Beyond the Fourth Grade Glass Ceiling: Understanding Reading Comprehension Among Bilingual/Bimodal Deaf and Hard of Hearing Students

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Beyond the Fourth Grade Glass Ceiling:
Understanding Reading Comprehension Among Bilingual/Bimodal Deaf and Hard of Hearing
Students

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This dissertation is dedicated to my teachers and students, past, present and future.

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Abstract

Research has found that, on average, deaf and hard of hearing (DHH) students graduate from high school reading at the fourth grade level (Allen, 1986). Additionally, DHH children of deaf parents (Charrow & Fletcher, 1974) and those with strong American Sign Language (ASL) proficiency (Strong & Prinz, 1997) tend to outperform DHH students without parents who are proficient in ASL.

The Simple View of Reading (SVR; Gough & Tunmer, 1986) suggests that reading comprehension is a product of decoding and language proficiency. Many DHH students have limited auditory access, and may struggle to acquire English, especially the more demanding academic English characteristics of school texts (Mayer & Wells, 1996). Academic English has been identified as a strong predictor of reading comprehension among hearing children (Uccelli et al., 2015). Guided by a modified SVR model, in this study I investigate DHH secondary school students' reading comprehension as predicted by receptive ASL proficiency, word reading fluency/decoding, and academic English proficiency.

Guided by prior research on DHH and hearing students, I investigate the hypothesis that for secondary school DHH students enrolled in ASL/English bilingual/bimodal schools for the deaf, academic English proficiency is a significant predictor of reading comprehension alongside ASL proficiency. In this study, a sample of secondary school DHH students were tested in ASL proficiency, academic English proficiency, word reading fluency (a proxy for decoding), and reading comprehension.

Using linear regression, an interaction between academic English proficiency and word reading fluency was detected, such that the lower the level of academic English

proficiency, the higher the impact of word reading fluency on reading comprehension. ASL skills predicted reading comprehension across all models. Findings support a model in which socio-demographic factors, ASL proficiency, and word reading fluency are predictors of reading comprehension for secondary DHH students.

This study is innovative in assessing three sets of language and reading skills essential for DHH students' reading comprehension. The continued adaptation of instruments that target these constructs, as well as studies with larger samples, are critical to further explore the innovative theoretical model of reading comprehension for DHH students proposed in this study.

Introduction

Rationale

The field of deaf education has long struggled to develop literacy skills among deaf and hard of hearing (DHH) children that are comparable to the literacy achievement of their hearing peers. Among professionals who work with DHH children, including parents, teachers, medical professionals, and speech pathologists, there is significant disagreement about whether American Sign Language (ASL) or spoken English is the most appropriate linguistic tool for supporting DHH children as they develop their language and literacy skills. There is even disagreement regarding the factors that affect literacy development in this population. There are those who believe based on evidence in the field that the experience of a DHH child developing English literacy is qualitatively similar to, but delayed from, the experience of the hearing child (Paul & Lee, 2010). However, others disagree that the application of theoretical models of reading development based on hearing children is appropriate for understanding how DHH students learn to read and write in a language to which they may have limited or no auditory access (Kuntze, Golos & Enns, 2014). Historically, educators and researchers have favored the use of either signed or spoken English in the classroom, focusing on audiological skills such as phonological awareness, phonics, and English grammatical structures, presented either orally or manually through a signed representation of English. However many children struggled and often failed to obtain grade-appropriate skills under this methodology (Allen, 1986). Today, researchers continue to grapple with understanding which linguistic skills undergird the literacy abilities of DHH students.

It is well documented in the literature that DHH students struggle to develop age-appropriate literacy skills in English, with the average DHH student graduating from high school having attained only fourth grade level reading comprehension skills (e.g., Allen, 1986; Strong & Prinz, 1997). Researchers have pointed to many particular literacy skills that may help to explain this persistent lag, most frequently a lack of phonological awareness knowledge (Luetke-Stahlman & Nielsen, 2003; Mayer, 2009; Park, Lombardino & Ritter, 2013; Paul & Lee, 2010), and poor depth and breadth of vocabulary awareness (Hamilton, 2012; Williams, 2012). Neither of these findings is necessarily unsurprising; a child with limited (if any) access to auditory channels is unlikely to develop phonological awareness[1] in the traditional manner, if at all. Additionally, because many important vocabulary words are learned incidentally rather than through direct instruction, DHH children may suffer from reduced incidental exposure to English vocabulary and English structures. Besides this potential limited exposure to their second language (English), those who are not regularly in the company of fluent signers could be, in addition, at risk of not developing age-appropriate vocabulary and language structures in their first language (ASL). Often English vocabulary must be taught directly due to limitations in access to spoken English for many DHH students. For those students with limited or no auditory access, their main representation of the word would likely be through print, though for those with more

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[1] Although phonology in spoken language research refers to the sounds of language, linguistics researchers studying American Sign Language have begun to refer to parameters of ASL as phonological elements in some cases (Mayberry, 1993; Newport & Meier, 1985), and some are beginning to investigate whether developing visual phonological awareness in ASL will have transfer effects on English literacy skills (see for example Morford, Kroll, Piñar & Wilkinson, 2014). Throughout this dissertation, phonology (and phonological awareness) will refer to spoken English phonology unless otherwise specified.

auditory abilities or who are able to effectively use amplification, they would also develop a phonological representation of the learned English vocabulary.

A great deal of research in deaf education focuses on sub-skills of literacy, such as phonological awareness, fluency, or vocabulary, in which many DHH students seem to be underperforming. However, this deficit focus does not take into account those DHH who achieve literacy skills that are comparable to similarly aged hearing students despite their limited auditory exposure to English. It is possible that an underlying delay in language acquisition due to lack of exposure to an accessible language from an early age may also partially explain English literacy delays for at least a subset of DHH learners. This could mean that improved L1 (ASL) fluency may have a significant impact on reading comprehension outcomes.

Research has shown that it is a particular subgroup of DHH students who seem to be consistently outperforming the rest of the population: DHH students who have deaf parents (Charrow & Fletcher, 1974). It is believed by some that the consistent exposure to an accessible first language, ASL, which is afforded to DHH children with deaf parents, may be a means of explaining the higher levels of reading comprehension among this subpopulation of DHH students (Shantie & Hoffmeister, 2000; Strong & Prinz, 1997). For example, there are studies that point to a correlation between ASL proficiency (measured through non-standardized measures, standardized measures, and proxies for ASL proficiency [home language and parents' signing ability]) and literacy achievement, including reading comprehension ability and English vocabulary knowledge (DeLana, Gentry & Andrews, 2007; Singleton, Morgan, DiGello, Wiles & Rivers, 2004; Strong & Prinz, 1997).

Theoretical Framework

In terms of the theoretical framework for this dissertation, I suggest a modification to the Simple View of reading for monolingual (Gough & Tunmer, 1986) and bilingual (Proctor et al., 2010) students. Gough and Tunmer's (1986) original model argued that reading comprehension was the product of language fluency and decoding ability. Proctor and colleagues (2010) expand upon this model for bilingual learners, adding first language reading comprehension and second language fluency to the model. For DHH students at the stage of development typical of middle or high school, linguistic competence and decoding are important facets of reading comprehension. However, I hypothesize that academic language skill in English also plays a significant role in the successful reading comprehension for DHH students enrolled in middle and high school. Research suggests that academic English skills are necessary for successful reading comprehension in the later grades (Bailey, Butler, Stevens & Lord, 2007; Zwiers, 2014), and a lack of such skill may play a role in the fourth grade glass ceiling experienced by so many DHH students (Allen, 1986; Strong & Prinz, 1997).

ASL Proficiency

ASL proficiency has recently come to the forefront of educational research with DHH students as an important factor in the development of this population. DHH children who are born to deaf parents typically develop language proficiency in ASL in a way that is similar to the way hearing children acquire spoken language; in some cases, elements of language may even be developed at an earlier age in signed as compared to spoken language (Newport & Meier, 1985). Research has found that the development of a first language, either ASL or, among post-lingually deafened individuals, English,

improves linguistic understanding and production of both English and ASL among DHH students, impacting such areas as English syntactical understanding and production, ASL phonology, and ASL grammatical awareness (Boudreault & Mayberry, 2006; Mayberry, 1993; Mayberry, 2007; Ramirez, Lieberman & Mayberry, 2013). The existing research provides a strong case for the critical influence of early language exposure and age-appropriate first language development – be it ASL or English, on DHH students' literacy proficiency.

In early research, it was unclear whether different achievement levels when comparing DHH children with deaf or hearing parents were the result of having deaf parents, or if hearing parents who have proficiency in ASL could provide the same benefit for their children in terms of literacy and language achievement and understanding. In an attempt to tease apart the influence of having deaf parents versus fluency in an L1, in this case ASL, Strong and Prinz (1997) measured student proficiency with ASL in their study predicting the reading ability of DHH. When controlling for whether parents were deaf or hearing, the students' ASL skill was still a significant predictor of reading achievement. This suggests that it was not necessarily the fact of having deaf parents that was the most important factor for reading comprehension, but rather the strong foundation in a first language that led to greater literacy achievement among the highest performing DHH learners. However, our understanding of the relationship between the two languages is still limited, and virtually no research addresses varying registers or focuses on the English that is used in academic contexts. This is surprising considering the importance of understanding and producing academic English in secondary and post-secondary education.

Academic English Proficiency

Academic English can be defined as the language of schooling, a language which is necessary for the successful completion of secondary and post-secondary education (Schleppegrell, 2001). Very infrequently has DHH student ability to use and understand academic English been researched, although some argue theoretically that lack of exposure to academic English, both through the oral and written modalities, may explain some variation in the reading achievement of DHH learners (Hamilton, 2012; Keenan & Bowers, 1988; Mayer, 2009). Given DHH students' average achievement of a fourth grade reading level upon high school graduation, and the well-documented fourth-grade slump that impacts the reading of scores of hearing elementary school students as they struggle to gain access to the discipline-specific texts that are introduced in mid-elementary school (Chall, Jacobs & Baldwin, 1990), it stands to reason that barriers in access and exposure to academic English may play a role in the literacy development of DHH children. It is an unfortunate gap in the literature that the role that understanding and production of academic language, and the relationships between ASL proficiency, academic English knowledge, and reading comprehension outcomes among DHH students have yet to be addressed.

Study Design

The purpose of this study is to fill a gap in the research concerning our understanding of how ASL fluency and academic English proficiency may predict the reading comprehension abilities of DHH students. Specifically, I explore the question of whether ASL proficiency and/or the understanding of academic English accounts for some of the unique variance in the reading comprehension scores of DHH students

enrolled in an ASL/English bilingual program. If so, what is the nature of the relationship between these linguistic and literacy skills?

This dissertation study begins with a review of the literature on DHH students' literacy attainment, the relationship between ASL proficiency and English literacy skills, and academic language (including specific discussion of academic English skill among English language learners (ELLs), as comparisons have been drawn between hearing ELL students and bilingual DHH students in the research literature), and the limited research addressing academic English proficiency among DHH children. As the average DHH child graduates from high school reading at only the fourth grade level (Allen, 1986; Strong & Prinz, 1997), it is clear that a better understanding of the ways in which these literacy skills develop and instructional methodologies for supporting such development are necessary in the field of deaf education. Academic language abilities among hearing native English speakers and English language learners seem to be an important skill for success in secondary and post-secondary school (Bailey, Butler, Stevens & Lord, 2007; Uccelli, Dobbs & Scott, 2013; Zwiers, 2014), and it is my hypothesis that this skill is also important for the later literacy achievement of DHH students. As prior research has also identified ASL proficiency as an important predictor of reading comprehension abilities (Cummins, 2006; Strong & Prinz, 1997), the role of ASL skill alongside academic English were explored.

Statistical analysis of the literacy abilities of DHH students were explored in this dissertation through assessment scores on the *Core Academic Language Skills Instrument* (*CALS-I*; Uccelli et al., in development) and the *American Sign Language Assessment Instrument* (*ASLAI*; Hoffmeister et al., in development). These two assessments served as

the key question predictors, with the outcome measure being reading comprehension as measured by the *Stanford Achievement Test – Hearing Impaired* (*SAT-HI*; Harcourt Educational Measurement, 1996) and the *Measures of Academic Progress* (*MAP*; Northwest Evaluation Association, 2014) assessments. I also took into account the influence of the control predictor of word reading fluency as measured by *the Test of Silent Word Reading Fluency* (*TOSWRF*; Mather, Hammill, Allen & Roberts, 2004), and the socio-demographic controls of whether the students have deaf or hearing parents, grade level, amplification use, gender and race/ethnicity.

Analysis began through a principal components analysis of the key question predictors in order to better understand the nature of these assessments. Because these two assessments are currently in development, it was important to understand whether they were assessing a single dimension of skill or multiple dimensions of ASL and academic English proficiencies. Next, I conducted an exploration of summary statistics and used correlations to examine potential relationships between the major variables. Finally, I created linear regression models to determine the predictive abilities of the key question predictors on the outcome, reading comprehension. Initial findings noted a statistically significant relationship between *CALS-I* scores and reading comprehension, and a significant interaction between *CALS-I* scores and word reading fluency. *CALS-I* scores and the interaction term were significant predictors of reading comprehension. These models also indicated a strong relationship between ASL proficiency as measured by the *ASLAI* and reading comprehension. In the final model, which included *CALS-I* scores, fluency, race, and the interaction term, neither *CALS-I* nor the interaction term achieved significance. However, *ASLAI* scores remained a strong predictor of reading

comprehension. The limited sample size may have underestimated the strength of the relationship between academic English proficiency and reading comprehension.

The discussion chapter presents the findings from these statistical analyses situated within the broader context of deaf education. These findings show that for DHH children in this sample, ASL proficiency is highly predictive of reading comprehension skills. Those who were found by the *ASLAI* to be more fluent signers also typically had stronger reading comprehension than students who were less fluent signers. This finding replicates the results of a number of studies on ASL and literacy (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Strong & Prinz, 1997). The finding unique to the present study was the relationship between *CALS-I* scores and reading comprehension, as well as the interaction between academic English and silent reading fluency. Additionally, race/ethnicity significantly predicted reading comprehension scores. However, in models that included the *ASLAI,* neither *CALS-I* scores nor the interaction term achieved significance. This indicates that there may be a relationship between more fluent use of academic language in English and stronger reading comprehension abilities among this population that is in part mediated by reading fluency and race/ethnicity, though this relationship disappears when controlling for ASL proficiency. Several hypotheses that may explain the reason that academic English proficiency does not maintain significance in the final models are explored.

This is the first study to examine the academic English skills in the DHH population. Considering that the average DHH student graduates from high school reading at the fourth grade level (Allen, 1986; Strong & Prinz, 1997), it is possible that exposure to and instruction in academic language is an important factor in the

development of more advanced English literacy skills for adolescent DHH students. The current findings do not support the modified Simple View of Reading (Gough & Tunmer, 1986) I proposed, but instead suggest that L1 (ASL) fluency, race/ethnicity, and word reading fluency are the most important factors influencing the reading comprehension of middle and high school DHH students who use ASL. However, results from linear regression models that did not include ASL proficiency do suggest that academic English knowledge may still be a factor in the reading comprehension of this population. Not only do DHH students need to be successful language users in their L1 (ASL), but they also may need to understand the intricacies and nuances of academic language in English in order to be successful readers at the secondary and post-secondary levels.

Chapter 1: Literature Review

Deaf Education

A better understanding of the nature of the relationship between spoken, signed, and written languages is needed to fully support deaf and hard of hearing (DHH) students' literacy development. This study focuses on students who are enrolled in bilingual schools for the deaf, which use both American Sign Language (ASL) and English (printed and/or spoken) for instructional purposes. These students may be considered bimodally bilingual – that is, they are developing proficiencies in both ASL and English (through print or spoken language depending upon their auditory access).

DHH students, who develop proficiency in ASL as well as English, are considered bimodal/bilingual. Bimodal/bilingual individuals have proficiency in two languages that differ in their modality; in this case, DHH students' first language --ASL-- uses a gestural-visual modality, whereas their second language --English-- uses an oral-written modality. Unfortunately, current demographic data on the percentage of DHH students in the United States whose native language is ASL is not available. However, the World Federation of the Deaf reports that 70 million DHH people worldwide use a signed language as their first language (World Federation of the Deaf, ND). Additionally, although this information is somewhat dated, Padden (1987) reports an upwards of 500,000 DHH or hearing individuals in the United States who use ASL as a first or second language. Additionally, at the schools for the deaf that identify as bilingual/bimodal discussed above, there are 4,456 students enrolled (data unavailable for eight schools) (NCES, 2013).

In the remainder of this chapter, I will outline the relevant research in deaf education, beginning with an exploration of the history of language use in deaf education, current research on practices that promote literacy achievement among DHH students, and the relationship between ASL proficiency and reading achievement. From here, I will move into a discussion of the literature on academic English, specifically what is known about academic English, our understanding of the academic English knowledge of English language learners (ELLs), and the minimal research addressing academic English among DHH students in particular. This literature review will conclude with a discussion of the Simple View of Reading (Gough & Tunmer, 1986) and its application to the current research.

Language of instruction in Deaf Education: A brief history

Deaf education in the United States has a tumultuous history, rife with shifts in pedagogical approaches linked with changing visions about the optimal language(s) of instruction for this population. In order to understand current practices in the field, especially concerning language and literacy as is the intention of this study, it is vital to historically situate the current work in the context of the evolution of formal education for DHH students in the U.S.. The story of ASL in U.S. formal education began in 1817 with Thomas Gallaudet and Laurent Clerc's use of sign language at the Connecticut Asylum for the Deaf, the first primary and secondary school in the United States for DHH children (Sayers & Gates, 2008). The linguistic approaches and instructional methodologies that emerged in that asylum were focused on visual (signed

language[2]) rather than on oral (spoken language) communication (Lane, 1984). Many schools across the nation adopted these techniques, and because of this Gallaudet and Clerc's influence on deaf education, specifically the use of sign language in the education of DHH students enrolled at public, state-run schools in the U.S., spanned several decades. However, after the Milan conference of 1880, sign language gave way to oral/aural education. This change was championed by Alexander Graham Bell, who argued that only oral languages could be considered true languages, and that oral education would give DHH students better opportunities to succeed in a hearing world (Marschark, Lang & Albertini, 2002; Moores, 2010). Excluding sign language from the curriculum became the norm in a number of countries, including the U.S., until William Stokoe's linguistic research on ASL conducted in 1970. This research argued that ASL was a natural language with systematic organization based on grammatical rules. It was also the first time since the Milan conference that signed language was considered an instructional tool at schools for the DHH in the United States (Stokoe, 1970).

