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ASL text comprehension in deaf children

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ASL TEXT COMPREHENSION IN DEAF CHILDREN

by

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DEDICATION

I dedicate this dissertation to my family for making me who I am, my husband for his endless patience and support, and, most importantly, all Deaf children.

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ASL TEXT COMPREHENSION IN DEAF CHILDREN

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ABSTRACT

Successful text comprehension relies on a range of skills, including decoding ability, vocabulary knowledge, syntactic knowledge, literal comprehension, and the ability to draw inferences. Most of our knowledge about text comprehension comes from written texts. In contrast, an ASL text is a composition of a literary work narrated in ASL. Although ASL texts have been available for some time, they have only more recently become used as an educational tool to facilitate ASL language development in Deaf children. Currently, we have a limited understanding of the interplay of different language-comprehension skills required to achieve text comprehension in ASL. In addition, while there are assessments of ASL vocabulary and syntax, there is no standardized assessment that examines the role of ASL text in the development of Deaf children's ASL comprehension skills. Consequently, we do not know whether the skills required for ASL text comprehension are parallel to those required for written text comprehension. This dissertation addresses these gaps in current research. First, I describe the development of an ASL Text Comprehension Task (ASL-CMP), a psychometrically sound assessment instrument to measure Deaf children's comprehension of ASL text. I report on the development of the task, and present a psychometric analysis establishing the reliability and validity of the new task. Second, I

administered the task to a large group of Deaf students (n = 356) between the ages of 8 and 18 years. Performance on the assessment was compared to performance on a range of ASL vocabulary tasks from the American Sign Language Assessment Instrument (ASLAI) to determine the relationships between different ASL skills. Analysis revealed significant positive relationships between ASL vocabulary, ASL syntax, and ASL text comprehension. Finally, I investigated the relationship between performance on the ASL text comprehension task and an English reading assessment among a subgroup of participants. Analysis revealed a significant positive relationship between ASL text comprehension and English literacy. I discuss the theoretical and educational implications of these findings.

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CHAPTER ONE

INTRODUCTION

Symbiosis of Language & Information

Language is essential in all aspects of life. It allows us to communicate, connect, and collaborate to create a series of meaningful experiences. Language allows us to acquire, create, and share old and new information. It is for this very reason early exposure to language is so important. Language exposure typically begins at a very young age, meaning children at a tender age can engage with information, develop thoughts, and develop an understanding of the world. Information exchanged through family interaction, educational-related events, and peer interaction inside and outside of the classroom enable children not only to absorb new knowledge but also to develop and hone their language skills and strategies to comprehend information in a range of forms. Because information can come in a wide range of forms, it is so important to examine and understand the process involved in how children use language to comprehend different forms of information. This dissertation is centered on comprehension of "text" in sign language as a source of information and as a meaning-making process for Deaf children.

Text as a Source of Information

Text comprehension is important for a wide range of reasons, such as sharing previous knowledge, creating new knowledge, or expanding pre-existing knowledge. Text is heavily used in classroom and everyday lives to communicate ideas, beliefs, and our understandings of the world; thus, it should be no surprise to see a strong correlation

between text-comprehension skills and academic and career success (Duke & Pearson, 2002). Skills and strategies involved in text comprehension are integral for deeper engagement with more complex information, which in turn support academic and career advancement, thus improving quality of life.

Text comprehension is, however, not a simple phenomenon; it is a complex process that embodies an interplay of different cognitive abilities (e.g. attention and memory) and language skills (e.g. decoding, vocabulary knowledge, grammar abilities, literal comprehension, and inferential skills) (Kintsch, 1988; Silva & Cain, 2015). Without adequate expertise of said abilities or skills, an accurate interpretation and understanding of the text is less likely. Given that text comprehension relies on a constellation of different skills, understanding the different cognitive abilities and language skills that contribute to the development of text-comprehension is essential. The ability to comprehend texts in academic contexts is pivotal, since without the ability to comprehend texts, children will likely struggle to master the knowledge and skills that are required of them when they leave high school.

Further, text comprehension is especially important in bilingual contexts. According to Cummins's linguistic interdependence hypothesis (1979, 2006), the skills in one's first language (L1) are critical for the development of skills in one's second language (L2) (see Figure 1). That is, the skills from L1 transfer and support the development of L2. For bilingual children, acquiring and demonstrating adequate text-comprehension skills in their L1 is essential for the development of comprehension skills in an L2. This notion is supported by several studies (van Gelderen, Schoonen, de

Glopper, Hulstijn, Simis, Snellings, & Stevenson, 2004; Sparks, Patton, Ganschow, & Humbach, 2012) including evidence from spoken bilingual children who speak French and English (Megherbi, Seigneuric, & Ehrlich, 2006), Spanish and English (Proctor, Carlo, August, & Snow, 2006), and Chinese and English (Tong, McBride, Shu, & Ho, 2018). These studies have found evidence of transfer between comprehension skills in L1 facilitating the development of comprehension skills in L2 (Cummins, 2006; Sparks, Patton, Ganschow, & Humbach, 2012; van Gelderen et al., 2004; Srisang, 2017).

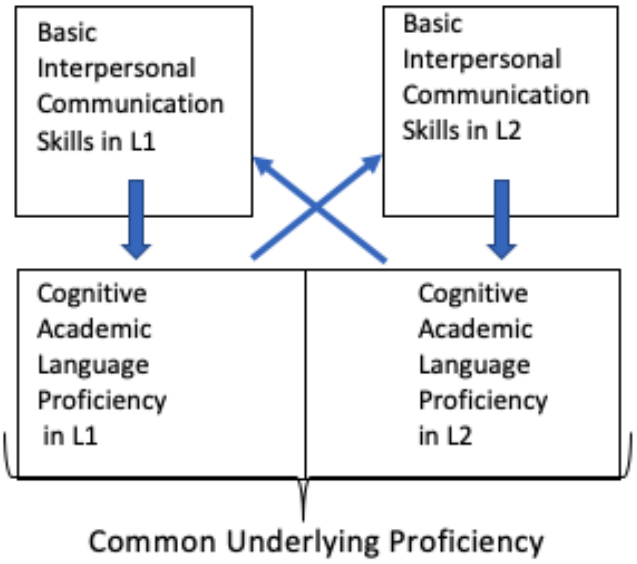

Figure 1. Linguistic Interdependence Hypothesis Model Posited by Cummins (2006).

The concept of linguistic interdependence has also been applied to the language development of Deaf children learning ASL and English. Several studies have revealed not only how language skills in ASL, such as vocabulary knowledge and syntax ability, are important indicators of ASL proficiency (Henner, 2016; Henner, Caldwell-Harris,

Novogrodsky, & Hoffmeister, 2016; Scott & Hoffmeister, 2016), but also have shown a positive relationship between ASL and English (Hoffmeister, 2000; Hoffmeister & Caldwell-Harris, 2014; Hrastinski & Wilbur, 2016; Scott & Hoffmeister, 2016; Strong & Prinz, 1997). These studies have revealed positive effects of ASL proficiency and negative effects of later exposure to ASL on Deaf children's achievement, suggesting the importance of ASL for access to both communication and language development in Deaf children (Hall, 2017; Henner, 2017). Moreover, both ASL and English are comprised of specific linguistic sub-skills, such as phonological awareness, vocabulary knowledge, syntax ability, and reasoning ability, and comprehension relies on these skills (Valli, Lucas, Mulrooney, & Rankin, 2011). Therefore, it would be beneficial to examine the interplay of different language skills within ASL to obtain a better understanding of comprehension skills in ASL in Deaf children. This, however, has proven to be challenging because it was not until recently technology has finally caught up with ASL.

Text as a Source of Information

With the advancement of digital technologies, the definition of "text" has been expanded (Lankshear & Knobel, 2013) to include ASL productions. With better technological resources, such as smartphones, video editing software, internet, and computers with a higher capacity to store and upload videos, documenting and storing textual information in ASL has become less difficult. This ability enables an increase in the production and reception of ASL text – a published recording of literary work narrated in ASL – especially in academic contexts. More Deaf children are being exposed to and taught through ASL texts in addition to English texts (Christie & Wilkins, 2007;

Snoddon, 2010). The advancement in digitized technologies means that teachers have been employing ASL texts, such as ASL poems and ASL stories, both fictional and expository, not only to promote Deaf children's world knowledge, but to also teach and develop different language skills, such as vocabulary, syntax, and reasoning in ASL.

Disparity in Comprehension of ASL in Current Literature

There is a sizable literature on Deaf children's English reading comprehension skills (Luckner, Seabald, Cooney, & Munir, 2006), there is a limited theoretical understanding of text comprehension in ASL. It is critical to broaden our understanding of language comprehension skills beyond written text and to explore the potential of different text mediums towards the development of comprehension skills. This is particularly important given a plethora of previous studies showing that Deaf children are struggling to master English-text comprehension (Allen, 1986; Hrastinski & Wilbur, 2016; Hoffman & Wang, 2010; Kyle & Cain, 2015; Scott, 2015; Traxler, 2000;). Furthermore, Luckner et al. (2006) and Harris, Terlektsi, and Kyle (2017) conclude that Deaf children have not been making significant improvement in the development of text-comprehension skills in English. This problem continues to persist, and many Deaf children struggle to develop adequate literacy skills such that they leave high school reading at an average of eight- to twelve-year-old age equivalence (Harris, Terlektsi, and Kyle, 2017).

Although a large population of Deaf children perform below average in English text comprehension, there is a small portion of Deaf children who do achieve well in this area (Hoffmeister & Caldwell-Harris, 2014; Hrastinski & Wilbur, 2016). Findings

suggest that successful English reading comprehension among Deaf children is tied to proficiency in ASL (Goldin-Meadow & Mayberry, 2001; Hoffmeister, 2000; Hrastinski & Wilbur, 2016; Prinz & Strong, 1998, Wilbur, 2000). However, current understanding of ASL proficiency is limited in that available ASL assessments tend to target lower-level comprehension skills, such as ASL vocabulary and syntax (Haug, 2008). Assessments that examine higher-level language comprehension in ASL are limited (Luckner et al., 2006; Haug, 2008). In fact, there is no normed assessment that tests Deaf children's comprehension of ASL text (Haug, 2008; Luckner, Seabald, Cooney, Young, & Muir, 2006). Thus, we do not have a full understanding of how Deaf children process and comprehend ASL texts, nor do we know which lower-level language comprehension skills are important for text comprehension in either ASL or English, nor how text comprehension transfers from one language to the other (Hogan, Bridges, Justice, & Cain, 2011; Sparks et al., 2012; Srisang, 2017).

Drawing from current literature and the current landscape of Deaf children's reading-comprehension skills in English, one possible explanation for Deaf children's poor English reading comprehension is their lack of strong foundation in ASL as a first language. Many Deaf children are born to hearing parents, and thus do not have early exposure to ASL (Hrastiski & Wilbur, 2016). Moreover, many schools do not offer formal education in ASL (Hall, 2017).

In this dissertation, I examine the theory that English literacy in Deaf students might be mediated by higher-level comprehension skills in ASL. If Deaf students whose first language is ASL have gaps in their ASL comprehension, these gaps could impede

their access to English as an L2. Currently, we do not have any measure that estimates Deaf children's higher-level comprehension skills when perceiving ASL text. The first part of this dissertation addresses this gap by developing a reliable and valid assessment of ASL text comprehension, the ASL Text Comprehension task (ASL-CMP). This tool is then used to evaluate ASL comprehension skills and their relationships with other ASL skills. Specifically, I examine the relationship between ASL vocabulary, ASL syntax, and comprehension of ASL text. I also investigate the relationship between ASL comprehension and written English comprehension among a group of Deaf students with varying language backgrounds.

Statement of problem

In spoken language, language-comprehension skills are comprised of many sub-skills, including vocabulary knowledge, syntax knowledge, literal comprehension, and inferential comprehension. In some studies, including this dissertation, these skills can be divided into two levels: lower-level and higher-level. Vocabulary and syntax are considered bottom-up word-level skills, in contrast to higher-level skills that require meaning processing (Landi, 2010). Furthermore, higher-level comprehension relies on vocabulary knowledge and syntactic abilities (Hogan et al., 2011; Silva & Cain, 2015). Each skill in both levels is a significant predictor of text comprehension (Ellenman, 2017; Silva & Cain, 2015; Proctor, August, Snow, & Barr, 2010; Sparks et al., 2012). Without a full understanding of the text, including information not stated explicitly, children will not only struggle to master text coherence, but may also construct an inaccurate interpretation of the text (Oakhill & Cain, 2012; Kendeou, van den Broek, White &

Lynch, 2007). Highlighting the relationships between lower-level and higher-level skills is particularly essential for providing appropriate instruction and intervention to poor comprehenders.

However, to date, there is no available research-based instrument that probes both literal and inferential comprehension in ASL; therefore, we do not know if the aforementioned relationship between lower-level and higher-level skills, as suggested in spoken-language studies such as English, French, or Spanish, are also important for optimal comprehension in ASL (Proctor et al., 2010; van Gelderen, Schoonen, Stoel, Glopper, & Hulstijn, 2007). Furthermore, we do not know if literal- and inferential-comprehension skills in ASL can support the development of reading-comprehension skills in English, as demonstrated in other studies on L1 comprehension and L2 comprehension (Proctor et al., 2010; Sparks et al., 2012, Srisang, 2017)

Purpose of the study

The primary purpose of this dissertation is twofold: 1. to develop a measure of ASL literal and inferential comprehension in Deaf children, and 2. to investigate the role of higher-level ASL comprehension skills in ASL and English knowledge as shown in figure 2. In spoken language, for which there is a wide range of assessment instruments, there is strong evidence that mastering different language-comprehension skills is important for reading comprehension. Additionally, there is strong evidence of positive correlations between L1 comprehension and L2 comprehension (Proctor, et al., 2010; Sparks et al., 2012). However, this statement cannot be made regarding ASL. Without a

reliable and valid measure that taps ASL comprehension skills through literal and inferential constructs in Deaf children, the relationship of lower-level skills and higher-level skills in ASL comprehension remains opaque, as does the relationship between ASL comprehension and English comprehension in bilingual contexts.

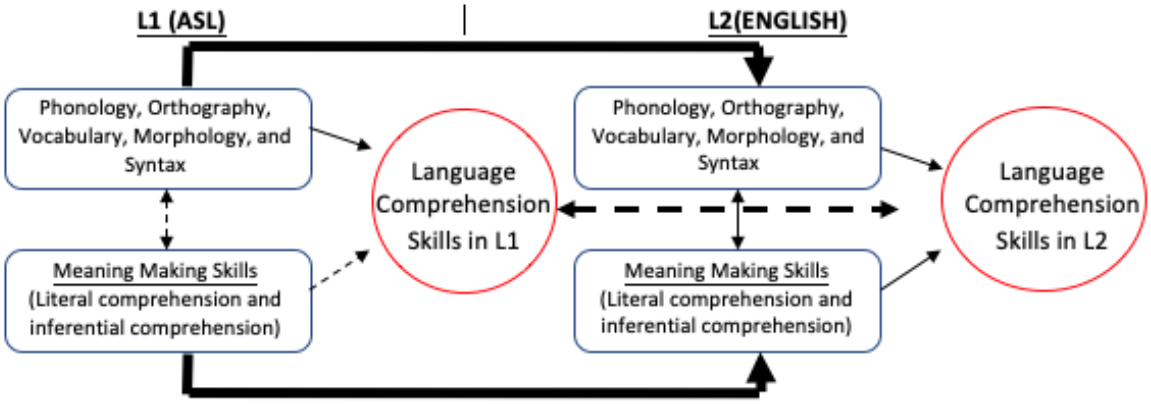

Figure 2. A Visual proposed model of linguistic skills as lower-level and meaning making skills as higher-level comprehension skills in ASL as an L1 and English as an L2.

Based on findings from Cummins's linguistic interdependence hypothesis, it is possible that the dearth of research on ASL comprehension may be a key factor underlying poor English literacy skills among Deaf children. Furthermore, this study will help teachers and practitioners understand student comprehension skills in ASL, such as differentiating between poor and skilled ASL comprehenders and the gaps in their language-comprehension skills. This is integral for effective instruction and intervention (see Elleman, 2017). This ability is critical, especially because many Deaf children leave high school with poor comprehension skills, not just in English, but possibly in ASL, too (Hrastinski & Wilbur, 2016).

The first study in this dissertation focuses on the development of the ASL Text Comprehension task (ASL-CMP), a new tool that assesses literal skills and inferential

skills as two components of higher-level comprehension in ASL. The study includes development and psychometric testing of the new assessment. The study highlights preliminary findings in relation to literal and inferential skills among Deaf children based on age and amount of exposure to ASL.

While the first study establishes the reliability and validity of the ASL-Text Comprehension task, the second study investigates the relationship between ASL lower-level skills, specifically ASL vocabulary knowledge and ASL syntactic abilities, and two higher-level skills, literal comprehension and inferential skills in ASL. This approach determines whether comprehension of textual information in ASL is shaped by the convergence of lower-level skills and higher-level skills, as demonstrated in studies of spoken language (Edele & Stant, 2016; Elleman, 2017; Kitsch, 1998; Oakhill & Cain, 2007; Silva & Cain, 2015). Finally in the third study, I use information on the participants' reading comprehension scores to probe the relationship between ASL comprehension and reading comprehension in English.

Significance of the study

This study is necessary for a number of reasons. First, considering that Deaf children are taught in both ASL and English, and with increasing usage of ASL texts in classroom instruction, we must address the lack of knowledge about the effectiveness of these texts and Deaf children's ability to comprehend ASL texts. Second, there is a lack of research on language skills in ASL (Chamberlain & Mayberry, 2000; Haug & Mann, 2008; Luckner & Handley, 2008). Third, Deaf students continue to perform below

average on reading comprehension, levelling off at the fourth-grade level when they leave high school (Mayberry & Lock, 2003; Traxler, 2000). Finally, evidence from other bilingual studies suggests facilitative relationships between comprehension skills in an L1 and comprehension skills in an L2 (Cummins, 1979; Proctor et al., 2010; Sparks et al., 2012, Srisang, 2017), but we currently do not have a full understanding of higher-level comprehension skills in ASL because there is no standardized measure available that examines literal and inferential skills in ASL. Consequently, we do not know whether ASL-Text Comprehension can serve as a domain for L1 comprehension skills, nor do we know what skills are required to achieve comprehension of ASL text, which may, in turn, provide resources for reading comprehension in English in Deaf children.

Since Deaf children do not have full organic access to spoken language, they cannot rely on auditory input entirely to develop language skills. Many Deaf children instead rely on visual input, ASL in this instance, as a more accessible and comprehensive source of linguistic information. This means there is a difference in how Deaf children acquire and process information relative to their hearing peers. In contrast to hearing children, who learn to read via aural input, many Deaf children learn English primarily through print (Hoffmeister & Caldwell, 2014). Despite the notion that learning a language, especially English, through a modality other than an auditory one has historically seemed to many almost impossible, it has been proven otherwise in many studies (Hoffmeister & Caldwell, 2014; Hrastinski & Wilbur, 2016; Mayberry, 2013; Scott & Hoffmeister, 2016; Prinz & Strong, 1998). Furthermore, approximately 40% of Deaf children in the United States receive their education through signed language at

some point (Henner, Novogrodsky, Reis, & Hoffmeister, 2018), which means they need to employ skills to comprehend both signed language and spoken/written English in various social and academic contexts. Moreover, there is a growing use of materials in ASL literature for instructional purposes (Christie & Wilkins, 2007; Snoddon, 2010; Wall, 2014). In addition to the aforementioned positive relationship between ASL proficiency and English literacy, we should examine the role of higher-level language-comprehension skills in ASL, not only to further understanding of the relationship between ASL and English in bilingual contexts, but also to address the missing link in Deaf education. That is, we do not have a full understanding of higher-level language-comprehension skills in ASL as an L1. We do not know if language-comprehension skills in ASL are important for text comprehension in ASL, nor do we know whether higher-level comprehension skills in ASL can support the development of both higher-level skills and overall text comprehension in English. The relationships shown in figure 2, such as the dashed lines and arrows, indicate not only missing links but also understudied areas of ASL which this dissertation aims to unearth.

