HH students. They suggested that PRI may be a better measure than PIQ for D/HH students when attending to information that requires visual processing. Again, another area of research that continues to promote an exercise in caution when interpreting the results. The factors involved in developing language and communication tools for measurement are more likely to have potential uncontrolled variables that affect testing outcomes.

Four functional communication assessments' psychometric properties were disseminated for the purpose of this research (see Table 1). The American Sign Language Discrimination Test (ASL-DT) from Bochner et al. (2016); American Sign Language Proficiency Instrument (ASLPA) from Maller et al. (1999); Sign Language Proficiency Instrument (SLPI) from Caccamise & Samar (2009); then the Language Rating Scale from Black & Glickman (2006).

Table 1

Evidence of Psychometric Properties in Communication Assessment

Instrument	Authors	Purpose	Evidence of Psychometric Properties		
			Validity	**Reliability**	**Fairness**
American Sign Language Discrimination Test (ASL-DT)	Bochner et al. (2016)	Convergent assessment tool to measure fluency of a visual language	Criterion-related (convergent) validity evidence (compare ratings between ASL-DT and SLPI) Construct-related validity evidence (changes in scores with years of signing)	Internal consistency based on the Rasch model (person and item separation)	Comparison of scores between demographic subgroups
American Sign Language Proficiency instrument (ASLPA)	Maller et al (1999)	Functional communication assessment for children who use sign language	Content-related validity evidence Construct-related validity evidence	Internal consistency reliability (KR-20) Inter-rater reliability	Comparison between three demographic groups
Sign Language Proficiency Interview (SLPI)	Caccamise & Samar (2009)	Interview tool using interrater reliability to measure sign language	Construct-related validity evidence Convergent validity evidence: Comparisons with years of signifying and ASLPI scores	Inter-rater reliability evidence	First independent rating and second independent rating
Language Rating Scale	Black & Glickman (2006)	Categorize language abilities in deaf patients inside psychiatric hospital	No evidence reported	No evidence reported	Compare results of functioning and cognitive levels between hearing and deaf samples inside a psychiatric hospital using a *t*-test

American Sign Language - Discrimination Test

Currently, there are some measurement instruments for visual language that are distinct from the spoken language modality as indicated by Table 1. Bochner et al. (2016) developed the American Sign Language Discrimination Test (ASL-DT) as a convergent assessment tool to complement the American Sign Language Proficiency Interview (ASLPA) designed by Gallaudet University, the sole university in the world where sign language is established as the primary language on campus. To evaluate the ASL-DT, Bochner et al. (2016) conducted *t*-test comparisons between scores for participants with different years of signing with fluency as measured by the ASL-DT as an indicator of construct-related validity. Additionally, ANCOVA analyses were used to compare scores on the ASL-DT and the ASLPA as evidence of criterion-related (convergent) validity. Results from these analyses indicated some shared variance, but the overall potential for inter-rater reliability is still subjective when it comes to interpreting ASL fluency test scores.

American Sign Language – Proficiency Assessment

Maller et al. (1999) reviewed six instruments developed in the 1990's for linguistic research and note that none had psychometric properties developed. Given the challenge based off their review, Maller et al. developed and administered a global screening instrument to determine level of ASL skills of nonnative deaf children with the ASLPA to develop psychometric properties. The standardization of this instrument was based on an 80 children sample age 6-12 years within three groups: (1) Native signers of deaf parents; (2) Deaf children with hearing parents who use sign language in educational settings; and (3) Deaf children of hearing parents who use manually coded English. Item analyses were undertaken, and reliability was evaluated using inter-rater reliability. The screening was based off development of language skills syntax within ASL acquisition. Expressive language was assessed by measuring several linguistic constructs within controlled situations using videotaped language sample measuring sign language proficiency utilizing interpersonal skills in open-ended dialogue. In order to use the ASLPA, assessors must have substantial knowledge of sign language structure. There is concern it may be difficult to train school-based personnel on how to administer the test as the instrument takes one half-hour to administer and two hours to code and score. Item difficulty and item analysis were explored and arranged according to difficulty and assigned an approximate age of acquisition. Three items had poor discrimination and the remaining questions had moderate item discrimination. Using the Kuder-Richardson 20, internal consistency was determined to be highly reliable as the coefficient was .81.

The results of the Maller et al. (1999) study bring into question whether cognitive scores can reliably predict deaf child's performance on spoken-language measures. Maller et al. stated that there is concern because tests that were designed for use with children with spoken and listening skills may underestimate a deaf child's cognitive skills. When administering the ASLPA, Maller et al. discovered that neither age nor grade correlated with sign language proficiency. Additionally, there was no gender effect. The scores were assigned based on ASL grammar in spontaneous signing. Deaf children of hearing parents had a noticeable language delay when compared to deaf children of deaf adults.

Sign Language Proficiency Interview

Caccamise and Samar (2009) examined the Sign Language Proficiency Interview (SLPI), which was developed at the National Technical Institute for the Deaf as a construct-referenced test that uses 11 levels and five areas of language to determine command levels of communication in ASL. The SLPI is an interview tool to assess a person's communicative competency using ASL. The researchers conducted a psychometric study of the SLPI which produced good (87%) inter-rater reliability and limited evidence of construct validity. The SLPI consists of an 11-item construct-referenced test of language skills that relies on interviewer and highly subjective qualitative scoring rubric. The structured conversation is with a deaf interviewer recorded by video. Trained raters of the rubric evaluate the language produced based off knowledge and use of conversational ASL, variety of vocabulary understood and produced, accuracy and clarity of language production, rate, and grammar. The SLPI remains the most widely used measure of ASL proficiency. It continues to be subjective to situational and rater bias which invites a third rater to determine levels and it lacks an independent objective criterion measure.

Language Rating Scales

Apart from assessing proficiency in communication via visual language modalities, Black and Glickman (2006) developed the Language Rating Scale (LRS) to evaluate the fluency of communication for deaf patients inside a psychiatric hospital. Deaf patients within a psychiatric hospital are at higher risk for misdiagnosis due to language isolation and practitioners unfamiliar with communication deficiencies. Black and Glickman identified that validity and reliability of diagnosable disorders are highly questionable when language heterogeneity is considered. In reviewing hospital records, a prevalence of specific diagnoses when clinical interviews were used as a means for diagnosis was found. When assigning a controlled sample of hearing patients to run a two-sample *t*-test with a deaf patients' comparison group, deaf patients had a wider range of diagnoses and 75% of the patients lacked fluency in sign language. Mood disorders were three times more likely to be assigned for deaf patients. Mean scores of self-harm with clinical interviews were significantly higher for deaf patients. However, interpreting these results using a direct comparison is difficult, given the language gap. The study provides some insight towards how assessing language may separate language deprivation from biological damage. Black and Glickman selected two scales, the Clinical Evaluation of Risk Functioning Scale-Revised (CERF-R) and the Allen Cognitive Level Scale (ACL) that had high inter-rater reliability and modified them to measure inpatients who were deaf to produce a more effective way to improve the connection for culturally affirmative practices between mental health and language used in clinical interviews. In evaluating hearing patients (N=180) and deaf patients (N=64), it was reported that hearing patients had a significantly lower level of cognitive functioning with a mean score 4.1 with standard deviation of 0.76 while deaf patients had a mean score of 4.7 with a standard deviation of 0.71. Given this finding, 75% of the deaf patients could be classified as language deprived as they did not demonstrate a full intact language. Findings reported that inaccurate assessment of language may lead to behavior problems, mental illness, and/or substance abuse. The results from the studies of the ASL-DT, ASLPA, and SLPI (Bochner et al., 2016; Caccamise & Samar, 2009; Maller et al., 1999) appear to demonstrate reliability but still invite the question of predictive validity. Although the selection of these assessment tools and the sampling might exhibit little to no predictive bias by race or gender, the lack of fairness evidence may indicate that it is difficult to provide equitable treatment to a traditionally underserved population with little to no tools designed with measuring effective communication through a visual medium. The interpretation and use of communication assessments among students with hearing loss comes with notable challenges. One challenge with this type of assessment is the fact that human raters are needed to rate the individuals' communication proficiency. Computers are not designed yet to observe and measure sign language efficiently. ASL is highly dependent on visual examination. Software remains unavailable to visually rate sign language. As a result, results from research on functional communication among individuals with hearing loss continues to be subjective and highly dependent on rater characteristics, including rater training and the varied results from raters, such as rater errors and systematic biases (Wind, 2018). Despite researchers' efforts, there is growing concern over identifying the minimum language requirements when it comes to evaluating communicative proficiency for students with hearing loss.

Measuring Language Development

When reviewing risk factors in language development, there continues to be a measurement challenge. The deaf population continues to be a small incidental sample. Bochner et al. (2016) argued for an objective way to assess communication since linguistics inside ASL, which "relies on signal recognition (phonological decoding) and higher-order components of comprehension" (p.476). Given that raters may have developed sign language as a second language, their scoring criteria may differ from native users. Criterion validity is threatened since ASL is a visual language and cannot easily be recorded through written means. Measuring speech recognition struggles to play a role in initial programming. Given that English can be measured in the field of deaf education, Luckner and colleagues (2005) conducted a meta-analysis using forty years of research into literacy and hearing loss to conclude that there is enough evidence of effectiveness to teach literacy in the field of deafness. Kyle and Harris (2006) tested tasks that could predict reading literacy through single word and sentence comprehension. Single word reading ability used the British Ability Scales II (BAS II) and sentence comprehension skills used the Primary Reading Test (PRT) along with a nonverbal intelligence test (NVIQ) were collected. Phonological awareness had the biggest separation as hearing students performed significantly higher in identifying alliteration and rhyme similarity.

Additionally, Kyle and Harris found once they were able to control the hearing loss and NVIQ in their sample, the strongest predictor for deaf children's reading was productive vocabulary and speechreading. Mayberry et al. (2011) conducted a meta-analysis on phonological awareness to report that speech recognition has about a one in ten chance of predicting reading success for a student with hearing loss. For students who acquired speech or had residual auditory access to language, their results may be artificially inflated.

There continues to be a need in figuring out optimal communication modalities at a younger age for students with hearing loss. As noted above, neither age nor grade level had any meaningful correlation with results in determining language (Maller et al., 1999). Literacy level modification in the assessment does not help without knowing how much access to information a student has had (Pollard & Barnett, 2009) prior to testing. There is an ongoing need to examine the interaction effect of receptive and expressive skills when it comes to visual language. It is hypothesized that academic intervention efforts will continue to be futile until a student's preferred method of communication is optimized. Additionally, as many as 81% of students with hearing loss who attended college were at severe risk for problems associated with low health literacy (Pollard & Barnett, 2009). Thus, identifying a strength in communication modality prior to intervention may increase input to critical information.

The rating of communication using sign language is difficult to track and report. Interrater reliability for assessments of ASL has significant implications as a diagnostic tool. Subjective assessments are more open to the possibility of rater bias. For example, personal characteristics unrelated to competence may influence scoring. Thus, criterion validity is threatened since ASL is a visual language and cannot be recorded through written means. Bochner et al. (2016) argued for an objective way to assess communication since the linguistic elements in ASL can be difficult to evaluate. Specifically, measuring sign language proficiency requires the evaluator to be fluent with the language. Current assessments are designed to measure what a participant can construct in a visual language. Production of handshapes and expressive content may be inflated if the person is capable of storytelling or the scores may be pulled down if there is excessive content and inappropriate use of grammatical features involving handshapes or fingerspelling.

Fingerspelling involves the intersection of short-term memory abilities with signing and speech skills. Hall and Bavelier (2011) tested the serial spanning capacity with fingerspelling of ASL/English bilinguals. Some subjects acquired sign language starting from birth within the family, other subjects acquired sign language as a second language later in life and all had normal hearing. A combination of letters and/or numbers were used. A higher digit span using spoken English was reported. Encoding was higher when participants mouthed the letter/numbers presented in English. Recall was stronger when higher digit span was performed in ASL. In investigating short term memory, Hall and Bavelier found that the perceptual information of ASL had a shorter recall in linguistic material. The act of fingerspelling information could impact the length of memory requirement to be retained/recalled by a deaf student. Observation of fingerspelling from a student may not necessarily match the student's capacity to retain information.

In reviewing research methodology in the field of deafness, the design appears to have a boilerplate template consisting of a definition of hearing loss, expectations that deaf students will perform below their able-bodied counterparts, intervention will be targeted to restore ability based on remediating hearing loss, the effect size will be small, and that more research will be needed. The current research created by the author intends to fill the gap by assigning psychometric value to deaf individuals who were already tested. The individual's experiences are not objectified but rather the results stemming from administration of a communication skills assessment were explored in creating a stronger research design to reduce the knowledge gap when it comes to functional communication from an initial encounter.

Researchers appear to agree that there is no ideal way to measure language development and verbal intelligence with deaf children. There is neither agreement upon a standard assessment procedure nor an ideal measurement in existing frameworks within relevant literature. There is item difficulty, validation, and reliability issues, test administration issues, and sign adaptation issues, all of which are of critical importance. Without attempts to assess the functioning of deaf students across several different communication modalities, the information provided to determine the best language programming for each student is not valid or reliable. Validating the current communication assessment tool utilized by the State of Alabama’s Department of Mental Health hopes to fill this gap (Collier, 2005; Cormier, 2012; Kyle & Harris, 2006; Lukomski, 2002; Vernon, 2005).

CHAPTER III

METHODOLOGY

Positionality Statement

There is a need to recognize the vested interest coming from this researcher's background. As a deaf person who advocates American Sign Language as his primary language, this researcher is trained in deaf mental health care, first as a substance use counselor, then as a school psychologist before entering the doctoral program culminating in this research. There is a need to recognize that personal knowledge and experience situated within this angle of investigation. As a deaf researcher, it is important to evaluate deaf research while limiting subjective interpretation within the results. The purpose of this research is to provide information and guidance for conducting assessment with the deaf and hard of hearing population that may go undetected by individuals unfamiliar with the hidden impact of deafness. This researcher did not see a need to question the value placed on phonocentrism. There is an ongoing need to value language that is not solely related to speech or hearing. Speech and hearing have significant connection within research on psychometric properties for spoken language outcomes whereas research in alternative mechanisms for communication are lacking. The quantitative process afforded an opportunity to collect and analyze numerical data to find patterns, make predictions, and generalize results to wider populations. With quantitative data, the framing and communication of conclusions were written to limit the influence in the interpretation of results.