In the 1990's the bilingual/bicultural education movement gained traction, which encouraged educators to recognize their DHH students who use ASL as bimodally bilingual (ASL/English) and bicultural (Deaf/hearing culture) (Moores, 2008; Pittman & Huefner, 2001). This movement was the catalyst for research on the efficacy of using ASL in the classroom, as well as research on the relationship between English literacy

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[2] Although throughout this dissertation I refer to ASL in particular as the signed language used in deaf education schools and programs in the United States, at the time that the Connecticut Asylum was established this was not the common language. The signed language originally used at the asylum was the sign language used in Paris in the 1800s. This language then merged with local signed languages in the United States, such as Martha's Vineyard Sign Language, to become ASL, the predominant sign language in use in North America today (Groce, 1988).

and ASL knowledge (Cummins, 2006; Strong & Prinz, 1997). This was in part inspired by Jim Cummins' (1979; 1981) research on bilingual students and his proposed linguistic interdependence hypothesis, which holds that native language (L1) proficiency may facilitate second language (L2) proficiency. Those who embrace the bilingual/bicultural movement argue that ASL as the L1 of DHH students should be used to support English, the L2 (Marschark, Lang & Albertini, 2002). Although many schools still use either spoken or signed English for instruction, a sizable subset of schools have become bilingual schools for the DHH. Bilingual education for DHH students most often means instruction and communication primarily in ASL and exposure to English through reading and writing. In the sections that follow, we will explore the current research on the literacy achievement of DHH students and the relationship between ASL proficiency and literacy skills in English previously established in the literature.

Factors that contribute to DHH students' literacy achievement

Research on DHH students' literacy achievement is still scarce, with a meta-analysis identifying only 52 articles published over a 40-year period (1963-2003) addressing the literacy development of this population (Luckner & Handley, 2008). Yet, of all the areas of educational research with DHH students, it is perhaps literacy achievement and instruction that has received the most attention. This is at least in part due to the troubling fact that, on average, the DHH high school student graduates having attained only a fourth grade reading level (Allen, 1986; Strong & Prinz, 1997). Researchers in the field of deaf education have sought to determine which English literacy skills are most important for successful reading within this population and the most effective ways to teach said skills. However, a good proportion of this research

focuses on lower-level skills, such as phonological awareness for those students with sufficient amplification and/or access to spoken English, rather than higher order reading comprehension skills (for example, see Luetke-Stahlman & Nielsen, 2003; Mayberry, del Guidice & Lieberman, 2011; Miller, Lederberg & Easterbrooks, 2013; Park, Lombardino & Ritter, 2013). The research that does exist on DHH students' reading comprehension is largely descriptive in nature, and many of the studies that examined reading comprehension were case studies with a small number of participants, or single-subject research. Only 17 of the 52 studies published between 1963 and 2003 address the reading comprehension of DHH students using experimental or quasi-experimental intervention studies, or correlational research (Luckner & Handley, 2008).

One of the most controversial questions in the field of deaf education literacy research is that of phonological awareness – what role does this auditory skill play in the reading development of DHH students? Some researchers support the phonological route theory of reading development, arguing that phonological awareness is indeed important for the literacy development of DHH students (for a review, see Luckner & Handley, 2008). Although phonological awareness is normally considered by researchers in terms of classic methods of instruction that rely upon auditory perception, programs such as Visual Phonics purport to allow profoundly deaf children to build phonological awareness skills without necessarily relying upon audition. Instead, Visual Phonics teaches phonological awareness and phonics skills through handshapes that represent letter sounds (Trezek, Wang, Woods, Gampp & Paul, 2007). Recent meta-analyses have pointed to mixed findings on the importance of phonological awareness for reading achievement among DHH children, with some finding a strong relationship between

phonological awareness and reading comprehension among DHH students (Luckner &

Handley, 2008), and others concluding that phonological awareness may not serve as a

strong predictor of reading achievement for this population (Mayberry, del Guidice &

Lieberman, 2011). Research has identified a possible link between phonological

awareness and reading comprehension abilities among students enrolled in programs that

primarily used signed English as opposed to ASL, or other communication methods such

as cued speech (though the vast majority of all these students were still found to be

reading below grade level, even those with more developed phonological awareness

skills) (Luetke-Stahlman & Nielsen, 2003; Park, Lombardino & Ritter, 2013). Some

researchers have investigated explicit phonological awareness instruction, and have found

that such instruction improves phonological awareness among DHH students, though

students varied in their ability to internalize and apply this skill to reading (Miller,

Lederberg & Easterbrooks, 2013).

Other researchers have proposed a direct-route model of reading, wherein DHH

children bypass phonological awareness to access words and their meanings directly

(Mayberry, del Guidice & Lieberman, 2011). If this theory can be supported by data, it

would imply that phonological awareness plays a limited role, if any at all, in the reading

comprehension of DHH students. In fact, recent criticism of the phonological route

theory argues that phonological awareness assessments of DHH children may in fact be

measuring their response to visual and tactile rather than phonological cues in words

(McQuarrie & Parrila, 2009). The authors found that DHH students were more likely to

respond correctly to phonological awareness tasks in which words were congruent

visually or tactilely, lending support to the theory that DHH children may in fact be

relying more on visual and tactile information than on phonological information. This calls into question the results of phonological awareness studies with DHH children (McQuarrie & Parrila, 2009).

Mayberry and colleagues (2011) argue that native or near-native fluency in a first language, i.e., ASL for DHH students, is a stronger predictor of reading comprehension development than phonological awareness skills in English. Supporting this theory is a study that found evidence that DHH students use semantic rather than phonological or syntactic information to make sense of what they read – that is, the students in this study appeared to attend less to English audiological or grammatical information, and rely more upon individual word meanings and sight word recognition in order to understand what they have read (Miller et al., 2012). While the role played by phonological awareness in the reading development of DHH students is still unclear, it is possible that linguistic competency could be an equal, if not greater, factor in the reading comprehension of DHH children.

Another area of relatively intense study in the field is the applicability of the skills identified by the National Reading Panel (2000) – phonemic awareness (a sub-skill of phonological awareness, explored above), fluency, vocabulary, phonics, and comprehension to the reading development of DHH students. Both decoding ability, which is the application of phonics knowledge to the reading of words, and spoken and/or signed vocabulary knowledge in Dutch Sign Language have been found to be strong predictors of success in reading for DHH students (Coppens, Tellings, Schreuder & Verhoeven 2013). Limited research has been done on the factors contributing to DHH students' reading comprehension beyond basic processes (such as phonological awareness

or decoding) or vocabulary knowledge. As noted earlier, of these studies that do examine

higher level reading skills, such as fluency and comprehension, many are purely

descriptive (Luckner & Handley, 2008).

Although no research has explored the correlation between English reading

fluency and overall achievement, researchers have found that targeted fluency instruction

for DHH students, in this case the reading aloud or signing "aloud" (depending on the

mode of communication used by the student) of a story 2-3 times per week, resulted in

both improved fluency and improved comprehension performance on a standardized

assessment (Schirmer, Schaffer, Therrien & Schirmer, 2012). There is evidence that ASL

reading fluency[3] is correlated with reading comprehension achievement of DHH children

(Easterbrooks & Huston, 2008).

Instruction in comprehension strategies seems to be a promising strategy for

improving the literacy skills of DHH students – in fact, in a meta-analysis of the existing

research, the teaching of comprehension strategies being related to increased reading

achievement was the most common finding in the literature on reading comprehension

and this population (Luckner & Handley, 2008). For example, the teaching of

metacognitive strategies for use during reading, inclusion of think-alouds, and direct

instruction in strategy use, appeared to have a positive impact on the reading

comprehension outcomes of DHH students who use ASL or signed English (Akamatsu,

1988; Andrews & Mason, 1991; Ewoldt, Israelite & Dodds, 1992; Schirmer & Bond,

1990; Strassman, 1992; Walker, Munro & Rickards, 1998). Similarly, DHH students who

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[3] Signed reading fluency most often refers to asking children to sign a text as they read. In Easterbrooks and Huston (2007), the authors created an ASL signed reading fluency rubric and asked students to engage in successive translation, first reading a sentence in English silently and then signing it in ASL.

were identified through assessment as stronger readers seemed to be more proficient in their use of metacognitive strategies than less skilled readers (Gibbs, 1989). However, there is evidence that DHH students are limited in their independent application of such strategies, even after the strategies have been taught (Easterbrooks & Stephenson, 2006). In an attempt to determine whether simplification of syntax would improve comprehension, Cumming, Grove and Rodda (1985) found that such grammatical changes had no impact on reading comprehension outcomes. However, others have found that knowledge of English syntax is significantly related to overall reading comprehension (Boisclair & Sircois, 1996; Kelly, 1996). While simplifying syntactic structures may not aid the reading of DHH students, it is possible that syntactic awareness does impact their reading comprehension abilities.

Unfortunately, the majority of these studies are almost two decades old, and very few specifically address students who use ASL in the classroom – many include children who were enrolled in oral, total communication, and signing English classrooms. More recent research on the reading comprehension of DHH students who use ASL is needed to better understand the needs of this unique population. Additionally, specific data on the reading comprehension of bimodally bilingual DHH students who use both ASL and English is important for our understanding of the way reading develops among this population.

Based on this body of literature, it would seem that the current findings in the field are that the findings of the National Reading Panel (2000) are generally applicable to DHH students. However, no research has yet looked at the relationship between the

mastery of more academic forms of English and reading comprehension among this population, while controlling for L1 (ASL) proficiency.

It is telling that in most of these studies, even DHH students with relatively strong literacy skills were still frequently underperforming when compared with their grade matched hearing peers. Those with stronger phonological awareness skills, improved fluency, more advanced vocabularies, and better comprehension strategy knowledge, were still typically performing more poorly than the average reading performance of hearing students. While there is no doubt that these foundational skills contribute substantially to the reading abilities of all students, including those who are DHH, perhaps it is not enough for research to focus on these skills alone. Just as research with hearing students is now searching for more complex models that investigate factors beyond those suggested by the National Reading Panel (2000), it may be time for Deaf Education research to look outside of the findings of the National Reading Panel (2000), which are based on research conducted with hearing children and in many cases rely heavily upon full auditory access to English. While these skills are certainly important for reading comprehension, it is possible that the field of deaf education must search for additional skills that are more specific to the literacy needs and strengths of DHH students.

The Relationship Between ASL & English proficiency

It is only within the last 40 years that research has begun to turn its attention to the relationship between ASL proficiency and success in acquiring English among DHH students. Several language development researchers have explored the ways in which ASL develops as either a first or second language among DHH students, finding that the

later ASL is acquired as a first language, the higher the frequency in DHH students' errors in ASL production and comprehension (Boudreault & Mayberry, 2006; Mayberry, 1993; Mayberry, 2007). Researchers have found that early and late L1 language learners performed similarly within-group on language tasks, regardless of whether the language was spoken (for hearing English language learners) or signed (for DHH students exposed to ASL as their first language) (Mayberry & Lock, 2003) – in other words, early language exposure regardless of the modality (gestural-visual or oral-aural), the role of early language exposure seems to be critical for both achieving a higher L1 proficiency and for reading comprehension. Furthermore, early research in the field provided evidence that DHH children who are exposed to ASL later in life not only do not develop native-like proficiency in ASL, but also struggle more with English than children who are exposed to ASL earlier (Newport & Meier, 1985). For these reasons, the relationship between ASL skill and English literacy has become an important and controversial topic in the field of deaf education.

For many years it was believed that there was a negative correlation between the two languages (Jones 1979), and families reported that they were counseled away from the use of ASL because of the belief that it would interfere with the acquisition of English (Tompkins, 2004). ASL was largely absent from educational programming for DHH students after the Milan conference of 1880 and the late 1970's. When signing was used at all, it came in the form of signed English systems, as it was believed that making English more accessible through the gestural-visual mode would enable students to become more successful readers and writers. Results of studies involving the efficacy of signed English or simultaneous communication (the use of English and sign language

simultaneously, which is often the type of instruction present in classrooms that use signed English) in the classroom with DHH students have been mixed, with some claiming a positive relationship between signed English and reading comprehension (Mayer & Akamatsu, 2000; Wilson & Hyde, 1997) and others arguing that signed English messages are often distorted and difficult for the DHH student to parse (Tevenal & Villanueva, 2009). Still others argue that signed English should not be the primary classroom language, but may have some utility for the direct teaching of English grammatical structures (Wilbur, 2000). These mixed findings have been difficult to interpret and apply to the typical deaf education classroom, and it is unclear how beneficial the practice of using signed English has been for the average DHH student. However, with Strong and Prinz's (1997) seminal work on the relationship between ASL and reading comprehension, researchers began to investigate a relationship that had been frequently noted in anecdotal data: that DHH children of deaf parents, who had been raised using ASL, were typically more successful readers and writers of English. It was my hypothesis that this finding would be replicated in the current study.

A correlation between ASL proficiency and general reading comprehension has been confirmed several times over in the research on deaf education (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Hermans, Ormel & Knoors, 2010; Strong & Prinz, 1997). Students with stronger ASL abilities also tend to use less common lexical items during writing as compared to low ASL skill students, although they still struggle with the correct use of English function words (Singleton, Morgan, DiGello, Wiles & Rivers, 2004). As noted above, it is possible that the ASL/English relationship is rooted in the differences in achievement between DHH children with deaf or hearing parents, as those

students with deaf parents are also typically identified as the stronger ASL users (Charrow & Fletcher, 1974). As noted earlier, in a study where parental hearing status was held constant, students who were moderate to strong ASL users continued to outperform weak ASL users on English reading comprehension regardless of whether or not their parents were deaf (Strong & Prinz, 1997), suggesting that there is enough variability in ASL proficiency even among DHH children with deaf parents. In another study which used parental skill with ASL as a proxy for ASL proficiency among students, children whose parents were rated as fluent signers, whether they were deaf or hearing, also scored significantly higher on a measure of reading comprehension (DeLana, Gentry & Andrews, 2007).

Cummins (2006) explains this phenomenon with his linguistic interdependence hypothesis, arguing that DHH students gain language proficiency through instruction in ASL, which benefits them in both the development of their ASL proficiency (or L1 in Cummins' framework) and their English reading skills (their L2). Furthermore, theoretical models of language acquisition argue that a strong foundation in ASL is a prerequisite for the development of strong English skills (Bailes, 2001; Cummins, 2006), with some making the case that auditory and oral models of reading development based upon the experiences of hearing children are inappropriate to apply to DHH children who are more often visual/spatial learners. Instead, a new model based in the particular visual modality of DHH children should be developed to more completely understand how reading develops among this population (Kuntze, Golos & Enns, 2014). Although some have argued that the linguistic interdependence hypothesis is not appropriate for DHH children as ASL has no written form (Mayer & Wells, 1996) and that signed English may

still be useful for completing this linguistic transfer (Wilbur 2000), the correlation between ASL and reading skill in the literature has led some researchers to believe that a move towards a more visual framework has merit (Kuntze, Golos & Enns, 2014). Simple exposure to both ASL and English is unlikely to be sufficient for linguistic development and transfer, and that educators must engage in what is called "cultivated transfer" – the connections between the languages and modalities need to be explicitly taught to DHH students (Bailes, 2001; Hermans, Ormel & Knoors, 2010).

There are several weaknesses in this literature that must be addressed. Many studies examining the relationship between ASL proficiency and reading comprehension have used proxies for ASL proficiency, such as parental sign fluency or home language (DeLana, Gentry & Andrews, 2007) or non-standardized measures of ASL (Strong & Prinz, 1997). To my knowledge, there is only one study that has used a standardized rubric to measure ASL production in relation to English literacy skills, though this study focused on writing rather than reading comprehension (Singleton, Morgan, DiGello, Wiles & Rivers, 2004). In addition to not addressing reading comprehension, the previous study only captured expressive ASL proficiency, which could possibly underestimate student ASL proficiency. Additionally, no study has systematically examined the academic English proficiency of DHH students or its relationship with other skills, despite the importance of academic English for the reading and writing development of hearing students (Bailey, Butler, Stevens & Lord, 2007; Uccelli, Dobbs & Scott, 2013; Zwiers, 2014). The present study seeks to extend this prior research by examining the relationship between ASL proficiency and English reading comprehension, and additionally explores the role that academic English proficiency

plays for DHH students. In the next sections, we will explore the growing body of research on academic language development and instruction.

Academic Language

The Relevance of Academic Language for DHH students

Academic language refers to the language of schooling, a language necessary to master to be successful in academic arenas (Schleppegrell, 2001). Prior research on monolingual and bilingual students has already documented that academic language is both challenging and necessary for success in secondary and post-secondary school (Cummins, 2014; Schleppegrell, 2004; Zwiers, 2014). Prominent literacy researchers have in the past noted a slowing down in performance of typically developing students around the fourth grade level. This fourth grade slump experienced by many students coincides with the introduction of informational texts and the expectation that students comprehend and learn increasingly complex and abstract content through reading rather than, or perhaps in addition to, the face-to-face instruction they have received up until that point (Chall, Jacobs & Baldwin, 1990).

Coincidentally, fourth grade has been described as the reading comprehension ceiling for many DHH high school graduates (Strong & Prinz, 1997; Trezek & Wang, 2006; Wauters, Van Bon, Tellings & Van Leeuwe, 2006). Thus, guided by prior theoretical and empirical evidence on the contribution of academic language proficiency to literacy skills for hearing students (Bailey, Butler, Stevens & Lord, 2007; Uccelli, Dobbs & Scott, 2013; Zwiers, 2014), this study seeks to investigate if low academic English proficiency might be partially behind the difficulty of DHH students' text comprehension. To my knowledge no research has directly measured academic English

proficiency in DHH students, or the contribution of academic English to reading comprehension.

School learning to a large extend requires language learning, in particular academic language learning. Prior research has documented that the language knowledge all students bring to school is often insufficient for academic success (Cummins, 2014; Schleppegrell, 2004). Research suggests that while language learning is part of school learning for all students, the distance between the language of school tends to be greater for students who come from homes where the language and literacy practices do not match or resemble those expected for school reading and learning. Discrepancies between ways of using language at home and at school have been documented in particular for students who speak a different language at home and/or those who do not come from literacy-rich environments (Cummins, 2014). Some have referred to academic English proficiency as an invisible criterion for success in secondary and post-secondary school (Zwiers, 2014). In the pages that follow, I will explore the theoretical and practice-oriented literature on academic English proficiency among English language learners (ELLs), and the application of these findings to deaf and hard of hearing (DHH) students.

What Is Academic English Proficiency?

In early research that sought to address the differences between more academic and more colloquial language, two broad constructs representing each of these areas emerged: basic interpersonal communication skills (BICS) and cognitive academic language proficiency (CALP) (Cummins, 1984). This early distinction between the types of language used in social settings versus academic settings was helpful for understanding broadly the types of challenges children faced as they moved through the

grades. However, this division is both broad and vague, limiting its usefulness in the discussion of the differences between more colloquial and more academic language. More recent research in this area has made progress in further refining our understanding of academic English proficiency across academic contexts and content areas.

The division of academic and colloquial English into distinct categories is artificial and not an accurate reflection of the nature of language. It may be more accurate to suggest that language exists on a continuum ranging from more or less academic (Snow & Uccelli, 2009). However, there are some ways in which more academic and more colloquial language can be distinguished. For example, academic English tends to be more authoritative and detached than more colloquial language, which may be more expressive in stance. Academic English also features explicit markers of organization that connect ideas logically across a text in order to build an argument, which are also not frequently found in more colloquial language (Uccelli et al., 2015). Academic English also typically features wide lexical diversity academic vocabulary in the service of precise distant communication (Fang, Schleppegrell, & Cox, 2006; Schleppegrell, 2004; Snow & Uccelli, 2009).

Syntactical features also frequently differ when comparing more colloquial to more academic English, with more complex syntax appearing more frequently in academic texts (Uccelli et al., 2015). Academic English frequently features nominalizations, wherein sentences with actors and actions are transformed into complex nouns (Fang, Schleppegrell & Cox, 2006; Halliday, 1993; Nagy & Townsend, 2012; Schleppegrell, 2004), and where densely packed information, and passive language are featured more frequently (Chenhansa & Schleppegrell, 1998; Nagy & Townsend, 2012).