The Architecture of this Dissertation

This dissertation contains five chapters. The current chapter is the introduction. Chapter 2 is a literature review of theoretical models of reading, text comprehension, and ASL development in deaf children that serve as frameworks for this dissertation. Chapter 3 focuses on the psychometric properties of the new ASL-Text Comprehension tool that examines Deaf children's literal and inferential comprehension in ASL. Chapter 4 presents a two-part study employing the new ASL comprehension task. While the first

part examines the relationship between literal comprehension and inferential comprehension with lower-level ASL skills, the second part explores the relationship between ASL comprehension and English comprehension. Finally, the last chapter of this dissertation includes discussion, implications, and conclusion drawn from the studies, as well as future considerations.

Definitions of Key Terms

- *American Sign Language (ASL***)**: A visual gestural language that Deaf people use to communicate that contains sophisticated and complex linguistic characteristics and constraints (Hoffmeister & Caldwell-Harris, 2014; Lieberman & Mayberry, 2015; Valli, Lucas, Mulrooney, & Rankin, 2011).
- *American Sign Language Assessment Instrument (ASLAI):* A norm-referenced instrument developed by a research team at Boston University to determine ASL skills in Deaf children (Hoffmeister et al., 2015). The instrument contains 11 tasks that evaluate different constituent components of ASL.
- *ASL Text:* A published video-text composition in ASL (Snoddon, 2010). It is used in the new ASL comprehension task to test Deaf children's literal comprehension and inferential comprehension.
- *ASL-Text Comprehension task (ASL-CMP):* A newly developed task that probes Deaf children's higher-level literal and inferential language-comprehension skills in ASL when perceiving ASL text.
- *Deaf*: A term used throughout the paper to refer to individuals with all types of hearing loss or preferences for various communication systems.

- *Deaf children of Deaf parents (DD):* Deaf children whose parents are Deaf and thus are likely to be raised in a signing environment (Hall, 2017; Ramsey & Padden, 1998).
- *Deaf children of hearing parents (DH):* Deaf children whose parents are hearing and thus are less likely to be raised in a signing or bilingual environment in the first five years of their lives (Hall, 2017; Mayberry & Lock, 2003).
- *Lower-level skills:* Specific language skills that serve as a foundation for language development, such as vocabulary and syntax (Silva & Cain, 2015).
- *Higher-level skills:* Specific language skills that require higher-level thinking skills and extralinguistic knowledge, such as literal comprehension, comprehension monitoring and inferential comprehension (Silva & Cain, 2015).

CHAPTER II

LITERATURE REVIEW

Introduction

Many Deaf children leave high school with poor comprehension skills in English. It is possible that this detrimental fact is linked to not just inadequate understanding of English literacy in Deaf children, for whom English is a second language, but also a lack of understanding of American Sign Language (ASL) as a first language. This chapter provides a review of literature related to text comprehension to understand the underlying skills involved. Further this paper provides a literature review related to how comprehending texts in ASL may be analogous to traditional printed text comprehension. I begin with a review of theoretical models that inform our current understanding of text comprehension as a process in both monolingual and bilingual contexts. Second, I explore text comprehension as a process, including foci on both higher and lower level language-comprehension skills. Finally, I propose a theoretical model of both ASL and English text comprehension as a process in Deaf bilingual children.

Theoretical Models of Text Comprehension Skills

Text comprehension can be described as a "process of simultaneously extracting and constructing meaning through interaction and involvement" with a text (The RAND Reading Study Group, 2002). Text comprehension skills are essential for independent learning because they allow people to use, develop, and hone the skills required to make sense of different types of texts as they navigate information in the modern world. For comprehension to occur, an individual must not only be able to access the language used

in a text, but also able to employ decoding and other skills (Cartwright & Duke, 2015). Given the complex nature of comprehension, there are several models in place that examine, identify, and understand the phenomenon in both monolingual and bilingual children. One prominent model of comprehension is the simple view of reading (SVR) developed by Gough and Tunmer (1986). Others have expanded on this model to specify different types of comprehension skills. The lower-level and higher-level language-comprehension model, for example, illustrates the importance of different component skills within the language-comprehension domain (Hogan, Bridges, Justice, & Cain, 2011). And, the third model, specifically designed for bilingual children, has expanded the SVR model to include the linguistic interdependence hypothesis, which posits that the skills in a first language can be transferred to a second language, and vice versa (Cummins, 1979).

The simple view of reading comprehension (Figure 3), proposed by Gough and Tunmer (1986), states that reading comprehension is the product of two broad domains: decoding and language-comprehension. While decoding means one's ability to analyze and process symbolic information of words, language comprehension encompasses a range of cognitive and other skills, such as vocabulary knowledge, syntactic abilities, literal comprehension, and inferential skills. For reading comprehension to develop according to the SVR model, automaticity in decoding must be acquired along with adequate cognitive and language comprehension skills (Hoffman, 2017). Support for the SVR comes from several studies of reading development in different languages, such as French (Megherbi, Seigneuric, & Ehrlich, 2006), Greek (Kendou, Papadopoulos, &

Kotzapoulou, 2013), Hebrew (Joshi, Ji, Breznitz, Amiel, & Yulia, 2015), among others (Sparks, Patton, & Luebbers, 2019).

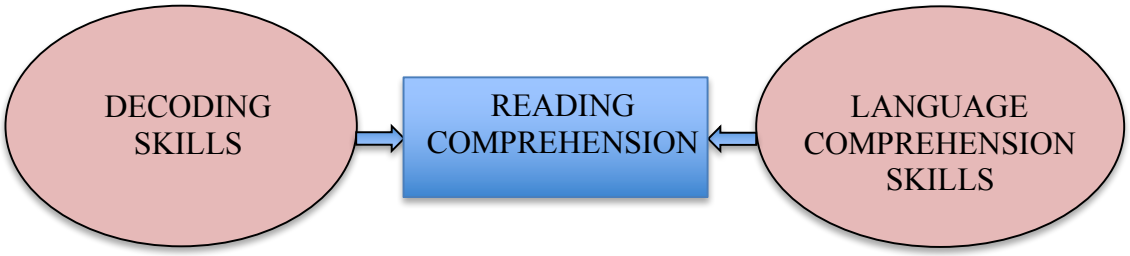

Figure 3. Visual model of SVR (Gough & Tunmer, 1986)

However, the SVR model is limited in terms of identifying sources of strengths or weaknesses within the comprehension process, given that it treats language comprehension as a single construct. Indeed, the SVR model has found to be consistent over time across languages in relation to what is necessary for reading comprehension in a broad sense, it however does not pinpoint where in the two domains that is responsible for the challenges in the development of comprehension skills (Ehri, Nunes, Stahl, & Willows, 2001; Hogan et al., 2011; Kintsch, 1998; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2002), and those skills should not be overlooked or clumped together (Hoffman, 2017).

Such limitations have led several studies to extend the SVR model to consider the different sub-skills that are integral for both decoding and, relevant to the current paper, language comprehension. Comprehension sub-skills have been categorized as lower-level skills and higher-level skills in some studies, where the lower-level skills include vocabulary and syntactic knowledge and higher-level skills include literal comprehension, inferential comprehension, comprehension monitoring, and text structure

knowledge (Hogan et al., 2011; Silva & Cain, 2015) (Figure 4). Separating lower- and higher-level skills of reading comprehension is not clear-cut, yet it is useful for descriptive purposes such that we have better understandings of how these skills interact with each other in the process of full comprehension (Hogan et al., 2011; Nassiji, 2003; Silva & Cain, 2015). Examining and measuring these subskills allows us to pinpoint strengths and weaknesses in young individuals. Therefore, measuring these components is not just essential in understanding the development of reading comprehension but also provides us with more information as to how we can support the development of comprehension skills in young struggling readers.

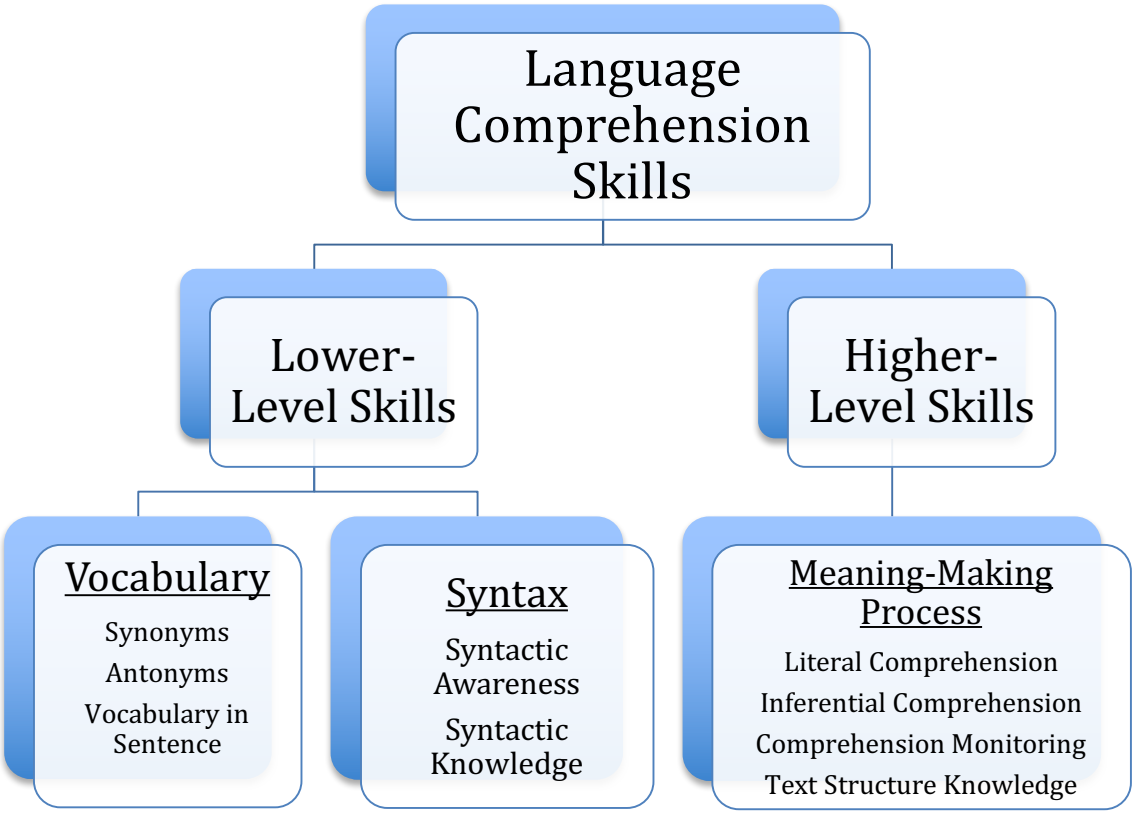

Figure 4. Visual model of lower-level and higher-level language comprehension skills (Hogan et al., 2011; Silva & Cain, 2015).

Although the SVR model was originally designed for monolingual English speakers, it was not until recently that the SVR model has been modified to consider the needs of spoken bilingual children, by incorporating Cummins's linguistic interdependence hypothesis (see Figure 1). The linguistic interdependence hypothesis posits that proficiency of oral language and sociolinguistic skills in a first language (L1) is integral for second language (L2) learning because of the common underlying dimension that is shared when learning a second language (Cummins, 1979). Based on that understanding, several scholars have expanded the SVR model by incorporating the linguistic interdependence hypothesis into the model to attest the hypothesis, the relationship between the component skills in a first language (L1) and a second language (L2) (Bonifacci & Tobia, 2017; Proctor, August, Snow, and Barr, 2010), spoken language in this instance. In seminal work, Proctor et al. (2010) have extended the SVR model by adding the linguistic interdependence hypothesis to examine the relationship between the L1 in Spanish, and English as an L2 as illustrated in figure 5.

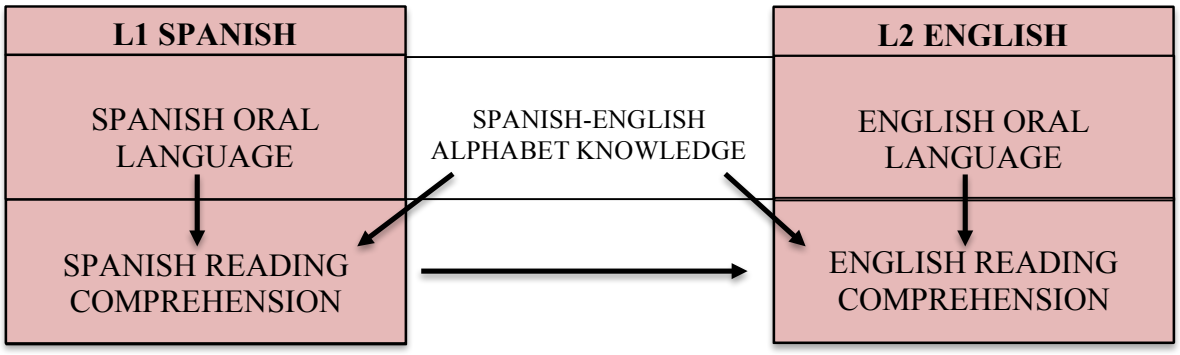

Figure 5. Visual model of modified SVR for Spanish bilingual learners (Proctor et al., 2010)

Text comprehension: lower- and higher-level skills

Clearly, there is a wide range of skills that each learner brings to a literacy task (Silva & Cain, 2015), and learners do not acquire skills uniformly. In the past few decades, there has been an increasing interest in using the relationship between both lower-level (e.g. vocabulary knowledge, syntax abilities) and higher-level comprehension skills (e.g. literal comprehension, making inferences, and monitoring comprehension) and text comprehension (Elleman, 2017; Landi, 2010; Silva & Cain, 2015). Both lower-level and higher-level skills are important indicators of text-comprehension (Hogan et al., 2011; Perfetti & Adlof, 2012; Pettit & Cockriel, 1974; Silva & Cain, 2015; Saadatnia, Ketabi, & Tavakoli, 2017; van Kleeck, 2008). Some learners may have a large body of vocabulary knowledge but inadequate syntactic knowledge. Some learners struggle to develop decoding skills but possess a breadth of world knowledge (Braze, Tabor, Shankweiler, & Menel, 2007). Ultimately, each language-comprehension skill plays an important role in overall reading comprehension. For example, vocabulary knowledge has consistently been revealed to correlate with reading comprehension across ages (Cromley & Azevedo, 2007; Mokhtari & Niederhauser, 2012; Thorndike, 1973). While some studies have found that reading comprehension can be explained by vocabulary knowledge over and above other language skills (Binder, Cote, Lee, Bessette, & Vu, 2017), there is also evidence for the effect of syntactic abilities on reading comprehension (Nation & Snowling, 2011; Potocki, Ecalle, & Magnan, 2013). Even though language-comprehension skills may vary in timing, both vocabulary knowledge and syntactic abilities play an important role in their contribution to the formation of an accurate

mental representation of the text (Cain & Oakhill, 2007; Kintsch, 1998; Nation, 2005).

According to Hogan et al. (2011), vocabulary knowledge and syntax ability are lower-level language-comprehension skills for two reasons: 1. They can be acquired naturally; and 2. They "serve as the foundation that supports what have been labelled *higher-level* language skills, which are required to construct a mental model of a text's meaning" (p. 3). Thus, relying on vocabulary and syntax skills for reading comprehension in children is not necessarily sufficient. They also need to be able to construct a literal understanding of the text and employ inference making to produce accurate interpretation of the text that may not be explicitly stated (Perfetti, Yang, & Schmalhofer, 2008). A better understanding of lower- and higher-level skills has important implications for quality of instruction and intervention, and understanding component skills increases the likelihood of supporting individuals' success in academic, social, and employment contexts (Cunningham & Stanovich, 1997; Elleman, 2017; Silva & Cain, 2015; Stanovich, 1986). This is particularly important for those children struggling with reading comprehension (Ahmed, Francis, York, Fletcher, Barnes, & Kulesz, 2016; Cromley & Azevedo, 2007; Landi, 2010).

Literal Comprehension and Inferential Comprehension

One way to conceive of higher-level skills is to consider literal and inferential comprehension, which together allow readers to construct not only accurate meaning but go beyond to construct accurate interpretation or goal of the text (Basaraba, Yovanoff, Alonzo, & Tindal, 2013; Kintsch, 1998; Saadatnia et al., 2017).

Literal comprehension is text-based in that it involves identifying and

understanding what is explicitly stated in a text (Bishop & Adams, 1992; Pettit & Cockriel, 1974). Literal reading comprehension is important because it serves as a foundation for more complex reading skills (Basaraba et al., 2013; Kintsch, 1998). However, recalling or offering an idea on a literal level alone is not enough for deeper, accurate comprehension. Inferential skills allow the comprehender to make accurate decisions about the text by integrating literal information with information not explicitly stated in the text, using prior knowledge and reasoning skills, to construct an accurate situation model (Kintsch, 1998; Landi, 2010; Nassaji, 2003; Perfetti, Landi, & Oakhill, 2005). For example, consider the following sentence: *"John checked the weather on his iPhone, so he packed a beanie and gloves in his bag."* Although the sentence does not explicitly state that it will become cold later, this can be inferred. The skilled comprehender not only takes advantage of contextual clues, such as *weather*, *his, beanie,* and *gloves,* but also uses inferences to make informed decisions. The less-skilled comprehender, in contrast, may struggle to comprehend due to weak vocabulary and syntactic knowledge. For example, the word *beanie* may not be common, but because of global knowledge and the context in which the word is used, the skilled comprehender should be able to deduce that it is an object that one wears to keep warm. Furthermore, syntactic knowledge allows the comprehender to make sense of pronouns and referents that may be difficult for less-skilled comprehenders (Cain & Oakhill, 2007; Yuill & Oakhill, 1988). For example, consider the words *his* and *he* in the sentence *"John checked the weather on* ***his*** *iPhone, so* ***he*** *packed a beanie and gloves in* ***his*** *bag."* The less-skilled comprehender may not be able to make the connection that *his* is a possessive

form for John and the pronoun *he* refers to John. Alternatively, less-skilled comprehenders may not have strong inferential skills, and thus they are unable to infer that a) John is going somewhere cold; or, b) the weather will become cold later. Literal comprehension is, generally, easier than inferential comprehension and is fundamental for accurate inference-making (Basaraba et al., 2013; Kintsch, 1998; McCormick, 1992; Silva & Cain, 2015). For example, McCormick (1992) conducted a study on 80 fifth-graders with reading difficulties, for more than 20 weeks. Students read 20 second- and third-grade level texts, both narrative and expository, from the *Understanding What We Read* program by the Nystrom Company. The students wrote their responses to literal and inferential questions. Results reveal that the students performed better on the literal questions than the inferential ones (70% vs. 61% accuracy, respectively), and the difference in performance was statistically significant (McCormick, 1992). Basaraba et al. (2013) examined the literal, inferential, and evaluative skills of 1,217 fifth-graders using multiple-choice reading comprehension (MCRC). They found a non-linear relationship between the three (literal, inferential, and evaluative) skills, but literal items were less challenging than inferential items. Similarly, Silva and Cain (2015) studied 82 young children, 4 to 6 years old, to investigate the development of reading-comprehension skills. The children took the British Picture Vocabulary Scale-II (a receptive vocabulary task), The Test for Reception of Grammar, and read the wordless picture book *Frog On His Own* (Mayer, 1973). Based on four literal questions and five inferential questions about the story, the children were significantly more accurate in literal comprehension than in inferential comprehension. Moreover, Silva and Cain

(2015) found, using hierarchical linear regression analysis, that, in addition to vocabulary being the only predictor of both literal and inferential comprehension, vocabulary also accounted for unique variance in reading comprehension.