This researcher underwent training on the CSA (Williams & Crump, 2019) in Spring 2016 with version 1.2.5 available at the time. Crump and Hamerdinger (2017) published an article identifying that 265 CSA's were stored within the Alabama Department of Mental Health. Correspondence revealed that there were no psychometric properties affixed to the CSA to which proved promising as a unique opportunity to contribute to the body of knowledge. Permission was secured from the authors after meeting them in person at the Mental Health Interpreter Training Institute in the summer of 2017. Permission was obtained from the Institutional Review Board in October 2019. After IRB approval, Alabama Department of Mental Health released deidentified data to this researcher. At the time of writing, the CSA is currently on version 2.2.

Participants

In order to address the research questions provided previously, the study used secondary analysis of existing data collected from participants who have currently been identified and assessed by the Office of Deaf Services inside the Alabama Department of Mental Health using the CSA. To ensure effectiveness, communication assessments were written into the administrative code for any deaf person who receives mental health services in the state of Alabama (Administrative Code, 2010) and South Carolina Department of Mental Health (2014). The CSA is currently designed to provide information about an individual's communication skills. The study participants are receiving mental health services at a regional mental health center in Alabama. Factors that may affect the demographics and inference made about the outcome of a deaf or hard of hearing individual were not explored.

Crump & Hamerdinger (2017) reported 265 clients as of March 2016 who were identified within the Alabama Department of Mental Health. Regional mental health providers were required by state code to have a communication assessment on file for any client who was deaf in their system. After obtaining Institutional Review Board permission, this researcher disseminated the deidentified data released by the Office of Deaf Services. The following variables were collected: date of birth, age of onset for hearing loss, etiology, and 78 variables associated with the CSA (Reading, Writing, Reading/Writing combined, Receptive Fingerspelling, Expressive Fingerspelling, Receptive/Expressive Fingerspelling combined, Manual communication, and Expressive manual communication skills). After reviewing all datasets, all of the cases that had implausible values, obvious data entry errors, and multiple missing values were excluded from the final sample. A total of 99 individual assessments met the inclusion criteria of having enough measurable data in 79 variables. These variables were accounted through six of the eight domains in order to test for psychometric properties for the purpose of this research.

Instrumentation

The current study is based on the Communication Skills Assessment (CSA). The assessment was developed by Roger Williams from South Carolina and Charlene Crump from Alabama. Currently, the Alabama Department of Mental Health uses the CSA as an instrument for measuring functional communication among individuals with hearing loss.

For the purpose of assessment standardization within the CSA, Williams and Crump (2019) recommended that every person who takes the test responds to the same item under similar conditions through a mental health facility. CSA is a performance-based assessment that encourages two raters to work collaboratively in assessing an individual. One of the raters will consist of a native deaf signer. The other individual rater will be a sign fluent person who can conduct the spoken and listening aspect of the communication assessment (Crump & Williams, 2019).

In order to maintain standardization in administering the assessment, the team must possess a level of fluency by obtaining one of the following: a high rating in the Sign Language Proficiency Interview; obtain a certification from the National Registry of Interpreters for the Deaf; or obtain a high rating on the Educational Interpreter Proficiency Assessment. These three certifying bodies demonstrate sign fluency and an understanding of the linguistic structure within ASL (Crump & Williams, 2019).

Training for the CSA requires a minimum of eight hours provided by Roger Williams, Charlene Crump, or their designated instructor. During the training, the philosophy of the CSA is explored. The overview of the instrument and patterns of various communication modalities are discussed. Several samples of collected information and written assessments are provided. After training, the assessors must conduct several assessments and provide videotaping and writing samples. Raw data and final report are collected. The authors recommend at least one of three different evaluations including severe language deficit, atypical language patterns, and a late deaf post-lingual individual. Ongoing training is needed to review assessment tools, language use, and difference in language skills (Crump & Williams, 2019).

The CSA includes assessment tasks related to eight domains (see Table 2). Each domain reflects a different component of communication for individuals who have varying degrees of hearing loss. For individuals with some residual hearing loss, measurement is needed to evaluate their speech capabilities and the degree to which they can recognize speech (or lip-reading). For people who use visual language, there are two different possibilities assessed in the CSA instrument: fingerspelling, or sign language. Comparisons of individuals' expressive and receptive language skills are critical since one may be stronger than the other. In comparing these strengths and weaknesses across the communication spectrum may prepare the individual for an effective communication plan. Proficiency in reading and writing in a predominantly spoken language community is also measured, because these forms of communication may provide individuals with an alternative method to communicate in these settings (Crump & Williams, 2019).

Standardizing the CSA was designed to be administered under consistent procedures so that the CSA experience is as similar as possible across all mental health facilities. These similar experiences should make the scoring output more directly comparable. Guidelines for test administration focused on the timing of assessment, room set up (e.g. good lighting and clear sightlines), and general administration when shifting between specific communication skills. Follow up questions were specified or not allowed for each section.

Table 2

Domains included in the Communication Skills Assessment

Domain Name	Description
Expressive sign language	Production of Sign Language
Expressive fingerspelling	Sign production using manual alphabet
Writing	Tool used to make languages be read
Speech	Spoken language
Receptive sign language	Ability to understand sign language
Receptive fingerspelling	Ability to read ABC’s in sign language
Reading	Assess Reading Comprehension
Speech recognition	Recognition/translation of spoken language

The first domain in the CSA is Expressive Sign Language. *Expressive sign language* involves showing a short video clip (“For the birds”), then measuring the test-taker’s ability to summarize the story. Measurement in ten different sub-domains (sign production, fluency, expressing complete thought, providing detail, following main topic, using ASL classifiers appropriately, use of space via absent/referent methods, incorporation of time and numbers, facial expression variety associated with grammar and sentence structure, and facial expression is consistent with topic) is assessed by the rater ranging from zero to ten for expressive sign language content. Next, *Expressive fingerspelling* involves the test-taker fingerspelling five different pictorial items. Eight points is assigned on the first try if the participant fingerspells it correctly. The test-taker receives four points if they sign it correctly on the second try. The test-taker receives zero points if they are unable to fingerspell (Williams & Crump, 2019).

Third, *Writing* consists of identifying five picture items and demonstrating the ability to utilize handwriting to write out the answer of what is the object presented before the participant. If the writing is clear and legible, the participant will earn two points for each item. If the word is recognizable even with incorrect spelling, it should be scored as an acceptable response. The second part involves two pictures. In the earlier version, if the test-taker can provide a complete description of the item in writing, they would earn 25 points. If there is a complex sentence structure with few errors, 15 points were awarded. If correct in grammar but short sentences, 10 points received. If in a simple sentence form with incorrect grammar, four points were given. If a single word is produced for the pictorial item, two points were earned (Williams & Crump, 2019). They have since revised to include a rubric to score between 0 and 20 points while considering quantity of response, vocabulary, complexity of grammar, accuracy of grammar, and spelling. The data sample has both the earlier and current scoring reflected as an ordinal value (e.g. 25 total points for earlier scoring version and 20 total points for current scoring version both reflect an ordinal score of 5)

In *Speech*, pictures are shown for the test-taker to speak out loud. A person with hearing capacity will be able to identify if the spoken word is comprehensible and score two points for the 10 items. If the word is not understandable, they will earn zero points. The second portion of the spoken language test includes five different pictures. If the participant can provide a complete description in spoken English, they will earn 16 points. If a complex sentence structure is provided with few errors, 12 points will be awarded. If the test-taker produces correct grammar but uses short sentences, eight points are received. If the test-taker produces a simple sentence form with incorrect grammar, four points are given. If a single word is produced for the pictorial item, two points are earned (Williams & Crump, 2019).

The *Receptive Sign Language* domain includes twenty items. The first thirteen items consist of the examiner, proficient in sign language questioning the participant and expecting a response. The next seven questions involve two pictures and questions provided by the examiner to identify if the participant can answer in their preferred sign system. Five points are assigned for each correct response (Williams & Crump, 2019).

Receptive fingerspelling involves the examiner fingerspelling out five different items. The test-taker will identify the word after reading the fingerspelling. They may write, say, or sign the answer. They are not allowed to fingerspell the word back. They are more likely to identify what they recently read through production of a signed concept. Eight points are assigned on the first try if the test-taker signs the word correctly. Four points are assigned if they sign it correctly on the second try. Zero points are assigned if they are unable to fingerspell (Williams & Crump, 2019).

The *Reading* domain involves 10 items on a white piece of paper with black ink approximately 36 - 44 font size. If the participant can identify the word by producing signed content and not fingerspelling each letter, they will earn one point for each word. The second part of reading domain involves five full sentences and four picture items. After reading the sentence, the participant will select a picture. If correct picture is chosen, 10 points will be assigned (Williams & Crump, 2019).

Finally, the *Speech Recognition* domain has five single common words to identify, and then 10 simple sentences to identify. Responses are measured through a rater who is capable of accessing sound or using technology that can transcribe spoken language. If a participant can respond correctly on the first try for the single word, they will earn two points. If they can identify the single word on the 2nd try, they will earn one point. If they cannot recognize the spoken word, they will earn zero points. The second part of the speech recognition portion tests the participant's ability to identify basic sentences that occur in everyday life. If they can identify the whole sentence, they will get nine points on the first try. If they get it on the second attempt, they will earn seven points. If they are unable to identify the sentence, then they will not earn a point (Williams & Crump, 2019).

Table 3

Range of Points within Domains inside the Communication Skills Assessment

Domain Name	Range of Points
Expressive sign language	Ten domains. Zero to ten points for production, fluency, express complete thought, provide details, follow main topic, use of classifiers, use of space, incorporate time/numbers, facial expression variation with grammar, and facial expression consistent with topic.
Expressive fingerspelling	Five pictures. 8 points if correct on first try. 4 points if correct on second try.
Writing	First part: Five picture items. Two points each. Second part: Two pictures. 25 points for complete description. 15 points for complex sentence with few errors. 10 points for correct grammar but short sentences. 4 points if simple sentence with incorrect grammar. 2 points for single word response.
Speech	First part: 10 items. Two points for comprehensible speech. Second part: Five pictures. 16 points for complete description. 12 points for complex sentence with few errors. 8 points for correct grammar but short sentences. 4 points if simple sentence with incorrect grammar. 2 points for single word response.

Receptive sign language	13 items query/response in sign language. Seven items query in sign language with selection of picture. Five points each.
Receptive fingerspelling	10 items. 8 points if correct on first try. 4 points if correct on 2nd try.
Reading	First part: 1 point for each one-word item identified. 10 words. Second part: 10 points for selecting the appropriate picture after reading a sentence. Five sentences.
Speech recognition	First part: Five single words. 10 simple sentences. If identify on first try two points. Second try, 1 point. Second part: Basic sentences in everyday life. 9 points on first try. 7 points on second try.

Data Collection

The current study was conducted using secondary data. Specifically, the data used were collected by the Alabama Department of Mental Health from 2012 - 2020. Permission was obtained from the Office of Deaf Services inside the Alabama Department of Mental Health to release their Communication Skills Assessment data to measure the intended effects. The Institutional Review Board from The University of Alabama granted permission to report the findings.

Data related to the speech and speech recognition domains of the CSA were not assessed as those domains do not focus on visual language outcomes, which were the focus of this study. Speech and Speech recognition is part of the original CSA to identify to what extent a deaf individual is capable of speaking or understanding speech. In most cases, the results are then used to support why Speech or Speech recognition is not an option for communicating with a deaf individual. Data from the six remaining domains in communication modalities were used in the analysis. The results were manually entered on a spreadsheet coded by each domain. All identifying information was deidentified prior to analysis. Raters were not identified so rater specific results were not provided.

Data Analysis Procedures

The data analysis procedure for this study involved evaluating the psychometric properties of six of the eight domains included in the CSA; Speech and Speech Recognition were not assessed. Expressive Sign Language, Expressive Fingerspelling, Writing, Receptive Sign Language, Receptive Fingerspelling, and Reading were assessed. An analysis of etiology was conducted for potential impact of expressive or receptive skills. Accordingly, a combination of analysis techniques were used based on Classical Test Theory (CTT) and Item Response Theory (IRT). The CTT analyses were conducted using SPSS, and the IRT analyses used the Facets software program (Linacre, 2015).

Classical Test Theory Analyses

The first set of data analysis techniques is based on Classical Test Theory (CTT). The CTT analyses were conducted using the SPSS software program. The CTT analyses observed responses on the raw score scale to examine the psychometric characteristics of an assessment procedure. Using CTT techniques, the current study focused on following indicators of psychometric quality: (1) item difficulty and item variance, (2) item discrimination, and (3) internal consistency reliability. With a spread of item difficulty, the goal was to determine the percentage of respondents who answer an item correctly. The items also discriminated between test-takers who know the material and those who do not. Finally, internal consistency reliability analyses were conducted to evaluate the degree to which the items are cohesive and measure similar characteristics. High values of these statistics (see results section) suggest evidence there is consistency in responses/ratings. Such analyses provided an overview of the psychometric characteristics of the CSA. Further, separate analyses within test-taker subgroups provided insight into differences in the instrument's characteristics for different groups of test-takers.

Item Response Theory Analyses

In addition to CTT analyses, IRT techniques were used to examine the psychometric properties of the CSA. The IRT analytic approach provided additional insight related to individual items, individual participants, and other facets of interest beyond what is provided using CTT techniques. In particular, researchers can use IRT approaches to explore the relative difficulty ordering of assessment items, the degree to which the items can be used to distinguish among individual students, and the degree to which the items functioned as expected within a measurement framework. Likewise, IRT models provide information about participant ordering and the degree to which participants' responses indicate that the items functioned in an expected way for individual participants.