These features have been found to be challenging for numerous students to understand and produce (Chenhansa & Schleppegrell, 1998).

In an effort to define a more inclusive and precise construct, researchers have recently proposed an innovative operationalization of a cross-disciplinary construct of academic English proficiency. This construct, Core Academic Language Skills (CALS) refers to a constellation of high-utility language skills that correspond to prevalent linguistic features of academic texts and are, consequently, hypothesized to predict reading comprehension across content areas (Uccelli, Phillips-Galloway, Barr, Meneses, & Dobbs 2015). That is, there are vocabulary items and means of communicating information that may be specific to a discipline, as well as lexical items and linguistic features that are applicable across a wide variety of subject areas (Snow & Uccelli, 2009). It has been hypothesized that a cross-disciplinary academic English proficiency construct may be critical for student upper elementary and middle school students (Uccelli et al., 2013).

To summarize, theories and data suggest that academic English is a way of using language that is detached from the physical environment, with discipline-specific and cross-disciplinary ways of organizing and presenting information to a distant audience. When considering DHH students who use ASL as their primary language and are frequently learning English through print, their proficiency in understanding the features that are particular to academic discourse in English may be especially important. A focus on cross-disciplinary academic English words and structures will also provide students with the linguistic skills that may be more broadly applicable in school-relevant text comprehension throughout secondary and post-secondary endeavors. For these reasons, I

focus my analysis on these cross-disciplinary features of academic language, such as markers of organization and stance, and language structures such as nominalizations and passive voice.

Academic Language Proficiency and its Contribution to Reading Comprehension in Monolingual and Bilingual Students

The research on the impact of academic English proficiency on the reading comprehension skills of hearing monolingual and bilingual students is relatively new, and much of it focuses specifically on academic vocabulary. For example, teaching middle school aged children high utility academic vocabulary and morphological awareness skills has been found to lead to improved vocabulary knowledge and reading comprehension (Kelley, Lesaux, Kieffer & Faller, 2010; Kieffer & Lesaux, 2012; Snow, Lawrence & White, 2009; Townsend, Filippini, Collins & Biancarosa, 2012). This appears to hold true for ELL students as well, as research has shown that the teaching of academic English structures, such as stance and academic vocabulary, seems to improve the writing (Chang & Schleppegrell, 2011) and reading comprehension (Kieffer & Lesaux, 2010; Townsend, 2009) of ELL students. This evidence that academic English skills may lead to improved reading comprehension is promising, and provides a basis for the study of academic English proficiency among DHH students.

Academic English is a challenging register for all students to master, and seems to present a particular hurdle for ELL students. Given the difficulty that ELLs face in acquiring academic English, a language they are frequently immersed in during the school day and that they have full auditory access to, we can imagine that DHH learners face at least the same, if not a greater level of challenge in acquiring academic English

structures. As deaf education teachers are frequently tasked with building language proficiency in ASL as well as in English, it is possible that a lack of exposure to academic English due to the natural inclination of teachers of the DHH to prioritize the development of more basic language proficiency skills may be part of the reason that DHH students struggle to break through the fourth grade glass ceiling in terms of reading comprehension. However, the existing research on academic English and DHH students is highly limited. The current study is unique in its use of a standardized assessment of academic English among a unique group, DHH adolescents enrolled in bilingual schools for the deaf. The following section will address the small number of articles that examine academic language use among DHH students.

The Potential Role of Academic English in the Reading Comprehension of DHH Children

In the section of general Academic English, I noted that early research into the difference between colloquial and academic language proficiency can be found in Cummins' (1979; 1981) theoretical division of these language types BICS (colloquial) and CALP (academic). It has been theorized that DHH students, in their development of English, are often exposed directly to English CALP through texts without developing BICS proficiency in spoken English; therefore, without this more colloquial language base, DHH students struggle to acquire academic English skills (Mayer, 2009). One researcher-practitioner sought to improve his DHH students' academic language skills in ASL, their L1 with the hypothesis that, based on Cummins' (1979) interdependence theory of language development, these skills may transfer to the development of academic English skills (Zernojov, 2005). However, other researchers question whether it is possible for academic language skills to transfer between a signed/visual and an

auditory/spoken modality, arguing that the lack of direct link between print and ASL makes such transfer improbable (Mayer & Wells, 1996). Counter to this hypothesis, the finding that a statistically significant relationship exists between ASL proficiency and reading ability (Strong & Prinz, 1997), seems to be a strong contradiction to these researchers' concerns. It is clear that further study on academic language skills of DHH students and the factors that influence them is necessary, as researchers have recently pointed out (Mayer, 2009).

Bartolome (1998) argues that language minority students are at a disadvantage for acquiring academic English because they may not be exposed to or participate regularly in academic discourses in their native language. If this is the case, no transfer of these language skills from the first language to the second language can occur. Similarly, DHH students will likely not have access to academic discourse either in ASL or English, given that the majority of DHH children are from hearing families (MacSweeney, Capek, Campbell & Woll, 2008). These families are unlikely to be able to communicate with their children in even basic ways, much less able to model academic discourses in either ASL or English. This makes exposure to and the teaching of English academic language skills in the deaf education classroom of even greater importance. However, the issue of academic language has not yet been broached empirically in the research.

In summary, although no research currently exists measuring the English academic language proficiency of DHH children, researchers have acknowledged the difficulty DHH students face in developing this particular English register (Mayer, 2009; Mayer & Wells, 1996). Some have theorized that ASL academic language proficiency may serve as a linguistic transfer point for academic English (Zernojov, 2005) and

general reading comprehension (Strong & Prinz, 1997), although this remains a point of contention in the research (Mayer & Wells, 1996). For this reason, the theoretical framework used for this study will focus on the potential role played by both ASL proficiency and academic English proficiency among this population of students.

Overall study design

Due to the importance of fluent use and understanding of academic English for success in secondary and post-secondary school, this study will investigate the contribution of academic language skills in English and of ASL proficiency on secondary DHH students' reading comprehension. The research base has already established a link between reading comprehension and ASL proficiency among DHH children (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Hermans, Ormel & Knoors, 2010; Strong & Prinz, 1997), as well as a link between academic English knowledge and reading comprehension among hearing monolingual and bilingual children (Chenhansa & Schleppegrell, 1998; Lesaux, Kieffer, Faller, & Kelley 2010; Snow, Lawrence & White, 2009; Townsend, Filippini, Collins & Biancarosa, 2012). To my knowledge, though, this will be the first study to use a standardized measure of receptive ASL and a measure of academic English proficiency to examine each skill's contribution to the reading comprehension skills of DHH students.

I hypothesize that both of these sets of linguistic skills play an important role in the reading comprehension of DHH children in middle and high school, a time when they are more likely to be exposed to and expected to gain information from academic texts. In this thesis, I adopt a modified Simple View of reading (SVR) as the model through which I examine the reading comprehension abilities of DHH students. The SVR defines

reading comprehension (R) as a product of decoding (D) and language comprehension (C) (Reading Comprehension = Decoding x Language Comprehension) (please see Figure 1) (Gough & Tunmer, 1986). That is, if a student has sufficient decoding ability, and sufficient oral language proficiency, he or she will be capable of successfully understanding a text. Conversely, in the absence of one of these components, reading comprehension will not happen.

This model was chosen because its emphasis on linguistic competence as a precursor to the ability to interact with text makes it an ideal framework through which to view the literacy skills of DHH students who may still be in the process of developing their L1 and L2 fluencies. However, The Simple View (Gough & Tunmer, 1986) model as it currently exists may not be sufficiently specific to explain the relationships between languages with different modalities (i.e., gestural-visual vs. oral-written), or even bilingual students in general. The paragraphs that follow will expound upon the classic Simple View model, and the modifications that have been made to this model for this thesis.

Figure 1: The Simple View of Reading (Gough & Tunmer, 1986)

Although prior research has argued that the Simple View is an acceptable framework for understanding the reading of bilingual students (Hoover & Gough, 1990), according to Proctor and colleagues (2010), for bilingual/biliterate learners successful L2 reading comprehension is a product of decoding in both the L1 and L2, language proficiency in English (the L2) and reading comprehension in the L1. This model proposes that ability to comprehend text in the first language (in this case, Spanish) is a contributing factor of reading comprehension in the second language for bilingual/biliterate students. Proctor and colleagues (2010) also argue that oral proficiency in the second language is necessary for successful L2 reading comprehension (see Figure 2).

Figure 2: The Bilingual Simple View of Reading (Proctor et al., 2010)
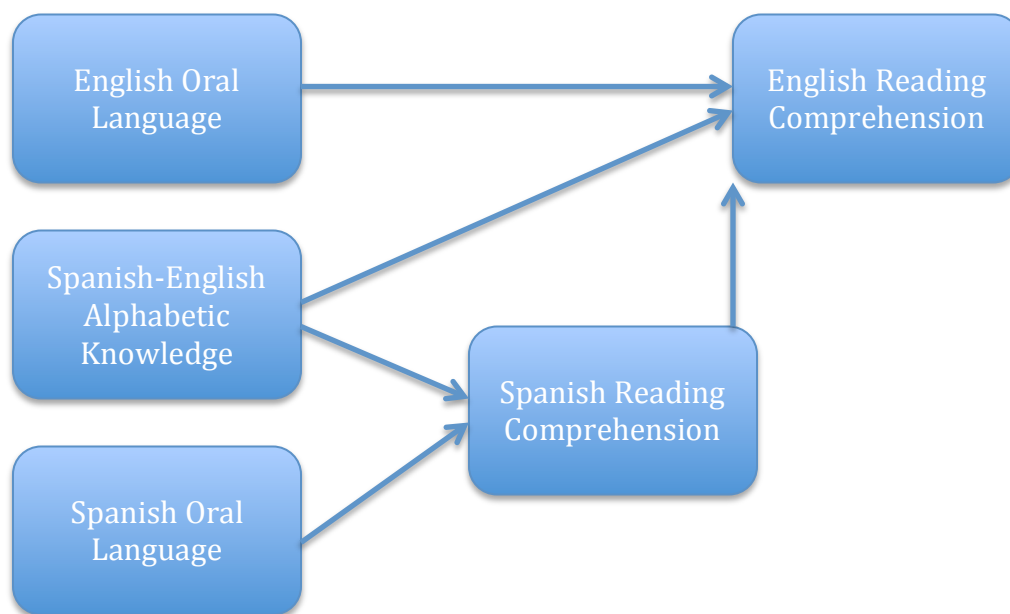
A difficulty in applying this modified Simple View model as it stands to DHH children is that there is no widely used written form of ASL[4], therefore first language reading comprehension cannot be developed with this population in a traditional way. If reading proficiency in the L1 was essential for bilingual learners to develop L2 reading skill, ASL-using DHH students would be unable to develop English reading comprehension under this model. Despite this shortcoming, however, the Simple View of Reading (Gough & Tunmer, 1986) provides an excellent starting point for understanding an analyzing the relationship between reading comprehension, decoding, and language development. Proctor and colleagues' (2010) modifications for ELLs seem highly relevant for DHH students, especially the extra consideration given to proficiency in both the L1 and the L2. However, I believe the model requires further revision before it is fully applicable to bimodally bilingual DHH students.

I argue that a modified version of the Simple View of Reading inspired by Proctor and colleagues' (2010) bilingual model is appropriate for framing the current research: For DHH children who use ASL at home and at school, and consequently are bimodally bilingual, successful L2 reading comprehension may require decoding in L2 (English), language proficiency in the L1 (ASL), and academic English proficiency. In other words, reading comprehension for this population can be conceptualized as:

L2 Reading Comprehension = L2 Decoding x L1 Language Proficiency x L2 Academic Language Proficiency.

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[4] Although there have been attempts to develop a written form of ASL, most notably that of SignWriting (Sutton, 2014), these attempts have not been widely used in the education of DHH students.

Guided by prior research, ASL proficiency is included as an important factor not only for the critical cognitive and L1 foundation for these students, but also as a potential source of transfer following Cummins' interdependence hypothesis. Students also certainly need to develop language proficiency in the L2 (English), particularly L2 academic language proficiency through exposure to print, rather than through spoken language. These students also must develop the ability to decode or recognize individual words in English. Although there are DHH children who successfully acquired English without ASL, in the current study, the focus is on bilingual/bimodal DHH learners. I argue that for those students being raised bimodally bilingual, that ASL instruction and development is crucial to their acquisition of language and literacy skills in both English and ASL. Please see Figure 3 for a visual display of this reading comprehension model.

Figure 3: The DHH Expanded Simple View of Reading
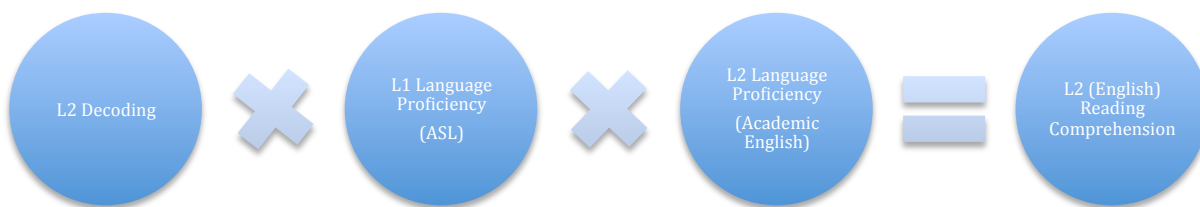
Among bimodally bilingual DHH students' literacy constitutes a relatively understudied area, while these learners' English academic proficiency is largely uncharted. In this current research context, this model is presented as a tentative framework to guide the present study. In particular, this framework seeks to capture the

more advanced language and literacy skills that are needed for success in middle, secondary, and ultimately post-secondary school.

Assessments Addressing the Skills in the Proposed DHH Expanded Simple View of Reading

Although numerous assessments of language and literacy exist, both of the primary sub-skills addressed in this thesis (academic English and ASL proficiency), have only recently come to the forefront of educational research. In an attempt to better understand how academic English skills develop, a team at the Harvard Graduate School of Education has developed the *Core Academic Language Skills Instrument* (*CALS-I;* Uccelli et al., 2015), a promising tool for understanding how academic English develops among hearing monolingual and bilingual students. An adaptation of this assessment is used in this study in an attempt to investigate for the first time DHH students' academic English proficiency, a critical yet underexplored area for this population.

Currently, few assessments of ASL proficiency exist. One of these is the *American Sign Language Proficiency Assessment*, which is a global measure of general language skill (Singleton, Morgan, DiGello, Wiles & Rivers, 2004). The *American Sign Language Sentence Reproduction Test* (Supalla, Hauser & Bavelier, 2014) asks students to repeat sentences they see in ASL from memory. While both of these assessments have their merits, they are holistic measures of ASL proficiency, and do not address subcategories of ASL skill (Morere & Koo, 2012). I propose in this thesis the use of an assessment that provides a score of ASL competency based in the ability to understand a comprehensive set of essential linguistic sub-skills. The *American Sign Language Assessment Instrument* (*ASLAI*), by Hoffmeister and colleagues (in development) breaks

down receptive and expressive linguistic abilities into sub-skills of ASL proficiency. This assessment was developed to give teachers and researchers a more complete understanding of the varying linguistic skills that make up ASL proficiency rather than rating a student as an overall "poor" or "advanced" signer without acknowledging relative strengths and weaknesses. This is important because such linguistic skills are often developmental, and understanding what students have mastered linguistically can give us more detailed information on ASL language development.

I use the *ASLAI* (Hoffmeister et al., in development) and the *CALS-I* (Uccelli, Barr, Dobbs, Galloway, Meneses, & Sánchez, 2014; Uccelli, Phillips Galloway, Barr, Meneses, & Dobbs, 2015) assessments in this study in order to better understand the relationship between ASL proficiency, and academic English proficiency and reading comprehension, among DHH students. In this study I will focus on language proficiency – both ASL and academic English, as the main predictors of DHH students' reading comprehension. The *CALS-I* was used alongside the *ASLAI* to determine whether a relationship exists between academic English and ASL proficiencies, and whether either or both of these language skills predict the reading comprehension of DHH students. Both instruments must be interpreted with caution, as they are currently undergoing development; however, both are promising tools for understanding the language and literacy skills of DHH students.

Finally, commonly used assessments are utilized to measure decoding and reading comprehension. First, as phonological awareness and phonics are controversial and difficult skills to measure with DHH students, the *Test of Silent Word Reading Fluency* (*TOSWRF*; Mather, Hammill, Allen & Roberts, 2004) is used as a proxy for decoding

ability/word reading fluency in English. In order to complete this assessment, students

must recognize boundaries for individual words in English. This measure will provide

information on how capable students are at identifying words in English. Reading

comprehension is measured through either *the Stanford Achievement Tests – Hearing*

Impaired (SAT-HI; Harcourt Educational Measurement, 1996) or *Measures of Academic*

Progress (MAP; Northwest Evaluation Association, 2014) assessment. These will be

discussed further in the methods chapter.

Figure 4: Assessment Measures of the DHH Expanded Simple View of Reading
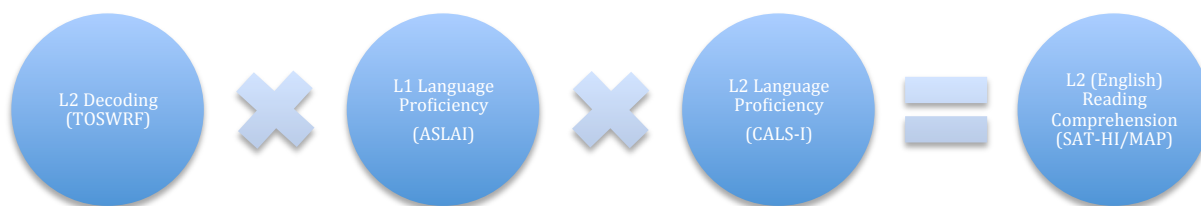
Academic English and ASL proficiency are emerging as important predictors of

reading comprehension ability among DHH and hearing students respectively. While the

research in the field of deaf education has contributed a great deal to our understanding of

how DHH children acquire English literacy skills, the area of academic English

proficiency in this population is virtually unstudied. This dissertation, through a

modification of the Simple View of Reading (Gough & Tunmer, 1986) explores the

potential relationship between reading comprehension and L1 proficiency (ASL) and/or

academic English knowledge. The next chapter will detail the population included in this

study and present the methods used in an effort to answer the following research questions:

1. What are the pairwise relationships between socio-demographic factors, DHH factors, word reading fluency, ASL proficiency, academic English proficiency, and reading comprehension?

2. Does academic English proficiency predict reading comprehension scores among secondary DHH students, when controlling for socio-demographic factors, DHH factors, and word reading fluency?

3. Does ASL proficiency predict reading comprehension scores among secondary DHH students, when controlling for socio-demographic factors, DHH factors, and word reading fluency?

4. Does English academic language proficiency account for unique variance in the reading comprehension performance of secondary DHH students, after controlling for socio-demographic factors, DHH factors, word reading fluency, and ASL proficiency?