There is evidence that inferential reasoning can be explicitly taught. Elleman (2017) conducted a meta-analysis of literal, inferential, and overall reading-comprehension instruction in young children. Based on 25 studies (including a total of 1,752 participants) between 1950 and 2014, Elleman examined how different instructional approaches impacted literal comprehension and inferential comprehension in K-12 educational settings. She found that teaching children inference-making affects children's performance on inferential measures in both skilled and less-skilled readers. Furthermore, less-skilled readers appear to benefit more from instruction on inference-making in contrast to skilled readers on literal comprehension. Small-group instruction was found to be more effective than other instructional approaches. Finally, less-skilled readers of all ages benefited from explicit instruction of both literal and inferential skills. Whether better-skilled or less-skilled readers benefited from explicit instruction or not, they both displayed developmental change in how they process text over time regardless of the differences in background knowledge (Cain, Barnes, Bryant, & Oakhill, 2001).

Literal and inferential skills are two separate yet interdependent domains in the construction of an accurate mental representation of the text. A skilled reader should demonstrate the ability to extract literal meanings from a text prior to merging that understanding with inferences using existent knowledge and information beyond the text to form an accurate interpretation and understanding of the goal of the text (Basaraba et

al., 2013; Cromley & Azevedo, 2007; Elleman, 2017; Kintsch, 1998). Without both literal and inferential skills, comprehension of the text cannot be obtained; thus, affecting the acquisition of new knowledge, skills and experiences (Basaraba et al., 2013; Cain & Oakhill, 2007; Kintsch & Rawson, 2007).

Text Comprehension in Spoken Bilingual Children

More than 50% of children in the world are bilingual (Ansaldo, Marcotte, Scherer, & Raboyeau, 2008). Jim Cummins, one of the early researchers in bilingual education, noticed that skills in a person's L1 can be utilized to scaffold the development of skills in their L2. This finding led him to posit the linguistic interdependence hypothesis, which states that the knowledge and skills of L1 can be transferred to support the acquisition of L2. His hypothesis is supported by studies on the relationship between comprehension skills in both L1 and L2 (Berens, Kovelman, & Petitto, 2013; Proctor et al., 2010; Sparks et al., 2012).

Berens, Kovelman, and Petitto (2013) studied second- and third-grade bilingual learners who spoke and received education in Spanish and English, examining the difference in language learning within dual-language contexts, whether there is a difference between learning to read in two languages at the same time or subsequently. Two hundred and thirteen children participated in the study; roughly half were from bilingual homes and had parents who were also bilingual, while the rest came from monolingual households. The children completed several language tasks in English and Spanish to establish their linguistic sub-skill abilities and reading proficiency in each language. The researchers found that Spanish spoken bilingual children learning Spanish

and English performed better on different English reading tasks than monolingual English-only learners. Furthermore, those bilingual children who were exposed to instruction in Spanish in a dual-learning environment earlier performed significantly better than those who received instruction in Spanish later. Berens, Kovelman, and Petitto (2013) suggest that bilingual learning contexts, particularly at the same time, promote an underlying grammatical and structural knowledge involved in reading and language processing in Spanish as an L1 that, in turn, supports reading development in English as an L2.

Proctor et al. (2010) conducted a study on 91 fourth-grade Spanish bilingual learners to evaluate the interdependence continuum between the Spanish as an L1 and English as an L2. They examined participants' oral language proficiency, alphabetic knowledge, and reading comprehension in both English and Spanish. They found that reading comprehension in Spanish correlated significantly with reading comprehension in English. They also found a small but positive effect of Spanish comprehension on English comprehension. Since their findings correspond with other studies that have demonstrated language skills are important predictive indicators of reading comprehension, in contrast to decoding skills in fourth graders, they recommend that instruction of English literacy skills should include attention to language and literacy development in Spanish as an L1.

Sparks et al. (2006) found that L1 reading skills in elementary school accounted for 40% of the variance in oral and written L2, indicating the importance of L1 skills in early years for later L2 success. Their findings are in line with van Gelderen et al. (2004)

regarding L1 literacy skills, in that the language skills in the L1 promote metacognitive knowledge and metalinguistic awareness that support the development of literacy skills in both the L1 and L2. The L1 is instrumental in the development of metalinguistic awareness and language-comprehension skills in the L2 in spoken bilingual children (Koda, 2005). Also, there are statistically significant correlations between language skills in the L1 and the L2, as well as L1 reading comprehension and L2 reading comprehension. Furthermore, these studies indicate that understanding bilingual children's language skills in L1 required for reading comprehension in L2 is of importance particularly to support the development of literacy skills in both L1 and L2. Having reviewed research findings in relation to text comprehension in spoken bilingual children, I now apply this background to the population of Deaf children learning ASL and English.

Deaf children as bilingual learners

ASL is a visual, natural language that has the same linguistic properties as other languages. ASL is predominantly used by Deaf residents in the US and Canada. Although ASL was first identified as a full language by the linguist William Stokoe in the 1960s, it has existed since the early 19th century. ASL contains essential linguistic components, such as phonology, vocabulary, grammar, and meaning (Stokoe, 1970; Valli, Lucas, Mulrooney, & Rankin, 2011). Thus, comprehension of ASL requires similar language skills as comprehension of spoken language (Valli et al., 2011; Lane, 1992; Pettito, 2009).

There are several studies that have garnered sufficient and consistent evidence that ASL is critical for Deaf children's linguistic, cognitive, and social development (Lange, Lange-Outlaw, Lange, and Sherwood, 2013; Knoors & Marschark, 2012; Garate, 2014; Henner et al., 2018). Although Deaf children may also acquire spoken language, its accessibility is not always guaranteed; in contrast, sign language is the only fully accessible language for Deaf children. Deaf children who were exposed to ASL at an early age demonstrate a similar milestone trajectory in their development as their hearing counterparts (Lilo-Martin, 1999). Furthermore, neuroimaging studies have found scant evidence of brain-processing differences in responses to visual and auditory language input in the development of language skills (Petitto, 2009; Hall, 2017). Early linguistic exposure to ASL, similar to that of English spoken language, is clearly critical for language development in Deaf children (Hrastinski & Wilbur, 2016: Mayberry, Chen, Witcher, & Klein, 2011). Early exposure to ASL allows children to acquire and employ different cognitive and linguistic processes to learn and achieve mastery of language (Lieberman & Mayberry, 2015; Hrastinski & Wilbur, 2016; Petitto, 2009). Deaf children who are exposed to sign language early in life acquire vocabulary knowledge, complex syntax, and world knowledge (Wall, 2014; Henner, 2016; Henner, Novogrodsky, Reis, & Hoffmeister, 2018), which, in turn, become important resources for the acquisition of new knowledge and skills across languages. However, this is not the case for many Deaf children because the majority of them are born to hearing parents (Mitchell & Karchmer, 2005). Consequently, they are less likely to have access to ASL from birth, and because of that, their age of exposure to ASL and eventually development of ASL language is

highly variable and their language acquisition is at-risk for delay (Hall, 2017; Humphries et al., 2017; Mitchell & Karchmer, 2005).

The Relationship between ASL and English in Bilingual Contexts

ASL proficiency has found to be an important predictor of English literacy skills in both Deaf children and Deaf adults (Chamberlain & Mayberry 2000; Hoffmeister, 2000; Novogrodsky, Caldwell-Harris, Fish, & Hoffmeister, 2014; Padden & Ramsey, 2000; Scott & Hoffmeister, 2016). Studies have found that Deaf children with early ASL exposure exhibit a benefit in the development of their written English skills, hence a positive relationship between ASL and English in bilingual contexts (DeLana, Gentry, & Andrews, 2007; Hrastinski & Wilbur, 2016; Scott & Hoffmeister, 2017; Strong & Prinz, 1997). Strong and Prinz (1997) studied 155 Deaf children and found that those who were proficient ASL users performed better on tests of English reading comprehension than those who were less proficient ASL users. DeLana, Gentry, and Andrews (2007) studied 25 Deaf children and found that those with parents who signed performed better on a reading-comprehension task than those whose parents did not sign. Moreover, they found a statistically significant correlation between the length of ASL usage and English reading achievement. Similarly, Hrastinski and Wilbur (2016) found a significant relationship between ASL proficiency and outcomes on two reading assessments, the Northwest Evaluation Association Measures of Academic Progress (NWEA MAP) and the Stanford Achievement Test, 10th edition (SAT-10). Specifically, on NWEA MAP, Deaf children who were proficient in ASL scored on average 41% accuracy, in contrast

to a mean of 10% accuracy for the lower ASL proficient group. They also found that children in the high ASL proficiency group were exposed to ASL since birth (M= 0.2 years, SD = 0.8) and placed in a bilingual school early (m= 5.9 years, SD= 3.9), while children in the lower proficient ASL group were exposed to ASL later (m=6.4, SD= 5.9) and enrolled in a bilingual school later (m=10.7 years, SD= 4.8). Likewise, highly proficient ASL Deaf children performed significantly better on SAT-10 than less proficient children. These findings align with Cummins' linguistic interdependence hypothesis, in that skills in the L1 (ASL) facilitate the development of skills in the L2 (English). In addition to overall ASL proficiency, in particular ASL vocabulary has shown to be an important predictor of reading comprehension (Novogrodsky et al., 2014).

Despite the known link between ASL and English, many Deaf children still struggle with reading comprehension, and specifically struggle with inference making in English measures (Harris, Kyle & Terlektsi, 2017). This could be a result of poor comprehension skills in ASL, poor comprehension skills in English, or both. Whereas in spoken language both lower- and higher-level language skills are predictors of text comprehension in L1 (Hogan et al., 2011; Silva & Cain, 2015), which supports comprehension in an L2 (Proctor et al, 2010; Spark et al., 2012; Srisang, 2017), it remains unknown whether the same relationships hold for Deaf children. First, little is known about the relationship between lower-level and higher-level comprehension skills in ASL, the first language. It is possible that Deaf children's poor reading comprehension in English as an L2 is linked to an absence of higher-level language-comprehension skills

in ASL as an L1. Thus a careful examination of the relationship between lower-level and higher-level skills in ASL is warranted. Understanding ASL comprehension will then inform our understanding of Deaf children's English development and help shape a model of Deaf children as bilingual learners.

Broadening the definition of text: ASL texts

Texts are ubiquitous. They can be found everywhere: inside classrooms, outside classrooms, at workplaces, at home, and in all aspects of our environments. They are used for many reasons: to communicate, to share, to learn, to instruct, to educate, to criticize, to express thoughts and feelings and, most importantly, to function in this world (van den Broek & Espin, 2012). Traditionally, text is described as a written, frozen body of information that can be read. However, with advancement in digital technologies, there is increasing acceptance that what counts as a text is broader than just the written form (Allison, Wee, Zhiming, & Abraham, 1999). According to New Literacies, a paradigm shift in terms of what constitutes as a form of literacy in response to changes of digital technology, in that text is considered an object of work that contains a message despite its physical form or mode (Lankshear & Knobel, 2013) as long as it allows for meaning-making (New London, 1996). Some examples of expanded types of texts are digitalized texts, such as digital storybooks, blogs, podcasting, and video games. Therefore, this definition can and should be extended to include filmed literary work narrated in ASL. I therefore use "ASL text" to mean a filmed composition of work that underwent an iterative process of editing and revising in addition to containing some kind of meaning and a purpose that is geared to the specific audience.

Although filmed literary work narrated in ASL is not new, the idea of using ASL text for learning in a bilingual context is relatively new (Wall, 2014). There has been an increase in use of ASL texts as sources of information for Deaf people (Snoddon, 2010; Wall, 2014) in response to advancement in digital technologies. Documenting and disseminating content in ASL has become less difficult. One can find ASL texts on many social media platforms (e.g. Facebook, Twitter, and Instagram). Moreover, there are several publishers that publish ASL texts, such as DawnSignPress, Sign Media Inc., and Gallaudet University's Deaf Studies Digital Journal. Thus, there is a wide range of ASL texts currently available that can be used for many different purposes, similar to traditional printed texts, such as to inform, to share, and to entertain. There are different genres and forms of ASL texts, such as ASL poems, ASL stories (both fictional and expository), ASL songs, and video instruction in ASL (Bahan, 2006; Blondel et al., 2008). As ASL texts have become more readily available, they have been increasingly used in the classroom. Teachers can use and produce ASL texts to help teach Deaf children (Wall, 2014). Wall (2014) reviewed theoretical paradigms of ASL story comprehension and how Deaf children make meaning from ASL stories. Through observation of eight Deaf children, she found that apart from being engaged in the stories, higher comprehension of ASL-text seemed to be linked to children's ability to process a wide range of language-related skills in ASL, such as ASL vocabulary knowledge and ASL syntax. Deaf children who were better at deciphering and deconstructing the information narrated in ASL had higher comprehension outcomes. Further, the children who had higher comprehension of ASL-text were also able to produce more cross-

linguistic transfer between ASL and English. However, there is limited understanding of ASL text and its pedagogical benefits in classrooms (Small & Cripps, 2004; Wall 2014) regarding whether Deaf children can acquire new knowledge and develop literacy skills through perceiving ASL texts.

Models of text comprehension for Deaf children

Given evidence from bilingual studies that language-comprehension skills in the L1 support those in the L2, (Cummins, 2006; Proctor et al., 2010; Silva & Cain, 2015; Srisang, 2017; van Gelderen, Schoonen, Stoel, Glopper, & Hulstijn, 2007), we should expect to see the same for the development of ASL and English in Deaf children. However, there are unique aspects to language development for Deaf children. Since many Deaf children do not have access to a spoken language, they cannot learn English as a spoken L2, but instead must learn English as an L2 in written form. From a bilingual perspective, children could leverage ASL, a visual language, as an L1 in order to access written English as an L2. However, this is contentious in several studies because ASL does not have a written form. It is for this very reason, Mayer & Wells (1996) argued that the development of literacy skills in the second language (English in this instance) is not possible for Deaf children who use ASL.

I, however, propose that comprehension of ASL text can and should be considered as a form of "reading" comprehension skills in Deaf children and, in contrast to Mayer & Wells (1996), can be used to support the development of literacy skills of both ASL and English in Deaf children. In the proposed model (figure 6), drawing from previous models, it is possible with increasing understanding of the relationship between

lower- and higher-level skills in ASL, the better we can support Deaf children in the development of comprehension skills in both ASL as an L1 and English comprehension as an L2. Currently, there is limited research on textual information in ASL and the relationship between language-comprehension skills in ASL in Deaf children. Not only do not have a clear understanding of the comprehension process in ASL but also how comprehension of ASL can support Deaf children's comprehension skills in English. We do not know if text in ASL can support the development of different sub-skills within the language-comprehension domain of ASL nor do we know if those subskills in ASL are important predictors of both ASL and English comprehension.

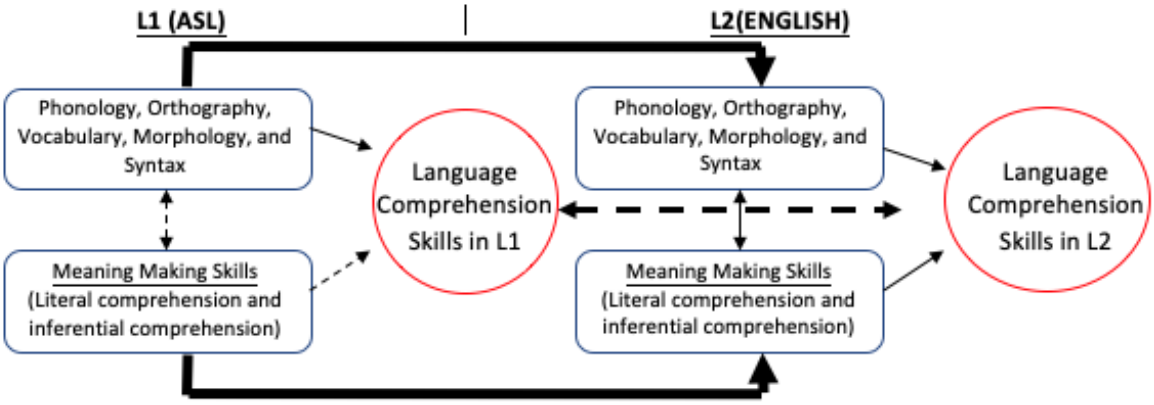

Figure 6. A Visual proposed model of linguistic skills as lower-level and meaning making skills as higher-level comprehension skills in ASL as an L1 and English as an L2.

Given previous studies in reading and bilingual research that revealed positive correlations between text comprehension in L1 and L2, it is worth examining ASL comprehension skills. With the proposed model, we can begin to obtain a better understanding of the interplay of those language-comprehension components in ASL, such as vocabulary knowledge, syntactic abilities, literal comprehension, and inferential

comprehension, which, in turn, may be used to inform future researchers, administrators, and practitioners with more meaningful and effective practices for instruction.

Conclusion and Next Steps

The notion of "text" has been expanded beyond traditional written compositions. Regardless of its form, text comprehension requires a constellation of language-comprehension skills that can be divided into lower- and higher-level skills. A range of language skills, including vocabulary knowledge, syntactic abilities, literal comprehension and inferential comprehension are important components of overall text comprehension in children, both in monolingual and bilingual contexts. With ASL established as a full language, there is a growing body of research that considers ASL literature and ASL literacy. Research on ASL texts suggests that ASL text in academic discourses creates opportunities for more biliteracy experiences among Deaf children (Byrne, 2015; Stone, 2014; Wall, 2014). This understanding is important because bilingual studies have found that the opportunity for L2 learning relies on a strong foundation of skills in the L1 before knowledge and skills can be transferred to an L2 (Coppens, Tellings, Schreuder, & Verhoeven, 2013; Cummins, 2006; Mayberry et al., 2011). This understanding once again ties with Cummins's linguistic interdependence hypothesis (2006) and previous studies in bilingual contexts that examine the role of L1 comprehension skills in the development of comprehension skills in the L2 (Proctor et al., 2010; Srisang, 2017; Kim, 2015; Edele & Stant, 2016).

Many classrooms for the Deaf have begun to incorporate ASL texts to teach and develop literacy skills (Wall, 2014). Despite recognition of ASL literature and linguistics

in academic fields of study and increasing use of ASL texts in academic discourse, there remains a limited understanding of the pedagogical implications of using ASL texts for learning. This dissertation is particularly important given evidence that comprehension of ASL requires similar skills to comprehension of printed texts (Henner, 2016; Novogrodsky et al., 2014; Scott & Hoffmeister, 2016; Wilbur, 2000).

Our knowledge of ASL proficiency has been informed by a number of currently available ASL assessments. While there are several such assessments for both research and educational purposes, there remain some gaps in current assessments in ASL. In particular, there are limited available assessments that probe comprehension of ASL texts. In fact, there is no standardized assessment instrument available that can access Deaf children's comprehension of ASL text through literal and inferential constructs. Thus, our current understanding of ASL text comprehension skills as a meaning making process is limited. Because we do not know the potential benefits of ASL texts in the development of meaning making skills, this is an important step to make so to support not only the development of higher-level language-comprehension skills in ASL as the L1, but also in the development of English as an L2. It would do well to develop an assessment that measures ASL text comprehension. With such a tool, we can then examine the relationships between discrete ASL language skills, and the relationship between ASL text comprehension and English text comprehension (Scott, 2015; Henner et al., 2018). For all the reasons above, the goals of this dissertation are: to develop a new assessment tool, and to fill in such gaps in the extant literature in particular the meaning making processes in Deaf children who rely on ASL in order to make sense of the world.