To explore the psychometric properties of the CSA, a psychometric technique based on the Rasch measurement theory was used (Rasch, 1960). The Rasch measurement theory approach allowed this study to consider the degree to which measurement instruments adhere to fundamental properties. Specifically, when using a Rasch measurement approach to analyze assessment data, there is a need to begin with two a-priori requirements regarding items and persons based on the concept of invariance: (1) the relative difficulty of the items must be the same for all participants; and (2) the order of the participants on the construct should be the same, regardless of the items to which they responded.

The requirements listed above are important because when there is evidence of acceptable adherence to invariant measurement, researchers can describe the relative ordering of items and the relative ordering of persons on a common linear scale that represents the construct, where the interpretation of item or person ordering does not depend on individual person or item characteristics. From a theoretical perspective, researchers can use information about item ordering and person ordering to provide additional insight into the construct in terms of the difficulty ordering of the items, as well as the characteristics of persons who have low and high locations on a construct. Finally, researchers can evaluate the degree to which individual items and persons depart from invariance using indicators of model-data fit. Evidence of misfit can alert researchers to potential areas for improvement to the items or directions for further analyses.

In this analysis, the partial credit (PC) formulation of the Many-Faceted Rasch Model (PC-MFR model) was used to analyze the data. The PC formulation was used because the items in the CSA include different scale lengths. Specifically, a PC-MFR model with facets for participants, etiology subgroups, domains, and items in which the rating scale structure was estimated separately for each domain:

$$ln\left[\frac{P_{ngdi(x=k)}}{P_{ngdi(x=k-1)}}\right] = \theta_n - \gamma_g - \lambda_d - \delta_i - \tau_{dk},$$

Where θ_n is the location of participant *n* (communication proficiency), γ_g is the location of etiology subgroup *g* (proficiency within subgroup), λ_d is the location of domain *d* (domain difficulty), δ_i is the location of item *i* (item difficulty) on the logit scale that represents communication proficiency. Finally, τ_k is the location on the logit scale at which there is an equal probability for a rating in category *k* and in category *k* – 1, specific to domain *d.*

To facilitate interpretation, all of the facet locations were centered (mean set to 0 logits) except for participants. In addition, the location of the "Unknown" etiology category was fixed to zero logits to serve as a reference point for comparing the locations of the other etiology subgroups. The estimates were oriented such that for participants and etiology subgroups, higher locations on the logit scale indicated higher levels of communication proficiency. For items and domains, higher locations on the logit scale indicated higher levels of difficulty (lower average ratings).

In a second analysis, an interaction was added between the domain and etiology subgroup facets in order to explore the degree to which the difficulty of each domain was invariant across subgroups:

$$ln\left[\frac{P_{ngdi(x=k)}}{P_{ngdi(x=k-1)}}\right] = \theta_n - \gamma_g - \lambda_d - \delta_i - (\gamma_g \lambda_d) - \tau_{dk}.$$

The interaction analysis produces an omnibus chi-square test that evaluates the null hypothesis that the difficulty ordering for each of the domains is invariant across the etiology subgroups. If a significant omnibus test is observed, pairwise interaction terms can be examined between each domain and subgroup that indicate the degree to which the observed difficulty for a particular domain is different within a particular subgroup compared to the overall difficulty estimate for the domain. These pairwise terms are reported as t-statistics that are typically evaluated as effect sizes, with values that exceed +2 or -2 indicating substantial differences in domain difficulty for a particular subgroup.

The psychometric properties of the CSA overall and within subgroups of test-takers who have different etiologies of deafness were also examined. Given that there was not enough of a sample size for single etiologies, some of the etiologies had to be combined into various categories to produce a measurable outcome. A total of six categories were established based on the potential with expressive or receptive skills. The first category involved individuals who acquired hearing loss through neo-natal exposure of substance use. This involved cocaine, fetal alcohol syndrome, maternal drug use, and ototoxicity. The second category involved those who were born hearing, acquired language, and then lost their ability to hear that can be attributed as an accidental exposure later in life. This included physical abuse, accidents, fluid in their ears, gunshot caused hearing loss, occupational exposure, and two physical conditions with stroke and tumor. The third category stemmed from various episodic infections that may contribute to hearing loss. This involved flu, ear infections, virus, fever, and illness from the mother during in utero. The fourth category indicates some type of genetic anomaly that creates hearing loss. This included hereditary, Waardenburg syndrome, and undeveloped cilia. The fifth category is vaccination to which various viruses have been detected and may have vaccinations or medical intervention available now to reduce the risk of hearing loss. This included cytomegalovirus, measles, mumps, rubella, and spinal meningitis. Of note, hypoxia was included in the vaccination category due to suspected similar psychomotor receptive/expressive skills in language (Cainelli et al., 2018). Finally, the sixth category is all the remaining individuals who are determined to have an unknown etiology of hearing loss. This final category allowed for a variable to be measured against those with determined etiologies.

Limitations and Delimitations

The current study has several limitations and delimitations. The analysis is limited to one assessment instrument – the Communication Skills Assessment (CSA). The CSA may not capture the full range of communicative competence for individuals with hearing loss. The convenience sample in these data fall under the purview of the Department of Mental Health. All selected individuals had a diagnosable mental illness and may present a language disorder. There was no norming sample established within the general community members who are D/HH

Researchers should continue to examine psychometric characteristics of future assessments that have been designed for use among individuals with hearing loss. Research continues to indicate a need for operationalizing of the criterion to assess language and identification of risk factors in language development.

There is a lack of information about raters and the potential for rater effect that future research may want to explore. All raters underwent eight hours of training provided by Crump, Williams, or their designated instructor. This study did not investigate nor identify inappropriate rater response processes, rater bias or the degree of inter-rater reliability related to the assessment in the context of mental health.

Along the same lines, the current study is limited in that data are not available related to the predictive validity of the CSA. Hopefully, the results from this study can inform the improvement of the CSA and demonstrate techniques for improving other related instruments. If another psychometric property becomes available, convergent, and concurrent validity can be explored.

Another limitation is related to the inclusion/exclusion criteria in selecting the sample of participants. With the Communication Skills Assessment, we broke down a small population sample into even smaller population sample (Henner et al., 2018). To date, quality control often excludes deaf individuals in samples. Objective inclusion and exclusion criteria may be worth developing within this sample of deaf individuals. Selecting a sample or basing eligibility criteria apart from mental illness may warrant further consideration. There may be a need to develop some type of systematic methodology to study the criteria and how it impacts the outcome of psychometric testing. After assessing the data, the criteria may be subject to change through the early stages of process to control measures.

Significance

The idea of introducing a visual language as early as possible and maintaining that language appears to be an anathema to current ideology. The US education system is not designed to promote inclusion as a sensory experience and the least restrictive environment in educational settings is designed around a physical handicap. Failure is expected when a dichotomous position when research is set up to integrate a deaf student within general education designed for spoken language outcomes (Mayberry et al., 2010). An implicit bias of what could be misconstrued as “normal” does a disservice to deaf individuals when considering the communication spectrum. There needs to be a goal to identify root causes within language gaps so we may work towards filling them in.

Mayberry et al. (2010) conducted a meta-analysis on phonological awareness to report that speech recognition has about 11% chance of predicting reading success for a student with hearing loss. Imagine the possibility if we can figure out optimal communication at a younger age. Maller et al (1999) discovered that age or grade did not have any correlation with results in determining language. This indicates there is a communication deficiency with people who have hearing loss. Pollard & Barnett (2009) reported that literacy level modification does not help without knowing how much communication access a student has. In short, academic interventions are futile until we can optimize a deaf student’s preferred method of communication. In another research sample, Pollard and Barnett (2009) found that 81% of students with hearing loss who had a college degree were at severe risk for problems associated with low health literacy. Educators often forget that hearing loss impacts aspects of communication such as comprehension and retention of materials.

Developing a bilingual approach is not the goal for this current research. Rather, the goal is to promote better language outcomes by developing psychometric properties for a communication skills assessment. There is a need to consider the importance of using a student’s preferred mode of communication. Imagine the possibilities on understanding what communication modality would best benefit a student with hearing loss. Instead of linguistic neglect, it is time to understand the facts that revolve around hearing loss by considering linguistic matching. The impact of a communication assessment is sorely needed.

Communicating is hard enough when a student isn’t mediating their thoughts through someone who hasn’t been exposed to personal level constructs where the correct word use carries with it an entire monograph of information to other intended parties. When people are unaware of a proficient method of communication for students with hearing loss, these same students may carry an emotional load of turning information into something worth deciphering for all parties involved. This emotional load creates a cascade effect in language development.

CHAPTER IV

RESULTS

After going through 256 Communication Skills Assessment, 99 participants met the criteria with enough information to measure six out of eight communication domains to develop psychometric properties. From those 99 participants, the following demographics were obtained. The mean age for the entire sample was 39 years, 4 months, (SD=18.04). Descriptive details about deafness-related variables are listed in Table 4.

Table 4: Demographics

Assessment Age		Age Onset		Education		Tinnitus		Severity Index	
Group	*n*	Group	*n*	Group	*n*	Group	*N*	Group	*n*
<18	15	Unknown	42	Residential	36	Intermittent	24	Moderate	3
19-29	18	Birth	9	Mainstream	58	Symptomatic	15	Profound	27
30-39	15	Before 6y	19	No data	5	No Concern	40	Severe	8
40-49	15	Teenager	2			No data	20	Progressive	4
50-59	14	20-29	6					Unknown	57
>60	15	30-39	3						
No data	7	40-49	3						
		50+	2						
		No data	13						

Demographic information related to age during communication skills assessment, age when diagnosed with hearing loss, manner of education, if any noticeable tinnitus reported, and severity scale for hearing loss were reported. Gender and ethnicity were not identified. As evidenced in Table 4, the CSA is not age limited. The focus of the assessment had a wide variety of age range as the focus was assessing basic language skills. The CSA evaluated one ten-year-old, three 12-year-old, and 11 high school age students. This information was not used when evaluating psychometric properties as the research focused on communication modality.

Table 5. Etiology categories.

SUD (n=9)	**Infection (n=11)**	**Post-Lingual (n=10)**	**Contagion (n=10)**	**Genetic (n = 11)**
Cocaine (1)	Asian Flu (1)	Physical abuse (1)	Cytomegalovirus (1)	Genetic (8)
FASD (4)	Ear infection (3)	Accident (1)	Oxygen (3)	Hereditary (1)
Maternal drug (1)	Virus (3)	Fluid in brain (1)	Measles (1)	Waardenburg (1)
Ototoxicity (3)	Fever (2)	Gunshot (2)	Mumps (1)	Undeveloped cilia (1)
	Maternal illness (1)	Occupational (3)	Rubella (1)	
	Neonatal sickness (1)	Stroke (1)	Spinal Meningitis (3)	
		Tumor (1)		

Note: Numbers in parenthesis represents total occurrences in their respective category

To investigate meaningful interpretations of etiology and the potential impact for expressive or receptive skills, there was a need to combine isolated diagnoses and limited selections to create a sampling size. The decision to categorize were based on the potential with expressive or receptive skills. A total of six categories for etiology were created.

As seen in Table 5, six categories were created to consider the potential impact of expressive or receptive skills in the CSA (Williams & Crump, 2019). The first category reflects in utero experience affected by substance use. Substance Use Disorder (SUD) category was created to reflect potential exposure in utero that may impact language considerations (Crump & Hamerdinger, 2017). This included an individual who was exposed to cocaine neonatally, four individuals who had a diagnosis of fetal alcohol syndrome, one individual exposed to drugs in the womb, and three individuals with a diagnosis of ototoxicity. From the CSA results (Williams & Crump, 2019), fetal alcohol syndrome disorder (FASD) suggests expressive skills may be superior to receptive skills which is hypothetically similar to results that fall within the substance use category. Second, infection in utero or shortly after birth were combined to increase statistical power. Third, candidates who acquired hearing loss later in life were categorized into a post-lingual (Crump & Hamerdinger, 2017) section to provide an additional result to compare. Fourth, contagion (Crump & Hamerdinger, 2017) provides a list of contagious diseases that are known to cause hearing loss. There is some research for virus that are known to cause hearing loss measuring through spoken language-based outcomes. Of interest, there were three candidates who reported hearing loss via a loss of oxygen to the brain. Brain hypoxia is not a contagion per se. Instead, hypoxia hypothetically demonstrates similar symptoms within neuronal development for fine motor and processing skills when compared to the virus listed in the contagion category (Cainelli, et al., 2018). Fifth, genetic or syndromic deafness (Crump & Hamerdinger, 2017) is hypothesized to affect unnatural development of language.

Table 6: Raw Score Value on the Communication Skills Assessment for each domain.

	Alpha within Domain	N Items	Mean Rating	SD
Reading A	0.97	10	10.57	6.03
Reading B	0.76	5	3.62	1.61
Writing A	0.84	5	8.21	2.99
Writing B	0.97	2	4.86	2.83
R/W	0.97	10	19.40	10.34
Receptive FS	0.96	5	5.46	4.44
Expressive FS	0.96	5	5.53	4.61
RecExp FS	0.96	6	5.92	5.48
RCMS	0.98	20	24.69	17.58
EMCS	0.99	10	43.91	38.79

Note: A/B reflect different samples. Reading/Writing combined (R/W), Fingerspelling (FS), Receptive/Expressive Fingerspelling combined (RecExp FS), Receptive Manual Communication Skills (RCMS), Expressive Manual Communication Skills (EMCS)

Classical Test Theory Results

Results from Table 6 give an overview of internal consistency and the range of scores. No details were provided for individual items or subgroups. When items are used to form a scale, they need to have internal consistency. The items should measure the same thing, so they should be correlated.

With a spread of item difficulty, the goal was to determine the percentage of respondents who answer an item correctly. The items needed to discriminate between test-takers who know the material and those who do not. Finally, internal consistency reliability analyses were conducted to evaluate the degree to which the items are cohesive and measure similar characteristics. High values of these statistics suggested that the items responses are internally consistent within a domain.. A reliability analysis was conducted on the 10 different domains that were measured on the CSA. Cronbach's alpha was .75 or stronger for all domains. A normed reliability analysis on the subscale of Reading B revealed Cronbach's alpha of 0.76. The normed reliability analysis on the subscale of Writing A revealed Cronbach's alpha of 0.84. The normed reliability analysis on the remaining subscales of Reading A, Writing B, Reading/Writing, Receptive Fingerspelling, Expressive Fingerspelling, Receptive/Expressive Fingerspelling, Receptive Manual Communication Skills, and Expressive Manual Communication Skills revealed a Cronbach's alpha of .97, .97, .97, .96, .96, .96, .98, .99, respectively.