Chapter 2: Research Design

Research Design

Research questions

Prior research has established a relationship between reading comprehension and American Sign Language (ASL) proficiency among deaf and hard of hearing (DHH) students (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Strong & Prinz, 1997). Although some researchers have pointed to a lack of academic English proficiency as an important factor in the reading comprehension skills of this population (Mayer, 2009; Mayer & Wells, 1996; Zernojov, 2005), academic English skills have not been empirically researched among DHH students. In this study, I address several related research questions in an attempt to gain an understanding of the relationships between ASL proficiency, academic English proficiency, and reading comprehension scores. As additional covariates, I explored word reading fluency and socio-demographic characteristics (grade level, race/ethnicity, gender), as well as DHH-specific factors (hearing amplification use, having deaf or hearing parents). The research questions that guided this study are:

1. What are the pairwise relationships between socio-demographic factors, DHH factors, word reading fluency, ASL proficiency, academic English proficiency, and reading comprehension?

2. Does academic English proficiency predict reading comprehension scores among secondary DHH students, when controlling for socio-demographic factors, DHH factors, and word reading fluency?

3. Does ASL proficiency predict reading comprehension scores among secondary DHH students, when controlling for socio-demographic factors, DHH factors, and word reading fluency?

4. Does English academic language proficiency account for unique variance in the reading comprehension performance of secondary DHH students, after controlling for socio-demographic factors, DHH factors, word reading fluency, and ASL proficiency?

In this chapter, I will discuss the research design for this dissertation study, beginning with an overall study design. Next, I provide a description of the participants and sites, as well as a description of the question and control variables that were used for the statistical analyses. After this, I provide details on the assessment measures, as well as a brief discussion of assessment modifications common in the field of deaf education and how they were used in this study.

Study Design

This study includes two key question predictors and one outcome predictor. Scores on a test of academic English proficiency serve as the first key question predictor. The second key question predictor was student scores on a test of American Sign Language proficiency. The outcome variable was student scores on a test of reading comprehension. In addition to these primary measures, I also included a small number of secondary measures as control variables. These included a measure of word reading fluency as well as socio-demographic and DHH variables. Each of these will be explored in detail below, following a description of the site and participants.

Sites

Three schools self-identified as bilingual/bimodal, bicultural residential schools for DHH students participated in this study. The first school is privately-run (site 1); and the other two schools are public and run by the state (sites 2 & 3). Sites 1 and 2 are located in the Northeast and site 3 is in the Western United States. Bilingual instruction in ASL and English constitutes the predominant instructional model in residential schools for DHH students in the U.S. Out of the 57 operational residential schools for the deaf that currently exist in the United States (deafed.net, 2012), 35 schools offer bilingual ASL and English instruction[5].

The two publicly-funded, state schools in this study enrolled 60% (site 2) and 82% (site 3) of students who qualified for free or reduced lunch (National Center for Research Statistics, NCES, 2011). These data are not available for site one, as it is a private school and does not publicly report this information. However, this private school operates at no cost to families and is funded through district money per individual students and private donations according to the school's website. The school is located in a suburban school district with only one other high school aside from this school for the deaf. This high school only has 27% of its students enrolled in free or reduced lunch (NCES, 2011), however this might not be representative of the socio-economic status (SES) of students at site 1, who may come from surrounding districts.

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[5] As evidenced by either a statement of bilingual philosophies in a vision or mission statement, and/or direct discussion of both American Sign Language and English instruction and use in their program descriptions.

These three sites were chosen for participation in this study due to their involvement with pilot and norming studies of the *American Sign Language Assessment Instrument* (*ASLAI*; Hoffmeister et al., in development)[6].

Participants

Participants in this study were middle and high school students enrolled in the three previously described bilingual/bimodal schools for DHH students. Initially, 42 students were included in this study, although one student was excluded due to lack of *ASLAI* score availability. This left 41 students who remained in this study: 16 students from site one, 19 from site two, and 6 from site three. Although this is a relatively small number of participants, research has noted difficulty in recruiting DHH students as deafness is a low-incidence phenomenon in an overtested population (Cawthon, Winton, Garberoglio & Gobble, 2011). Due to this difficulty, a number of influential literacy studies conducted with this population draw from smaller-than-ideal sample sizes of no more than 50 DHH students (see for example, Berent, Kelley, Schmitz & Kenney, 2009; Luetke-Stahlman & Nielsen, 2003; Miller, Lederberg & Easterbrooks, 2013; Park, Lombartino & Ritter, 2013; Schirmer, Schaffer, Therrien & Schirmer, 2012).

Of the 41 students, 19 were enrolled in middle school and 22 were enrolled in high school, and 24 participants were female and 17 were male. A small subset of the participants had at least one deaf parent (n=5), which implies that they were exposed to ASL from birth in the home. The remaining students came from hearing families, but 27 reported at least one family member in the home who had some signing proficiency[7]. No

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[6] One additional school was also involved in the *ASLAI* norming study. I approached this school for involvement in the current study, but they declined to participate.
[7] This could mean at least some proficiency with ASL, or with another signing system.

participant in this sample had been diagnosed with a secondary disability with the

exception of two students with a visual impairment. These students required assessments

to be administered in large print. A little over half the sample (51%) was white; the

remaining 50% included students of Latino/a, black, Asian, biracial, or other ethnic

backgrounds. The use of hearing amplification (hereinafter refer to as amplification)

varied widely, with the majority of participants using some type of amplification, either

hearing aids, cochlear implants, or both. However, a sizeable minority (n=14; 34.15%) of

students did not use any amplification.

Table 1: Demographic statistics for sample participants (n=41)

Demographic data for students in the sample		
Gender	Female	24 (59%)
	Male	17 (41%)
Grade	6th	8 (20%)
	7th	5 (12%)
	8th	6 (15%)
	9th	5 (12%)
	10th	1 (2%)
	11th	8 (20%)
	12th	8 (20%)
Parent Hearing Status	Hearing	36 (88%)
	Deaf	5 (12%)
Ethnicity	White	21 (51%)
	Latino/a	10 (24%)
	Black	2 (5%)
	Asian	3 (7%)
	Biracial	3 (7%)
	Other	1 (2%)
	Not Reported	1 (2%)
Amplification Use	Hearing aid(s)	19 (46%)
	Cochlear implant(s)	8 (20%)
	No amplification used	14 (34%)

Socio-Demographic Variables

I collected several pieces of socio-demographic data on participants. Due to the

small sample size, I coded these socio-demographic variables as dichotomous in order to

preserve as much power as possible in the final statistical models. To start, I collected

basic demographic information such as gender (coded as female=1, male=0), school level

(high school=1, middle school=0), and race/ethnicity (white=1, non-white=0). Due to the

small sample size and the relative few participants who would be in each race/ethnicity

category, I chose to code race/ethnicity as a dichotomous variable. In addition, I collected

demographic information that was specific to students who are DHH. These variables

included amplification use (amplification=1, no amplification=0), and whether their

parents were hearing or deaf (hearing=1, deaf=0).

Measures

Each school site provided data from standardized reading comprehension

assessments for all participants. I used these scores as the outcome variable. In addition, I

administered two assessments to all participants: one assessment of academic English

proficiency, and one assessment of word reading fluency. A team of researchers at

Boston University administered the assessment of ASL proficiency. I will describe these

assessments in further detail below.

Reading Comprehension

The outcome measure for this analysis addressed the reading comprehension

skills of these students. Across the three sites, the schools employed two assessments of

reading comprehension. Sites 1 and 2 used the *Stanford Achievement Tests, Hearing*

Impaired, which is a version of the Stanford Achievement Tests that has been normed

with DHH students (*SAT-HI*; Harcourt Educational Measurement, 1996). The *SAT-HI*

was designed for use with DHH students ranging from kindergarten through high school.

This assessment presents students with a variety of passages to read independently

followed by multiple-choice questions. These passages were primarily fiction, but also

included some advertisements, letters, and informational passages, primarily passages in

which students learn facts about animals. Instead of the rather than the *SAT-HI*, site 3

used *Measures of Academic Progress* (*MAP*; Northwest Evaluation Association, 2014)

testing to assess their students' reading comprehension. In order to complete analysis

with a common outcome measure for all participants, I converted scores on the *MAP*

assessment to scores on the SAT-HI via a grade-equivalent-based linking procedure.

First, I converted the MAP scale scores to grade equivalent scores, following the MAP

scoring guidelines. Next, I assume that grade equivalent scores on the MAP are

equivalent to grade equivalent scores on the SAT-HI. Under this assumption, I can use

the SAT-HI scoring tables to find the SAT-HI scale score that corresponds to the MAP

(and, equivalently, SAT-HI) grade equivalent[8]. The scaled scores from the *SAT-HI* that

corresponded to the MAP grade equivalents were the ultimate outcome measure for the

six students with MAP scores in this study. Scaled scores are preferred over grade

equivalents for research studies because of their statistical properties (Kolen & Brennan,

2014).

Test of Silent Word Reading Fluency

The *Test of Silent Word Reading Fluency* (*TOSWRF*; Mather, Hammill, Allen &

Roberts, 2004) was used because it measures the ability to quickly and accurately

recognize printed words without requiring the student to read orally, which may be

challenging or inappropriate for students who use signed rather than spoken language. To

complete the TOSWRF, students read a series of words printed with no spaces between

them (e.g., *onmygo*). Over a span of three minutes, students draw a line between as many

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[8]Available score conversion tables map all possible scale scores to grade equivalents, but not all possible grade equivalents to scale scores. I use the Primary 3 conversion table, which happens to have most of the 6 grade equivalents available to map to scale scores. I interpolate linearly when the exact grade equivalent is not available.

word boundaries as they are able (e.g., *on/my/go*). Fluency is reported as the raw score (which equates to the total number of words correctly identified in a three-minute time frame) and served as a control predictor in the linear regression models.

American Sign Language Assessment Instrument

The *ASLAI,* currently in development at Boston University by Dr. Hoffmeister and colleagues, assesses DHH students' ASL proficiency in a wide developmental span (ages 4 to 18). This innovative research-based assessment is designed to measure ASL proficiency through the following subtests: ASL Analogies, ASL Antonyms, ASL Synonyms, ASL Plurals, ASL Rare Vocabulary, ASL Syntax, and Vocabulary in Sentences. The assessment is computer-based and given entirely electronically. All subtests are presented as multiple-choice questions. Please see Appendix A for a more detailed description of the subtests.

Although the *ASLAI* has both receptive and expressive subtests, due to limitations in both access and time, I used only receptive scores. As the measure of ASL proficiency, I used a total receptive ASLAI score computed as the mean of average subtest scores on the receptive ASLAI. I determined that using an unweighted mean score, rather than raw score, of the receptive ASLAI subtests as the measure of ASL proficiency was appropriate after testing the unidimensionality of the set of subtests through a Principal Components Analysis. This analysis will be discussed further in Chapter 3 (Results).

Core Academic Language Skills Instrument

I measured academic English proficiency using the *Core Academic Language Skills Instrument (CALS-I),* which was developed by Uccelli and colleagues at the Harvard Graduate School of Education for use with English speaking students enrolled in

grades 4 through 8 (Uccelli, Barr, Dobbs, Galloway, Meneses, & Sánchez, 2014; Uccelli, Phillips Galloway, Barr, Meneses, & Dobbs, 2015). The purpose of this assessment is to examine students' ability to understand and produce language forms and structures that are typically present in academic English texts yet not frequent in colloquial conversations (Uccelli et al., 2014; Uccelli et al., 2015). This group-administered paper and pencil assessment lasts approximately 45 minutes. Guided by preliminary pilot work, the CALS-I form used in this study was an adaptation for DHH students of the CALS-I Form 1, which is divided into nine tasks: Connecting Ideas, Tracking Themes, Organizing Texts, Breaking Words, Identifying Definitions, and Understanding Responses. Two subtests of the original CALS-I, Comprehending Sentences and Writing Definitions, were excluded from this study. I discuss the reasoning for this decision further below in the description of the pilot testing. The tasks vary in response type from multiple-choice, to ordering sentences, to constructed response. The highest overall raw score achievable for the DHH-adapted CALS-I was 59, however, scores are analyzed using mean scores rather than raw scores. Please see Appendix A for a description of each of the tasks and the skills measured.

The authors of the *CALS-I* have found robust reliability (.82 according to split half reliability), and strong predictive and content validity (Uccelli, Barr, Dobbs, Galloway, Meneses, & Sánchez, 2014). The assessment developers report robust evidence of the CALS-I unidimensionality They also conducted linear regression analysis and found that even after controlling for reading fluency, CALS-I scores significantly predicted reading comprehension (as measured by a state-wide test or a standardized assessment) in hearing

4th- to 8th-grade students (Uccelli et al., 2014; Uccelli, Phillips Galloway, Barr, Meneses, & Dobbs, 2015).

Average percent correct across the seven included subtests on the CALS-I served as a question predictor for the present analysis. I conducted my own Principal Components Analysis (PCA) to examine whether the prior findings on the unidimensionality of this assessment would hold with the DHH population and the specific DHH-adjusted CALS-I form administered. This analysis will be explored further in Chapter 3 (Results). A small number of accommodations --guided by prior research-- were made when using this assessment with DHH students. I will discuss these accommodations in further detail below.

Pilot Testing

Before collecting the data for this study, I conducted a pilot test of the *CALS-I* with twelve high school students who attended a signing, total communication program for the DHH in a public high school in the northeast United States. Teachers described this program as using both ASL and English for instructional purposes. The goal of the pilot testing was to estimate whether the *CALS-I* was appropriate to use with this population and to determine necessary testing modifications for this study. Prior to participating in the pilot, I asked the teachers at the school to review the assessment to ensure that it was suitable for DHH students. Two teachers reported that the content and vocabulary within this assessment were appropriate for use with this population. I administered the assessment to students as a whole group, but encouraged them to ask questions if they did not understand either the task instructions or the content of the items. I also briefly interviewed a subgroup of students individually after they

participated in the assessment to determine the appropriateness of the instructions and format and to detect any other possible barrier or unintended influence towards completing the assessment, such as whether there were unknown vocabulary items that would inappropriately influence the performance on specific items or tasks.

Through the pilot testing, I determined that the Comprehending Sentences subtests would be removed from the assessment. This subtest measures skill in complex syntax by providing oral sentences that students need to match with a corresponding picture. The reliance on oral communication made this subtest inaccessible for most of the students due to their hearing loss. Once pilot testing was completed, I also decided that the Definitions Writing task (subtest 9) would not be used in this analysis, as the current rubric used for scoring the writing was not appropriate given the limited expressive vocabulary and grammatical fluency in English for these students. I administered and scored all other subtests in accordance with CALS-I standard procedures and used mean scores across subtests on each question predictor assessment in the present analysis.

CALS-I Accommodations

A small number of testing accommodations were made in accordance with research-based standard practices in deaf education. Most of the research that focuses on the literacy performance of DHH children has been conducted using assessments that were not designed specifically for this population (Morere, 2012) out of sheer necessity. Researchers and educators have used assessments designed for hearing children with DHH students with appropriate accommodations, such as interpreting test directions into ASL, additional time, out of grade level testing, or printed rather than orally delivered

directions (Cawthon, 2011; Qi & Mitchell, 2011). The precedent set by this literature on the appropriate accommodations for use with this population was important in the planning and implementation stages of this work. The following research-based accommodations were used during the administration of the *CALS-I* and *TOSWRF*: Interpreting directions into ASL, additional time, and out of grade level testing[9].

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[9] In other words, the CALS-I Form 1 which is administered for hearing students in grades 4 to 6 was used for middle and high school students in this DHH sample.

Chapter 3: Results

This dissertation study sought to determine whether ASL proficiency, and academic English proficiency contributed to reading comprehension skills among secondary DHH students. In order to test for such relationships, students in three schools for the deaf in the Western and Northeastern United States were assessed using the *Core Academic Language Skills Instrument* (*CALS-I;* Uccelli et al., 2015), American Sign Language Assessment Instrument (*ASLAI*; Hoffmeister et al., in preparation), and standardized assessments of reading comprehension that had been already administered by the schools. I also administered the *Test of Silent Word Reading Fluency (TOSWRF;* Mather, Hammill, Allen & Roberts, 2004) to control for word reading fluency. With these assessment results, I began with a Principal Components Analysis of the *CALS-I* and the *ASLAI* to examine the underlying unidimensionality of each assessment separately. After establishing that the measures were sufficiently unidimensional, I created a correlation matrix of key variables, to better understand the relationships between each of the variables. Finally, I conducted linear regression analyses to investigate which variables were predictive of reading comprehension among DHH students.

Principal Components Analysis

I conducted Principal Components Analyses (PCA) to examine the internal structure of both the *CALS-I* (Uccelli et al., 2015) and the *ASLAI* (Hoffmeister et al., in development). This investigation is particularly important given that both assessments are still in development, and their dimensionality is unknown for this particular population. This study represents the first attempt at using and analyzing the *CALS-I* to measure

academic English proficiency in a population of DHH students. Although I have item-level response data for the *CALS-I,* I only have subtest-level response data for the *ASLAI.* I use a straightforward Cronbach's alpha internal consistency measure as my estimate of reliability. Most of my subsequent reliability and dimensionality analyses are at the subtest level, for consistency across both tests.

First, I performed two Principal Components Analyses using average subtest scores on the *CALS-I* and the *ASLAI* to evaluate the unidimensionality or potential multi-dimentionality these assessment scores. As noted above, item-level information was not available for the *ASLAI.* Figure 5 is a scree plot of the eigenvalues of the *CALS-I* PCA, and Table 2 shows overall PCA results at the subtest level.

*Figure 5:* Scree plot of eigenvalues after PCA of the *CALS-I.*
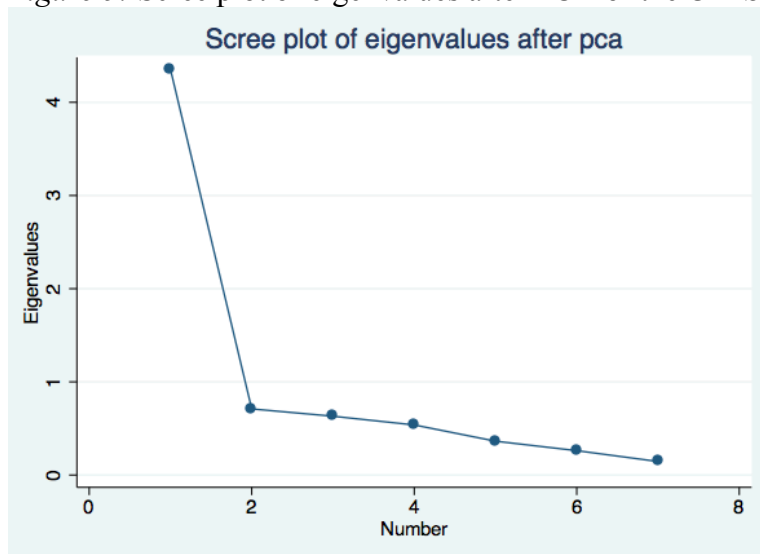
All of the *CALS-I* task-specific scores loaded positively onto a first principal component, which explained a high percentage (62%) of the variation (see Tables 2 and 3 for PCA results).

With only one eigenvalue greater than one and a first eigenvector with similar values across each of the *CALS-I* subtests, I proceeded assuming that the *CALS-I* is

sufficiently unidimensional for this population– that is, one principal component accounts

for most of the variation in scores (see Figure 5). Because the eigenvector values are

roughly equal, I will simply use the unweighted average of *CALS-I* scores as a key

question predictor, rather than individual subtests or weighted composites. I also

conducted item-level reliability analyses and item-level PCA for the *CALS-I*, where item-

level data were available. Item-level reliability estimates were similar to subtest-level

reliability estimates and are not shown. Item-level PCA showed more

multidimensionality, but these supplementary analyses do not change the overall

conclusion that average *CALS-I* scores are sufficiently precise and unidimensional at the

subtest level.