Research Goals

There is evidence of a relationship between L1 reading comprehension and L2 comprehension in spoken-language bilingual children (Proctor et al., 2010; Sparks et al., 2012). There is also evidence of a relationship between ASL proficiency and reading comprehension in the Deaf population across all ages (Scott & Hoffemister, 2017; Strong & Prinz, 1997). However, little research has been conducted on Deaf children's ability to comprehend ASL texts through literal and inferential constructs. Consequently, little is understood about ASL texts and, specifically, whether ASL-text comprehension is an important skill for English reading comprehension in Deaf bilingual children.

Finally, there is no normed assessment that evaluates Deaf children's abilities to comprehend ASL texts through literal and inferential constructs. Therefore, this study aims to establish a new assessment tool that allows us to examine the relationships between different language skills within ASL and the role of ASL comprehension in English reading comprehension. It would be interesting to investigate whether the relationship between language-comprehension skills in Deaf bilingual children who perceive ASL texts and read English texts for meaning-making are similar to spoken bilingual children.

This dissertation has two goals, and each goal has two parts to it:

1. The development of a reliable and valid assessment of ASL text comprehension.
    a. To establish reliability of the task with Deaf children of Deaf parents only; and,

   b. To test the task with Deaf children from a wide range of backgrounds to determine validity of the task by looking at common factors that affect comprehension such as age, early exposure to language, and type of question.

2. The evaluation of the relationships between language skills within ASL and the relationship between ASL-text comprehension and English-text comprehension.
   a. To determine whether or not ASL vocabulary and ASL syntax skills are necessary to comprehend an ASL text, including its effects on each literal and inferential comprehension of ASL text.
   b. To determine whether or not ASL text comprehension is related to English reading comprehension.

CHAPTER THREE

STUDY I

The Development and Evaluation of a New ASL Comprehension Task

Abstract

Being able to comprehend a language entails not only mastery of its syntax, lexicon, or phonology, but also the ability to use language to construct meaning, draw inferences, make connections to world knowledge. However, most available assessments of American Sign Language (ASL) focus on mastery of lower level skills, and as a result little is known about development of higher-order ASL comprehension skills. In this paper, we introduce the American Sign Language Text Comprehension Task (ASL-CMP), a new assessment tool to measure ASL text comprehension ability in deaf children. We first administered the task to a group of deaf children with deaf parents (n = 105, ages 8-18 years) in order to evaluate the reliability and validity of the task, and to develop norms. We found that the ASL-CMP has acceptable levels of internal consistency, difficulty, and discriminability. Next, we administered the task to an additional group of deaf children with hearing parents (n = 251, ages 8–18 years), and found that the ASL-CMP is sensitive to expected patterns: older children have better ASL text comprehension skills, literal questions are generally easier to answer than inferential questions, and children with early exposure to ASL generally outperform those with delayed exposure. We conclude that the ASL-CMP task is reliable and valid and can be used to characterize ASL text comprehension skills in deaf children.

Keywords: ASL, ASL assessment, literal comprehension, inferential comprehension.

The Development and Evaluation of a New ASL Comprehension Task Through Literal and Inferential Constructs

Introduction

Reading comprehension--the ability to extract meaning from a text, to evaluate that information, to draw inferences, and to make connections to outside information--is an essential skill for classroom learning, as well as for later academic, social, and occupational achievement (Ciullo, Ortiz, Otaiba, & Lane, 2016; Duke & Pearson, 2002; Shanahan, 2005; van den Broek & Espin, 2012). In 1994, the New London Group proposed a theory of multiliteracies (first published in 1996), which broadened the understanding of literacy to encompass the ability to engage with many forms of text. In a rapidly-evolving world of information and technology, they argued that texts encompass both traditional formats like essays, articles, or books, but should also consider forms such as speeches, blogs (Mackey & Jacobson, 2014; Shema, Bar-Ilan, & Thelwall, 2012), vlogs (Griffith & Papacharissi, 2009), graphic novels (Jiménez, et al., 2017), and online reading (Leu, et al., 2015). With a broadened definition of text, literacy can be considered as a constellation of skills through which a person can extract and construct meaning from these various forms.

ASL Texts

In parallel with these expanded definitions of text and literacy, some began to consider compositions in sign languages as a form of text, and the ability to engage with these compositions as a form of literacy (Kuntze, 2004; Kuntze, Golos, & Enns, 2014; Wall, 2014). We embrace this reimagining, and use it as a framework to examine the

complex linguistic and cognitive skills involved in engaging with passages composed in American Sign Language (ASL)[1], which we will refer to as ASL texts.

We define an ASL text as a composition expressed in ASL that is used to communicate information to others (Byrne, 2015; Christie & Wilkins, 1997). Although typically ASL is ephemeral, in the way that spoken language "disappears" once it is produced, signers can also of course record their own productions. ASL texts may be produced live, as in a lecture or presentation, or may be recorded by video or other medium (e.g., motion capture) or generated digitally (e.g., avatars). The form of ASL texts most analogous to a conventional understanding of written texts are signed videos that have been designed deliberately, often involving multiple iterations of editing and refining, and are recorded such that users can preview, review, and engage with them repeatedly. ASL texts can be classified into a host of literary genres, including poetry (Blondel, Bauman, Nelson & Rose, 2008; Christie & Wilkins,1997), satire (e.g., Hearing Knows Best [https://youtu.be/MoxVdw6T0LA] by Malzkuhn & Bottoms, 2017), fiction, jokes, and stories (Bahan, 2006; Byrne, 2015). Non-fiction ASL texts have become prevalent in recent years with the establishment of several ASL news outlets that produce news stories of particular relevance to deaf people or about the world at large (see The Daily Moth [https://www.dailymoth.com] by Abenchuchan, 2019 and Sign1News [https://sign1news.com] by Jones, 2018). Additionally, some museums have installed ASL expository texts adjacent to each exhibit that offer ASL users access to self-guided

[1] Our focus in this paper is on American Sign Language, though the approach would largely generalize to compositions in other sign languages.

tours (Martins, 2016). A more popular, generally less edited, example of an ASL text is the vlog, a short video message of one or two signers expressing an opinion or short narrative that is often shared through social media. Given the large and growing body of text available in ASL, it is critical to understand and evaluate how deaf children develop the ability to engage with this material (Snoddon, 2010).

Like all texts, ASL texts can be important sources of information through which people can expand their knowledge, skills, and experience. Additionally, by learning to comprehend an ASL text in their primary language, deaf students can gain familiarity with various genres, develop the ability to interpret explicit and implicit meaning, and make connections to prior knowledge or other texts (Kuntze, 1998; Kuntze, 2004; Kuntze, Golos, & Enns, 2014), which in turn contributes to later reading comprehension (Duffy, 2009). These modality-general skills are important not only for engaging deeply with ASL texts, but many scholars have proposed that ASL texts provide an entry point to engaging with written English texts (Bailes, 2001; Cummins, 2006; DeLana, Gentry & Andrews, 2007; Hoffmeister, 2000; Kuntze, 2004; Kuntze, Golos, & Enns, 2014). While comprehension of ASL text in deaf children has been, to our knowledge, underexplored, we expect that many of the same skills identified for written text comprehension underlie ASL text comprehension.

Text comprehension relies on a host of language and literacy skills. At a basic level, comprehending a text entails lower-level language skills including identifying words and parsing sentences (Perfetti & Stafura, 2014; Silva & Cain, 2015). In addition to these basic skills, higher-order skills are needed to integrate information explicitly

stated in the text as well as information implied by the text (Bishop & Adams, 1992; Cain & Oakhill, 2007; Pettit & Cockriel, 1974). This requires the use of prior knowledge, and the ability to construct a coherent interpretation of the text including drawing conclusions and making predictions (Cromley & Azevedo, 2007; Kintsch, 1998; Landi, 2010; Nassaji, 2003; Perfetti et al., 2005).

Better understanding the development of ASL text comprehension is of particular interest for deaf children because the majority of deaf children are at risk of limited language proficiency and low literacy levels (Hrastinski & Wilbur, 2016). Deaf children do not have auditory access to all of the sounds of speech, and even with the best-available technology and interventions their spoken language outcomes are variable and often poor (Bouchard, Ouellet, & Cohen, 2009; Dettman et al., 2016; Ganek, Mcconkey Robbins, & Niparko, 2011; Humphries et al., 2017; Kral, Kronenberger, Pisoni, & O'Donoghue, 2016; Manrique, Cervera-Paz, Huarte, & Molina, 2004; Niparko et al., 2010; Peterson, Pisoni, & Miyamoto, 2010; Szagun & Schramm, 2016). At the same time, more than 90% of deaf children have hearing parents who do not know a sign language at the time the child is born (Hall, 2017; Hall, Smith, Sutter, DeWindt, & Dye, 2018), so in addition to incomplete access to spoken language, deaf children also often have limited exposure to a sign language during early childhood. For all these reasons, it is critical to assess whether or not children have developed the complex language and literacy skills involved in engaging with an ASL text.

Existing Assessments of ASL comprehension

Despite the importance of higher-order text comprehension skills, existing ASL

assessments generally focus on basic proficiency in ASL vocabulary and grammar, and there is currently no means of evaluating the more advanced skills that are necessary for ASL text comprehension. Currently available ASL tests include, for example, the American Sign Language Vocabulary Test (ASL-VT; Mann, Roy, & Morgan, 2015), the MacArthur Bates CDI for American Sign Language (Anderson & Reilly, 2002), the ASL-CDI 2.0 (Caselli, Lieberman, & Pyers, 2020), the ASL Phonological Awareness Test (ASL-PAT; McQuarrie, Abbott, & Spady, 2012), the American Sign Language Proficiency Assessment (ASL-PA; Maller et al., 1999), the ASL Receptive Skills Test (Enns & Herman, 2011), ASL & Nonlinguistic Perspective Taking Comprehension Tests (Quinto-Pozos & Hou, 2015), and the Visual Communication and Sign Language Checklist (VCSL, Simms, Baker, & Clark, 2013). See Haug, 2008 for an overview of available ASL assessment tests. These tests predominantly focus on lower-level language skills including phonology, vocabulary, morphology, and syntax, rather than higher-level text comprehension skills. One exception is the American Sign Language Assessment Instrument (ASLAI; Hoffmeister et al., 2015), which includes sub-tasks that assess ASL analogical reasoning (Henner, 2015), and ASL complex syntax (Hoffmeister et al., 2015). Another exception is the Test of American Sign Language (TASL, Strong & Prinz 1997; Prinz, Strong& Kuntze, 1994), which probes deaf children's comprehension of ASL text as a set of literacy skills, but has not been evaluated for psychometric quality nor are there developmental norms (Haug, 2008). To our knowledge there is no currently available normed assessment that evaluates deaf children's comprehension of ASL text.

The Current Study

In the current study, we present a new assessment of ASL text comprehension called the ASL Text Comprehension task (ASL-CMP). The goal of the ASL-CMP is to measure ASL text comprehension skills among deaf children. We first describe the development of the ASL-CMP, and present an evaluation of its psychometric properties in a sample of deaf children who had access to ASL from birth. Following the psychometric evaluation, we present results from a larger sample of deaf children that included both those with deaf parents and hearing parents. The goal of the larger sample was to test three primary predictions:

1) We expected that, because they generally have earlier exposure to language, deaf children who have deaf parents would outperform deaf children who have hearing parents in accuracy on the test (Berke, 2012; Goldin-Meadow & Mayberry, 2001; Henner, Caldwell-Harris, Novogrodsky & Hoffmeister, 2016; Hoffmeister, 2000). Because the age of onset of ASL acquisition is generally correlated with language proficiency (see Mayberry & Kleunder, 2018 for a review), we also expected that age of entry into a school that uses ASL would be negatively correlated with ASL text comprehension among children who have hearing parents.

2) We predicted that accuracy on the ASL-CMP would increase during childhood and adolescence, as is generally found in studies of written text comprehension (Barnes, Dennis, Haefele-Kalvaitis, 1996; Cain & Oakhill, 1999; Nippold & Scott, 2010).

3) We predicted that accuracy would be higher for questions assessing literal comprehension than for those that required children to make inferences, as inferential

comprehension is generally more difficult than explicit text comprehension (Bowyer-Crane & Snowling, 2005; Cain & Oakhill, 2007; Johnston, 1984; Miller & Smith, 1985; Pettit & Cockriel, 1974).

Methods

Development of the Assessment

The ASL-CMP was created by a team of deaf native-signing linguists and educators and hearing linguists who are familiar with ASL. Deaf experts who have technical expertise as well as mastery of the language play a critical role in ensuring validity of ASL assessments (Haug, et al., 2016; Hauser, Paludneviciene, Daggett, & Kurz, 2015; Henner, Novogrodsky, Reis, & Hoffmeister, 2018; Hoffemister, 1988; Hoffmeister, et al., 2015). The ASL-CMP was developed as a subtest of the ASLAI, a large, comprehensive, norm-referenced ASL assessment. The ASLAI has been used to test receptive ASL skills in Deaf children from ages four to eighteen years across the United States (Henner et al., 2018). The ASLAI evaluates a wide range of linguistic properties of ASL, such as vocabulary, syntax, and analogical reasoning skills (Hoffmeister, et al., 2015). All tasks in the ASLAI, including the ASL-CMP, are administered via computer and are multiple-choice. All questions and answer choices are presented in ASL, and formatted with consideration of the linguistic demands of ASL, as described in Section 2.3.

Test Content of the ASL Text Comprehension Task

The ASL-CMP consists of three ASL texts that were adapted--not translated--from texts in two different reading assessments: the Qualitative Reading Inventory-5 (QRI-5), an informal reading assessment used to identify students' reading levels (Leslie & Caldwell, 2011) and the Houghton Mifflin Reading Assessment (Houghton Mifflin, 2010), a research-based diagnostic reading assessment. In contrast to test translation where the goal is a sentence-by-sentence match between the original and translated version, our goal in adapting these tests was to create texts that had an overall conceptual match with the original but the words, sentences, and structure of the text were free to differ (Hambleton & Patsula, 1998; Van de Vijver & Poortinga, 2005).

The English texts that served as the models for the ASL texts were titled *Bridges, Photosynthesis*, and *Marva Finds a Friend* (Leslie & Caldwell, 2011). The English texts were originally designed for children ages eight to twelve years. Two of the English texts (*Bridges* and *Photosynthesis*) are expository, non-fiction texts, and the third (*Marva Finds a Friend*) is fiction. Texts were selected based on the target age range, and because they contained a straightforward sentence structure, which enabled adaptation to ASL (e.g., no passive voice and simple sentence structure). The three adapted ASL texts and English translations of those texts are available at https://osf.io/dwhba/. The length of the ASL texts were two minutes, 39 seconds (*Bridges),* one minute, 36 seconds (*Photosynthesis*), and two minutes, 58 seconds (*Marva Finds a Friend).* Each ASL text was followed by five multiple-choice questions. Three of the questions were related to information that was explicitly mentioned in the text (literal questions) and two of the

questions were related to information that was implied by the text but not explicitly stated (inferential questions). Further, each set of five questions was consistent in structure such that there were two WHAT questions (one literal, one inferential), two WHY questions (one literal, one inferential), and one WHICH question (literal). The foils for each question were all ASL signs and consisted of two related but incorrect answers, and one unrelated answer. For literal questions, the related foils differed from the correct answer in either verb or subject in ASL. For example, if the correct answer was GIRL *WALK* SEE OLD HOUSE[2], related but incorrect answers used the verb *RUN* or *BIKE* instead of *WALK*. For inferential questions, the correct answer included information that must be deduced from the text. For example, in one of the ASL texts a girl sees a ghost and runs away. One of the questions asked why the girl ran away and the correct answer can be translated to, "She is scared." This is a plausible inference based on the text, but not explicitly stated. The three foils are less plausible explanations for her behavior (e.g., "she escapes because she is late for school," "she likes to run," or "because a dog chases after her").

The first draft of the ASL-CMP was piloted with a group of seven deaf, linguistically-trained, ASL-English bilingual adults who were not part of original task development. Target accuracy for the adult participants was 85% or higher (i.e. at least six out of seven participants selected the correct answer) for each question. Three questions (one literal and two inferential) did not meet this criterion, suggesting they

[2] Since ASL is not a written language, we use standard glossing conventions (i.e. capital letters) to represent ASL signs.

were either unclear or too difficult. The pilot participants were also asked to evaluate the quality of the ASL texts for clarity and grammaticality of signing production. In this process, one video was identified that was not appropriately edited (i.e. it had extended pauses and jump cuts). The problematic questions and text were then modified: the questions that did not yield high accuracy were replaced with new questions and one video was re-filmed for fluidity. We then re-tested the same participant group, at which point all questions were answered with 85% accuracy or higher. Finally, to confirm that questions were appropriately labelled as literal and inferential, all of the questions were evaluated by three teachers of deaf students with a master's degree in either deaf education or ASL who were unfamiliar with the test. There was 100% agreement in the classification of the questions as literal and inferential.

Test Procedures

Participants were recruited to take the ASL-CMP as part of a large-scale study involving the ASLAI assessment battery (Hoffmeister et al., 2015). All of the language tasks in the ASLAI, including ASL-CMP, were self-administered by participants on a computer. Prior to each of the sub-tests, participants watched an instructional video in ASL (see Henner, 2015; Hoffmeister et al., 2015). The instructions encouraged children to try their best when answering the questions on the test. The students then began a practice section that included one short ASL text and three questions (two literal questions and one inferential question). The students were given feedback on the practice trials. The ASL-CMP test questions immediately followed this practice. For each text, children first viewed the ASL text, and then saw a screen with the first question. Each

question screen contained six different small videos consisting of the ASL text on the bottom left, the question on the top left, and the four different answer choices on the right in a two-by-two grid (Figure 7). The participants were instructed to watch the question, click on each of the four answer videos, and then select whichever video they thought best answered the question by clicking on the relevant video screen. To reduce working memory load, the question screen and four answer screens showed a carefully selected image as a frozen frame when the videos were not playing. Each frozen frame contained a salient feature of an ASL sign that could help the participant remember the contents of the video (Hoffmeister et al., 2015).

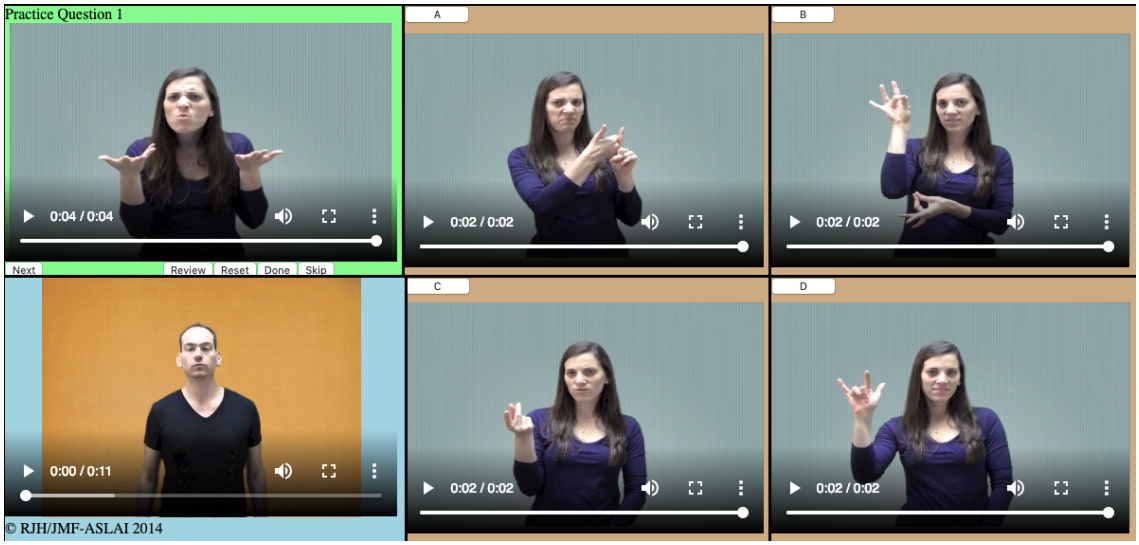

Figure 7. Sample screenshot of one test question. The top left panel is the comprehension question, with a still image of the sign WHAT. The bottom left panel shows the ASL text, which participants will have already reviewed, but is available for review as students make their answer. The four panels on the right are each of the answer choices, with a button labelled with a letter that corresponds to their answer choice. The written informed consent was obtained from the individuals in this image.