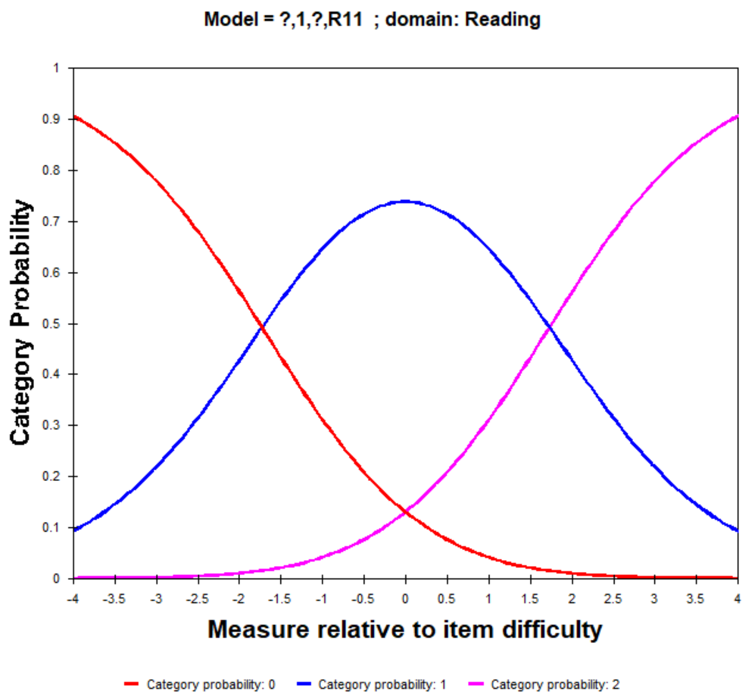
Item Response Rating Scale Preliminary Analysis

To check measurement properties before interpreting the data, it was useful to transform the ordinal responses into interval measures. In a preliminary analysis, the CSA responses generally adhered to the PC-MFR model requirements, with evidence of approximate unidimensionality (81.91% of the variance in ratings explained by Rasch measures) and overall acceptable mean square error (MSE) fit statistics for each facet. However, an examination of the rating scale structure revealed that many of the rating scale categories were not ordered as expected. For all domains except reading, at least one rating category was disordered. In the context of this assessment, category *ordering* means that higher categories in the CSA rating scales corresponded to higher levels of communication proficiency. Accordingly, category *disordering* means that for at least one pair of categories, higher categories did not correspond to higher levels of communication proficiency. This disordering is a problem because the estimates of examinee proficiency depend on a meaningful order of the rating scale categories.

Figure 1 illustrates the patterns observed with the original rating scales for the CSA. Each plot corresponds to one of the eight domains. The x-axis shows the logit scale, which is the linear continuum that represents communication proficiency, where lower values indicate lower levels of proficiency and higher values indicate higher levels of proficiency. The y-axis shows the conditional probability for a rating in a given category. Separate lines show the probabilities associated with each rating scale category. The intersection points between the curves show the location of the rating scale category thresholds (τ), which represent the point at which there is an equal probability for a rating in the pair of adjacent categories. The plot for the Reading domain (Plot A) shows expected rating scale category ordering because the first rating scale threshold (between category 0 and category 1) is located lower on the x-axis compared to the second threshold (between category 1 and category 2). In addition, each of the categories was the most probable for a distinct range of the logit scale; this means that the scale categories effectively identified examinees with different levels of communication proficiency in writing. However, for all of the other domains, the categories were not ordered as expected, and there was at least one category that did not have a distinct range on the logit scale.

Figure 1: Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model – Unrevised.

A



B

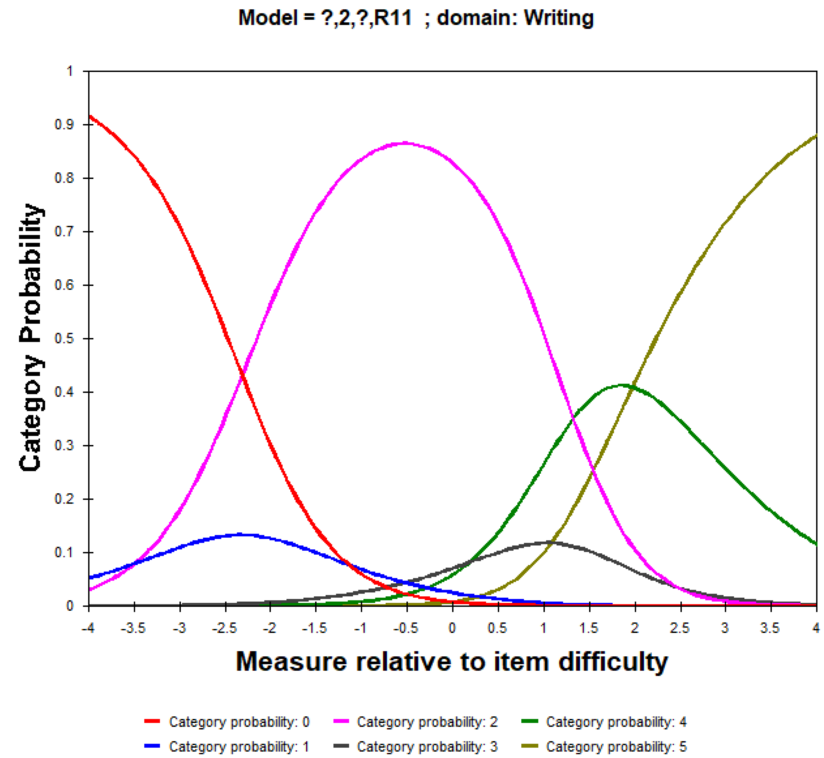
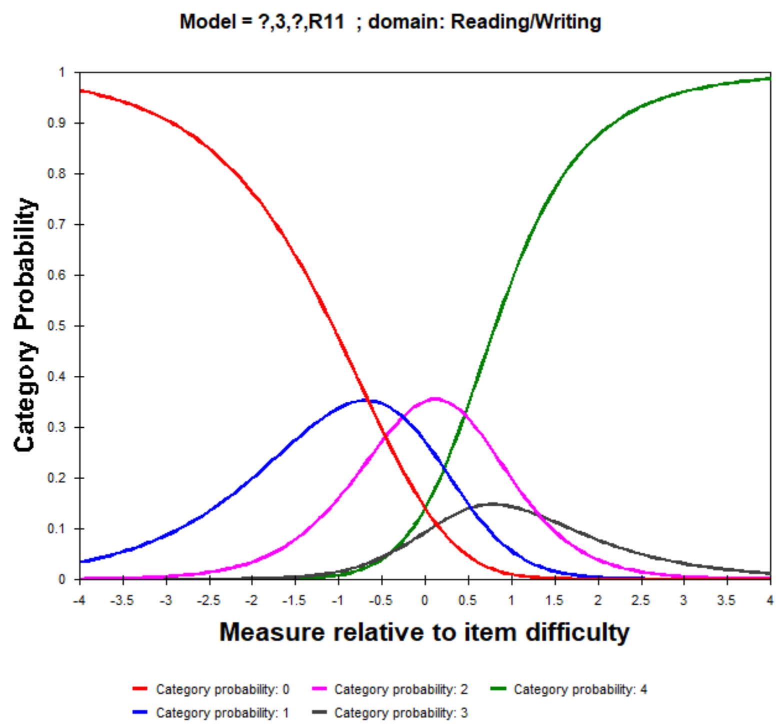


Figure 1: Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model – Unrevised - continued

C



D

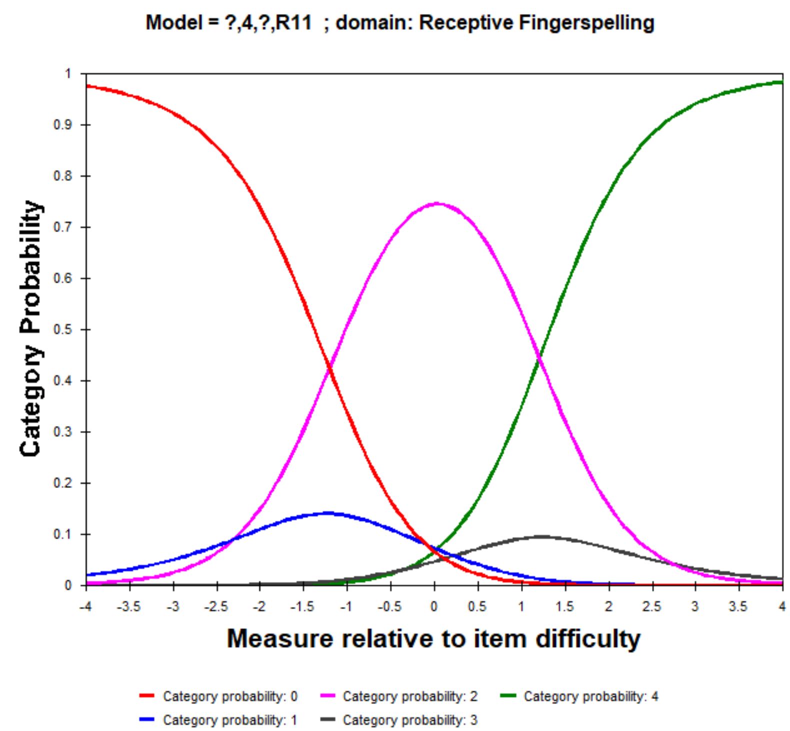
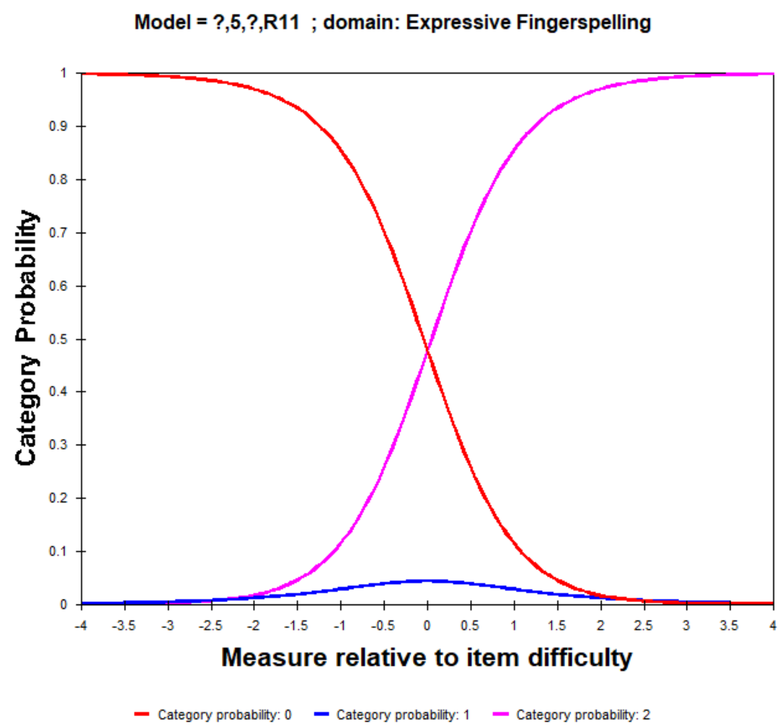


Figure 1: Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model – Unrevised – continued