The PCA conducted with the *ASLAI* yielded similar results. Initially, there were

two potentially substantial dimensions indicated by the scree plot, displayed in Figure 6.

Figure 6: Scree plot of eigenvalues after PCA of the *ASLAI*.
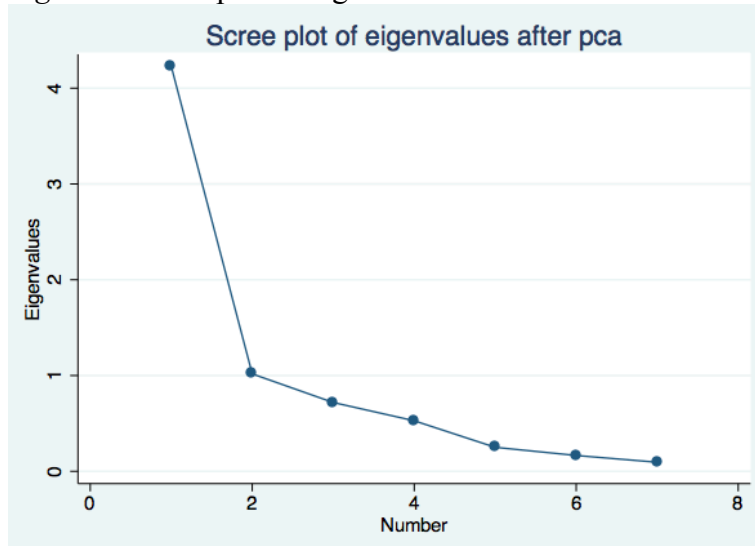
While there is one principal component with an eigenvalue of 3.82, a second component

has an eigenvalue of just over 1.0. Further exploration of the eigenvectors revealed that

the dominant contributor to this second composite was a single subtest, ASL Syntax.

The ASL Syntax subtest of the *ASLAI* displayed numerous data anomalies. This subtest had an average score of only 11% correct and a maximum score of under 50% (44). Additionally, almost half the students received a score of zero on this subtest. As noted above, the Syntax subtest has the heaviest weight in the 2nd principal component, and the eigenvector value for ASL Syntax is substantially lower in magnitude than the other subtests in the first principal component. These results suggest that the Syntax subtest is acting as a nuisance dimension in the *ASLAI*, so I conducted a PCA with the ASL Syntax subtest removed from the data.

Figure 7: Scree plot of eigenvalues after PCA of the *ASLAI*, with ASL Syntax subtest dropped.
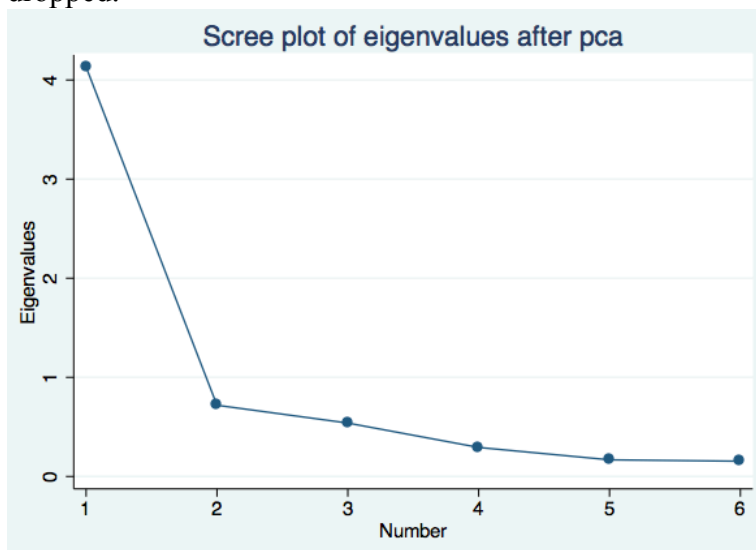
Once the ASL Syntax subtest was dropped, there was only one eigenvalue greater than one with a high percentage (75%) of the variation explained.

Table 2: PCA Results for the CALS-I, the ASLAI, and the ASLAI without syntax (n=41)

	Number of Subtests	Number of Items*	Subtest-Level Reliability	Proportion of Subtest Variance Accounted for by the First Principal Component 1
CALS-I	7	59	0.89	0.62
ASLAI	7	-	0.89	0.64
ASLAI without Syntax	6	-	0.90	0.75

*Number of items were not available for the ASLAI.

Table 3: PCA Loadings for the CALS-I, the ASLAI, and the ASLAI without syntax (n=41)

CALS-I Subtests	Eigenvector for the first principal component of CALS-I	ASLAI Subtests	Eigenvector for the first principal component of ASLAI with syntax	Eigenvector for the first principal component of ASLAI without syntax
Connecting Ideas	0.41	Analogies	0.39	0.40
Tracking Themes	0.42	Antonyms	0.39	0.41
Organizing Ideas	0.40	Plurals	0.33	0.33
Breaking Words	0.43	Syntax	0.17	
Identifying Definitions	0.35	Synonyms	0.42	0.44
Sure or Unsure?	0.36	Difficult Vocabulary	0.43	0.44
Understanding Responses	0.37	Vocabulary in Sentences	0.43	0.42

Given the results of this PCA, with only one eigenvalue greater than one, I proceeded under the assumption that the remaining subtests of the ASLAI were sufficiently unidimensional – that is, one principal component accounts for the majority of the variation in scores. In addition, because the loadings of the remaining subtests on the first principal component were similar, I use an unweighted average of the remaining *ASLAI* subtests as the composite score for *ASLAI*.

In sum, the two sets of PCA results support the use of the unweighted mean of the average subtest scores on the *CALS-I* and *ASLAI* (excluding the ASL Syntax subtest and the *CALS-I* comprehending sentences and writing definitions subtests for substantive

reasons, as discussed in the Pilot Testing subsection of Chapter 2) in subsequent regression models.

Summary Statistics

Table 4 displays the summary statistics of each variable, including the mean, standard deviation, minimum and maximum scores. Reading comprehension was measured with two instruments: the *SAT-HI* and the *MAP* assessment. In this study, most students (n=35) were assessed in reading comprehension using the same measure, the *SAT-HI.* However, a small number at site 3 (n=6) took the *MAP* assessment in lieu of the *SAT-HI.* Their scores were linked to the SAT-HI scale as described in Chapter 2.

All demographic and DHH variables are reported as dichotomous variables, with amplification reported as either use of amplification (hearing aids or cochlear implants, coded as 1) or no amplification (coded as 0), ethnicity reported as either white (1) or non-white (0), and grade level reported as either enrolled in high school (1) or not enrolled in high school (enrolled in middle school; 0). The means of these variables are therefore interpretable as proportions. Word reading fluency was reported as the raw score of number of words correctly identified. Two students were unable to complete the word reading fluency assessment due to their visual impairment.

Table 4: Summary statistics of demographic, control, predictor, and outcome variables.

Variable	Observations	Mean	Standard Deviation	Mean School 1 (n=16)	Mean School 2 (n=19)	Mean School 3 (n=6)
High School	41	0.54	0.50	0.44	0.63	0.5
Female	41	0.58	0.50	0.56	0.53	0.83
White	41	0.51	0.51	0.63	0.37	0.67
Hearing Parents	41	0.88	0.33	0.88	0.95	0.67
Amplification	41	0.66	0.48	0.44	0.89	0.50
Reading Fluency (raw scores)	39	48.33	26.10	59	41	42.67
CALS-I (average subtest percent-correct)	41	43.59	22.20	49.36	39.53	41.05
ASLAI (average subtest percent-correct)	41	63.12	19.29	72.5	58.16	58.83
SAT-HI (Scaled Scores)	35	605.57	53.03	625.56	588.74	-
MAP Scaled Scores*	6	187.33	29.85	-	-	183.57
MAP scores converted to SAT-HI scaled scores	6	592.33	63.85	-	-	592.33
SAT-HI Scaled Scores with linked MAP scores	41	603.63	54.06	625.56	588.74	592.33

*MAP scaled scores are RIT scores before conversion to the SAT-HI scale.

From this table, we can see that our population consisted of a fairly even number of students spread across middle and high school. Slightly more students were female (58%), and approximately half of the sample identified as white. A majority of the students came from homes with hearing parents (88%) which is reflective of a typical DHH population, where it is estimated that 10% of children who are DHH are born into homes with deaf parents (Shantie & Hoffmeister, 2000). In the word reading fluency test, participants identified a mean of 48.33 words correctly. In the CALS-I, participants earned an average percent correct score of 43.59. Students earned an average score of 63.12% (SD=19.29 range: 32-94%).

Overall reading comprehension scores on the *SAT-HI* for sites one and two averaged at a scaled score of 605.57 (approximately 3rd grade level, which is roughly equivalent to national level data for the reading performance of middle and high school DHH students). Scaled scores on the *SAT-HI* can range from 300 (approximately the pre-kindergarten level) to 900 (post high-school level). This sample mean score decreased by

fewer than two points with the addition of the six students from site three whose *MAP* scores were linked to *SAT-HI* scaled scores via grade level equivalencies (603.63; approximately 3rd grade level). Although *SAT-HI*-converted scores for the six students at site 3 are slightly lower on average than the scores for students at the other two sites (mean for site 3: 592.33 [grade level 2.6]; mean for sites 1 & 2: 605.57 [grade level 3.1]), these scores do not exceed the maximum or dip lower than the minimum for students at the first two sites. I will proceed using the *SAT-HI* scores with linked *MAP* scores as the reading comprehension outcome measure, accounting for all 41 students.

Pairwise relationships between socio-demographic factors, DHH factors, word reading fluency, ASL proficiency, academic English proficiency, and reading comprehension (RQ1)

The next step in this analysis was to conduct bivariate correlation analysis to examine the relationships between outcome, predictor, and control variables in order to address the first sub-question of this study: What are the pairwise relationships between socio-demographic factors, DHH factors, word reading fluency, ASL proficiency, academic English proficiency, and reading comprehension? I hypothesized that ASL proficiency, reading fluency, and academic English proficiency would be positively correlated with reading comprehension. This hypothesis was based on prior research both with DHH (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Easterbrooks & Huston, 2008; Herman, Ormel & Knoors, 2010; Strong & Prinz, 1997; Schirmer, Schaffer, Therrien & Schirmer, 2012) and hearing children (Chenhansa & Schleppegrell, 1998; Kelley, Lesaux, Kieffer & Faller, 2010; Kieffer & Lesaux, 2012; Lesaux, Kieffer, Faller, & Kelley 2010; National Reading Panel, 2000; Snow, Lawrence & White, 2009;

Townsend, Filippini, Collins & Biancarosa, 2012; Uccelli et al., 2013: Uccelli et al.,

2015) that found such relationships.

In order to investigate the correlations between pairs of variables, I created a

correlation matrix, pooling students from all three school sites, and using the linked

scaled scores on the *SAT-HI* that were obtained for the students who took the *MAP*

assessment. Reading comprehension scores are also presented for the 35 students who

took the *SAT-HI* directly as a check on these score conversions. Please see Table 5 for the

correlation matrix, and Figures 8 and 9 for scatterplot of the two key question predictor

assessments against the outcome measure of reading comprehension.

Table 5: Correlation matrix with scores from all sites (n=41)

	Hearing Parents	White	Female	Amp	High School	Fluency	ASLAI Mean	CALS-I Mean	SAT-HI with linked MAP scores	SAT-HI sites 1 and 2 only (n=35)
Hearing Parents	1									
White	-0.37* (0.02)	1								
Female	-0.01 (0.95)	-0.03 (0.86)	1							
Amp	0.36* (0.02)	-0.19 (0.24)	-0.19 (0.24)	1						
High School	0.10 (0.53)	-0.03 (0.87)	-0.09 (0.59)	0.36* (0.02)	1					
Fluency	-0.03 (0.84)	0.29+ (0.07)	0.17 (0.26)	0.08 (0.61)	0.43** (.006)	1				
ASLAI Mean	-0.24 (0.13)	0.32* (0.04)	0.22 (0.18)	-0.15 (0.35)	0.28† (0.08)	0.61*** (0.00)	1			
CALS-I Mean	-0.24 (0.12)	0.12 (0.47)	0.10 (0.54)	-0.07 (0.66)	-0.08 (0.63)	0.57*** (0.0002)	0.37* (0.02)	1		
SAT-HI with linked MAP scores	-0.33* (0.03)	0.45** (0.003)	0.19 (0.22)	-0.25 (0.12)	0.09 (0.57)	0.56*** (0.0002)	0.71*** (0.00)	0.37* (0.02)	1	
SAT-HI sites 1 and 2 only (n=35)	-0.19 (0.28)	0.48** (0.004)	0.24 (0.16)	-0.19 (0.30)	0.10 (0.56)	0.56*** (0.0006)	0.71*** (0.00)	0.26 (0.13)	1	1

† p<.10, * p<.05, **p<.01, ***p<.001

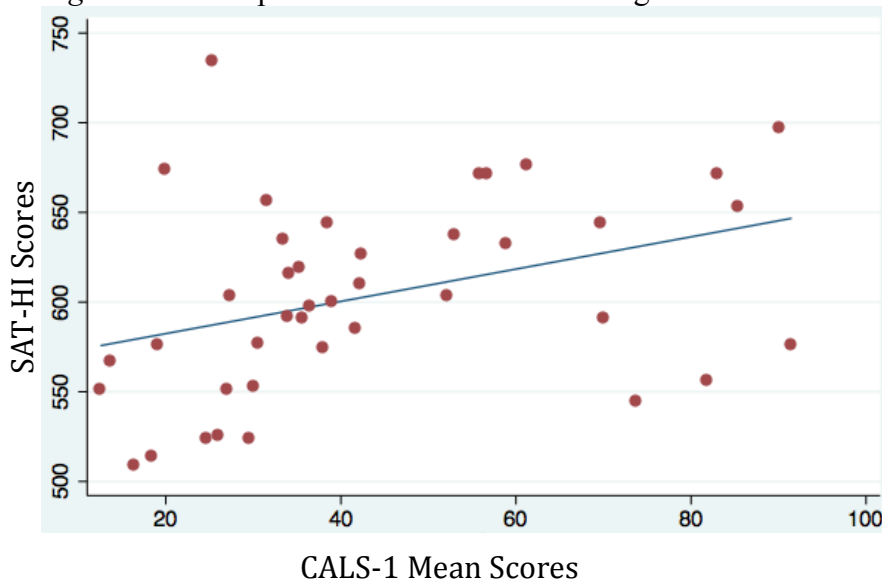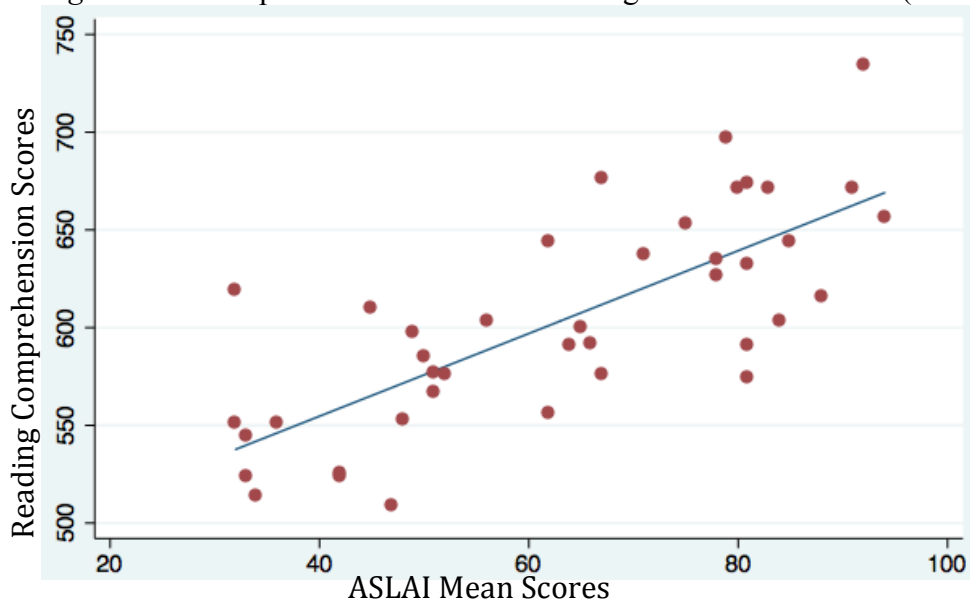*Figure 8*: Scatterplot of *CALS-I* mean scores against *SAT-HI* scores (n=41)

CALS-1 Mean Scores

Figure 9: Scatterplot of *ASLAI* mean scores against *SAT-HI* scores (n=41)

ASLAI Mean Scores

There were several statistically significant correlations between the variables.

Here I will highlight the correlations between question and outcome predictors, as these

are the most relevant to the theoretical model in this study.

CALS-I displayed positive correlations with the other three assessments. As

hypothesized, a positive, albeit low-to-moderate, relationship between *CALS-I* and

reading comprehension was identified for both the *SAT-HI* and the *SAT-HI* with linked *MAP*. It is interesting that *SAT-HI* scores on their own are not correlated with *CALS-I* scores. It has been noted in the past that different reading comprehension assessments tap into different cognitive processes (Cutting & Scarborough, 2006), which may have been the case in this instance. I also found a statistically significant, positive correlation --also moderate in magnitude-- between *ASLAI* scores and the *CALS-I*. Finally, a positive but non-significant relationship between *CALS-I* scores and word reading fluency was found.

The *ASLAI* exhibited moderate, positive, statistically significant correlations with both reading comprehension variables, also confirming the initial hypothesis. Likewise, there was a strong positive correlation between *ASLAI* scores and word reading fluency scores. As noted above, a statistically significant moderate correlation between the *ASLAI* and *CALS-I* scores was found as well as a positive relationship between *ASLAI* scores and race/ethnicity, indicating that white students tended to have higher *ASLAI* scores.

Academic English proficiency as a potential predictor of DHH students' reading comprehension, (RQ2)

In order to answer the second through fourth research questions of this study, I fit linear regression models to examine the relationships between the control, question, and outcome variables. The first models explored the *CALS-I* and *ASLAI* separately in order to better understand the unique variance in reading comprehension outcomes contributed by each assessment scores individually before including them in a single model to address the final research question. These results will be presented first with the *CALS-I*.

CALS-I as predictor of reading comprehension

Table 6 presents the results of the *CALS-I* linear regression models. Using an incremental approach, I explored first the relationships between the outcome measure and socio-demographic variables in Model 1. In Model 2, I added scores from the *CALS-I,* and then, in Model 3, I removed non-significant socio-demographic and DHH factors. Finally, word reading fluency was added in Model 4. Word reading fluency was added after the other covariates for the purpose of understanding the role of socio-demographic and key question predictors in the reading comprehension individually before controlling for word reading fluency. Model 4 revealed that the key question predictor of *CALS-I* scores was not significant when controlling for word reading fluency (p=0.08). This model obtained an R^2 value of 0.46, indicating that 46% of the variance in reading comprehension scores was explained.