For example, the question screen might contain a frozen frame of a wh-question, and the answer choices might contain an image of a critical sign. The ASL text was included on the screen to allow the participants to review the ASL text if needed. In

addition to the frozen frames, there was no time limit and participants could re-watch the ASL text, the questions, and possible responses as many times as needed. The ability to review the entire text at will is an important feature that distinguishes the current task from a listening comprehension task, in which the information "disappears" after it is presented. In the current task, akin to a reading comprehension task, participants could refer back to parts or all of the story as they were determining their responses to the questions. All of the participants' responses were automatically scored and saved on a server. Scoring was dichotomous: participants received one point for a correct response and zero points for an incorrect response.

Participants

All of the participants in the present study were recruited through Boston University's Center for the Study of Communications & the Deaf (CSCD). All participants were deaf children attending schools for the deaf where ASL was the primary language of instruction. Participants varied with regard to when they were first exposed to ASL, as well as their ethnicity, hearing ability, IQ and age of entry to school. All participants that were able to complete the test were included in the sample.

For the psychometric evaluation of the ASL-CMP, only participants that had deaf parents were included (n = 105). These participants were chosen because of their homogeneity of age exposure to ASL (i.e. all were exposed to ASL from birth). These participants had an age range of eight to eighteen years (M = 11.2 years).

The second set of analyses include an initial evaluation of the ASL-CMP among a wider group of deaf children. For these analyses, participants included the above sample

of deaf children who have deaf parents (n = 105), plus an additional group of deaf children with hearing parents (n = 251) between the ages of eight and eighteen years (*M*= 12.6; see Figure 8). The sample was racially and ethnically diverse: of the 356 participants, there were 185 White, 49 Hispanic/Latino, 26 African American, 16 Micronesian, 19 Filipino, 15 Asian, 22 other, and 24 did not report. Information about age of entry into a school for the deaf was available for a subset of participants (n = 202). Of these, children with deaf parents (n = 48) entered school between birth (i.e., via early intervention) and nine-years-old (*M* = 3.62 years), and children with hearing parents (n = 154) entered school between one year and 18 years (*M* = 7.12 years).

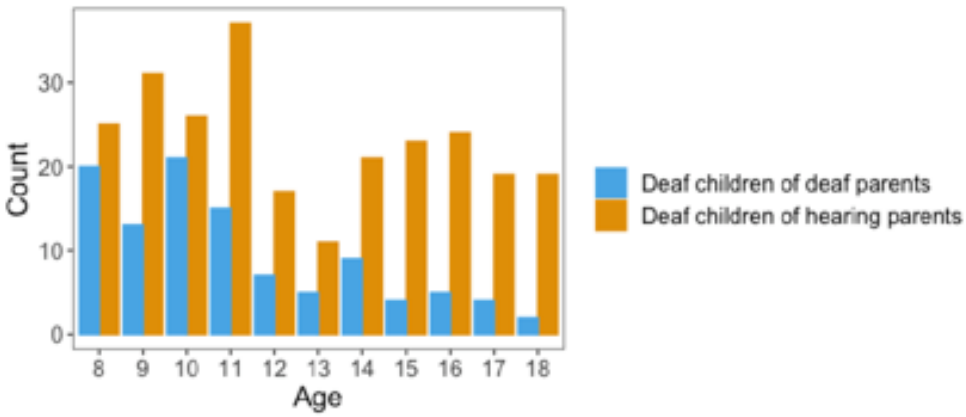

Figure 8. Number of participants with deaf parents (n=105) and hearing parents (n-251) at each age.

Results

Psychometric analysis of the normative sample

All analyses were conducted with the statistical software R. Psychometric analysis focused on the consistency and reliability of the test questions. We first used

item response theory (IRT) to determine discrimination (how well an item differentiates between high- and low-skilled participants) and the level of difficulty of each question in a standardized test (Yang & Kao, 2014). In contrast to classic test theory, IRT considers both individual participants and individual items which provides greater sensitivity about the items in relation to individual abilities. Items with a discrimination value of 0.20 or above are considered acceptable, while values below the 0.20 threshold do not sufficiently discriminate between the skilled participant and the unskilled participant (Baker, 2001; Taib & Yusoff, 2014). The acceptable range of difficulty for each question is 0.20 and 0.80 (Baker, 2001). Values below 0.20 indicate that the question is too difficult, and above 0.80 indicate that the question is too easy. In general, questions that do not meet the criteria for both discrimination and difficulty should be revised or deleted (Baker, 2001; Ebel, 1954). As presented in Table 1, results from the IRT analysis indicated that all of the questions in the ASL-CMP test except for two literal questions had acceptable discrimination power and appropriate range of difficulty. These questions were removed.

In addition to item response and discrimination, we assessed internal consistency among questions on the task. We initially computed Cronbach's alpha of the ASL-CMP across all questions, which revealed an acceptable internal consistency of alpha .80. To determine consistency within each type of question, we also computed Cronbach's alpha separately for questions that assessed literal and inferential comprehension as two different, but related, constructs. We used a criterion of an alpha of .70 or greater, which indicates that the items are measuring the same construct (Santos, 1999; Tavakol &

Dennick, 2011). We removed the two literal questions in addition to one inferential question that did not meet the criteria (described above). The Cronbach's alpha for the final set of seven literal questions was .75. and for the five inferential questions was .72. Thus the final version of the ASL-CMP, consisting of 12 questions, had acceptable levels of internal consistency (alpha =.85), discriminability, and difficulty.

Next, we evaluated concurrent validity by determining the relationship between the ASL-CMP and two other ASL vocabulary tests from the ASLAI, ASL Antonyms (Novogrodsky, Caldwell-Harris, Fish, & Hoffmeister, 2014) and ASL Synonyms (Novogrodsky, Fish & Hoffmeister, 2014). Both of these tests used the same format as the ASL-CMP, and both tests asked students to select a set of four different signs that best matches the given sign, synonymously or antonymously. We conducted Pearson correlation analyses for performance on the ASL-CMP and the two ASL vocabulary tasks in the ASLAI (Hoffmeister et al., 2015). Scores on both vocabulary tests were positively and significantly correlated with scores on ASL-CMP (antonyms: $r= .76$, $p < .001$; synonyms: $r=.74$, $p < .001$).

Finally, we used quantile regression to create growth charts of deaf children with deaf parents on the ASL-CMP (Figure 9). There was an increase in accuracy on the ASL-CMP with age, and an apparent ceiling effect at 12 years.

Question #	Type of Question	Mean(sd)	Item Difficulty	Item Discriminability	a if deleted
1	Inferential	0.61(0.49)	0.61	0.56	0.62
2	Literal	0.73(0.44)	0.73	0.30	0.68
3	Literal	0.57(0.50)	0.57	0.34	0.67
4	Literal	0.71(0.45)	0.71	0.45	0.65
5	Inferential	0.47(0.50)	0.47	0.30	0.71
6	**Literal**	**0.50(0.50)**	**0.50**	**0.19[a]**	**0.70**
7	**Literal**	**0.22(0.42)**	**0.22**	**0.04[a]**	**0.72**
8	Inferential	0.73(0.44)	0.73	0.53	0.64
9	Literal	0.71(0.45)	0.71	0.42	0.66
10	**Inferential**	**0.47(0.50)**	**0.47**	**0.25**	**0.73[b]**
11	Literal	0.76(0.43)	0.76	0.55	0.63
12	Literal	0.72(0.45)	0.72	0.56	0.63
13	Literal	0.66(0.48)	0.66	0.51	0.64
14	Inferential	0.71(0.45)	0.71	0.61	0.61
15	Inferential	0.72(0.45)	0.72	0.42	0.67

Table 1. Item difficulty and discrimination of the questions in ASL-CMP.
[a] denotes unacceptable discriminability value
[b] denotes change in alpha when removed
Bold row denotes omission in the final analysis

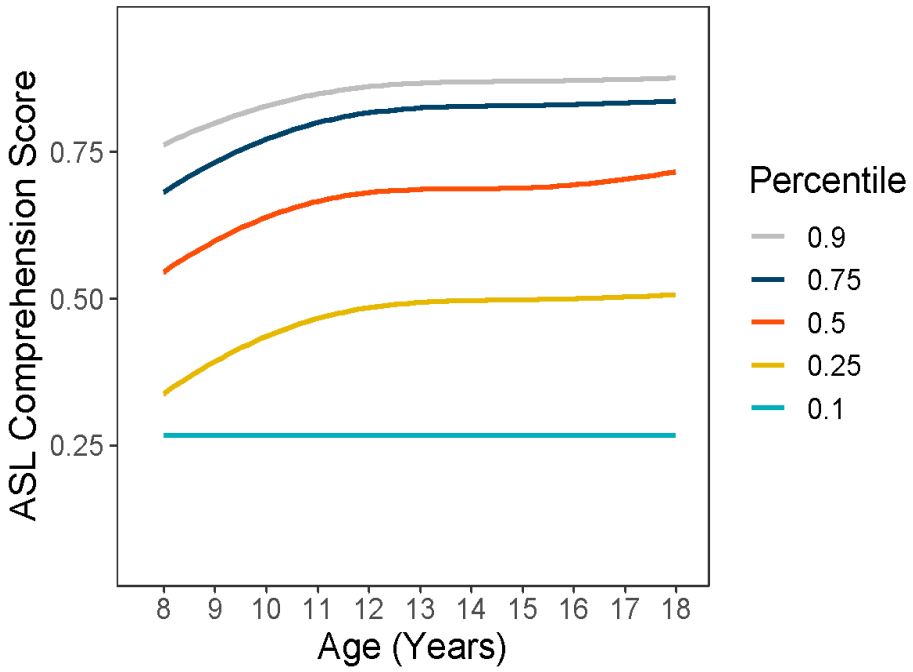

Figure 9. The relationship between age and accuracy on the ASL-CMP for deaf children of deaf parents (n=105). Lines indicate the 10th, 25th, 50th, 75th, and 90th percentiles, and were generated using the gcrq function in the R package quantregGrowth. The graph is not intended to be used to classify children's performance as within/above/below the normal range.

Evaluation of the ASL-CMP in deaf children with deaf parents and deaf children with hearing parents

Following the initial psychometric analysis, we assessed performance on the revised ASL-CMP on a larger group of participants, including children with deaf parents and those with hearing parents (n=356). If the test is sensitive to differences in age and amount of language exposure, then we would expect to see higher accuracy in deaf children who have deaf parents vs. deaf children who have hearing parents, higher accuracy in children with hearing parents who entered school early vs. those who entered school late, and higher accuracy in older vs. younger children. We also predicted that

accuracy would be higher for literal than inferential questions. Figure 10 illustrates overall performance by age and participant group. Performance for deaf children with hearing parents shows greater change with age than for deaf children with deaf parents.

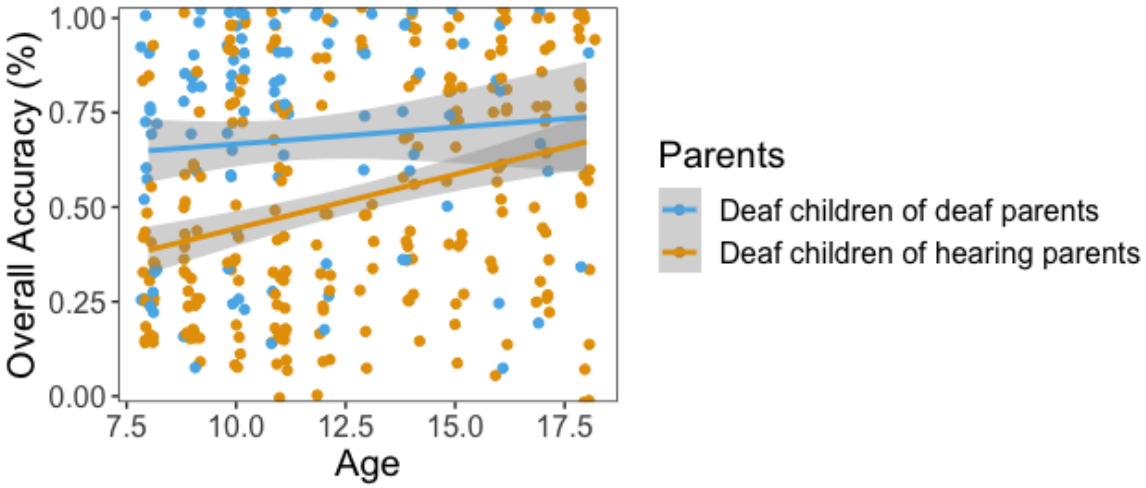

Figure 10. The proportion of the questions answered correctly as a function of age and parental hearing status. Points were jittered slightly to avoid overlap.

To analyze performance, we conducted a mixed-effects logistic regression using accuracy as the dependent variable (correct = 1, incorrect = 0; Table 2). In our initial model (Model 1), the fixed effects were participant group (deaf children who have deaf parents, deaf children who have hearing parents), age (continuous), and type of question (literal, inferential). Random effects were included for story, participants, and items. Analysis revealed significant effects of participant group and question type: deaf children with deaf parents had higher accuracy than deaf children with hearing parents ($M_{\text{deaf parents}}$ = .68, *sd* = .28; $M_{\text{hearing parents}}$ = .52, *sd* = .30), and literal questions were answered more accurately than inferential questions (M_{literal} = .58, *sd* = .32; $M_{\text{inferential}}$ = .55, *sd* =.33). Age was

also a positive and significant predictor of performance[3]. Children who have deaf parents appear to reach ceiling at about 12-years-old, which aligns with the target age range for this instrument (See Figure 9).

To investigate possible interaction effects, we ran a second regression model (Model 2) in which we added an interaction between parent hearing status and age, and an interaction between parent hearing status and question type. This analysis revealed no significant interaction effects. Further, Akaike's information criterion (AIC) revealed that adding the interaction terms to the model did not improve model fit: Model 2 (AIC= 4875.4) did not improve the model fit as compared to Model 1 (AIC= 4874.5; $\chi(2) = 3.07$, $p = .22$). There were no significant differences in the developmental trajectories of ASL text comprehension in deaf children with deaf versus hearing parents, and no interaction between question type and participant group.

For many deaf children, age of entry to school marks the time they are first immersed in ASL as a language of communication and instruction. For the subset of participants for whom we had information about age of entry to school (n = 202), we investigated the relationship between age of entry and performance on ASL-CMP by parental hearing status. We performed a mixed-effects logistic regression that was the same as the base model described above but also included an interaction between the participant group and age of school entry. We found a significant interaction between age of entry and parent hearing status, ($\beta = 0.18$, SE = 0.09, $z = -1.98$, $p = 0.047$). Post hoc

[3] A spearman correlation between age and ASL-CMP score was also significant ($r_s = .19$, $p < 0.01$)

	Model 1			Model 2		
Predictors	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*
(Intercept)	0.58	0.26 – 1.28	0.179	1.26	0.31 – 5.06	0.742
Age	1.15	1.09 – 1.22	**<0.001**	1.07	0.95 – 1.20	0.275
Type of Question (Literal)	1.23	1.06 – 1.42	**0.006**	1.39	1.05 – 1.84	**0.021**
Parent hearing status (hearing)	0.33	0.22 – 0.48	**<0.001**	0.12	0.02 – 0.57	**0.008**
Age *Parent hearing status (hearing)				1.10	0.97 – 1.26	0.145
Parent hearing status (hearing) * Types of Question (Literal)				0.84	0.61 – 1.17	0.309
Random Effects						
σ^2	3.29			3.29		
τ_{00}	2.21 $_{StudentID}$			2.19 $_{StudentID}$		
	0.09 $_{Story}$			0.09 $_{Story}$		
ICC	0.41			0.41		
N	3 $_{Story}$			3 $_{Story}$		
	356 $_{StudentID}$			356 $_{StudentID}$		
Observations	4296			4296		
Marginal R^2 / Conditional R^2	0.063 / 0.448			0.065 / 0.448		
AIC	4874.5			4875.4		

Table 2. Mixed effects logistic regression of factors predicting accuracy on the ASL-CMP. Model one demonstrates original factors, while model two also includes two interaction terms.

analyses indicated that, as predicted, there was a significant, positive correlation between age of entry and performance for the deaf children of hearing parents (n=154; β = -0.10, SE = 0.03, z=3.17, p = 0.002), but not for the deaf children of deaf parents (n= 48; β = 0.08, SE = 0.09, z = -0.93, p = 0.35). This suggests that children who may have limited exposure to ASL at home show an increase in performance as a function of the amount of time they have spent in a school where ASL is the primary language of instruction.

Discussion and Conclusion

In this study, we presented the development and validation of the ASL-CMP, a new ASL text comprehension task. We piloted the task on a group of native deaf signing adults, and then conducted a validation study with over 100 deaf children with deaf parents. This led to subsequent adjustments to ensure the task had high internal consistency and concurrent validity. We then analyzed performance in a group of more than 300 deaf children. Our findings suggest that the ASL-CMP is sensitive enough to detect patterns that are expected based on existing reports of deaf children's academic development, and is an appropriate measure of ASL text comprehension skills in children younger than twelve years of age. Below we discuss the primary findings, along with limitations and areas for further research.

As expected, deaf children of deaf parents, who were more likely to be exposed to ASL from birth, outperformed deaf children with hearing parents, who had more variable ages of exposure to ASL (Hall, 2017; Henner et al., 2016; Hrastinski & Wilbur, 2016; Kuntze, Golos, & Enns, 2014; Mitchiner, 2014). Children with deaf parents are likely to

be exposed to ASL from a wider range of individuals and in a broad range of contexts. This may lead to increased opportunities to develop inference-making skills, in which they need to extract information from ASL that is not explicitly stated. In contrast, deaf children with hearing parents may have had fewer opportunities to use ASL in these ways. Despite later exposure to ASL among the deaf children who have hearing parents, as a group they still showed evidence of development of higher-level comprehension skills in ASL over time. Further, it is important to note that not all deaf children with hearing parents performed below those with deaf parents. We speculate that many hearing parents who learn ASL likely provide a similarly rich environment for learning ASL as that provided by many deaf parents. This is additionally revealed in our analysis of age of school entry, which was a significant predictor of performance on the ASL-CMP for children with hearing parents. This provides promising evidence that exposure to ASL, even if it begins at school entry, can support students' acquisition of higher level ASL comprehension skills.

Our data revealed developmental patterns in deaf children's ASL text comprehension. Specifically, we found that older children had higher scores on the ASL-CMP than younger children. This pattern was particularly evident for children of deaf parents between the ages of 8 and 12 years and for children with hearing parents. This parallels findings from studies of literacy development in written language which show that text comprehension develops over a similar age range (Cain, Oakhill, & Bryant, 2001; Pettit & Cockriel, 1974; Silva & Cain, 2015). Many of the older children, particularly those with deaf parents, appeared to have already developed the ability to

comprehend the ASL texts used in the task by eight-years-old. In future studies, it will be important to include deaf children who have deaf parents younger than eight years, to better understand when comprehension skills are first developed among deaf children with early language exposure.