E



F

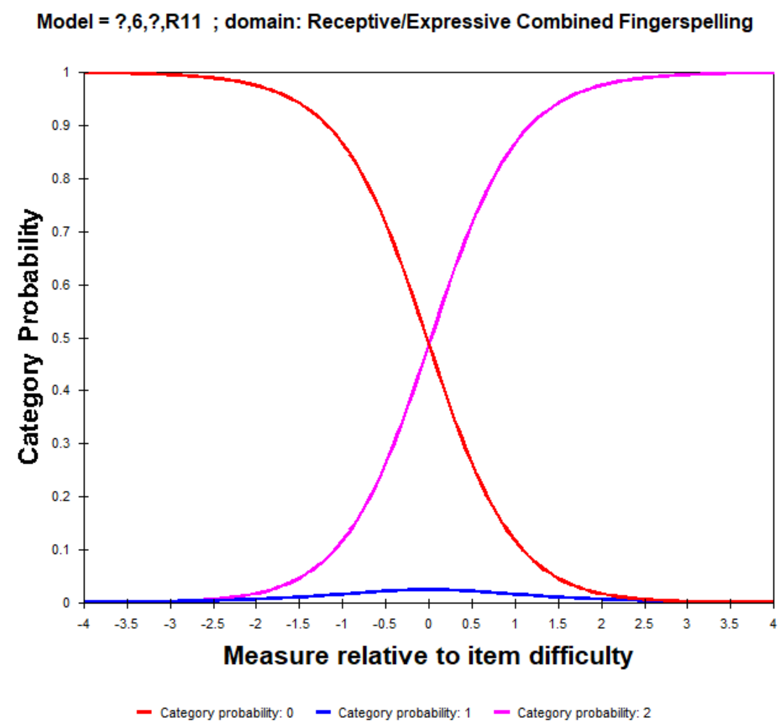
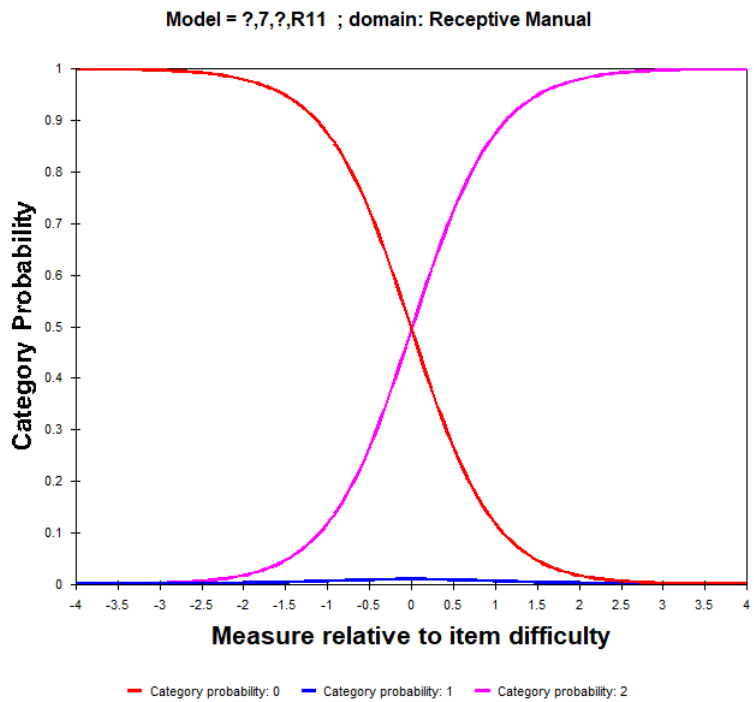
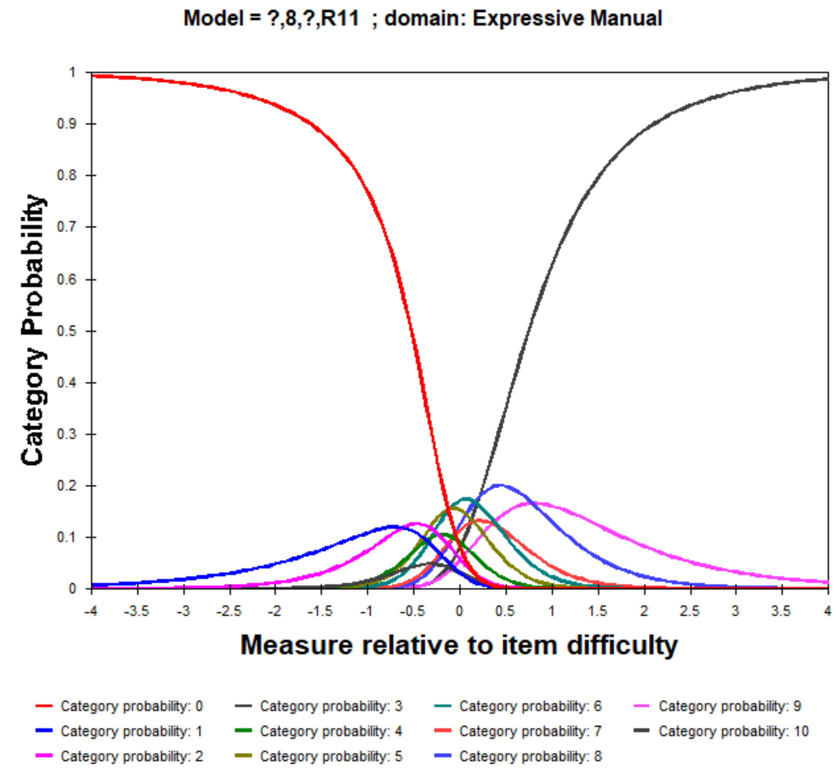


Figure 1: Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model – Unrevised - continued

G



H

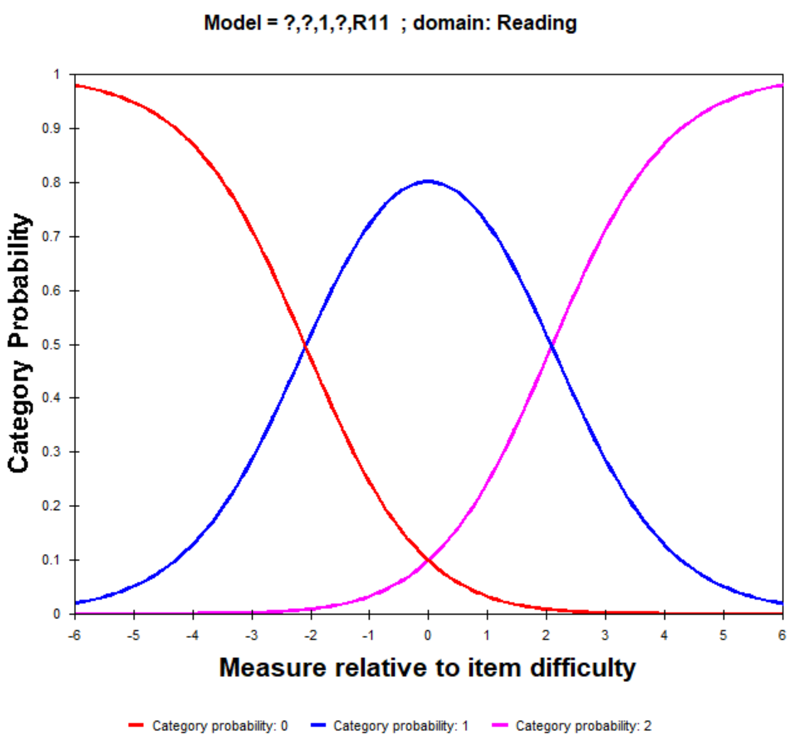


Item Response Rating Scale Revision – Secondary Analysis

Recognizing these issues, it was necessary to combine several rating scale categories in all of the domains except for Reading in order to obtain meaningful estimates from the Rasch model. Adjacent rating scale categories were combined using evidence from the scale category threshold locations until the results indicated ordered and distinct rating scale structures for all domains. The following adjustments were made. For Writing, the six-category scale (0, 1, 2, 3, 4, 5) was reduced to a three-category scale (0, 1, 2). For Reading/Writing and Receptive Fingerspelling, the five-category scale (0, 1, 2, 3, 4) was reduced to a four-category scale (0, 1, 2, 3). For Expressive Fingerspelling, Receptive/Expressive Combined Fingerspelling, and Receptive Manual, the three-category scale (0, 1, 2) was reduced to a two-category scale (0, 1). Finally, for Expressive Manual, the eleven-category scale (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11) was reduced to a four-category scale (0, 1, 2, 3). Figure 2 shows the revised scale category probabilities.

Figure 2: Revised Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model

A



B

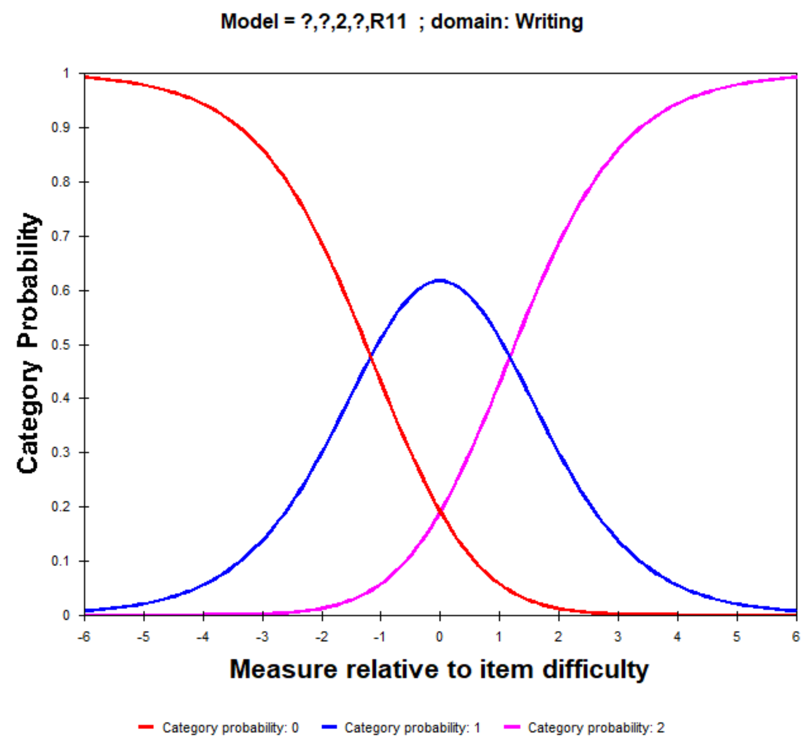
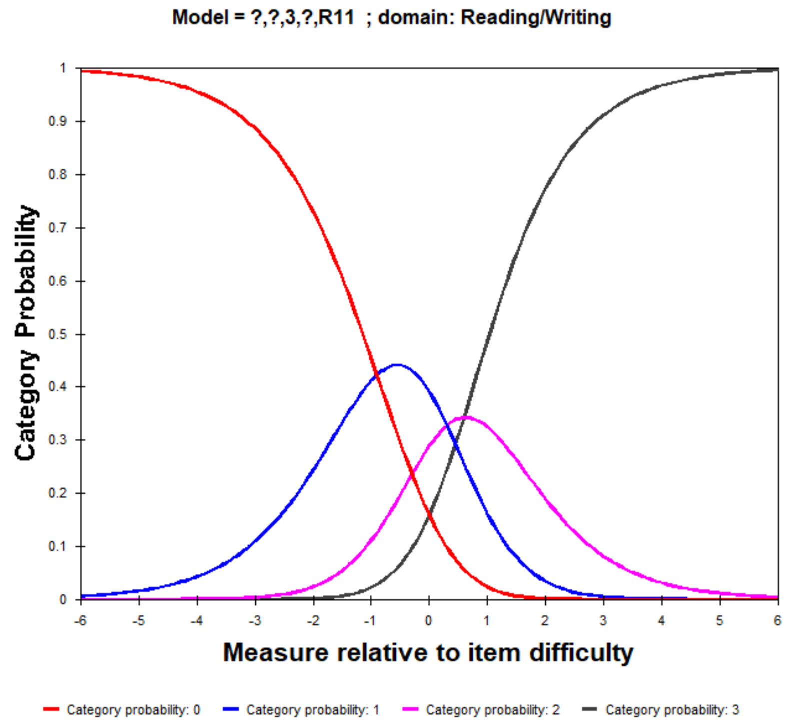


Figure 2: Revised Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model - continued

C



D

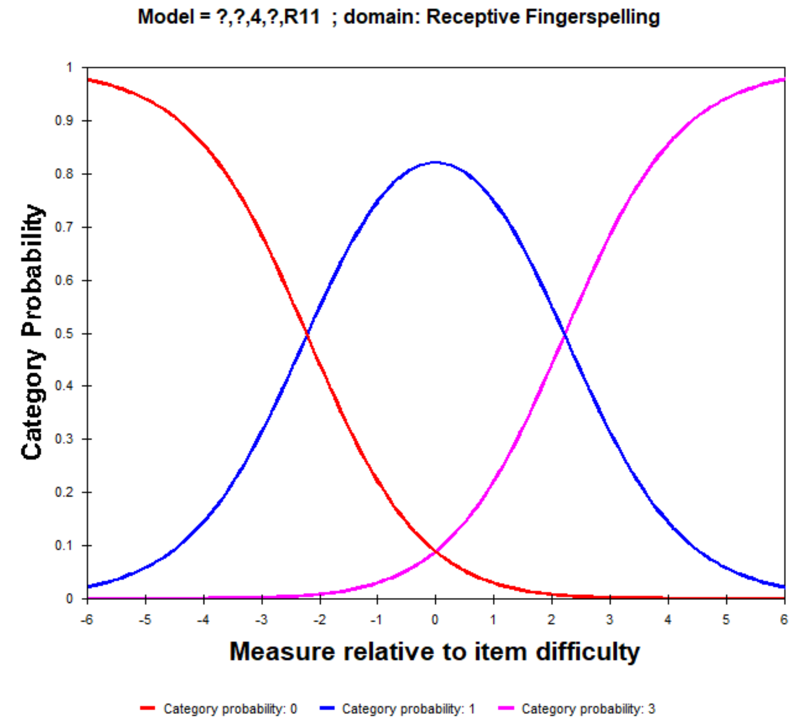
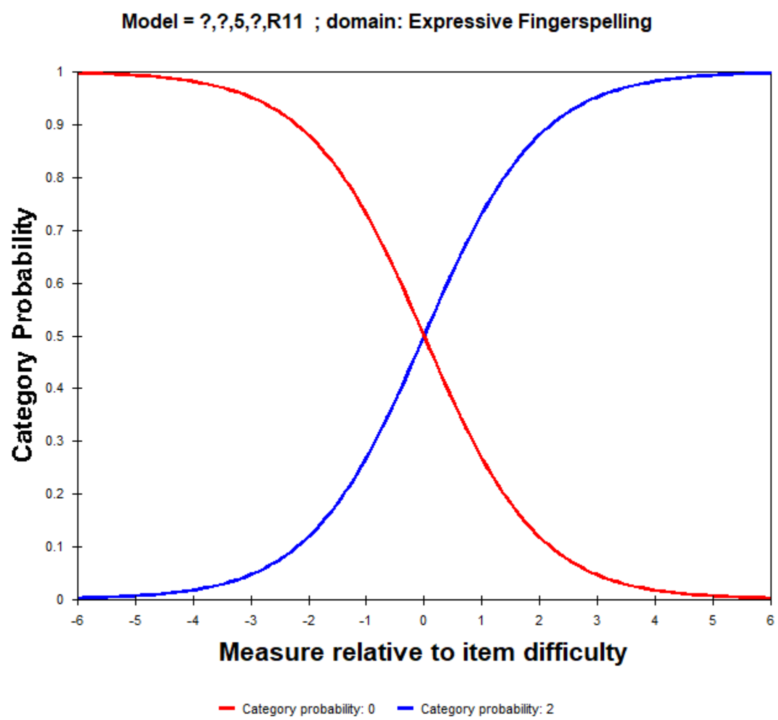


Figure 2: Revised Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model - continued