Table 6: *CALS-I* predicting reading comprehension (n=41)

Model Number	M1	M2	M3	M4
Hearing Parents	-25.18	-13.36		
HS	20.18	22.32		
Amplification	-17.18	-19.54		
Female	20.75	17.39		
White	40.64*	39.35*	44.62**	31.80*
CALS-I		0.72*	0.78*	0.59†
Fluency				0.82**
Intercept	593.27***	554.64***	546.72***	522.82***
R^2	0.32	0.40	0.31	0.46

† p<.10, * p<.05, **p<.01, ***p<.001

Across all models, race/ethnicity had a statistically significant association with reading comprehension scores, with students who were white more likely to achieve higher reading comprehension scores than non-white students. No other demographic or DHH variables were significant. Scores on the *CALS-I* were also positively and statistically significantly predictive of reading comprehension scores initially (see Models

1-3), although this relationship was weaker when word reading fluency was included (see Model 4, $p < 0.10$). I also found word reading fluency to be a significant predictor of reading comprehension. While a relationship seemed to exist between academic English proficiency and reading comprehension, this relationship is not significant when word reading fluency is accounted for.

It stands to reason that students who have different levels of reading fluency will have different abilities to read and comprehend both academic and non-academic texts. In a study of hearing children, reading fluency was found to explained unique variance in reading comprehension scores, indicating that more fluent students were more able to understand what they have read than less fluent students (Kim, Petscher & Foorman, 2015). Due to the existing relationship between reading comprehension and word reading fluency established in previous research (Jenkins, Fuchs, den Broek, Espin & Deno, 2003), it was additionally possible that an interaction existed between *CALS-I* scores and word reading fluency – that is, for students who have varying levels of word reading fluency, *CALS-I* scores may a different relationship with reading comprehension scores. This possibility is explored in the model presented below. Table 7 presents the results of the linear regression models including an interaction term between *CALS-I* scores and word reading fluency.

Table 7: *CALS-I* predicting reading comprehension with interaction between *CALS-I* and fluency (n=41)

Model Number	M5
White	30.93*
Fluency	1.75**
CALS-I	1.90**
CALS-I x Fluency	-0.02*
Intercept	474.56***
R^2	0.52

† p<.10, * p<.05, **p<.01, ***p<.001

In model 5, the interaction term of *CALS-I* scores and fluency was statistically significant (p=0.03). These results indicate that for DHH students with high levels of fluency, CALS-I scores have less of an impact on their reading comprehension than for those students with low levels of fluency. Accounting for the interaction between CALS-I and fluency, racial gaps still persist on average for this population. Please see Figure 9 for visual representations of the interaction effects of English decoding and proficiency on reading comprehension for students who identified as white. Non-white students' scores were identical, but 31 points lower than scores in Figure 10.

Figure 10: Differential effects of word reading fluency and *CALS-I* scores on reading comprehension among white participants from model 5. Each line represents a quartile of academic English comprehension; CAL=21 represents the first quartile, or 25th %ile, CALS=43 represents the second quartile, or 50th %ile, and CALS=64 represents the 3rd quartile, or 75%ile. (n=41).
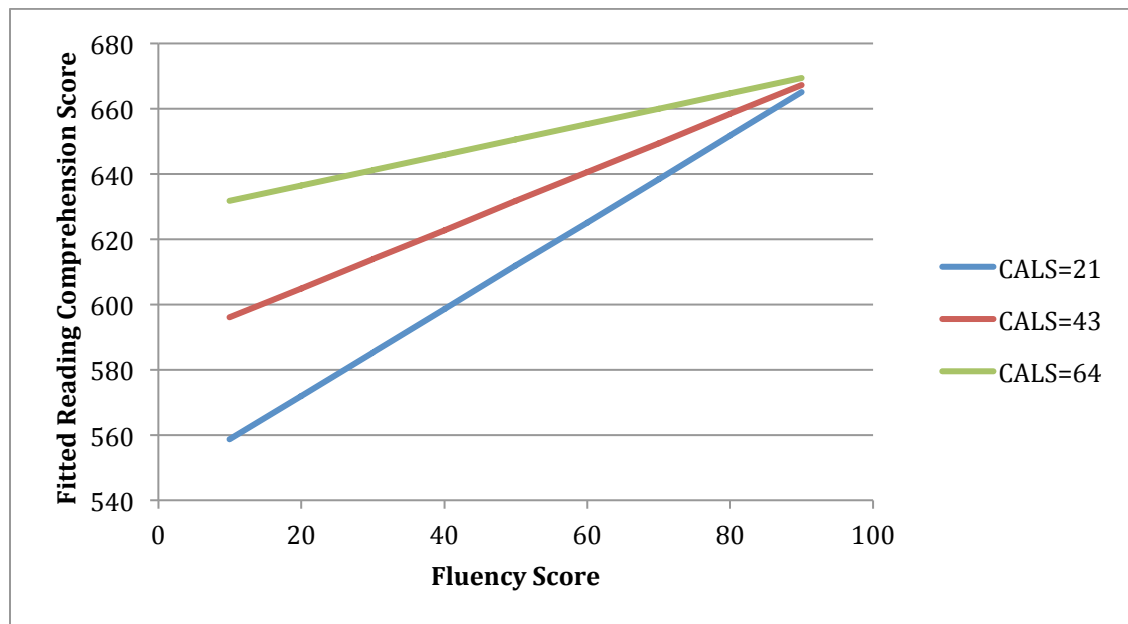
This graph displays the final model for the *CALS-I's* relationship with reading comprehension that I chose (Model 5). In this graph, we see the interaction between word reading fluency and *CALS-I* scores at the first (21), second (43) and third (64) quartiles. It

seems that at higher levels of decoding, the impact of language proficiency is weaker –
and vice versa – at higher levels of language proficiency, the impact of decoding is
weaker. This finding of an interaction effect differs from prior studies conducted with
hearing students (Uccelli et al., 2014; Uccelli et al., 2015), though a recent study did
identify a similar interaction between decoding and language comprehension on the
outcome of reading comprehension (Proctor, Harring & Silverman, 2015). It is expected
that for bilingual/bimodal DHH readers the relationship between English decoding and
academic English proficiency will differ from that of hearing students given their
differential access to the sounds of English and ability to decode words in a traditional,
phonological manner, yet these findings suggest that more research is necessary to
illuminate this relationship. Additionally, white students on average earned higher scores
than non-white students, even when controlling for *CALS-I* scores and word reading
fluency.

ASL Proficiency as a potential predictor of DHH students' reading comprehension (RQ3)

To address the research question, does ASL proficiency predict reading
comprehension scores among secondary DHH students, when controlling for socio-
demographic factors, DHH factors, and word reading fluency, I underwent a similar
process of model building. First, I added ASLAI scores to a model with only demographic
and DHH variables with reading comprehension scores as the outcome measure. In Model
7, I retained only the significant demographic and DHH variables, and finally added word
reading fluency to the final model. Table 8 presents the results of linear regression models
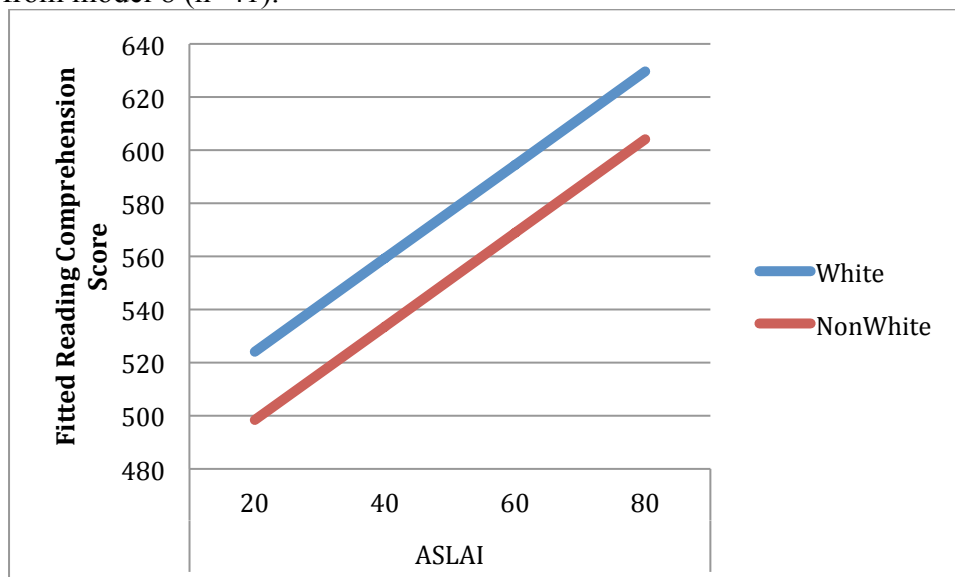with *ASLAI* scores.

Table 8: ASLAI predicting reading comprehension (n=41)

Parameter	M6	M7	M8
Hearing Parents	-11.21		
HS	-6.31		
Amplification	-6.26		
Female	4.18		
White	21.64†	25.27*	25.61*
Fluency			0.31
ASLAI	1.89***	1.90***	1.76***
Intercept	488.31***	470.49***	462.92***
R^2	0.64	0.62	0.65

† p<.10, * p<.05, **p<.01, ***p<.001

ASLAI scores remained statistically significant and similar in magnitude regardless of control variables included in the model (p<0.0001). Race/ethnicity continued to be the only demographic or DHH variable that was statistically significant (p=0.03), even when controlling for ASL proficiency. Unlike the models including *CALS-I* scores, word reading fluency was not significant, however, we include it in the model on substantive and theoretical grounds. Please see Figure 11 for a display of the relationships between *ASLAI* scores, race/ethnicity, and reading comprehension.

Figure 11: ASLAI scores predicting reading comprehension scores by race/ethnicity from model 8 (n=41).

The ASLAI scores account for more variance in reading comprehension than CALS-I as indicated by the R-squared values and anticipated by the correlation matrix. I choose Model 8 as the final model for this sub-question. These results indicate that ASL proficiency is a strong predictor of reading comprehension above and beyond the contribution of race/ethnicity and word reading fluency. Similar to the *CALS-I*, I tested for an interaction between ASL proficiency as measured by scores on the ASLAI and word reading fluency, however this interaction was not significant (p=0.64).

These initial models were built to examine the individual relationships between *CALS-I* scores and *ASLAI* scores and the outcome measure of reading comprehension, when controlling for DHH and demographic variables, as well as for word reading fluency. These initial results indicated that there was a positive relationship between *CALS-I* scores and reading comprehension that may be moderated by word reading fluency. On the other hand, scores on the *ASLAI* were predictive of reading comprehension scores but word reading fluency was not a statistically significant predictor. No significant relationship existed for an interaction between ASLAI scores and word reading fluency on the outcome measure of reading comprehension. Race/ethnicity continued to be a significant predictor of reading comprehension in the models that included the *ASLAI*.

ASL proficiency as a predictor of DHH students' reading comprehension when controlling for academic English knowledge (RQ4)

From here, I moved to building the models that address the final research question for this study: Does ASL proficiency account for unique variance in the reading

comprehension performance of middle and high school DHH students, after controlling

for English academic language proficiency, word reading fluency, and socio-

demographic (school level, age and gender) and DHH (amplification and parental hearing

status) variables? As with the models above, these are built using an incremental process.

Model 9, presented below, included all the socio-demographic variables, as well

as *CALS*-I and *ASLAI* scores. Following the same incremental process as in previous

regression models, I then removed all non-significant variables from the model. Next,

word reading fluency was added. The final step in model building was to add the

interaction term to Model 12. Please see Table 9 for the results of these models.

Table 9: CALS-I and ASLAI's prediction of reading comprehension (n=41)

Parameter	M9	M10	M11	M12
Hearing Parents	-8.51			
HS	-4.25			
Amplification	-7.54			
Female	4.10			
White	22.20†	25.30*	25.47*	25.62*
Fluency			0.29	0.82†
CALS-I	0.21	0.26	0.18	0.89
CALS-I x Fluency				-0.01
ASLAI	1.79***	1.79***	1.68***	1.63***
Intercept	482.72***	466.17***	461.30***	442.39***
R^2	0.65	0.63	0.66	0.67

† p<.10, * p<.05, **p<.01, ***p<.001

The results from this analysis identified ASL proficiency as a statistically

significant predictor of reading comprehension for this population of DHH students

(p=0.0000). Model 12 explained 67% of the variance in reading comprehension scores

among the students in this sample. Race/ethnicity was also a significant predictor of

reading comprehension (p<0.05), while word reading fluency was not statistically

significant (p=0.10). Even though I recognize that my sample lacks sufficient power

to detect these interactions (assuming they exist), I ran them as a set of exploratory

proof of concept models that might illuminate our understanding of potential

interaction effects on DHH students' reading comprehension. Please see Figure 12 for a display of the relationships found in Model 12.

Figure 12: Reading comprehension outcomes for participants with varying levels of word reading fluency at high (+1SD) levels of ASL (82) and academic English proficiency (64), and low (-1SD) of ASL (43) and academic English proficiency (21) in model 12.
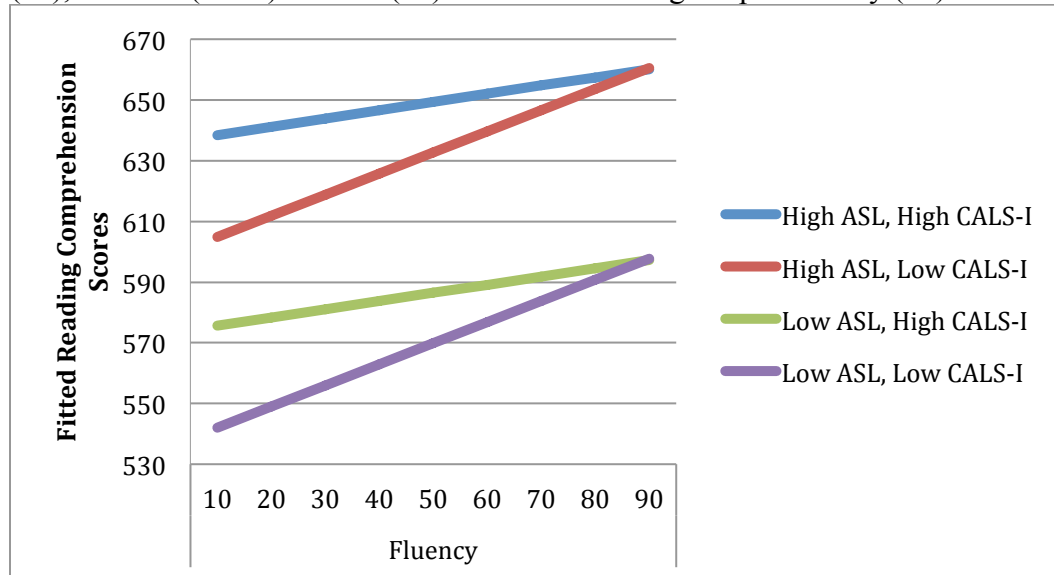
In this table, high fluency refers to a raw score of 75 and high *ASLAI* scores are the third (75th) quartile. Low fluency refers to a raw score of 25 and low *ASLAI* scores are in the first (25th) quartile. High and low ASL scores are included to demonstrate the difference in reading comprehension for students at different levels of language fluency. Although *CALS-I* scores do have some predictive utility prior to the inclusion of ASL proficiency scores, they do not retain significance once *ASLAI* scores are included. For this reason, Model 8 (see Table 7 and Figure 11) is selected as the final model. This was the most parsimonious model for predicting the reading comprehension of DHH adolescent students and had a substantial R^2 statistic. According to this model, *ASLAI* scores and race were a strong predictor of reading comprehension among DHH students. However, these results should be cautiously interpreted. Word reading fluency was not significant when academic English and the interaction term were added to earlier models

but may be as additional studies are conducted with larger sample sizes. Additionally, the

significance of academic English in prior research with hearing children (Gritter, Beers &

Knaus, 2013; Kieffer & Lesaux, 2012; Moore & Schleppegrell, 2014), as well as its

significance in models that do not include ASL proficiency (see Model 5), would suggest

that academic English may still be an important factor in the reading comprehension of

DHH students, despite their exclusion from the final model. It is possible that the current

sample size was not large enough to maintain these results in the presence of ASL

proficiency, and that a larger sample size would have yielded statistically significant

results for *CALS-I* scores and word reading fluency. It is also possible that there is not a

substantively strong relationship between *CALS-I* scores and reading comprehension in

the presence of the competing variable. Further research will be necessary to untangle

these complex relationships. I will discuss potential interpretations and the educational

significance of these results in the discussion section.

Chapter 4: Discussion and Implications

In this study I examined the relationships between academic English proficiency, American Sign Language (ASL) proficiency, and reading comprehension in secondary deaf and hard of hearing (DHH) students who attended three residential, bilingual/bimodal (ASL and English) DHH schools. The goal of the study was to identify significant predictors of reading comprehension for a population that has been shown to lag considerably behind age-expected norms in this critical literacy domain. The key question predictors examined were ASL proficiency and academic English proficiency. In addition, word reading fluency was explored as an important covariate, in conjunction with a number of socio-demographic and DHH factors.

To measure ASL proficiency, I used scores from the *American Sign Language Assessment Instrument (ASLAI,* Hoffmeister et al., in development). This researcher-designed assessment was administered to participating students by a team from Boston University led by Dr. Hoffmeister. To assess students' academic English proficiency, I administered the innovative research-based *Core Academic Language Skill Instrument* designed to assess high-utility language skills hypothesized to support reading comprehension across content areas in hearing students *(CALS-I;* Uccelli, Barr, Dobbs, Galloway, Meneses, & Sánchez, 2014; Uccelli, Phillips Galloway, Barr, Meneses, & Dobbs, 2015). Through a pilot study, I modified the *CALS-I* to assess DHH students and administered it following research-guided accommodations proven to be appropriate for this population. In addition, in order to control for basic word-level decoding skills, I administered the *Test of Silent Word Reading Fluency (TOSWRF)* (Mather, Hammill, Allen & Roberts, 2004). The outcome variable, reading comprehension, was measured

through standardized tests of reading comprehension administered by the faculty of the three participating schools as part of their regular school assessments. Two of the schools used the *Stanford Achievement Tests, Hearing Impaired (SAT-HI;* Pearson, 2003), and the third school administered the *Measures of Academic Progress (MAP*; Northwest Education Association, 2012*).* The *MAP* scores were linked to *SAT-HI (*Pearson, 2003) scaled scores via grade equivalent scores.

A total of 41 secondary school DHH students (19 middle school students and 22 high school students) participated in this study. Demographic information on each of the 41 participants was collected. Principal Components Analyses (PCA) were performed on the *CALS-I* and *ASLAI* independently. PCA results revealed that each of the key question predictor measures was sufficiently unidimensional in nature. Based on these results, I took the unweighted mean of the average subtests as the score for both the *CALS-I* and the *ASLAI.* Next, I created a correlation matrix to explore the relationships between all of the study variables. The final step was to build linear regression models to better understand which skills best predicted DHH participants' reading comprehension.