Lastly, there was a small but significant difference in accuracy on the ASL-CMP task based on the type of question, with higher overall accuracy on literal questions than on inferential questions. This is also compatible with previous studies showing literal comprehension is acquired prior to inferential comprehension (Basaraba et al., 2013; McCormick, 1992; Pettit & Cockriel, 1974). This suggests that literal comprehension may serve as a precursor to the ability to make inferences about information that is not explicitly stated in the text. Importantly, our findings are based on a small number of items, and the magnitude of the difference in performance between literal and inferential questions was small. We speculate that these differences would hold across a larger sample, but this must be borne out in future research.

Educational application of the ASL-CMP

The ASL-CMP is a tool for measuring ASL text comprehension in deaf children ages 8 to 12, and will be useful for a range of purposes. First, the ASL-CMP provides a broad-strokes understanding of how ASL text comprehension develops over childhood. Since this task has been normed using a relatively large group of deaf children of deaf parents, it can be useful for clinicians and practitioners in determining whether a child has age-appropriate ASL text comprehension skills. Teachers may use this task to adapt

their instruction to support the development of higher-level thinking skills, and to assess the quality and effectiveness of their ASL instructional approaches. Importantly, although the task has been normed, the ASL-CMP is not intended to diagnose deaf children with language delays. Instead, we recommend that this assessment be used to complement existing ASL assessments in that it measures more advanced language skills than are currently possible.

The ASL-CMP is a computer-based test that is automatically scored. No expertise or training is needed to administer the task. Scores at the individual and school level can be delivered rapidly. This is especially important for deaf children who attend classrooms in which there are no professionals who are fluent in ASL (Henner et al., 2018; Hoffmeister, 1988; Hrastinski & Wilbur, 2016). Inquiries about using the ASL Text Comprehension can be directed to the Learning Center for the Deaf, Center for Research and Training at CRT@tlcdeaf.org or to their website (www.ASLEducation.org).

Theoretical implications of the ASL-CMP

While text comprehension was previously conceived of primarily as the comprehension of a written composition (e.g., a book, article, essay, poem), a broader conception of literacy makes it possible to see that higher-level thinking skills underlie the ability to consume compositions of a wide range of forms. Because these different forms of literacy may share a common underlying proficiency (Mackey & Jacobson, 2014), developing literacy skills through engagement with one type of text may generalize and benefit children's ability to comprehend additional text types (Mayer,

2009; Mayer & Sims, 1994), both within and across languages. It is important to consider how ASL text comprehension might then support children's development of other skills, both in ASL and other languages such as English. Specifically, one might expect those with strong ASL text comprehension skills to also develop strong English literacy skills (Bailes, 2001; Cummins, 2006; Hrastinski & Wilbur, 2016; Kuntze, Golos, & Enns, 2014). With this novel way of assessing ASL text comprehension, we can begin to empirically test these questions.

Limitations and areas for further research

The data here show a clear ceiling at around 12 years of age, but children as young as eight already achieve above-chance performance, so more data is needed to determine if the test is appropriate for children younger than eight. The sample size, although larger than many studies of deaf children, is relatively small compared to most normative samples. In a larger sample, we may expect to see more robust interactions between participant group and age, as well as more fine-grained development of literal and inferential comprehension skills. Another limitation is that, because we did not have full demographic information on all of the participants in our sample, we were not able to tease out individual differences and how they impacted performance on the ASL-CMP. Due to the small number of questions, seven literal and five inferential, the ASL-CMP cannot reliably distinguish literal and inferential comprehension as two independent constructs, but rather it provides a measure of overall ASL comprehension. Finally, in the current analysis we looked at correct responses only. In future work, we hope to carry out

an analysis of incorrect responses to determine whether children are more likely to choose distractors of a specific type.

Conclusion

In summary, development of text comprehension skills in ASL is an important component of language and literacy development among deaf children. The newly developed ASL-CMP task is a first step in understanding how high-level text comprehension skills develop in children learning ASL. Our task is sensitive to ASL text comprehension in children from a wide range of backgrounds, and suggests that ASL text comprehension improves as children are exposed to ASL both at home and at school. The ASL-CMP makes it possible to evaluate children's ASL text comprehension skills, and identify children who may need support in developing such skills. Further, with a direct assessment of deaf children's text comprehension skills in ASL, we can begin to identify strategies to improve text comprehension skills in deaf children across languages.

CHAPTER IV

STUDY II

The Interrelationships Between Lower- and Higher-Level Skills in ASL Comprehension, and the Relationship Between ASL-Text Comprehension and English-Text Comprehension

Abstract

Given that text-comprehension skills are integral for future academic, social, and employment success, understanding the myriad skills that contribute to text comprehension is essential, especially in Deaf children in bilingual contexts. Although text comprehension, as posited by the Simple View of Reading, is informed by decoding and language-comprehension skills, text comprehension as a set of skills is more complex than it first appears. Language-comprehension skills contain specific language components that are integral for comprehension, such as vocabulary knowledge, syntactic abilities, literal comprehension and inferential comprehension. While much research has been devoted to spoken-language comprehension skills, little is known about parallel development in sign languages such as ASL. This study has three aims: first, to establish the correlation between lower-level language-comprehension skills (vocabulary knowledge and syntactic abilities) and higher-level language-comprehension skills (literal and inferential comprehension); second, to establish the predictive effect of lower-level skills on higher-level skills based on parental hearing status, and third, to identify the relationship between ASL comprehension and English comprehension. Data were drawn

from a sample of 251 Deaf children. Initially, a series of *t*-tests and correlational analyses were carried out to determine the difference in performance on the ASL-CMP in the two participant groups—deaf children with deaf parents and deaf children with hearing parents. Then, regression analyses were performed to determine the effects, if any, of lower-level skills, in addition to age and parental hearing status, on literal comprehension and inferential comprehension. There were main effects of age and ASL vocabulary knowledge, and an interaction between participant group and ASL syntax knowledge on literal comprehension accuracy. For inferential comprehension accuracy, there were main effects of both ASL vocabulary and ASL syntax. Finally, there was evidence of a statistically significant correlation between ASL comprehension and English comprehension, suggesting a possible transference between ASL-text comprehension and English-text comprehension.

Keywords: *ASL assessment, lower- and higher-level skills in ASL, Linguistic Interdependence Hypothesis.*

Introduction

If children can comprehend textual information, their knowledge and skills expand, and this is fundamental in all aspects of life: social, academic, and professional (Silva & Cain, 2015). Furthermore, with strong comprehension skills, children can access a wide range of textual information across content areas such as history, science, and math, making progress in their learning. There is consistent evidence of a significant positive correlation between comprehension skills and future academic and career success (Perfetti, 1999; Silva & Cain, 2015; Stanovich, 1986; Thorndike, 1973). This correlation is equally true for bilingual children: text-comprehension skills in L1 enable them to develop comprehension skills in L2 (Hogan, Bridges, Justice, & Cain, 2011). Understanding language-comprehension skills as a set of literacy skills is essential not only for children's futures, but also for teachers to develop effective instruction and intervention to promote literacy skills in young children, particularly those who struggle to acquire new knowledge and skills from text (Hogan et al., 2011).

This factor is particularly important in Deaf children as many face challenges in comprehending textual information in English. On average, Deaf children perform poorly on measures of English vocabulary knowledge, syntactic abilities, and reading comprehension (Hrastinski & Wilbur, 2016; Scott & Hoffmeister, 2017). We have yet to understand why Deaf children struggle to display gains in English. It is possible that a barrier to this understanding is the lack of recognition of the positive association between ASL proficiency and English literacy skills. Such a relationship appears parallels spoken bilingual studies on the benefits of the L1 on the development of the L2 skills (Cummins,

2006; Edele & Stant, 2016; Kim, 2015; Kroll, Bobb, & Hoshino, 2014; Siu & Ho, 2015; Sparks, Patton, Ganschow, & Humbach, 2012; Scott, 2015). Nevertheless, little is known about Deaf children who use ASL and English in their learning (Haug, 2008). This lack is, however, unsurprising given that the majority of Deaf children in the United States are educated in mainstream environments where ASL is not used as a language of instruction (Scott, 2015) and being Deaf is not a common occurrence. Despite this, approximately 40% of Deaf children have been exposed to signed language at some point in their formal education (Henner, Novogrodsky, Hoffmeister, & Reis, 2018); therefore, from a bilingual viewpoint, it is necessary to investigate ASL language-comprehension skills in Deaf children. Unfortunately, there have only been a few studies that examined such relationships. We do not know whether these language-comprehension skills in ASL, as evidenced in other languages, are crucial for text-comprehension skills in Deaf children who learn via both ASL and English. It is possible also that this oversight may account for the variability of Deaf children's poor literacy outcomes. Therefore, this study investigates the relationship between lower-level language- skills (ASL vocabulary knowledge and ASL syntax ability) and higher-level language-comprehension skills (literal comprehension and inferential comprehension), as well as the relationship between ASL comprehension and English comprehension in Deaf children.

Text Comprehension as a Set of Skills

According to the Simple View of Reading (SVR), a research-based model proposed by Gough and Tunmer (1986), text comprehension is the result of decoding and language-comprehension skills. Although seemingly simple, text comprehension is more

complex than it first appears. Both Davis (2006) and Scarborough (2001) report that decoding and language comprehension consist of complex underlying skills. Scarborough (2001) illustrated that decoding and language-comprehension skills are informed by multivariate skills, such as cognitive skills (e.g. memory and executive functions), vocabulary, syntax, literal comprehension, inferential comprehension, comprehension monitoring and text structure knowledge (Cain, 2007; Edele & Stant, 2016; Nassaji, 2003; Perfetti, 1999). Each skill, at various points in time, has been proven to contribute to the variance in reading comprehension across ages (Kamhi and Catts, 2012; Silva & Cain, 2015); hence, the importance of understanding precisely how each skill develops independently, as well its interaction with other skills for the purpose of solidifying and advancing text-comprehension skills.

Moreover, there is a growing body of literature in recent decades that claims that text comprehension is affected by an individual's language-comprehension skills (Catts, Hogan, & Adlof, 2005). Although decoding is essential in the development of text comprehension, certain reading studies have found that once decoding becomes automatized, language-comprehension skills become more important for reading comprehension. Text comprehension is shaped by vocabulary knowledge, syntax skill, literal comprehension, and the ability to make inferences (Edele & Stant, 2016; Elleman, 2017; Silva & Cain, 2015). These skills are consistent across studies on different types of comprehension, such as listening comprehension, reading comprehension, and text comprehension, in both monolingual and bilingual contexts (Edele & Stant, 2016; Hogan et al., 2011; Silva & Cain, 2015). These language-comprehension skills contribute unique

variance to text comprehension ability (Catts et al., 2005; Edele & Stant, 2016; Silva & Cain, 2015). It is important to understand not only language-comprehension skills independently, but also how they interact with each other in the development of comprehension skills among young children. Understanding the interplay of language-comprehension skills is particularly important for teachers and practitioners, who play a pivotal role in teaching and developing text-comprehension skills in young children (Elleman, 2017). These findings are equally applicable to bilingual learners, suggesting that, for such learners, some language-comprehension skills are transmodal in the L1 and the L2 (Kroll et al., 2014), in that the skills in the L1 can be utilized to support the development of comprehension skills in the L2, and vice-versa (Cummins, 2000; Proctor et al., 2010; Sparks et al., 2012).

Vocabulary Knowledge

If there is one thing that is consistent in the empirical literature on reading, it is the robust relationship between vocabulary knowledge and text comprehension. Vocabulary knowledge is determined and measured by both breadth and depth of word knowledge. While the quantity of words determines learners' breadth of vocabulary knowledge, depth of vocabulary knowledge is in relation to a learner's ability to use a word in different contexts, demonstrating a deeper understanding of the word (Moghadam, Zainal, & Ghaderpour, 2012). There are different dimensions that can be used to inform comprehenders' vocabulary knowledge, such as spelling, pronunciation, morphology, and their relationship with other words in semantic contexts (e.g. synonym,

antonym, connotation, and collocational meaning) (Haastrup & Henriksen, 2000; Meara, 1996). Combined, these forms can be used to shape comprehenders' overall vocabulary knowledge.

Since text consists of words, it is unsurprising to find that there is a high correlation between vocabulary knowledge and text-comprehension skills across ages (Cromley & Azevedo, 2007; Mokhtari & Niederhauser, 2012; Potocki, Ecalle, & Magnan, 2013; Thorndike, 1973). An early study by Thorndike (1973) indicates that the correlations across different reading tests, such as Davis Reading test, Gates Reading, and Iowa Silent Reading with vocabulary knowledge in general among those in Grades 2, 4, 6, and 8 are significantly high, ranging from .66 to .75. Similarly, a longitudinal study performed by the NICHD Early Child Care Research Network (2005) yielded a high correlation, at .56, between vocabulary knowledge and reading comprehension in slightly more than thousand children. Finally, in Silva and Cain's (2015) study of 82 young children, 4 to 6 years old, vocabulary knowledge was significantly correlated with listening comprehension through both literal and inferential constructs, at .23 and .47, respectively. In addition to correlation, vocabulary knowledge has also been demonstrated in many empirical studies as a significant predictor of reading comprehension (Mokhtari & Niederhauser, 2012). Silva and Cain (2015) found, in their study of 82 children aged 4 to 6 years old, that both literal and inferential comprehension can be predicted by vocabulary knowledge ($\Delta R^2 = .10$, $p < .01$; $\Delta R^2 = .08$, $p < .05$, respectively).

Numerous studies conclude that vocabulary knowledge is an important language

skill for higher-level comprehension. However, vocabulary knowledge alone is insufficient to ensure optimal comprehension, as previously believed (Ehrlich & Remond, 1997; Nation & Snowling, 2011; Potocki, Ecalle, & Magnan, 2013). According to Nation and Snowling (2011), when vocabulary knowledge is controlled, comprehension skills can still be affected by syntactic abilities, especially among poor readers. This aspect indicates the importance of understanding the effect of syntactic abilities at the sentence level as another language skill integral for higher-level comprehension.

Syntactic Abilities

Syntax is a system of grammatical rules that dictate how words should be positioned in a sentence (Brimo, Lund, & Sapp, 2018). Syntactic processing allows readers to construct a mental representation when reading at a sentence level by making cohesive decisions informed by word recognition and vocabulary knowledge to create an accurate interpretation of the sentence. Syntactic processing is a multifaceted skill comprising two main constructs: 1. syntactic knowledge, and 2. syntactic awareness (Gottardo, Mirza, Koh, Ferreira, & Javier, 2017). While syntactic knowledge is determined by the ability to identify errors in sentences, syntactic awareness is determined by the ability to also to repair the sentences to appear grammatically correct (Gombert, 1992). Therefore, for comprehension to occur, readers, in addition to vocabulary knowledge, must possess adequate syntactic knowledge to process the information at a sentence level.

Several studies have distinguished between skilled comprehenders and poor

comprehenders, when controlling for vocabulary knowledge, based on their syntactic abilities. In these studies, poor syntactic abilities yielded a negative effect on overall text-comprehension performance (Brimo, Lund, & Sapp, 2018; Deacon & Kieffer, 2018; Layton, Robinson, & Lawson, 1998; Mokhtari & Niederhauser, 2012; Nation & Snowling, 2011; Ryan & Ledger, 1984; Dreher & Zenge, 1990). Notably, there have been mixed findings regarding the role of syntactic abilities in reading comprehension when considering the aforementioned skills required for syntactic processing (Brimo, Lund, & Sapp, 2018). However, when studies do consider the differences between syntactic knowledge and syntactic awareness, the results reveal a significant effect of syntactic abilities on reading comprehension (Gottardo, Mirza, Koh, Ferreira, & Javier, 2017; Gottardo, Stanovich, & Siegel, 1996; Kieffer & Lesaux, 2007; Kintsch, 1992). For example, Deacon and Kieffer's 2018 study of 100 third-graders and fourth-graders provides significant evidence of syntactic awareness in Grade 3 as an important predictor of reading comprehension in Grade 4 (Satorra-Bentler $\Delta\chi^2 = 6.93$; $\Delta df = 1$; $p = .010$). Cutting and Scarborough (2006) studied 97 7- to 15-year-old children and found syntactic knowledge accounted for 1% to 5% variance in reading comprehension outcomes. Moreover, longitudinal studies, such as Muter et al. (2004) and Demont and Gombert (1996), reveal that syntactic knowledge accounted for 4% to 24% of the variance in young children's reading comprehension.

Lower-Level Skills

In addition to the above studies, the interrelationship between vocabulary knowledge and syntactic abilities as lower-level skills is essential to reading

comprehension. Although each skill independently predicts reading comprehension (Clarke, Snowling, Truelove, & Hulme, 2010; Silva & Cain, 2015), vocabulary knowledge and syntactic abilities are correlated. Readers with poorer vocabulary skills will also demonstrate deficits in syntactic abilities, which, in turn, affects their comprehension (Cain, 2010; Scott, 2004). Moreover, some studies found that vocabulary and syntax are two critical lower-level components contributing to the development of comprehension skills (Brimo, Lund, & Sapp, 2018; Florit et al., 2011; Kenedeou, Bohn-Gettler, White, & van den Broek, 2008). Finally, another study concludes that reading comprehension is informed by both vocabulary knowledge and syntactic abilities (Clarke et al., 2010).

Lower-level skills are important predictors of text comprehension, but are insufficient for overall comprehension (Hogan et al., 2011). Since language is not always explicit, literal comprehension and inference-making are two important dimensions of higher-level comprehension skills, which are integral for optimal interpretation of the text (Hogan et al., 2011; Silva & Cain, 2015; Tompkins et al., 2013).

Literal Comprehension and Inferential Comprehension

Although the idea that literal and inferential skills are two separate dimensions remains debatable, they are symbiotic in the sense that literal comprehension can serve as a vehicle for inference-making (Miller & Smith, 1984). Whether they are discrete or dependent, literal and inferential skills are both important higher-level comprehension skills because, without the ability to comprehend a text on both literal and inferential

levels, the goal of the text may be misconstrued or lost. Regarding other higher-level skills, such as comprehension monitoring, and text structure knowledge (Hogan, Bridges, Justice, & Cain, 2011), literal comprehension and inferential skills are two common measurable dimensions in reading studies that are used to determine children's comprehension of a text.

Literal comprehension is informed and constructed by a learner's ability to process and combine lower-level linguistic input using word recognition, vocabulary knowledge, and syntactic abilities. Literal comprehension is described as text-based in the sense that comprehension is shaped by one's ability to make meaning based on information explicitly stated in the text. For example, *John married James, so John moved to Idaho.* If I asked who moved to Idaho, and you responded "John," this demonstrates an ability to use the source of information to answer the question.

However, literal comprehension skill is not necessarily sufficient for maximal comprehension. For example, if I asked you why John moved to Idaho, with adequate inferential skills you should be able to infer that it was because James is perhaps from Idaho. Making inferences allows the reader to go beyond the text to deduce meaning by extending the literal meaning derived from the text with information not explicitly stated using prior knowledge, skills, and experience. Without the ability to converge literal information with inferences, interpretations and goals of the text may not be achieved (Hansen & Pearson, 1983).

Silva and Cain's 2015 study on 82 children found that both literal and inferential comprehension correlate significantly with reading comprehension and predict variability

in reading comprehension (β=.43 for literal and β=.33 for inferential, both p. <.001). Moreover, both literal and inferential skills mediated significantly in the relationship between vocabulary and reading (Point estimate [PE] = .100, bias-corrected (BC) 99% CI [.023, .231] and PE= 0.64, BC 99% CI [.006, .183], respectively). Furthermore, Elleman's 2017 meta-analysis reviewed different studies examining the role of higher-level skills in reading comprehension and found that teachers who spent more time on teaching both literal- and inferential-comprehension skills had a significant positive outcome on overall text comprehension, especially for those who were poor comprehenders. Therefore, lower- and higher-level skills are distinct and have important pedagogical implications.