E



F

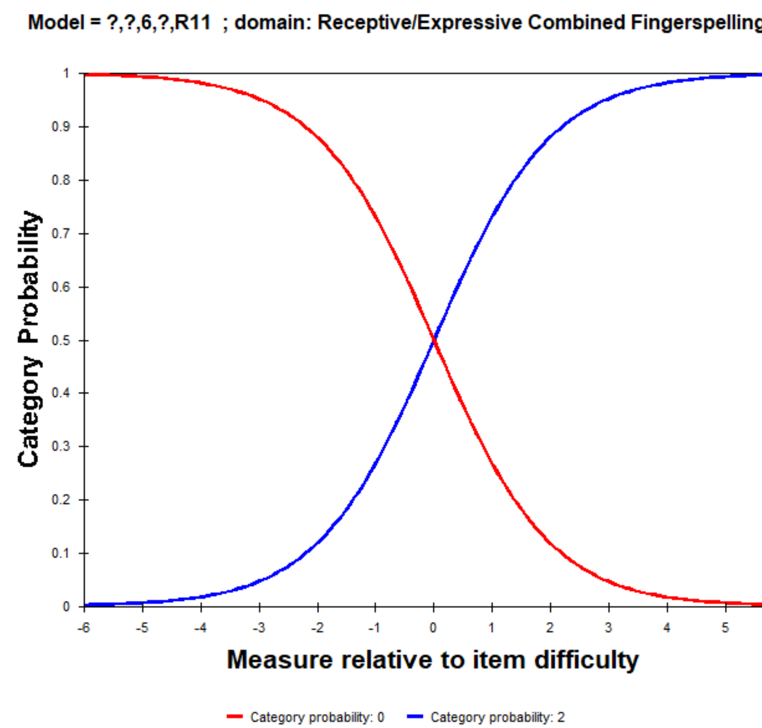
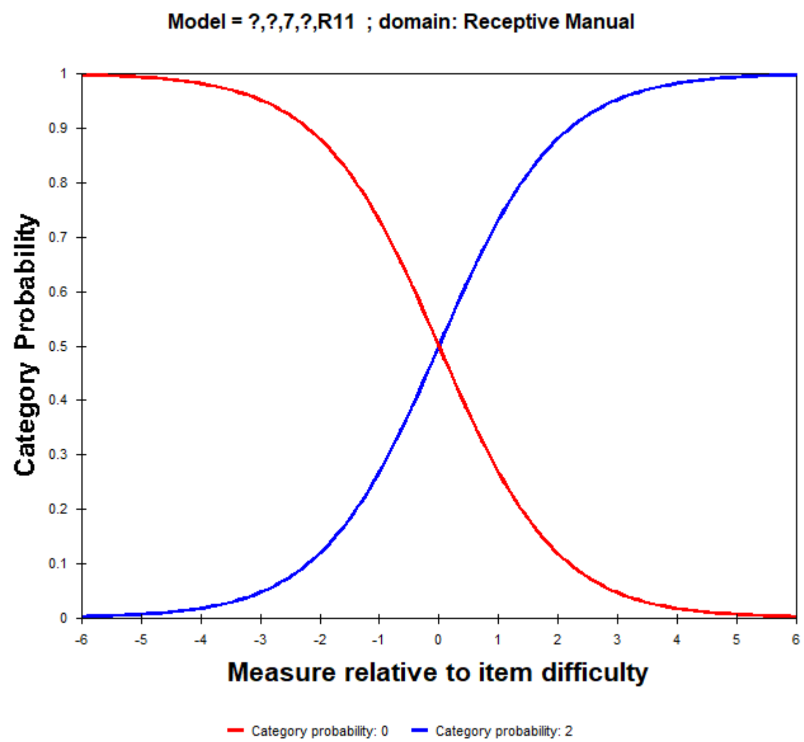
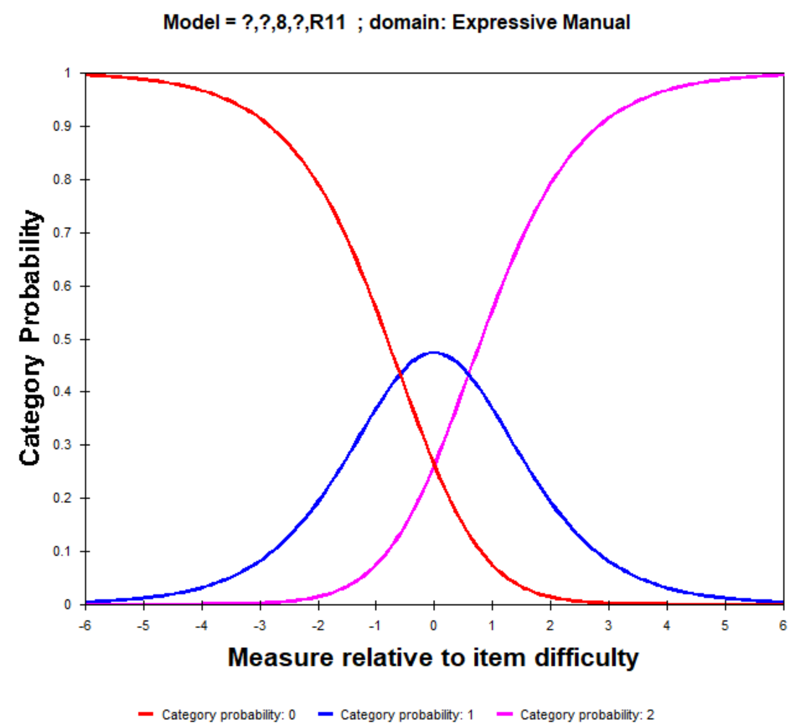


Figure 2: Revised Communication Rating Scale Category Probabilities – Partial Credit Formulation of the Many Facet Rasch Model - continued

E



F



Final Rasch Model Results

After the rating scales were revised, it was possible to interpret results (Table 7) from the analysis. Item level analysis using facet was conducted with participants, etiologies, and communication domains.

Table 7: Summary Result for each Facet

		Participant	**Etiology Group**	**Domain**	**Item**
Measure	*M*	-0.22	0.12	0.00	0.50
	SD	1.78	0.45	0.31	2.00
Standard Error	*M*	0.29	0.07	0.08	0.32
	SD	0.28	0.01	0.03	0.40
Infit MSE	*M*	1.02	1.03	0.97	0.98
	SD	0.41	0.22	0.31	0.42
Outfit MSE	*M*	0.94	0.90	0.92	0.94
	SD	0.46	0.27	0.32	0.46
Reliability of Separation		0.95	0.98	0.92	0.89

Overall, the participants were located lower on the logit scale compared to the domains and items. This indicates that the items were relatively difficult for the participants in this sample. In addition, the model-data fit statistics (infit and outfit MSE) indicated adequate overall fit to the model, with average values around 1.00 for all facets. However, the standard deviations for the fit statistics indicated some unexpected responses for individual participants, subgroups, domains, and items. Finally, the reliability of separation statistics were quite high for all of the facets, indicating that the elements within each facet had distinct locations on the logit scale.

Figure 3 is a variable map that shows the locations of each of the participants, etiology subgroups, domains, and items on the logit scale that represents communication proficiency. The left-most column is the logit scale on which all of the facets were calibrated. Next, participant locations are shown using asterisks. Then, the etiology subgroup locations are presented. For participants and domains, higher locations mean higher levels of communication proficiency.

The fourth column shows the domain locations on the logit scale, followed by item locations in column five, where an asterisk represents two items, and a period represents one item. For domains and items, higher locations indicate more difficult items and domains. The final columns show the calibrations of the rating scale categories for the domains with re-scaled rating scales that included three or more categories (Reading, Writing, Receptive Fingerspelling, and Expressive Manual). Horizontal lines show the location of the rating scale category thresholds.

Item fit to the Rasch model was evaluated with infit mean square statistics; value between 0.7 and 1.4 for individual items are optimal. Appendix B shows the item characteristics for the 78-item Rasch solution. By selection, only eighteen items (11, 13, 33, 34, 35, 36, 39, 44, 47, 52, 54, 56. 57, 58, 64, 75, 76, 77) had a mean square infit value below 0.7 and fourteen items (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 23, 24, 31, 32) had a mean square infit value above 1.4. Appendix C shows the domain characteristics for the six-item Rasch solution for etiologies. By selection, all etiologies fell within optimal range. Appendix C shows the characteristics for the eight -item Rasch solution for receptive/expressive domains. By selection, all domains fell within optimal range.

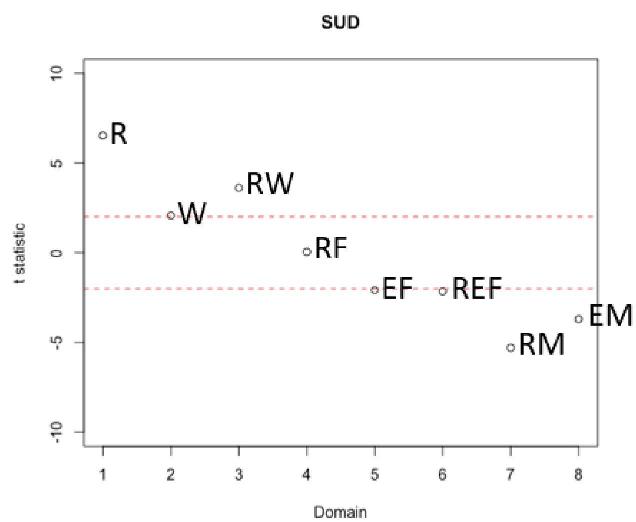
Differential Item Functioning Results

Results from the DIF analysis revealed a statistically significant omnibus test for the interaction between domains and etiology subgroups: $\chi^2(48) = 553.1$, $p < 0.001$. As a result, pairwise interaction terms were examined for each domain to examine whether the difficulty observed for a particular subgroup was different from the overall difficulty estimate.

Inspection of these statistics indicated significant differences for each etiology subgroup on at least one domain. The statistics are illustrated in Figures 3, 4, 5, 6, 7 and 8 where values greater than +2 were significantly harder for the specified subgroup than expected given the overall estimate for the domain and the locations of the persons within the subgroup, and values less than -2 were significantly easier for the specified subgroup than expected given the overall estimate for the domain and the locations of the persons within the subgroup.

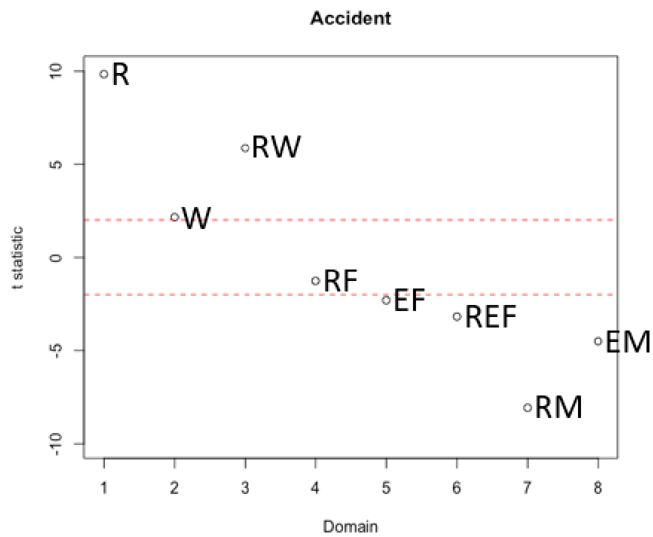
The SUD subgroup (Figure 3) and the Accident (Figure 4) subgroup exhibited similar patterns of differences in domain difficulty. For these two subgroups, the Reading, Writing, and Reading/Writing combined domains were significantly more difficult compared to the overall domain measure, and the expressive fingerspelling, receptive/expressive combined fingerspelling, receptive manual, and expressive manual domains were significantly easier compared to their overall measures.

Figure 3: DIF Analysis – Etiological Considerations – Substance Use



Note L to R: Reading (R), Writing (W), Reading/Writing (RW), Receptive Fingerspelling (RF), Expressive Fingerspelling (EF), Receptive/Expressive Combined Fingerspelling (REF), Receptive Manual (RM), then Expressive Manual (EM).

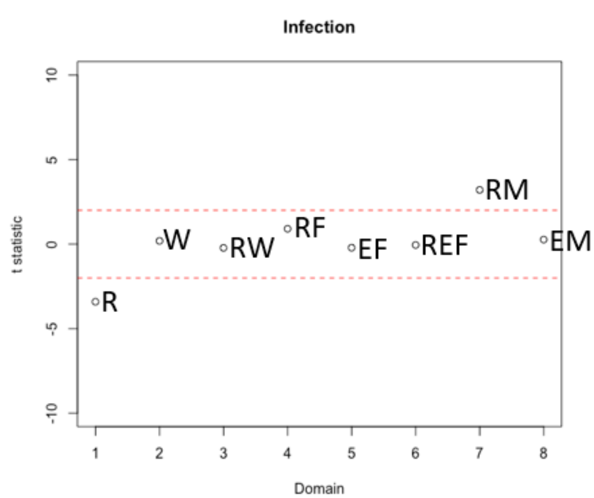
Figure 4: DIF Analysis – Etiological Considerations – Accident



Note L to R: Reading (R), Writing (W), Reading/Writing (RW), Receptive Fingerspelling (RF), Expressive Fingerspelling (EF), Receptive/Expressive Combined Fingerspelling (REF), Receptive Manual (RM), then Expressive Manual (EM).

For the Infection (figure 5) subgroup, the Reading domain was significantly easier than expected, and the receptive manual domain was significantly harder than expected.

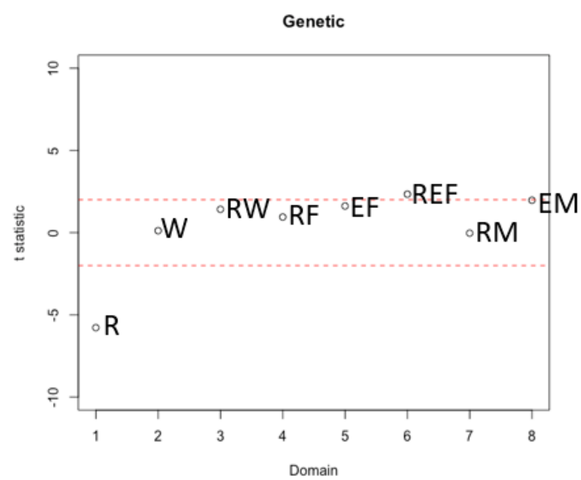
Figure 5: DIF Analysis – Etiological Considerations – Infection



Note L to R: Reading (R), Writing (W), Reading/Writing (RW), Receptive Fingerspelling (RF), Expressive Fingerspelling (EF), Receptive/Expressive Combined Fingerspelling (REF), Receptive Manual (RM), then Expressive Manual (EM).