Initially, two sets of independent regression models were built to examine the impact of each key question predictor – *CALS-I* and *ASLAI* scores – on reading comprehension, above and beyond the contribution of word reading fluency, socio-demographic and DHH factors. In the first set of linear regression models, results revealed a statistically significant relationship between *CALS-I* scores and reading comprehension scores, above and beyond the contribution of race/ethnicity (the only significant predictor among the socio-demographic and DHH variables tested). In other words, even after controlling for the influence of ethnicity, students with higher *CALS-I*

scores tended to have higher reading comprehension scores. Also, a statistically significant interaction between the *CALS-I* scores and word reading fluency was detected. This interaction revealed that academic English proficiency had a differential effect on reading comprehension at different levels of word reading fluency. At higher levels of academic English proficiency, the impact of decoding was weaker. This could be due to the opacity of English orthography, wherein higher levels of decoding are more intertwined with higher levels of language proficiency. This is in contrast to more transparent orthographies, wherein once decoding is mastered, language proficiency is more important for reading comprehension. In the second set of linear regression models, *ASLAI* scores were found to be a strong predictor of reading comprehension above and beyond the contribution of race/ethnicity and word reading fluency. The findings revealed that, on average, students with higher *ASLAI* scores tended to have higher reading comprehension scores even after controlling for word reading fluency and race/ethnicity. Somewhat surprisingly, word reading fluency did not achieve significance in these models once ASLAI scores were included as predictor.

The final set of regression models investigated the contribution of *ASLAI* scores and *CALS-I* scores when both were added to the same model. In these models, neither *CALS-I* scores, nor the *CALS-I* and word reading fluency interaction term, achieved significance as predictors of reading comprehension scores. The only consistent and significant predictor in these models was *ASLAI* with word reading fluency approaching significance, once the interaction term of CALS-I/word reading fluency was added. The major findings from this analysis will be summarized and interpreted in the sections that

follow. Finally, the limitations of the current study, as well as the implications for theory and instruction will be discussed.

Main Findings

Substantive individual differences in language and reading skills: The role of socio-demographic characteristics

First of all, even though these findings align with prior research in that the participating students had on average a low performance on assessments of reading comprehension, they also revealed considerable individual variability on a number of factors. These factors included socio-demographic characteristics as well as language and literacy skills, including word reading fluency and reading comprehension, academic English proficiency, ASL proficiency, and participants' language histories. In light of this variability, it may be necessary for the field of deaf education to move beyond considering DHH students as a single, or even dichotomous, group. The great variability found in each of the above factors belies a far more nuanced, complex analysis on the range of factors that may exert great influence over DHH readers' literacy development. Race/ethnicity, age of onset of language exposure, reading fluency, academic English proficiency, ASL proficiency all seem to play a role in the reading comprehension of this population. It is likely that the reading comprehension and development of DHH students will be more satisfactorily explained through multiple or much more complex regression models than the ones permitted by the design of the current study. The significant differences in DHH students' socio-demographic factors, DDH factors, ASL and English language proficiency call for a more nuanced analysis of distinct subgroups that pays particular attention to DHH students' language use and history. Future research should

take into account these essential factors and examine their impact in more depth when considering how to characterize the predictors of reading comprehension, as well as the developmental literacy trajectories of DHH students.

In the present study, two socio-demographic characteristics emerged as significantly correlated with reading comprehension. First, there was a statistically significant correlation between having hearing parents and reading comprehension scores, such that participants with deaf parents tended to outperform participants with hearing parents. This result is consistent with prior findings that DHH children of deaf parents tend to outperform DHH children of hearing parents in English language knowledge (Charrow & Fletcher, 1974). Deaf adults are likely to already be proficient in ASL and thus serve as fluent language models for their DHH children from birth. It is possible that this early onset of language exposure (i.e., ASL) is what truly accounts for the significance of this variable. Many DHH students who have proficient signing skills are also most often students whose parents are deaf and consequently proficient in ASL. In this study, we did not collect data on parents' ASL proficiency or on students' onset of ASL or English language exposure, yet to further understand the impact of the language environment on DHH students' reading comprehension. These will be important variables to consider in future analyses with larger samples.

The second socio-demographic variable in this study that correlated with reading comprehension was race/ethnicity. Students self-identified as white tended to outperform students self-identified as non-white in reading comprehension, in ASL proficiency, and in academic English proficiency. This finding is similar to other studies, which have found differential performance between U.S. white and non-white hearing students in

reading and other academic areas (for example, see Rojas-LeBouef & Slate, 2012). Additionally, previous research specifically on students with disabilities identified a significant difference in achievement between white and non-white students with disabilities, as well as for those of higher versus lower socio-economic status (Wei, Lenz & Blackorby, 2013), such that students with disabilities who were white tended to outperform students with disabilities who were non-white. In this study, the mean reading comprehension score on the *SAT-HI* for white students was 627.33 (approximately 4.4 grade level equivalent), while the mean reading comprehension score for non-white students was 578.75 (approximately 2.3 grade level equivalent). However, it is important to note that in this sample a large majority of white students reported having a family member in the home who was able to sign (89%) while less than half of non-white students reported having such a family member (43%). Furthermore, 100% of the children who reported having deaf parents in this sample were white. It may be that the race/ethnicity variable is actually capturing the presence of a fluent user of ASL in the home. It is possible that the assignment of students to the dichotomous white/non-white categories is also capturing or partially capturing the effects of socio-economic status (SES), though I am unable to determine whether this is the case with the current data. As in our society race/ethnicity tends to be highly conflated with SES, future research must collect more detailed information on SES and ethnicity. Furthermore, more specific data on DHH students' language environment and language history will be essential as categorical socio-demographic indicators, such as SES or ethnicity, tend to be only poor proxies for the language learning opportunities and literacy practices that students have experienced (Uccelli et al., 2015).

Academic English proficiency and its relationship with reading comprehension

Previous research has found that academic English proficiency is an important predictor of reading comprehension among hearing children (Gritter, Beers & Knaus, 2013; Kieffer & Lesaux, 2012; Moore & Schleppegrell, 2014; Uccelli et al., 2014; Uccelli et al., 2015). The hypothesis I explored in this study was that such a relationship would also be found among DHH middle and high school students. In this sample, academic English proficiency was found to be a statistically significant predictor of reading comprehension when added to regression models that did not include ASL proficiency. This suggests that academic English proficiency may play an important role in the reading comprehension of DHH students. Yet, this construct must be explored further to fully understand its nuanced relationship with reading comprehension in this population. Furthermore, an interaction between word reading fluency and *CALS-I* scores was detected. This interaction revealed that the impact of academic English proficiency on reading comprehension was stronger for students at the lower levels of word reading fluency.   Please, see Figures 9 and 10 in Chapter 3 (Results). Given that DHH students' exposure to English may be primarily through print, especially for the population of students included in this study, this intriguing relationship between word reading fluency and academic English proficiency calls for more research that will illuminate the extent to which these two constructs and their interaction depart from the findings advanced in the context of hearing students' reading development. As was seen in the interaction term between *CALS-I* scores and word reading fluency, the impact of decoding was weaker at higher levels of language proficiency. Proctor and colleagues (2015), in a study of bilingual English/Spanish students, found no interaction between decoding and language

proficiency for Spanish, a more transparent language, but did find an interaction between decoding and language proficiency in English, a more opaque language. In the present study an interaction term was significant between decoding/fluency and academic language proficiency. For DHH students with limited or perhaps no access to the sounds of English, the English orthography may be considered fully opaque. A new hypothesis emerges on the basis of the findings from this study, as well as those from Proctor and colleagues (2015): It might be the case that whether decoding/fluency and language proficiency interact as predictors of reading comprehension is in part dependent of the orthographic opacity of the language. In more transparent orthographies, such as Spanish, it is likely that once decoding is mastered, language proficiency becomes the key predictor of reading comprehension. In contrast, in an opaque orthography, higher levels of decoding are more intertwined with language proficiency, as decoding orthographically opaque words will be facilitated by language proficiency. This hypothesis aligns with the Lexical Quality Hypothesis, which argues that poor word representation quality, both phonologically and lexically, may hinder reading comprehension (Perfetti, 2007). More research is necessary to fully understand these complex relationships.

As in all other models, race/ethnicity was a predictor of reading comprehension alongside *CALS-I* scores, word reading fluency, and the interaction between the two. As stated above, given limitations in the data, it is unclear what the race/ethnicity variable is actually accounting for, and it may be confounded with issues of SES and home language use. These results should be interpreted with caution.

ASL Proficiency as critical predictor of reading comprehension

Theorists in the field of deaf education have hypothesized that students with a strong language base in ASL will have stronger linguistic abilities that allow them to understand and produce more advanced written English (Bailes, 2001; Cummins, 2006; DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Singleton, Morgan, DiGello, Wiles & Rivers, 2004; Strong & Prinz, 1997). In fact, research has demonstrated that ASL proficiency is a strong predictor of reading comprehension, even stronger than whether or not the student had deaf parents (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Strong & Prinz, 1997). These results can be interpreted in light of Cummins' (1979; 1981) linguistic interdependence hypothesis, i.e., that children can draw upon their knowledge of their first language (L1) to support their linguistic understanding of their second language (L2). For signing DHH students, a more advanced understanding of their first language, ASL, seems to support the development of skills in their second language, English. The additional complexity when compared to bilingual students, though, is that for DHH students English entails both a different language and a different modality of communication.

This study is unique in its use of a standardized receptive measure of ASL proficiency in the *ASLAI*. Prior research has often relied upon productive measures (Herman, Ormel & Knoors, 2010), proxies for ASL proficiency such as having deaf or hearing parents or length of ASL exposure (DeLana, Gentry & Andrews, 2007), or non-standardized receptive measures (Strong & Prinz, 1997). The regression models that explored the impact of ASL (without including *CALS-I)* on reading comprehension revealed that a stronger proficiency in ASL was predictive of higher reading comprehension scores. The only additional variable that was significant in this analysis

was race/ethnicity, such that non-white students tended to display lower reading comprehension scores than their white peers. Please see Figure 11 in Chapter 3 for a visual representation of the differential levels of ASL proficiency and their prediction of reading comprehension between white and non-white students in the current sample.

As a note of caution, it is important to note that this relationship has been tested in the present study only with students who are enrolled in schools that use ASL as instructional language. Thus, though Cummins' theory and prior research would suggest that the positive contribution of ASL to reading comprehension is likely to be significant across DHH students, the findings of this study cannot be generalized beyond the sample. It is necessary to entertain the possibility that the relationship between ASL and reading comprehension might vary according to DHH students' language of instruction. Further research will be necessary to understand the effect of ASL proficiency for subgroups of DHH students with different languages of instruction.

ASL proficiency, word reading fluency, and academic English proficiency as predictors of reading comprehension

In the exploration of all variables together, the final model revealed that when controlling for word reading fluency and academic English proficiency, *ASLAI* scores were still a strong predictor of reading comprehension among the middle and high school DHH students who participated in this study. Although previous models found a statistically significant effect of academic English proficiency and word reading fluency, neither of these variables achieved significance in the final model. For these DHH students, ASL was the strongest predictor of reading comprehension scores. Students who achieved higher scores on the *ASLAI* tended to score more highly on tests of reading

comprehension, even when controlling for word reading fluency and academic English proficiency.

This leaves the somewhat surprising circumstance of both academic English and word reading fluency failing to retain significance in models that include ASL proficiency. Extensive research has identified both word reading fluency and academic English proficiency to be important predictors of reading comprehension and other literacy skills among hearing children (Jenkins, Fuchs, den Broek, Espin & Deno, 2003; Kelley, Lesaux, Kieffer, Faller & Kelley, 2010; Gritter, Beers & Knaus, 2013; Kieffer & Lesaux, 2012; Moore & Schleppegrell, 2014; Uccelli, Dobbs & Scott, 2013). There are a number of plausible hypotheses to explain why the effects of ASL proficiency may override the influences of word reading fluency and academic English proficiency in this sample. I will explore these hypotheses in detail below.

The first hypothesis is that academic English proficiency and word reading fluency may impact reading comprehension differently in subgroups of DHH students with different language histories. It is possible that students who had early exposure to ASL, and experienced a more typical language growth trajectory than students who were exposed to ASL later in life, would be differentially impacted by word reading fluency and academic English proficiency on their reading comprehension. It is possible that earlier onset of exposure to ASL may support typical language and literacy development among this population, meaning that students who were exposed to ASL from a young age would be developmentally prepared to develop academic English abilities similarly to hearing students. This hypothesis is supported by research finding different language development trajectories for those who develop ASL as a first language early as

compared to those who develop ASL as a first language late (Mayberry, 1993; Mayberry 2007). As ASL proficiency is also strongly predictive of both literacy skills (Bailes, 2001; Cummins, 2006; DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Singleton, Morgan, DiGello, Wiles & Rivers, 2004; Strong & Prinz, 1997) and other areas such as mathematics ability (Kritzer, 2009) and psychological development (Schick, de Villiers, de Villiers & Hoffmeister, 2007), ASL proficiency may serve as a proxy measure for overall academic skills. Thus, it would seem feasible that earlier ASL exposure would support academic English language development. Unfortunately, the current study had too few participants and not enough detail about their individual language experiences to test this hypothesis. Future research should examine early and late age of onset of ASL exposure in DHH students to test for differential effects of academic English proficiency and word reading fluency on their reading comprehension.

The second hypothesis is related to the instruments used in this study. The reading comprehension tests used as the outcome measures included more narrative than expository texts. This could mean that these reading comprehension measures did not include enough expository text features of the type that would be associated with the skills measured by the *CALS-I*, thus limiting the *CALS-I's* predictive power of these reading comprehension assessments. Future research should seek to assess reading comprehension of expository texts to determine whether a stronger relationship exists between this type of reading comprehension, and the academic English features assessed by the *CALS-I*.

Related to this hypothesis, it is also possible that there are domains of academic English proficiency important for the reading comprehension of DHH students that are

not included in the *CALS-I*. The *CALS-I* was developed for use with hearing English speaking students, who typically are assumed to be fully fluent in more colloquial ways of using English. Researchers have previously hypothesized that DHH students may not be consistently exposed to more colloquial, conversational language in English, given that in signing schools for this population, teachers are charged with developing both conversational and academic language skills in the L1 (ASL) and the L2 (English) - however, since DHH students may be exposed to English primarily through print, they may not receive sufficient exposure to more colloquial linguistic forms (Mayer, 2009). DHH students may still be developing their abilities to use and understand colloquial forms of English while simultaneously being exposed to formal, academic English. The CALS-I includes a constellation of language skills that correspond to highly prevalent linguistic features in academic texts that are not frequent in colloquial conversations. Yet, there might be key domains of English proficiency that hearing students acquire through conversation, but that for DHH students are only accessible through text. Perhaps the *CALS-I* would need to be further expanded to capture a wider range of language domains relevant to the English development of secondary DHH students. Furthermore, the *ASLAI* measures vocabulary, a critical skill that is not included in the *CALS-I*. An expanded version of the *CALS-I* that includes a measure of academic vocabulary knowledge would be worth exploring.

The next hypothesis could be related to whether reading development is qualitatively different or similar for DHH and hearing children. This issue is one that has recently emerged in theoretical models of reading comprehension designed with DHH students in mind. Some researchers believe that the reading development of DHH

students is qualitatively similar to that of hearing children, but delayed (Paul & Lee, 2010). Within this model, it is argued that similar reading skills develop in parallel ways for DHH students, albeit later than such skills appear for hearing children. However, other researchers argue that models of reading that are built from what we know about the reading development of hearing children are actually insufficient for capturing the differential skills that bilingual/bimodal DHH students may need to develop in order to be successful readers (Kuntze, Golos & Enns, 2014).

In dialogue with this debate, I propose some important adaptations to a model originally tested only with hearing children. One hypothesis worth pursuing in the future is that in fact ASL proficiency, word reading fluency, and academic English proficiency might indeed all independently contribute to predict reading comprehension. Whereas the empirical evidence of this study points in this direction, this sample did not offer sufficient power to detect an effect, even if the effect was there. As Figure 13 in Chapter 3 (Results) illustrates, Model 12 reveals an upward trend for reading comprehension for higher *CALS-I* in particular for students with low word reading fluency. Although a full power analysis is beyond the scope of this dissertation, it is important to note that a sample correlation of 0.3 requires a sample size of 43 to be statistically significant. However, if the population correlation is 0.3, sampling variation will ensure that the sample correlation will be less than 0.3 approximately half the time. In order to ensure likely rejection of the null hypothesis, a much larger sample will be necessary.

Regardless, for the DHH students in this sample, academic English proficiency and word reading fluency were both significant predictors of reading comprehension when ASL proficiency was not accounted for. However, in a model that included ASL

proficiency, both of these factors failed to retain their significance. Though academic English proficiency may be an important skill for the reading comprehension of this population, it seems that language skill in ASL for many of these students was the overriding factor with the strongest predictive power over reading comprehension outcomes.

In light of these findings, I revisit and revise my initial suggestion for modifications to the Simple View of Reading (Gough & Tunmer, 1986) and the bilingual Simple View of Reading (Proctor, August, Snow, & Barr, 2010). Below, I propose a model for the continuing exploration of reading comprehension among DHH students who use ASL as their primary language.

Revisiting the Simple View of Reading

According to Gough and Tunmer (1986), the Simple View of Reading is Decoding x Language Comprehension = Reading Comprehension. Proctor and colleagues (2010) expanded upon this theoretical model, arguing that for bilingual students, Decoding x L2 Language Proficiency x L1 Reading Comprehension = L2 Reading Comprehension. That is, for bilingual students, not only decoding skills and oral language proficiency in their second language, but also reading comprehension skills in their first language, contribute to proficiency in reading comprehension in their second language.

Using the current data to construct an evidence-based reading comprehension model for bilingual/bimodal DHH students, the proposed model departs not only from the Simple View of Reading (Gough & Tunmer, 1986), but also from the Simple View of Reading for bilingual learners (Proctor et al., 2010) because DHH students are learning to

read in a second language that differs in modality from their L1. In Chapter 1 (Literature Review), I hypothesized that for adolescent DHH students who use ASL as their primary language, L2 reading comprehension could be understood following Proctor et al.'s (2010) proposal, i.e., L2 Reading Comprehension (English) = Decoding (English) x L1 Language Proficiency (ASL) x L2 Academic Language Proficiency (English). The Common Underlying Proficiency Hypothesis (Cummins, 1979) would suggest that L1 proficiency plays a role in reading comprehension, and the findings from this study suggest that this holds true for DHH students who use ASL as their L1, despite the difference in modality across L1 (ASL) and L2 (English). L1 reading comprehension is not a viable option in a reading model for DHH readers, as there is no consistently used written form of ASL. My findings revealed that although academic English proficiency was predictive of reading comprehension in a model on its own, its influence was overshadowed by that of ASL proficiency. These data would suggest the following exploratory model for predicting the reading comprehension of DHH students.

Figure 13: ASL proficiency, socio-demographic variables, and reading comprehension
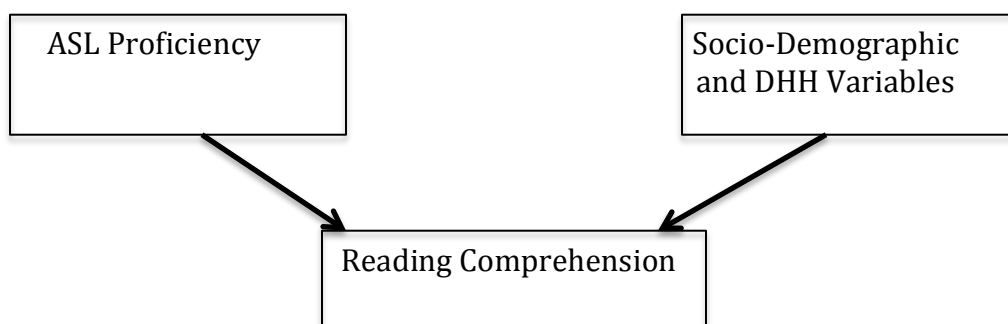
Although Model 8, which included only ASL proficiency, race/ethnicity, and word reading fluency, was the best model to predict reading comprehension with the current data, the role of academic English is still worth exploring, especially given its

significance for the prediction of reading comprehension in early models that did not include ASL proficiency. It also only stands to reason that English proficiency is an essential requirement to understand a text written in English. In light of this, I suggest the following possible theoretical model based upon the exploratory proof of concept model developed as Model 12 as a guide for future research on the reading comprehension of bilingual/bimodal (ASL/English) DHH adolescents.