The Relationship Between Lower- and Higher-Level Skills in Bilingual Learners

Studies of bilingual learners have also examined the roles of lower-level skills and higher-level skills in comprehension. Evidence exists of correlations between lower-level skills and higher-level skills within listening and reading comprehension in several studies (Cummins, 1979; Dufva & Voeten, 1999; Edele & Stant, 2016; Hartsuiker, Pickering, & Veltkamp, 2004; Proctor, August, Carlo, & Snow, 2006; Siu & Ho, 2015; Sparks, Patton, Ganschow, & Humbach, 2012; van Gelderen, Schoonen, Stoel, Glopper, & Hulstijn, 2007). Dufva and Voeten (1999) studied Finnish children who learned English as an L2, testing language skills in both Finnish and English. The results indicate that the children's performances on English measures could be explained by 58% of their L1 skills in phonological memory, word decoding, and listening/reading-comprehension

skills. Edele and Stant (2016) found that, by studying bilingual Russian and Turkish learners, L1 listening-comprehension skills predicted their L2 reading comprehension. They found also that higher-level skills in L1 listening comprehension were significant in reading comprehension in L2 for the Turkish learners (9% of the variance), but not for the Russian learners. The study, however, concludes that understanding skills within L1 was important in advancing L2 skills. Proctor, August, Carlo, and Snow (2006) found the effects of different L1 skills in Spanish, such as alphabetic knowledge, oral proficiency, and reading comprehension, on L2 reading comprehension in English. Van Gedleren et al. (2004) found that vocabulary and grammar knowledge serve as important indicators of both L1 and L2 comprehension. Finally, a longitudinal study by Sparks et al. (2012) investigated the relationship between L1 skills and L2 skills, following 54 high school participants in the United States from first grade to tenth grade. The students took a large battery of tests in both L1 and L2, and the results indicate that L1 literacy skills were predictive of reading comprehension in the L2 in different languages (Spanish, German, and French).

Overall, based on previous studies, language skills are important not only for monolingual learners, but also bilingual learners. Therefore, understanding different language-comprehension skills as predictors within lower and higher-level comprehension skills in the development of text comprehension is integral for learning, particularly for those with comprehension difficulties (Graesser et al., 1994). Understanding the relationship between lower- and higher-level comprehension skills have found to have positive educational implications particular to those who are

struggling on different comprehension tasks (Elleman, 2017).

It is well documented that language skills are an important foundation for text comprehension in monolingual and bilingual learners (Hogan et al., 2011; Proctor et al., 2010; Sparks et al., 2012). Language skills at both lower- and higher-level have demonstrated their importance in the development of children's reading-comprehension skills in bilingual contexts. This understanding ties into Cummins' interdependence hypothesis that skills in the L1 can be transferred to the L2 (Cummins, 2000). However, we do not yet know whether this hypothesis applies to Deaf children who learn through ASL, or whether higher-level language-comprehension skills in ASL as an L1 will support Deaf children in acquiring the skills needed to comprehend English text as an L2.

Comprehension Skills in Deaf Children

Today, Deaf children leave high school with an average of a fourth-grade reading level (Scott & Hoffmeister, 2017), and are described as poor comprehenders of English (Kyle & Cain, 2015). Kyle and Cain (2015) found that many Deaf children share similar characteristics with typical learners who struggle with text comprehension in English. While there are many Deaf children struggling to develop comprehension skills, there is a small group of Deaf children who are skilled comprehenders in English. Studies have identified that those skilled comprehenders are also proficient in ASL, suggesting an important relationship between ASL and English (Henner et al., 2018; Hrastinski & Wilbur, 2016; Scott & Hoffmeister, 2017). There is evidence of benefits from early exposure to ASL because it supports and advances cognitive and language development

in Deaf children (Chamberlain & Mayberry, 2008; Mayberry, 1989), in contrast to Deaf children who are not exposed to ASL until later (Hall, 2017; Henner et al., 2018; Humphries et al., 2017; Scott & Hoffmeister, 2017). Deaf children of Deaf parents tend to outperform their peers on many language measures in both ASL and English (Chamberlain & Mayberry 2008; Henner, 2016; Prinz & Strong, 1998; Scott & Hoffmeister, 2017). Furthermore, the longer Deaf children are placed in signing environments, the better they perform on different literacy measures in both ASL and English (Henner et al., 2018; Hrastinski & Wilbur, 2016). Thus, it can be inferred that ASL holds great value for reading-skill development among Deaf children.

The Role of ASL

ASL entails vocabulary and grammatical structure (Sandler & Lilo-Martin, 2006). Emmorey's 2002 study indicates that ASL has psychological functions similar to those found in spoken language. ASL and spoken language are processed in a similar area in the brain (Campbell, MacSweeney, & Waters, 2008). Moreover, language-comprehension skills in ASL, such as vocabulary, antonyms and synonyms, ASL syntax, and analogical reasoning all contribute to overall ASL language proficiency (Chamberlain & Mayberry, 2008; Henner, 2016; Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister, 2016; Novogrodsky, Fish, & Hoffmeister, 2014). These findings indicate not only the importance of language skills in ASL to process and acquire new knowledge presented in ASL, but also the similarities between ASL and spoken language (Chamberlain & Mayberry, 2000; Henner et al., 2018).

To comprehend informational text in ASL, Deaf children should be expected to develop and demonstrate adequate skills, such as decoding, vocabulary, and grammar knowledge in ASL, literal comprehension and making inferences, especially to achieve the construction of a situation model, a mental representation constructed as described in a text (Kintsch, 1998), of the text in ASL. If these skills are not developed, the goal of the ASL text will not be achieved. However, little research has been conducted on ASL text as a source of comprehension. Thus, we do not know what to expect from Deaf children when perceiving ASL texts. There is limited understanding of Deaf children's ASL-text comprehension skills despite previous bilingual studies having demonstrated that L1 comprehension skills can be transferable to support the skills for L2 learning, including reading comprehension in the L2 (Cummins, 1979; Koda, 1995; Sparks et al., 2012; van Gelderen et al., 2007).

In response to evidence illustrating the benefits of using ASL texts in both academic and social contexts (Snoddon, 2011), there is an increase in the use of ASL texts in classrooms. However, there is still much to be learned about ASL comprehension and the interplay of the language-comprehension skills that contribute to overall ASL comprehension. According to the literature, we should expect that the perceiver demonstrates command of lower-level and higher-level skills to construct an accurate understanding of an event or affair of the text in ASL. Language-comprehension skills are integral for reading comprehension in young children (Gough & Tunmer, 1986; Oakhill & Cain, 2012; Perfetti, Landi, & Oakhill, 2005); therefore, it is necessary to consider the same when ASL comprehension is concerned.

However, there is a paucity of research examining how ASL language skills contribute to overall ASL-text comprehension in young Deaf children.

The Current Study

This study investigates the role of lower- and higher-level language skills, specifically ASL vocabulary knowledge, ASL syntactic abilities, ASL literal comprehension, and ASL inferential comprehension, and how they each inform comprehension skills in ASL using the newly developed ASL text comprehension task (Figure 11). In addition to the interrelationship between language skills in ASL, this study examines the relationship between ASL comprehension and reading comprehension in English. This understanding is drawn from the literature review and the idea that ASL vocabulary and ASL syntactic knowledge can predict significant variance in Deaf children's literal- and inferential-comprehension skills. Furthermore, we should expect that Deaf children's comprehension skills in ASL should correlate with reading comprehension in English. Finally, the results from this study can provide teachers and practitioners with specific areas of development in ASL to help create an effective instruction and intervention design to promote higher-level comprehension skills in both ASL and English.

To achieve the study goals, I first examine the correlation between age, parental hearing status, two lower-level skills — vocabulary knowledge and syntactic abilities, and two higher-level skills — literal and inferential comprehension, in Deaf children from ages 8 to 18 years. I hypothesize that each skill (ASL vocabulary knowledge, ASL syntactic abilities, literal comprehension, and inferential comprehension) will correlate

with each other.

Figure 11. The model of the missing relationships between ASL text comprehension and vocabulary and grammar in ASL, and ASL-text comprehension and reading text comprehension in English.

The next aim is to investigate whether ASL vocabulary and ASL syntax each predict literal and inferential comprehension. In line with previous studies, we hypothesized that each vocabulary and syntax would each serve as a significant predictor of higher-level comprehension skills. Finally, we investigated the relationship between ASL comprehension and reading comprehension in English. We predicted that there would be a positive correlation between ASL comprehension and English reading comprehension.

Method

Participants

Three hundred and three Deaf children from ages 8 to 18 from four Deaf signing schools in the United States participated in a large study as part of the development of the ASL Assessment Instrument (ASLAI) (Hoffmeister et al., 2013). The ASLAI is a battery

of norm-referenced assessments that includes the following subtasks of specific language skills: ASL vocabulary, ASL syntax, ASL reasoning, and ASL comprehension (Hoffmeister et al., 2013). Although the data used in the current study were retrieved from the larger study as part of the development of the ASLAI, 52 participants did not complete all of the tasks. The data from the remaining 251 participants, including 84 Deaf children of Deaf parents (DD) and 167 Deaf children of hearing parents (DH), were collected in this study (see Figure 12). Children varied in age of school entry, but all were taught in both ASL and English in the classroom.

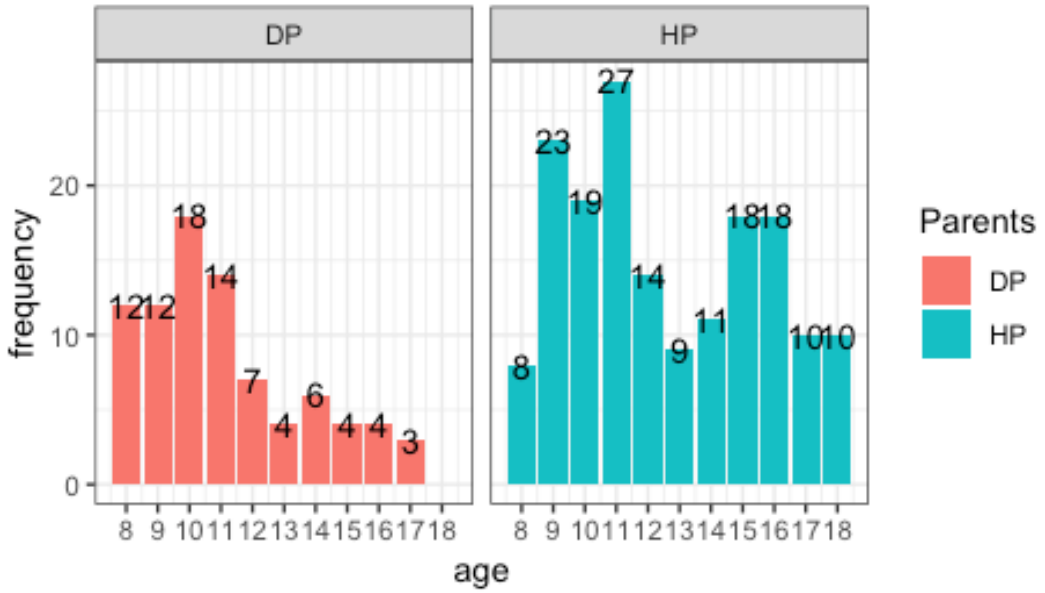

Figure 12. Deaf children in the present study DD (pink) (n=84) & DH (blue) (n=167).

Design

The participants completed a range of language skills in the ASLAI. All the measures used in this study were completely in ASL. Additionally, all the tasks were designed as a multiple-choice format using ASL texts instead of English texts. The outcomes of all measures in the ASLAI were dichotomous, meaning the correct answer

was worth one point, and no points were awarded for incorrect answers. Although standardized scores were reported to the school for each participant relative to age norms, this study used participants' raw scores (0% to 100%). Furthermore, the participants' overall vocabulary knowledge was based on a composite score of three ASL receptive vocabulary tasks (antonyms, synonyms, and difficult vocabulary), one ASL syntax knowledge task, and the newly developed ASL-Text Comprehension task that included information about their literal and inferential comprehension.

Measures

Vocabulary knowledge. The participants' vocabulary knowledge was determined by performance on three receptive ASL vocabulary measures: the ASL antonyms task, the ASL synonyms task, and the ASL difficult vocabulary task from the ASLAI. The following is a short description of each task:

- *ASL antonyms task*: Assesses the participants' ability to identify two lexical items in ASL that are opposite in meaning. The task contains 14 multiple-choice questions with four possible answers (reported Cronbach's alpha for internal consistency at .90).
- *ASL synonyms task*: Assesses the participants' ability to identify two lexical items in ASL that are similar in meaning. The task contains 15 multiple-choice questions (reported Cronbach's alpha = .84 for internal consistency).
- *ASL vocabulary difficult task*: Assesses the participants' ability to choose the correct lexical item in ASL that best matches the definition, again in

ASL. The task contains 25 questions (reported Cronbach's α= .86).

ASL Syntax Ability. The participants' knowledge of syntax in ASL was determined by their performance on the ASL syntax task, which assesses the participants' syntactic knowledge by asking them to identify the one in a set of the four ASL sentences that is grammatically correct.

- *ASL Syntax Difficult task* contained 18 questions, with two sentences each for nine ASL sentence types: plain, relative clause, conditional, negation, agreement, rhetorical, topic-comment, complement, and wh-question. The participants' ability to choose the sentence that is grammatically correct in ASL is evaluated (reported Cronbach's α = .79).

ASL Comprehension Ability. The participants' ability to comprehend ASL texts was assessed to establish their performance on overall ASL-text comprehension with information about their abilities to respond to literal and inferential questions.

- *ASL-Text Comprehension task (ASL-CMP)*: Assesses the participants' literal- and inferential-comprehension skills. This task contained three stories in ASL, followed by five questions for each story, three literal questions and two inferential questions, for a total of 15 questions. However, three questions were omitted from this study (due to unacceptable discriminability value; see previous study in Chapter 3 for more information). Therefore, 12 questions were used in this study, seven literal and five inferential questions (reported alpha for ASL-CMP is .85).

Reading Comprehension Ability. The participants' ability to comprehend English texts were computed as scaled scores based on their performance on the reading-comprehension task in the Stanford Achievement Tests, Hearing Impaired (SAT-HI) (Harcourt Educational Measurement, 1996). Although they did not take the test at the same time, we collected the participants' scores when they took the ASLAI.

- *Reading-comprehension task*: The participants read several passages and then responded to multiple-choice questions after each passage.

Research Questions

Research Question 1: Are the lower-level language-comprehension skills, ASL vocabulary and ASL syntax, and higher-level language comprehension skills, ASL literal comprehension and ASL inferential comprehension correlated?

Hypothesis 1: There are significant correlations between the said variables in Deaf children.

Research Question 2: Are there differences in performance on lower-level and higher-level tasks in Deaf children of Deaf parents (DD) and Deaf children of hearing parents (DH)?

Hypothesis 1: There is a significant difference between DD and DH on all measures, vocabulary knowledge, syntactic abilities, literal comprehension, and inferential comprehension in ASL.

Research Question 3: Does performance on ASL vocabulary and ASL syntax predict performance on literal comprehension and inferential comprehension in Deaf children?

Hypothesis 1: There is a significant effect of ASL vocabulary and ASL syntax on literal comprehension and inferential comprehension.

Hypothesis 2: There is a significant effect of age and parental hearing status on the relationship between lower-level and higher-level language-comprehension skills in Deaf children. Therefore, ASL literal comprehension and ASL inferential comprehension performance are significantly predicted by age and parental hearing status in addition to ASL vocabulary knowledge and ASL syntactic abilities.

Research Question 4: Is there a relationship between ASL-text comprehension and reading comprehension in English?

Hypothesis 1: There is a significant positive correlation between ASL-text comprehension and reading comprehension in English.

Procedure

All participants took the ASLAI at their schools, usually in the computer labs, since the ASLAI is entirely computer-based. It took each participant approximately two 90-minute sessions to complete the entire battery of tasks on the ASLAI, depending on age and individual needs. Prior to taking each task, the participants were issued instructions in ASL for each assessment. Although most of the participants completed the test independently, there were native Deaf postgraduate research assistants proctoring the

test who were readily available to provide support, such as selecting responses for participants who might have struggled to operate the computer or addressing computer problems (e.g. delayed videos, limited bandwidth, or non-responses).

Results

This study sought to obtain a better understanding of language-comprehension skills in ASL by examining the relationships between different language-comprehension skills that contribute to overall comprehension among Deaf children, as well as the relationship between ASL comprehension and reading comprehension in English. To establish such relationships, I began with an exploratory analysis of the data extracted from 251 Deaf children ages 8 to 18 years across the country who were recruited to take the ASLAI, including the newly developed ASL-CMP task. Then, linear model regression analyses were performed to determine the main effects of predictor variables. Finally, a correlation analysis was conducted to determine the relationship between ASL comprehension and English comprehension, both as a simple correlation and while controlling for ASL vocabulary and syntax knowledge.

Are the lower-level language-comprehension skills, ASL vocabulary and ASL syntax, and higher-level language comprehension skills, ASL literal comprehension and ASL inferential comprehension correlated?

To address the first research question, a correlational analysis between three different ASL vocabulary-related tasks, one ASL syntax task, and two ASL comprehension tasks (literal comprehension and inferential comprehension) was carried

out. Table 3 reveals that performance on all tasks are highly correlated with each other. Given the results of this correlational analysis, all the three vocabulary-related tasks (ASL synonyms, antonyms, and vocabulary difficult) were highly correlated from .74 to .78. Therefore, their performance on all vocabulary tasks were averaged into a composite measure called ASL Vocabulary Knowledge as shown in Table 3 and in subsequent analyses.

	1	**2**	**3**	**4**
1. ASL Vocabulary	--			
2. ASL Syntax	.80***	--		
3. Literal Comprehension	.77***	.69***	--	
4. Inferential Comprehension	.70***	.65***	.73***	--

***p* < .05. ** *p* < .01. *** *p* < .001.**

Table 3. The correlations between tasks. ASL Vocabulary is a composite of the three ASL vocabulary-related tasks: *a*ntonyms, ASL *s*ynonyms, ASL *v*ocabulary: difficult).

Are there differences in performance on lower-level and higher-level tasks in Deaf children of Deaf parents (DD) and Deaf children of hearing parents (DH)?

Drawn from the scatterplot as shown in Figure 13, our second research question concerned whether there are differences in performance regarding lower-level and higher-level tasks between DD and DH. We teased out the participants to examine the relationship between lower-level and higher-level skills for each participant group.