For the Genetic (Figure 6) subgroup, the Reading domain was significantly easier than expected, and the receptive/expressive combined fingerspelling domain was significantly harder than expected.

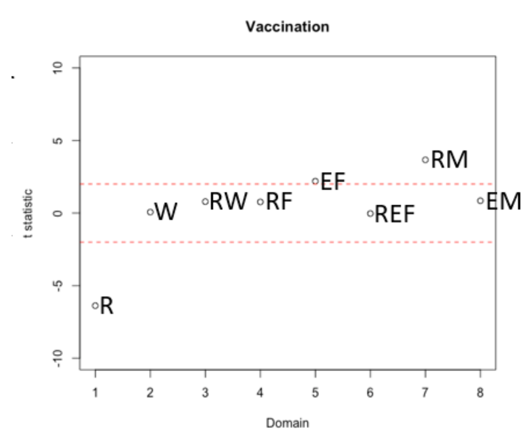
Figure 6: DIF Analysis – Etiological Considerations –Genetic



Note L to R: Reading (R), Writing (W), Reading/Writing (RW), Receptive Fingerspelling (RF), Expressive Fingerspelling (EF), Receptive/Expressive Combined Fingerspelling (REF), Receptive Manual (RM), then Expressive Manual (EM).

For the Vaccination (Figure 7) subgroup, the Reading domain was significantly easier than expected, and the expressive fingerspelling, and receptive manual domain was significantly harder than expected.

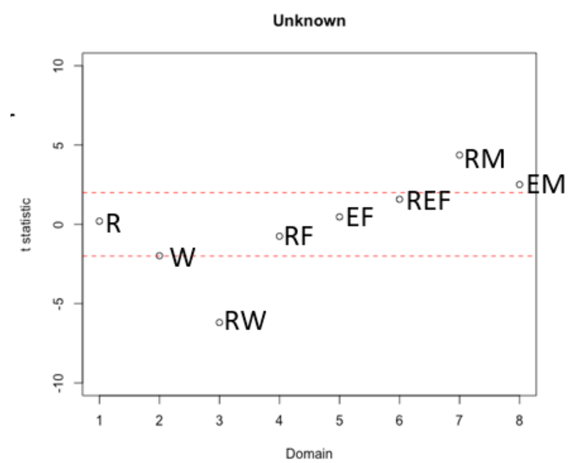
Figure 7: DIF Analysis – Etiological Considerations –Vaccination



Note L to R: Reading (R), Writing (W), Reading/Writing (RW), Receptive Fingerspelling (RF), Expressive Fingerspelling (EF), Receptive/Expressive Combined Fingerspelling (REF), Receptive Manual (RM), then Expressive Manual (EM).

For the Unknown etiology (Figure 8) subgroup, the reading/writing domain combined domain was significantly easier than expected, and the Receptive Manual and Expressive manual domains were significantly harder than expected.

Figure 8: DIF Analysis – Etiological Considerations –Unknown



Note L to R: Reading (R), Writing (W), Reading/Writing (RW), Receptive Fingerspelling (RF), Expressive Fingerspelling (EF), Receptive/Expressive Combined Fingerspelling (REF), Receptive Manual (RM), then Expressive Manual (EM).

Summary

In measuring those etiologies, the DIF analysis revealed statistically significant interactions between domains and etiology subgroups. The specific patterns of differences varied by domain and etiology. In the reading domain, the rating scale categories were ordered as expected. Scale categories in 11 other domains were not ordered as expected given that they did not have a distinct rating on logit scale. It became necessary to combine several rating scales in all domains except reading in order to obtain meaningful estimates from the Rasch Model. Writing was reduced from a six-category scale to a three-category scale. Reading/Writing and Receptive Fingerspelling five category scale was reduced to a four-category scale. Expressive

Fingerspelling, Receptive/Expressive Combined Fingerspelling, and Receptive Manual three category scale was reduced to two-category scale. Finally, Expressive Manual's eleven category scale was reduced to a four-category scale to show revised scale probabilities. With the revision, it was possible to interpret results (Table 7) for analysis

In both types of analyses (CTT and IRT), the psychometric properties of the CSA overall and within subgroups of test-takers who have different etiologies of deafness were examined. When considering the continuum that represents communication proficiency intersecting with the probability for rating in any given category, items were relatively difficult for participants in this sample. Model-data fit (Infit/Outfit) indicated adequate overall fit to model with average values around 1.00 for all facets. Standard deviation indicated some unexpected responses from individual participants, subgroups, domains, and items. Reliability of separation statistics were quite high for all facets indicating elements within each facet had distinct locations on logit scale.

Given that there was not enough of a sample size to examine psychometric properties within single etiologies, some of the etiologies had to be combined into various categories to create a pairwise interaction within the communication domain. A total of six categories were established based on the potential with expressive or receptive skills. The first category involved individuals who acquired hearing loss through neo-natal exposure of substance use. This involved cocaine, fetal alcohol syndrome, maternal drug use, and ototoxicity. The second category involved those who were born hearing, acquired language, and then lost their ability to hear through some type of design to which is attributed as an accidental exposure later in life. This included physical abuse, accidents, fluid in their ears, gunshot caused hearing loss, occupational exposure, and two physical conditions with stroke and tumor. The third category stemmed from various episodic infections that may contribute to hearing loss. This involved flu, ear infections, virus, fever, and illness from the mother during in utero. The fourth category indicates some type of genetic anomaly that creates hearing loss. This included hereditary, Waardenburg syndrome, and undeveloped cilia. The fifth category is vaccination to which various viruses have been detected and may have vaccinations or medical intervention available now to reduce the risk of hearing loss. This included cytomegalovirus, measles, mumps, rubella, and spinal meningitis. Of note, hypoxia was included in the vaccination category due to suspected similar psychomotor receptive/expressive skills in language (Cainelli, et al., 2018). Finally, the sixth category is all the remaining individuals who are determined to have an unknown etiology of hearing loss. This final category allowed for a variable to be measured against those with determined etiologies.

Chapter 5

DISCUSSION

The purpose of this research was to examine the Communication Skills Assessment (CSA) to determine the psychometric properties related to reliability, validity, and fairness. The guiding research question posed was this: To what extent does the CSA reveal differences in functional communication among individuals who were assessed?

The following questions were created for the purpose of this research.

1. What are the psychometric properties of the Communication Skills Assessment (CSA) related to reliability, validity, and fairness?
2. To what extent are there differences in the difficulty of the domains included in the CSA?
3. To what extent does the CSA reveal differences in functional communication among individuals with different etiologies of deafness?
4. Are there certain etiologies for which individuals demonstrate strength and/or weaknesses in receptive and/or expressive skills?

This chapter aims to discuss the findings presented in Chapter Four and to discuss the implications as well as limitations of the findings, and what implications they may have on future research or current assessment for the deaf and hard of hearing population.

Creating accessible measures include consideration of sign language versions of assessments. A quality translation through a word for word conversion of a test item invites construct irrelevant variance when conceptual and cultural translation are not taken into consideration. Careful consideration to implement translation of visual materials, use of items in an effective communication medium, layout, and data collection to measure translation and delivery (Henner et al., 2017) were developed by Williams and Crump (2018) in order to implement the CSA.

William and Crump's framework (2019) emphasized several domains to measure communication to optimize a formal learning experience. This was not a test of achievement with a ladder for basal, baseline, or ceiling. Nor was it a test of cognition with a bell curve to measure where intelligence is. This research was focused on the measurement of the psychometric properties for a communication assessment to assess an individual's proficiency across communication modalities from what was collected within the state of Alabama to provide comparison across communication spectrum to determine strength in communication modality.

Psychometric Findings

In predicting the outcome by better understanding and improving the reliability of CSA, results from Table 6 give an overview of internal consistency and the range of scores using Classical Test Theory. In checking measurement properties before interpreting the data, ordinal result responses had to be transformed into interval measures. No details were provided for individual items. Reliability analysis conducted across 10 domains measured on the CSA suggest internal consistency. No details were provided for individual items or subgroups.

When considering the CSA from a psychometric perspective using Item Response Theory, the rating scale did not order as expected. For all domains except reading, at least one rating scale category was disordered. As a result, it became necessary to combine these categories by creating adjacent rating scale categories. The threshold location was reached when the following adjustments were made. For Writing, the six-category scale (0, 1, 2, 3, 4, 5) was reduced to a three-category scale (0, 1, 2). For Reading/Writing and Receptive Fingerspelling, the five-category scale (0, 1, 2, 3, 4) was reduced to a four-category scale (0, 1, 2, 3). For Expressive Fingerspelling Receptive/Expressive Combined Fingerspelling, and Receptive Manual, the three-category scale (0, 1, 2) was reduced to a two-category scale (0, 1). Finally, for Expressive Manual, the eleven-category scale (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11) was reduced to a four-category scale (0, 1, 2, 3). When considering scale length, wider scales may have greater variance, therefore smaller scales may offer one possible explanation for more effective rating scale results. It may be useful to consider eliminating items or considering factor analysis when adding items to a scale. Another possible reason for this recoding is that the sample came from the Department of Mental Health to which reliability could become questionable when diagnosable mental illness and language intersects (Black & Glickman, 2006).

In the preliminary analysis, an examination of rating scale structure revealed that the Expressive Manual domain had very few observations in several rating scale categories. Within this domain, the average estimated proficiency among those participants who received a rating of 1 was higher (M = -0.70) than the average estimated proficiency for participants who received a rating of 2 (M = -1.01) for items in this domain. Given the ordinal nature of the scale, the average proficiency estimates should be non-decreasing as scale categories increase. These results suggest that rater interpretation of this 11-category scale did not accurately assess the intended order. After consulting with the co-authors of the CSA (2019), they intend to conduct several controlled studies of measuring several different constructs within expressive language, using the domains of sign production, fluency, ability to express complete thought, providing details, following main topic, using ASL classifiers appropriately, use of space/movement, incorporation of time/numbers, ASL grammar, and facial expressions consistent with the topic. At the time of this writing, the authors have conducted some inhouse study with their current trained raters to further drill down their rubric based on recommendations from this paragraph.

Implementing a Language Plan for D/HH Individuals

It is important for school professionals to parse out developmental aspects from language complications when considering hearing loss. Recognizing the dilemma with all these confounding factors are exactly the reason why it is critical to have direct service professionals who are well vested in the field of deafness as linguistic experts to rule out special factors. Due to the paucity of these direct service professionals, it is critical to consider specialized training for working professionals in the human service field then sign language interpreters. Because the primary diagnostic means for special education is communication, it is imperative that the educational team consider variations in receptive/expressive skills. Without the ability to recognize potential communication difficulties, schools are doing a disservice for our students with hearing loss. It is recommended to identify a student's receptive/expressive skills. Matching their language may not be the best technique when it comes to accommodations.

There is a need for a communication plan for each participant with hearing loss (Crump & Hamerdinger, 2017; Crump & Williams, 2019; Lukomski, 2008). In order to do this, a communication assessment for each participant with hearing loss is needed. Crump and Hamerdinger (2017) were able to identify how multiple influences stemming from the causes of hearing loss may cause language differential during real time interaction. This type of communication assessment may be extremely beneficial to identify effective communication in order to become proactive prior to information exchange.

The results indicate there is a need to look at an underlying possibility of etiology interference within the transmission of language. Some patterns of language exist in conjunction with specific etiologies. Cognitive resources are required to acquire language. Dysfunction in a cognitive system increases risk for maladjustment. Deaf children have been found to have greater rates of neurocognitive deficits that impacts functional language development (Landsbarger et al, 2014). It is unclear if this is a result of etiology or a result of being deprived of language. Diversity in congenital or early onset of deafness often leads to diversity in developmental outcomes. Data from this study provides some understanding of how communication patterns may manifest from various etiologies.

Directions for Future Research

As currently designed, the CSA (2019) does not measure fluency or skill but rather provide comparison across the communication spectrum to determine an individual's communication modality with strongest proficiency. The current sample came through the Alabama Department of Mental Health. Data were controlled through the inclusion of all domains from the CSA. This does not necessarily represent the deaf and hard of hearing community at large. The assessment itself was a static one-time probe of an individual. Language may undergo significant changes and a future assessment of the same individual may produce different results given learning outcomes, trauma, or physical manifestations.

CSA (2019) is designed to be rated by subjective assessors with one individual who is deaf and one individual who is hearing. Even as a team with expertise in two different communication modalities rating communication skills, there was some difficulty in establishing reliability. Bochner et al. (2016) reported only one known interrater reliability study using sign language conducted by Caccamise & Samar (2009). Henner et al. (2018) indicate that reliability measures can be conducted with receptive skills in sign language. Whereas measuring an expressive language is problematic due to rater effect. The CSA (2019) considered that difficulty and developed a rubric for evaluators to score accordingly. Considering the expressive language component results initially proved problematic for this research. The concern was reviewed (C. Crump, personal communication, October 27, 2020) with the co-author. Results of this study provided the opportunity for the CSA authors to consider the need for additional training in specific categories based off this preliminary analysis of the CSA. At the time of this writing, the authors are conducting small controlled samples of various elements within expressive sign language to drill down some future training opportunities. Given the significant heterogeneity of the D/HH population, the co-authors may wish to pursue strengthening the psychometric measures in their appendix by creating a norming sample and increasing their representative sample within the etiology subgroups for future research.

The goal was to see if establishing psychometric properties for an Alabama required Communication Skills Assessment would create additional resources for evaluating communication for deaf and/or hard of hearing students. Review of the data indicates that in order to evaluate younger students, more research is needed. From this current sample, the CSA evaluated one ten-year-old, three 12-year-old, and 11 high school age students. Given the representative sample, evaluating anyone under the age of 14 years may prove problematic. Future research may want to consider attempting further development and refinement of the CSA instrument if there is intent to continue assessing younger students (Carrigan & Copolla, 2020).