Figure 14: ASL proficiency, academic English, word reading fluency, socio-demographic variables, and reading comprehension
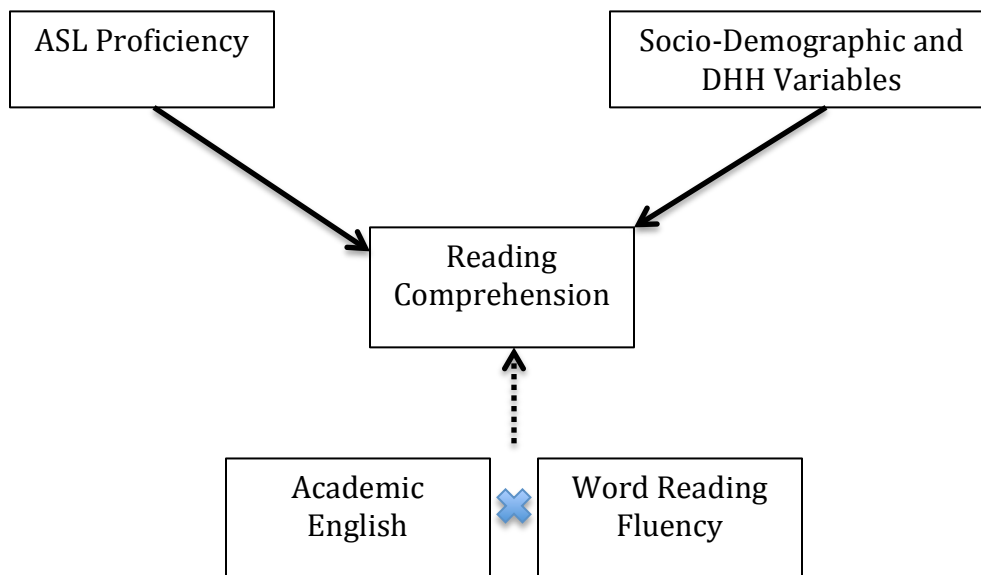
According to the results of this study, ASL proficiency has been consistently identified as the key predictor of reading comprehension. The contribution of word reading fluency and academic English proficiency was detected, yet not consistently present in all models. I have included these variables in this theoretical model due to the significant associations detected and the need to further explore the implications of these relationships in larger samples and within and across subgroups of DHH students. Further research on the precise nature of the relationship between academic English and word

reading fluency, as well as among academic English, word reading fluency, and reading comprehension for DHH students is necessary. The failure to detect a significant contribution in the more complex models built for this sample could be a result of the small number of students who participated in this study. It is possible that a larger sample size would have found a more robust relationship between academic English knowledge and reading comprehension. Future research should seek to further explore how to best operationalize academic English proficiency and its relationship to word reading fluency, as well as the role academic English plays in reading comprehension, alongside ASL proficiency, for DHH adolescents within a larger sample of participants.

Limitations

There are several limitations to this research that must be addressed. First, this study is only able to examine associations between variables; no causal claims can be made with these data. Second, this study includes a limited sample size. Because deafness is a low-incidence disability, a number of influential studies have relied upon less than ideal sample sizes that do not exceed 50 students (see for example, Berent, Kelley, Schmitz & Kenney, 2009; Luetke-Stahlman & Nielsen, 2003; Miller, Lederberg & Easterbrooks, 2013; Park, Lombartino & Ritter, 2013; Schirmer, Schaffer, Therrien & Schirmer, 2012). However, in order to understand these relationships more fully, future research should strive for larger sample sizes.

Another limitation that must be discussed includes the measures used for this study. To assess participants' ASL proficiency and academic English proficiency, the only instruments available in the field were still under development when administered to this study sample. The *ASLAI* is currently undergoing the norming process, and the

CALS-I has not been designed purposefully to measure DHH students' academic English proficiency. Thus, it is possible that besides the adaptations and accommodations used in the *CALS-I* administration, measurement error exists or that external variables not accounted for may be influencing student scores on these assessments or the construct validity for this population. However, both assessments are one of a kind in their respective fields, and provide valuable information on the performance of DHH students in ASL and academic English. Additionally, across the three school sites, two different measures of reading comprehension were used. Only one of these measures (the *SAT-HI*) has been normed on DHH children. Although the use of linked scaled scores from the *MAP* assessment to the *SAT-HI* did not change the range and mean of the outcome measure significantly, these linked scaled scores may not have perfectly corresponded to one another. Prior research has noted that popular reading comprehension assessments may be assessing different cognitive processes or skills (Cutting & Scarborough, 2006). These reading comprehension assessments also do not account for potentially unfamiliar vocabulary or low fluency levels of DHH students, and thus may be limited in their ability to accurately assess pure reading comprehension.

Due to the nature of the *CALS-I*, I was unable to use the measure of syntax that was included, as it relied upon the ability to hear spoken English. Additionally, I was not able to use the Syntax subtest of the *ASLAI* due to anomalies in the data. Thus, an important limitation of this study is the absence of measures of syntactic understanding in English and ASL. Understanding syntax is an important factor in linguistic competency, both in academic English as well as in ASL. Future research should strive to include a measure of syntactical understanding in one or both languages.

An accurate interpretation of what are the underlying factors behind the significance of the race/ethnicity variable in this study is not possible given the limited available data on DHH students' SES, age of onset of language exposure and language histories more broadly. It is unclear whether the effects of race/ethnicity on the outcome measure were a product of other factors, such as SES or factors related to the language history of participants, such as the presence of a signing family member. Future research should seek to collect data not only on race/ethnicity but also on students' and school SES, as well as more precise data on students' language histories

Finally, this research was conducted at bilingual/bimodal schools for the deaf that use ASL as their primary instructional language. This is a sub-population of DHH students enrolled in K-12 education, DHH students in other schools or programs may signed English, cued speech, or speech only as their preferred communication methods. As discussed previously, these findings revealed considerable variability even within this subgroup of the DHH population. It is important, however, to highlight that these findings cannot be generalized to be applicable to students enrolled in different types of deaf education settings.

Despite these limitations, this study contributes to our understanding of the relationship between ASL proficiency, academic English proficiency, and reading comprehension among ASL/English bilingual and bimodal DHH students. Further research in this area may contribute to a better understanding of how to support DHH students so that they might exceed the fourth grade glass ceiling for reading comprehension found in prior research. Future research should strive not only for larger sample sizes, but perhaps expand to include students enrolled in post-secondary

education who may have stronger reading and language comprehension skills in both their L1 and their L2.

Implications

The field of deaf education has long endeavored to identify skills that will support the reading comprehension of DHH students. Recent researchers have found a number of areas that seem important for the fluent reading and understanding of English for this population of students. These include fluent proficiency in ASL alongside the more mainstream practices of using reading comprehension strategies and improving reading fluency, which were first identified as important for reading comprehension among hearing children (Akamatsu, 1988; Andrews & Mason, 1991; Easterbrooks & Huston, 2008; Ewold, Israelite & Dodds, 1992; Schirmer & Bond, 1990; Schirmer, Schaffer, Therrien & Schirmer, 2012; Strassman, 1992; Strong & Prinz, 1997; Walker, Munro & Rickards, 1998).

The results from this study confirm a strong, positive relationship between ASL proficiency and reading comprehension, which has been found in previous research in the field (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Strong & Prinz, 1997). It seems to be true that students with more advanced linguistic competency in their L1, ASL, tend to be more skilled comprehenders of text in their L2, English. Through developing L1 competency, DHH students may be in a better position to develop their L2 reading comprehension skills. Many schools for the deaf across the country have established ASL departments, staffed with native signers who provide instruction for DHH students in their native language, much in the same way that native English speaking hearing students are enrolled in English Language Arts class for

the entirety of their educational careers. Such departments and classes may be useful in supporting the development of language skill in ASL. This study and prior studies suggest a link between ASL proficiency and a number of other skills (DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Kritzer, 2007; Schick, De Villiers, De Villiers & Hoffmeister, 2007; Strong & Prinz, 1997), which would suggest that such classes may be beneficial.

Academic English language skills are understudied in this population. Researchers have argued theoretically that a lack of cognitive academic language proficiency (CALP) may be responsible for the depressed reading comprehension scores of these students (Mayer, 2009), and anecdotal data suggest that intensive instruction in academic language in both ASL and English may contribute to improved academic skills, including reading comprehension, among signing DHH students (Zernovoj, 2005). However, this is the first study to empirically examine the relationship between academic language proficiency in English and reading comprehension among DHH students. Although further research with a larger sample size is necessary to fully understand the strength of this relationship and its possible interaction with other skills, initial findings suggest that this relationship is an important one with this population. It is possible that the participants in this sample struggled with academic English due to lack of or limited exposure to this linguistic register, both auditorily and through print. Findings from this study showed significant associations between academic English proficiency and reading comprehension.

This warrants further exploration of whether classroom attention to the academic English of texts might support middle and high school students as they develop the

higher-order reading comprehension skills necessary for secondary and post-secondary education. The *CALS-I* has potential for application for informing the instruction of DHH students beyond its impact on reading comprehension. Academic English skills are necessary for access to post-secondary education, which is in turn a gatekeeper for certain types of careers. The *CALS-I* assessment may be useful in guiding instruction in skills that have been shown to be important for academic success. The *CALS* construct and the *CALS-I* offer at least a starting point in the effort to delineate the universe of language skills relevant to the reading comprehension for DHH students. Certainly, though, this construct needs to be further investigated and most likely expanded to include the set of language-for-reading skills that are particularly key for this population.

Although the relationship between academic English proficiency and reading comprehension should be interpreted with caution, these results suggest that academic English skills may be important for the reading comprehension of DHH students. Jean Chall and colleagues' (1990) research on the fourth grade slump indicates that the transition to reading more academic texts often begins around the fourth grade level. Although in this sample, the relationship between *CALS-I* proficiency and reading comprehension was not found to be as strong as the relationship between *ASLAI* scores and reading comprehension, such a relationship does indeed seem to exist. It seems that, despite the stronger role played by L1 language proficiency for DHH students, academic English proficiency is still a potential predictor of reading comprehension among adolescents. It seems to be the case that, for this population, L1 (ASL) proficiency, race/ethnicity, and decoding all have an important impact on reading comprehension skills.

Conclusion

In this dissertation, I examined the relationships between academic English proficiency, American Sign Language (ASL) proficiency, and reading comprehension, controlling for word reading fluency. I measured academic English proficiency using the *Core Academic Language Skills Instrument* (*CALS-I;* Uccelli et al., 2015). I measured ASL proficiency using the *American Sign Language Assessment Instrument* (*ASLAI*; Hoffmeister et al., in development), and I measured reading comprehension using the *Stanford Achievement Test – Hearing Impaired* (*SAT-HI;* Harcourt Educational Measurement, 1996) and the *Measures of Academic Progress* (*MAP;* NWEA, 2012). Word reading fluency was assessed using the *Test of Silent Word Reading Fluency* (*TOSWRF*; Mather, Hammill, Allen & Roberts, 2004). I also controlled for socio-demographic variables, such as grade level, gender, race/ethnicity, and deaf and hard of hearing (DHH) variables, such as amplification use and whether the participant has deaf or hearing parents.

Main Findings

Academic English proficiency, as measured by the *CALS-I,* had an impact on reading comprehension outcomes in models that did not include ASL proficiency. Furthermore, an interaction term between word reading fluency and *CALS-I* scores achieved significance in the same early models. It appeared that *CALS-I* scores had differential impacts on reading comprehension at varying levels of reading fluency. For the lower the proficiency in academic English, the higher the impact of word reading fluency in this sample. This suggests that academic English proficiency is a promising construct in need of further exploration with larger sample sizes and more detailed

information on the language backgrounds of individual participants. It is somewhat puzzling that both word reading fluency and academic English proficiency became non-significant once ASL proficiency was added into the model, as both skillsets have been found to be important predictors of hearing students' reading comprehension (Jenkins, Fuchs, den Broek, Espin & Deno, 2003; Kelley, Lesaux, Kieffer & Faller, 2010; Kieffer & Lesaux, 2012; Uccelli, Dobbs & Scott, 2013). Perhaps for DHH students, the development of their L1, ASL, holds more crucial importance for reading comprehension such that it overshadows the effects of word reading fluency and academic English.

The main finding of this study is the critical role that ASL proficiency plays in the reading comprehension of DHH students at the middle and high school level. Scores on the *ASLAI* were the strongest predictors of reading comprehension scores within this sample, and was the only question predictor that retained significance in the final model. This finding replicates prior research that found ASL proficiency to be a statistically significant predictor of reading comprehension among DHH students who use ASL (Cummins, 2006; DeLana, Gentry & Andrews, 2007; Herman, Ormel & Knoors, 2010; Strong & Prinz, 1997).

Race/ethnicity also appeared to play an important role in reading comprehension scores, with white students consistently outperforming non-white students. This was the only socio-demographic variable to achieve significance, and its predictive power for reading comprehension scores was maintained across all models. However, I did not have sufficient information to explore whether the race/ethnicity variable was conflated with additional factors such as the presence of a signing family member, having deaf parents,

or socio-economic status (SES). Future research should disentangle the impact of these factors, which are conflated in the current race/ethnicity variable.

Research in deaf education has struggled to identify causes for the glass ceiling effect many DHH students experience at the fourth grade level in reading comprehension (Allen, 1986; Strong & Prinz, 1997). Prior research has questioned whether academic English skills may be in part responsible for these depressed reading scores (Mayer, 2009; Zernojov, 2005). This study is the first to assess the academic English proficiency of DHH students and examine this skillset's relationship with reading comprehension. Given the current findings, it certainly seems possible that academic English is an area of challenge for DHH students, and that this may in fact contribute to reading comprehension skills. This skill, alongside language proficiency in ASL, the students' L1, both appear to individually be important predictors of reading comprehension scores within the present sample. It is our responsibility as educators to provide DHH students with the best possible education to allow them to succeed in secondary and post-secondary school. Part of such an education may include providing students with a solid language foundation in their L1 (most likely ASL for those students who are enrolled in bilingual educational programs) as well as systematically teaching students about the features of academic English and how to use them. Perhaps through such instruction that more precisely identifies the language skills in need of further development, we might aid DHH students in breaking through the fourth grade glass ceiling.

Appendix A: Description of included subtests (adapted from Uccelli et al., 2015)
CALS-I

CALS-I task	Skill measured	Sample item	Source(s) for research-based design
Unpacking complex words	Skill in decomposing morphologically derived words	• The student reads a set of morphologically derived words followed by an incomplete sentence, and students are asked to complete the sentence by extracting the base from the derived word (e.g., "ethnicity. The city had many ___ groups."). • Additional examples of morphologically complex words tested: *invasion*, *durability*, *contribution*	This task consists of a subset of items from Kieffer's morphological decomposition task, which is an adaptation of Carlisle's (2000) measure (Kieffer & Lesaux, 2007, 2008, 2010). Responses were scored as correct or incorrect following Kieffer's scoring protocol. Correct responses included phonetically logical versions of the word (e.g., *popular* and *populer* were scored as correct).
Connecting ideas logically	Skills in understanding school-relevant connectives and discourse markers	• Students are asked to select the missing marker from among four options (e.g., "Kim was sick; ___ she stayed home and did not go to school." Options: *otherwise*, *yet*, *in contrast*, *as a result*"). • Students are asked to select the best continuation for an	The development of this task was informed by prior researcher-designed assessments (Uccelli, 2011; Sanchez & Garcia, 2009). The selection of frequent academic markers at different levels of difficulty was informed by databases of students' word knowledge, (Dale & O'Rourke, 1981) word

		incomplete sentence from among three options (e.g., "Most teachers think that homework is important. <u>On the other hand</u>…"). • Additional examples of markers tested: *consequently*, *nevertheless*, *in conclusion*	frequency in school texts (Zeno et al., 1995), and academic lexical bundles derived from corpus analyses (Biber, Conrad & Cortes, 20014; Cortes, 2004, 2006; Simpson-Vlach & Ellis, 2010).
Tracking participants and themes	Skill in anaphoric resolution	• Students are asked to match the underlined text with its antecedent by selecting among three options (e.g., "China resisted the move for change. In 1989 students protested to demand changes, but the army opposed these changes. Troops were sent to stop <u>the movement</u>."). • Additional passages were similar in length and included concrete and abstract referents.	The design of this task was informed by a prior researcher-designed assessment used in studies of middle school students' reading comprehension (Sanchez & Garcia, 2009).
Organizing argumentative texts	Skill in argumentative text organization	• Students are asked to order six fragments of a brief essay introduced by conventional markers (e.g., *in my opinion*, *one reason*, *in conclusion*) in order to display a conventional	The design of this task was informed by the story anagram task used by Stein and Glenn (1978) and Cain and Oakhill (2006) in their reading comprehension studies.

		argumentative text structure.	
Recognizing academic register	Skill in identifying academic definitions	• Students are asked to select the most academic definition from a set of three definitions of the same familiar word. • Sample word definitions used for this task: umbrella, clown, debate	This task was inspired by research on children's register awareness. However, the specific design was not modeled after any prior research (Anderson, 1996; Gibbons, 1998).

ASLAI

ASLAI task	Skill measured	Sample item
Recognizing synonyms in ASL	The student sees a still image of a person signing a word and then four still photos of other signs. The examinee must choose the ASL word whose meaning most closely resembles the original ASL word.	Target: BOILING-MAD Synonym options: FIRE; BREAK-DOWN; ANGRY; SCARE
Recognizing antonyms in ASL	The student sees a still image of a person signing a word, and then four still photos of other signs. The examinee must choose the ASL word whose meaning most closely resembles the opposite of the original ASL word.	No sample available
Recognizing correct pluralization in ASL	The student is shown a picture with a set of objects. The student then sees four videos of a signer describing a set of objects using ASL plural classifier markers. The examinee must then choose the video that correctly describes the picture.	Set of objects: Stacked soda cans Plural options: Various handshapes describing stacked objects.
Knowledge of rare ASL vocabulary	Students are shown a video in which a signer articulates a relatively uncommon word in ASL. These uncommon words may be academic in nature, or may simply be words that are used less frequently in everyday conversation. Students watch four videos of signers using the word; in three videos it is used incorrectly and in one it is used correctly. Students must choose	No sample available

	which video used the word correctly.	
Ability to understand and recognize analogies in ASL	Students are presented with a recording of a signer using an analogy in ASL and must select the picture that best represents the meaning of the analogy.	No sample available
Ability to recognize the meaning of vocabulary items as they are expressed within a given context	The students are presented with a video of a signer using a word within a context and must choose a picture that best represents the meaning of the word.	No sample available

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