When looking at the data presented in chapter four, etiology emerged as an interesting unknown that deserved further exploration. Etiology may indicate attendant problems with acquiring and processing language, quite apart from the deafness itself (Crump & Hamerdinger, 2017). Certain etiologies may affect expressive or receptive skills for the development of language (Williams & Crump, 2018). Learning new material or producing measurable outcomes may require additional adjustments. Understanding the difference in language development invites recognizing the need for organization and integration of language sequencing skills to access education (Marschark et al, 2008). In considering the results from a psychometrically sound communication assessment, certain communication modalities were stronger or weaker in processing language. It may be useful for support service personnel to consider reviewing future CSA's to determine effective communication akin to planning treatment around an individual's strongest form of communication (Lukomski, 2008; Siegel, 2002).

For future research to consider evaluating communication assessments, there is a need to consider language deprivation as a neurodevelopmental risk (Hall et al., 2017). Results from the CSA indicate that there is a possibility that certain etiologies contribute to a biological deficit framework. If so, this invites further research to consider the differences between language deprivation and neurodevelopment risk. Etiology results and mental illness (Black & Glickman, 2006) appear to prompt some further examination given some biological mechanism alteration in expressive and/or receptive language skills.

Conclusion

The study set out to see if the Communication Skills Assessment (CSA) tested what it intended to test and what impact the CSA has on future assessments. Although not a definitive answer, the findings suggest a step in the right direction that there is promise with the CSA. Reliability of separation statistics were quite high for all facets, indicating elements within each facet had distinct locations on the logit scale (Appendix A). The CSA demonstrates reliability but still invite the question of predictive validity. Due to the heterogenous nature of this sample with mental illness and communication patterns, validity is harder to assess. If future research becomes available from other states, convergent and concurrent validity would be worth exploring when comparing to the current psychometric results in this dissertation. Based on findings, the CSA demonstrates fairness in their assessment through internal review from six test raters. In addition, fairness also means that participants understand what is expected of them on the assessment. To this end, 99 individuals were able to complete the assessment which demonstrates some instructional reliability in equitable treatment in the testing process. Further research may want to examine demographic variables for both testee and the tester.

This researcher recommends this CSA for students age fourteen and older to assess communication modalities. Given that Long & Alvares (1995) were the source of inspiration in developing the CSA (Williams & Crump, 2019), Long & Alvares had the idea of matching vocational aptitude and communication preferences in order to create sustainable employment for D/HH individuals, this ties in rather well when we consider how vocational rehabilitation staff are invited to the D/HH's student Individual Education Plan at the age of fourteen. When evaluators are aware of the base theoretical orientation implications, the CSA can then work towards becoming balanced, informed, and effective in evaluating the participant's proficient communication skill.

The CSA is not designed as an intervention. Diversity in assessment brings value when critically looking at how standardized approaches continue to explore evaluating effective communication within the field of deafness. In terms of evaluating tools to assess language for those who are deaf, it may be helpful and relevant is doing some criterion-related validity evaluation of the tool. Essentially, do results on the test correlate with other outcomes that we think it should relate to? Do people who do better on the language measure have better academic or employment outcomes, adaptive functioning, or do better on a nonverbal cognitive assessment?

Methodological issues continue to confound researchers as they explore the context of language research with deaf people (Henner et al., 2017). In this study, reading and writing results from the CSA appeared harder for individuals who acquired hearing loss through infection, genetics, or vaccination. Given the results, this researcher wonders how much fine motor skills may be impacted by certain etiologies (Crump & Hamerdinger, 2017).

Processing manual receptive sign communication skills were stronger for infection, vaccination, and the unknown. The results may provide some additional insight towards cross-modal recruitment of the brain (Mayberry, et al., 2011; Neville, et al., 1998) given the difference in receptive and expressive language skills in certain etiologies. It is possible that the occipital lobe (receptive) may be recruited to pick up the cognitive slack since the temporal lobe is unable to access sound, thus becoming stronger in perceiving information (Penicaud et al., 2013).

In this research, post-lingual causes were more likely to have difficulty capturing visual motion in receptive language. The distinction for post-lingual deafness (accident), the development and acquisition of spoken language may differ due to an earlier exposure to an auditory experience with a later start of exposure to an expressive visual language. One area that may be worth exploring further is the difference in reading and sign language. Print may be frozen/grounded whereas sign language has a 3-D construct of a language that is not frozen, spoken, or easy to locate through later developed expressive skills (Bosworth et al., 2019). It may require some more mental translation and this translation still cannot be done by the quantum supremacy of google at the time of writing.

Future research should consider building tools to consider the conditions imposed by the long-term impact of language deprivation (Hall, 2017), consider the implication of acculturative stress within language (Aldalur, 2020), explore fatigue levels from a concentration or perceptual load standpoint (Lavie, et al., 2009), examine personal biases of the examiner or the examinee or the perceived priority within communication strategies for either the test assessor or the participant, or explore the impact of rater effects on assessment results (Wind, 2018).

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Appendix A

Figure 9: Communication Proficiency Variable Map

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+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
|Logit|+Examinee|+Etiology Subgroup        |-Domain                                                                                      |-Item    | S.1 | S.2 | S.3 | S.4 | S.8 |
|-----+---------+--------------------------+---------------------------------------------------------------------------------------------+---------+-----+-----+-----+-----+-----|
|   3 + *       +                          +                                                                                             + **.     + (2) + (2) + (3) + (3) + (2) |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|     | *       |                          |                                                                                             |         |     |     |     | --- |     |
|     |         |                          |                                                                                             |         | --- |     |     |     |     |
|   2 +         +                          +                                                                                             +         +     +     +     +     +     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     | ****    |                          |                                                                                             | .       |     |     |     |     |     |
|     | *       |                          |                                                                                             | .       |     |     |     |     |     |
|     | *****   |                          |                                                                                             | **      |     | --- | --- |     |     |
|     | **      |                          |                                                                                             | *       |     |     |     |     |     |
|     | ****    |                          |                                                                                             | .       |     |     |     |     |     |
|   1 + ******  +                          +                                                                                             +         +     +     +     +     + --- |
|     | ****    |                          |                                                                                             |         |     |     |     |     |     |
|     | *****   |                          | Receptive Fingerspelling                                                                    | .       |     |     |     |     |     |
|     | *****   | Genetic      Infection   |                                                                                             | *       |     |     |  2  |     |     |
|     | ****    | Vaccination              |                                                                                             | **.     |     |     |     |     |     |
|     | ****    |                          |                                                                                             | .       |     |     |     |     |     |
|     | ******  |                          | Reading                                        Writing                                      | ****.   |     |     |     |     |     |
*   0 * **      * Unknown                  * Expressive Manual                              Receptive/Expressive Combined Fingerspelling * **.     *  1  *  1  * --- *  1  *  1  *
|     | **      |                          | Expressive Fingerspelling                                                                   | ****    |     |     |     |     |     |
|     | ***     | SUD                      | Receptive Manual                                                                            | ****    |     |     |     |     |     |
|     | ***     |                          | Reading/Writing                                                                             | *****.  |     |     |     |     |     |
|     | ***     | Accident                 |                                                                                             | *****   |     |     |  1  |     |     |
|     | *       |                          |                                                                                             | .       |     |     |     |     |     |
|     | **      |                          |                                                                                             | *       |     |     |     |     |     |
|  -1 + *       +                          +                                                                                             +         +     +     +     +     + --- |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|     | ****    |                          |                                                                                             |         |     |     |     |     |     |
|     | *       |                          |                                                                                             |         |     | --- | --- |     |     |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|     | ***     |                          |                                                                                             | .       |     |     |     |     |     |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|  -2 + *****   +                          +                                                                                             +         +     +     +     +     +     |
|     | *       |                          |                                                                                             |         | --- |     |     |     |     |
|     | *       |                          |                                                                                             |         |     |     |     | --- |     |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|  -3 +         +                          +                                                                                             +         +     +     +     +     +     |
|     | *       |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|     |         |                          |                                                                                             |         |     |     |     |     |     |
|  -4 + ***     +                          +                                                                                             +         + (0) + (0) + (0) + (0) + (0) |
|-----+---------+--------------------------+---------------------------------------------------------------------------------------------+---------+-----+-----+-----+-----+-----|
|Logit| * = 1   |+Etiology Subgroup        |-Domain                                                                                      | * = 2   | S.1 | S.2 | S.3 | S.4 | S.8 |
+----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
```

Appendix B

Table 8: Infit - Communication Skills – Item Version Rating Scale Statistics in “CSA” Order

Item	Obs.Avge	Measure[a]	S.E.	InfitM[b]	OutfitMS
1	1.11	-0.59	0.21	1.63	1.67
2	1.12	-0.64	0.22	1.64	1.7
3	1.11	-0.59	0.21	1.69	1.74
4	1.08	-0.5	0.21	1.72	1.79
5	0.88	0.38	0.22	1.92	1.91
6	1.02	-0.22	0.22	1.57	1.62
7	1	-0.13	0.22	1.59	1.63
8	1.05	-0.36	0.22	1.63	1.68
9	1.08	-0.5	0.21	1.52	1.56
10	1.12	-0.64	0.22	1.56	1.6
11	0.83	0.62	0.22	0.48	0.45
12	0.65	1.46	0.22	1.05	1.05
13	0.8	0.77	0.22	0.64	0.66
14	0.65	1.46	0.22	1.21	1.31
15	0.67	1.36	0.22	0.92	1.01
16	0	7.75	1.84	1	1
17	0	7.75	1.84	1	1
18	0	7.75	1.84	1	1
19	0	7.75	1.84	1	1
20	0	7.75	1.84	1	1
21	0.49	1.67	0.2	1.1	1.05
22	0.53	1.55	0.2	1.17	1.11
23	2.09	-0.71	0.15	1.55	1.45
24	2.04	-0.59	0.15	1.79	1.88
25	2	-0.5	0.15	1.34	1.12
26	1.92	-0.32	0.15	1.52	1.32
27	2	-0.5	0.15	1.15	1.13
28	1.97	-0.43	0.15	1.38	1.11
29	1.96	-0.41	0.15	1.19	1.07
30	1.99	-0.47	0.15	1.14	1.06
31	1.55	0.4	0.14	2.5	2.55

Item	Obs.Avge	Measure[a]	S.E.	InfitM[b]	OutfitMS
32	1.66	-1.78	0.22	1.68	1.77
33	0.58	1.32	0.23	0.58	0.53
34	0.6	1.21	0.23	0.51	0.48
35	0.58	1.32	0.23	0.66	0.64
36	0.57	1.37	0.23	0.46	0.41
37	1.12	-0.2	0.25	0.72	0.63
38	0.99	0.17	0.25	0.78	0.69
39	1.18	-0.4	0.26	0.67	0.56
40	1.03	0.05	0.25	0.74	0.64
41	1.01	0.11	0.25	0.7	0.6
42	1.2	-0.56	0.26	0.71	0.59
43	1.05	-0.11	0.25	0.77	0.71
44	1.05	-0.11	0.25	0.62	0.54
45	0.97	0.14	0.25	0.72	0.62
46	0.86	0.45	0.25	0.75	0.68
47	1.03	-0.04	0.25	0.57	0.5
48	0.84	0.51	0.25	0.75	0.61
49	1.41	-0.92	0.28	0.99	0.71
50	1.39	-0.84	0.27	0.92	0.67
51	1.14	-0.01	0.25	0.76	0.67
52	1.12	0.05	0.25	0.66	0.56
53	1.18	-0.14	0.26	0.83	0.79
54	1.09	0.12	0.25	0.67	0.57
55	1.24	-0.34	0.26	0.88	0.78
56	1.26	-0.41	0.26	0.68	0.52
57	1.22	-0.27	0.26	0.64	0.49
58	1.18	-0.14	0.26	0.57	0.45
59	1.31	-0.55	0.27	0.82	0.61
60	1.22	-0.27	0.26	0.81	0.77
61	1.24	-0.34	0.26	0.8	0.64
62	1.31	-0.55	0.27	0.8	0.59
63	1.22	-0.27	0.26	0.75	0.7
64	1.01	0.37	0.25	0.64	0.57
65	1.28	-0.48	0.26	0.85	0.65
66	1.26	-0.41	0.26	0.71	0.55

Item	Obs.Avge	Measure[a]	S.E.	InfitM[b]	OutfitMS
67	1.28	-0.48	0.26	0.75	0.56
68	1.2	-0.21	0.26	0.73	0.58
69	1.08	-0.26	0.18	0.87	0.88
70	1.02	-0.07	0.18	0.83	0.91
71	0.97	0.08	0.17	0.76	0.9
72	0.93	0.2	0.17	0.74	0.96
73	1.01	-0.04	0.18	0.76	0.85
74	0.93	0.2	0.17	0.74	0.72
75	0.96	0.11	0.17	0.68	0.69
76	0.88	0.32	0.17	0.69	0.68
77	0.85	0.42	0.17	0.66	0.91
78	0.97	0.08	0.17	0.83	1.01

Note. Items are arranged in descending order of CSA (see Item column). [a] Item difficulty in logits; item difficulties are anchored at a mean of 0 and SD of 1. [b] Mean square infit statistic with expectation of 1. Values greater than 1.4 indicate unexpected noise; values less than 0.7 indicate dependency in the data

Appendix C

Table 9: Infit - Communication Skills – Domain Rating Scale

Group	Etiology	Obs.Avge	Measure	S.E.	InfitMS	OutfitMS
1	SUD	0.79	-0.34	0.07	1.21	1.21
2	Infection	1.25	0.61	0.08	0.89	0.76
3	Genetic	1.41	0.56	0.08	0.86	0.6
4	Vaccination	1.38	0.45	0.07	0.73	0.59
5	Accident	0.66	-0.54	0.07	1.36	1.25
6	Unknown	1.01	0	0.04	1.12	1.02

Domain	Domain	Obs.Avge	Measure	S.E.	InfitMS	OutfitMS
1	Reading	0.95	0.07	0.06	1.39	1.43
2	Writing	0.15	0.1	0.14	1.13	1.08
3	Reading/Writing	1.95	-0.44	0.05	1.52	1.41
4	Receptive	0.8	0.66	0.1	0.79	0.77
5	Expressive	1.07	-0.1	0.11	0.72	0.62
6	Receptive/Expressive	1	0	0.09	0.7	0.61
7	Receptive	1.23	-0.35	0.06	0.76	0.62
8	Expressive	0.96	0.06	0.06	0.76	0.85