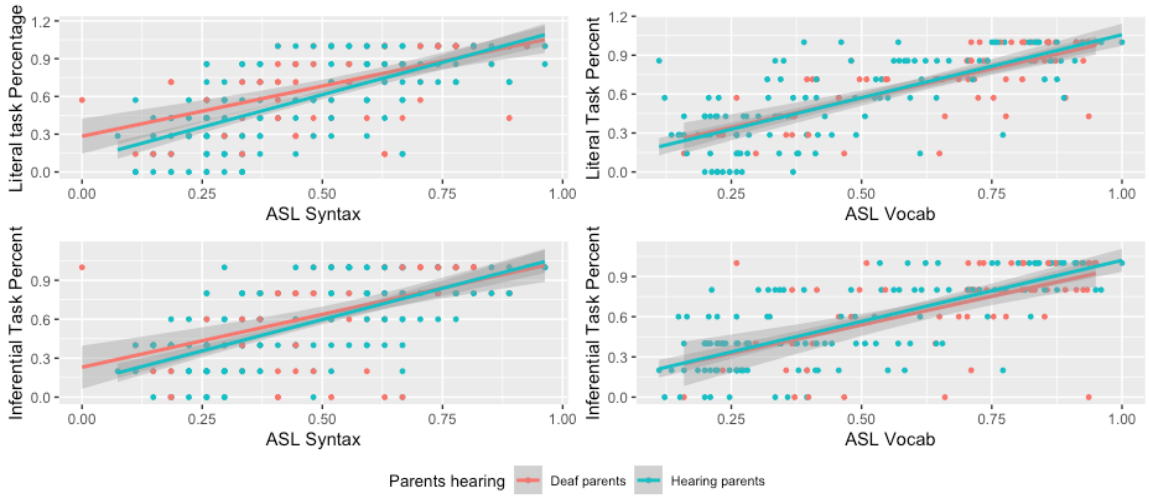

Figure 13. Scatterplots. Trend lines between ASL syntax /ASL vocabulary and parental hearing abilities for literal comprehension and inferential comprehension.

Table 4 reports descriptive statistics that include means and standard deviations for each following variable: age, ASL vocabulary knowledge, ASL syntax, literal comprehension, and inferential comprehension, as well as *t*-values to indicate whether there are statistical differences between participant group, Deaf children of Deaf parents (DD, *n*= 84) and Deaf children of hearing parents (DH, *n*=167). Analysis as shown in Table 4 reveals that there are significant differences on all measures, including age. Finally, there is a significant difference regarding overall ASL-text comprehension for DD children (0.71) and DH children (0.56); (T(179.05)= 3.88, p <.001).

	DD mean (s.d.)	DH mean (s.d.)	t-value
Age	11.11(2.51)	12.60(3.00)	-4.18***
ASL Vocabulary Knowledge	.68(.22)	.48(.26)	5.65***
ASL Syntactic Abilities	.56(.21)	.46(.22)	3.44***
ASL Literal Comprehension	.73(.28)	.57(.33)	4.02***
ASL Inferential Comprehension	.69(.32)	.56(.32)	3.09***

***p* < .05. ** *p* < .01. *** *p* < .001.**

Table 4. Means, standard deviations, and t-value between DD(N=84) and DH(n=167).

Further analysis was conducted to establish the relationships between ASL vocabulary, ASL syntax, literal comprehension, inferential comprehension for each participant group (DD and DH). As demonstrated in Table 5, for Deaf children of Deaf parents, all said variables except for age correlate highly with each other. The largest correlated measure for each literal and inferential comprehension in DD is ASL vocabulary knowledge, at $r = .78$ for literal task and $r = .61$ for inferential task.

Variable	1	2	3	4	5
1. Age	--	-0.06	0.05	0.01	-0.03
2.ASL Vocabulary knowledge		--	0.78***	0.73***	0.61***
3.ASL Syntactic Abilities			--	0.60***	0.56***
4.ASL Literal Comprehension				--	0.74***
5.ASL Inferential Comprehension					--

***p* < .05. ** *p* < .01. *** *p* < .001.**

Table 5. Correlations across variables of Deaf children of Deaf parents (n-84)

Similarly to Deaf children of hearing parents (see Table 6), ASL vocabulary knowledge and each literal comprehension and inferential are also statistically significant (*r* = .73 and r =.70, respectively). Additionally, ASL vocabulary knowledge and ASL syntactic abilities are highly correlated in both participant groups Deaf children of Deaf parents and Deaf children of hearing parents (*r* = .78 and *r* =.80, respectively). The only difference between participant group is age. In contrast to Deaf children of Deaf parents, age as a variable is significantly correlated with performance on all tasks in Deaf children of hearing parents.

Variable	1	2	3	4	5
1. Age	---	0.40***	0.32***	0.26***	0.21**
2. ASL Vocabulary Knowledge		---	0.80***	0.73***	0.70***
3. ASL Syntactic Abilities			---	0.71***	0.68***
4. ASL Literal Comprehension				---	0.70***
5. ASL Inferential Comprehension					---

***p* < .05. ** *p* < .01. *** *p* < .001.**

Table 6. Correlations across variables of Deaf children of hearing parents (N=167).

Based on our correlation analysis, we speculated that performance on ASL syntax and vocabulary was differentially distributed for deaf children with deaf vs hearing parents. We used a violin plot to visualize the distribution of performance on ASL vocabulary and syntax in each group (Figure 14). The plots demonstrate that ASL vocabulary and ASL syntax scores have different distributions among students with Deaf parents and hearing parents, in that more Deaf children of Deaf parents indicated to have higher accuracy in both ASL vocabulary and ASL syntax than students of hearing parents.

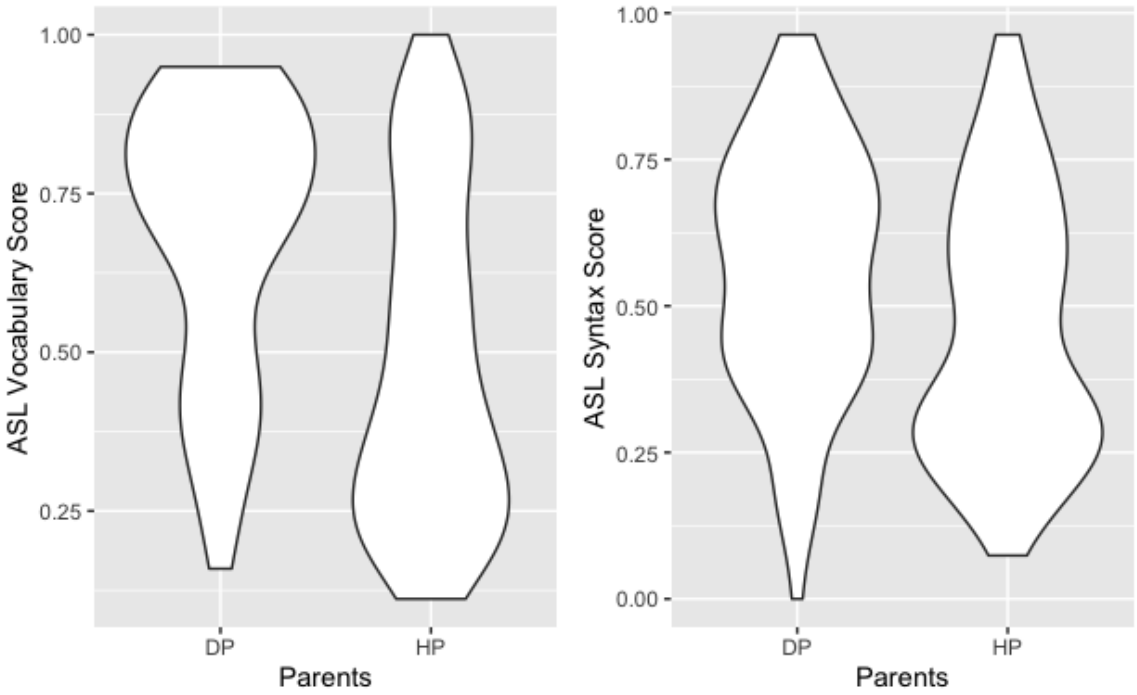

Figure 14. Violin Plots. Distribution of ASL vocabulary and ASL syntax scores based on parental hearing status.

Does performance on ASL vocabulary and ASL syntax predict performance on literal comprehension and inferential comprehension in Deaf children?

One of the major goals of this study was to determine the effect of ASL vocabulary and ASL syntax on each higher-level skill, literal-comprehension and inferential-comprehension skills. Two sets of linear model regression analyses were conducted. The first set focused on literal comprehension, the second on inferential comprehension. In addition to ASL vocabulary and ASL syntax, age and parental hearing status were added as factors into the model.

Literal Comprehension: I analyzed the effect of lower level skills on literal comprehension (Model: Literal Comprehension~ Parents + Age + Vocabulary

Knowledge + Syntactic Abilities). Although there were significant effects of both ASL vocabulary and ASL syntax on literal comprehension, the residual plot of the initial model appeared invalid (see Figure 15). The residuals did not follow the normal distribution well, thereby suggesting that the regression model for the literal comprehension could be improved. Drawn from earlier exploratory data analysis we added an interaction term for participant group and ASL syntax. The revised linear regression model for ASL literal comprehension (Literal Comprehension~ Parents + Age + Vocabulary Knowledge + Syntactic Abilities + Syntactic Abilities * Parents), as illustrated in Table 7, indicates interaction between parental hearing status and ASL syntax to be significant in the model.

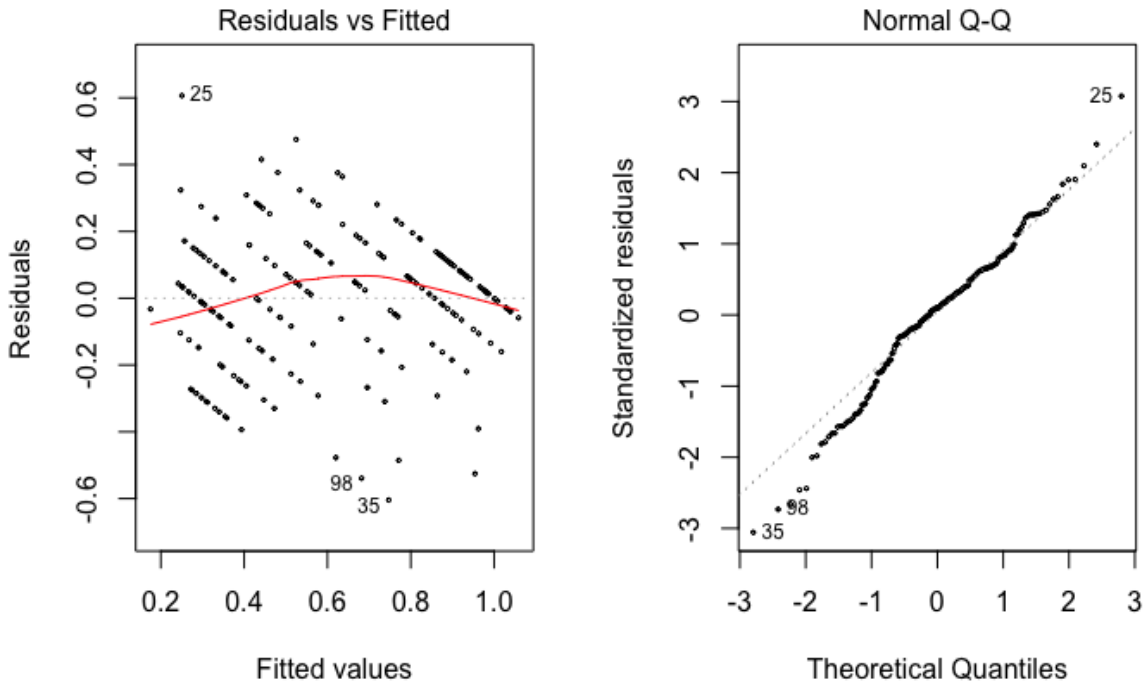

Figure 15. Residual plots of the initial analysis for literal comprehension.

Furthermore, an ANOVA test was then carried out to confirm improvement in the model that includes the interaction term, meaning the effect will change depending on participant group. From the ANOVA result, there is a significant improvement in the revised model ($F(1, 187) = 4.57$, $p < .05$). The revised model, as displayed in Table 7, indicates that the effect of literal comprehension, the coefficient of the vocabulary knowledge in ASL is 0.74, which means that every unit increase in vocabulary corresponds to a .74 increase in the literal comprehension when holding all other variables constant.

	Estimate(s.e.)	***t*-value**
(Intercept)	0.30(0.10)	3.14**
Parental Hearing Status (DH)	-0.14(0.08)	-1.72
Age	-0.01(0.01)	-2.31*
ASL Vocabulary	0.74 (0.10)	7.58***
ASL Syntax	0.12(0.15)	0.79
DH and ASL Syntax	0.32(0.15)	2.14*

Note. **R-squared = 0.63; *$p < .05$. ** $p < .01$. *** $p < .001$.**
Table 7. Regression analyses of predictors of literal comprehension.

The results however show weak evidence to suggest a one-unit increase in ASL syntax score is associated with .12 increase in literal comprehension score for Deaf children of Deaf parents, in contrast to significant .32 increase in literal comprehension score for Deaf children of hearing parents when holding all other variables constant. A post-hoc analysis was then carried out to explore the nature of the interaction. I conducted two separate linear regression analyses by participant group. The results of the

post-hoc analysis confirmed the difference in that literal comprehension accuracy in Deaf children of hearing parents can be explained by both syntactic abilities and vocabulary knowledge. Whereas, literal comprehension in Deaf children of Deaf parents is not dependent on their syntactic abilities but only vocabulary knowledge.

Inferential Comprehension: I repeated the same analysis for inferential comprehension (see Table 8). Based on the analysis of literal comprehension, I applied the initial model as well as the model with the interaction term, and conducted an ANOVA to compare the two models: Model 1: Inferential Comprehension ~ Parents + Age + ASL Vocabulary + ASL Syntax; and 2. Inferential Comprehension ~ Parents + Age + ASL Vocabulary + ASL Syntax + ASL Syntax * Parents. The results of the ANOVA revealed that there is no significant improvement in the model if the interaction term is added into the equation ($F(1, 187) = 0.97$, $p = 0.33$ (n.s.)). Therefore, the interaction term was not added into the linear regression model.

The model yields strong evidence of an effect of ASL vocabulary and ASL syntax skills on inferential comprehension score. For a one-unit increase in ASL vocabulary, we found a 0.62 increase in inferential comprehension. Similarly, for a one-unit increase in ASL syntax performance, we found a 0.40 increase in inferential comprehension.

	Estimate (s.e.)	*t*-value
(Intercept)	0.08(0.07)	0.29
Parental Hearing Status (DH)	0.02(0.04)	0.56
Age	-0.01(0.01)	-0.31
ASL Vocabulary	0.62(0.11)	5.53***
ASL Syntax	0.40(0.12)	3.21**

Note. **R-squared = 0.53; *$p < .05$. ** $p < .01$. *** $p < .001$.**
Table 8. Regression analysis of predictors of inferential comprehension

Correlation Between ASL Comprehension and Reading Comprehension

Is there a relationship between ASL-text comprehension and reading comprehension in English?

To address the final research question, regarding the relationship between ASL-text comprehension and reading comprehension in English, I conducted a correlational analysis comparing Deaf children's performance on the ASL-Text Comprehension task and their performance on reading comprehension task in the Stanford Achievement Tests, Hearing Impaired (SAT-HI).

The SAT-HI is a norm-referenced assessment that measures Deaf children's language skills in English (SAT-HI; Harcourt Educational Measurement, 1996). The scaled scores on the SAT-HI ranges from 300 to 900, pre-kindergarten level to post high-school level. A scaled score of 600 is equivalent to approximately a 3rd grade reading level (Scott, 2015).

Table 9 displays descriptive statistics of the participants (n= 158) whose reading comprehension scores from SAT-10 were available. DD children performed on average slightly better than DH, as expected (Scott, 2015; Trezek & Wang, 2006). Further, the mean scores showed severe delay on reading performance outcomes (Kyle & Cain, 2015).

	English Reading Comprehension	
Subgroup (mean age)	**Mean (sd)**	**range**
DD (10.96)	595.80(58.9)	487-731
DH (12.20)	588.43(62.21)	430-739

Table 9. Descriptive statistics of Deaf children of Deaf parents (DD) and Deaf children of hearing parents' (DH) performance on SAT-10.

A Pearson product-moment correlation coefficient was computed to assess the relationship between ASL-text comprehension and SAT-10 reading comprehension based on 158 Deaf children from ages 8 to 18. The results yielded a statistically significant correlation between ASL comprehension and English comprehension ($r = .66$, $p < .001$) (see Figure 16).

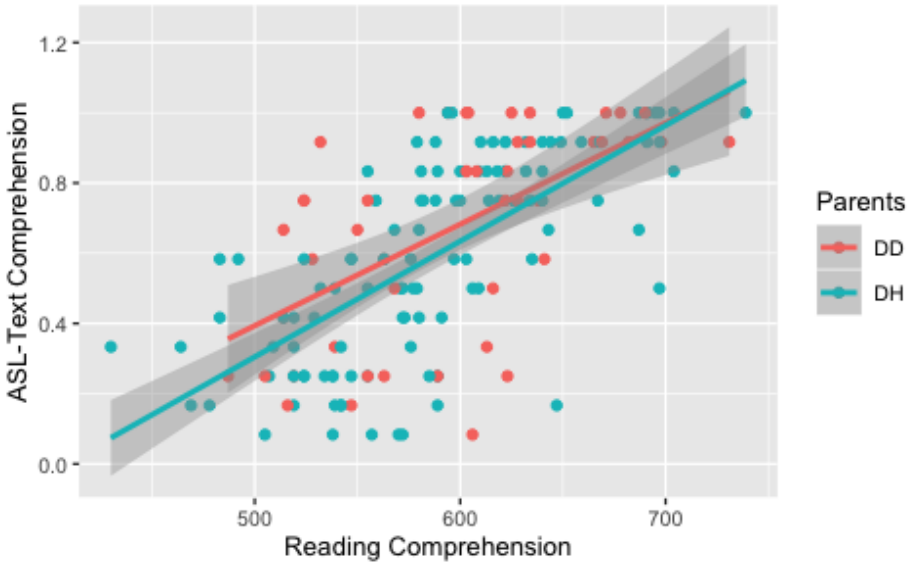

Figure 16. The correlation between ASL-text comprehension and reading comprehension in English (SAT-HI).

A partial correlation was then carried out to measure the degree of association between ASL text comprehension and English reading comprehension, while controlling for the effects of ASL vocabulary and ASL syntax. We were interested in finding whether or to what extent there is a relationship between ASL-text comprehension and English-text comprehension while accounting for additional confounding variables that are related to both variables of interest, such as ASL vocabulary knowledge or ASL syntactic abilities. It is possible that performance on reading comprehension in English was mediated by either ASL vocabulary or ASL syntax knowledge, or both.

We first built models that included SAT score and ASL comprehension score as dependent variables, with parents' hearing ability, students' age at test, and ASL vocabulary and ASL syntax scores as predictors. Then we calculated the correlation between the residuals of the models. Similar to the correlation coefficient, the partial

correlation coefficient takes on a value in the range from -1 to 1. While the value 0 conveys that there is no linear relationship, -1 indicates a perfect negative linear relationship and 1, a perfect positive linear relationship (Marchand-Martella, Nelson, & Morgan, 2013).

Initially, we ran the partial correlation analysis using only 62 out of 251 participants because only 62 participants had a complete set of data points across all tasks. This analysis yielded only a weak relationship between ASL and English comprehension with $r = 0.12$. However, we then conducted an analysis including 152 participants with SAT reading comprehension scores who had completed one of the three vocabulary tasks, the difficult vocabulary task. Since all of the three ASL vocabulary tasks were highly correlated, we decided to carry out another analysis using their performance on difficult vocabulary task as the measure of ASL vocabulary. The results of the partial correlation analysis revealed a moderate, positive correlation with $r = 0.24$ between ASL-text comprehension and English-text comprehension. Therefore, we do have evidence to suggest that English reading comprehension is correlated with ASL-text comprehension when controlling for ASL vocabulary and ASL syntax abilities.

Discussion and Implications

The important goals of this study were to identify the relationship between lower-level and higher-level language-comprehension skills in ASL in Deaf children, and to identify the relationship between ASL comprehension and English comprehension. The results of the first part of the study showed that there are correlations between lower-level

and higher-level skills of ASL comprehension. Further, there is evidence of differences in performance across tasks between DD and DH. The results of this study imply that early exposure to ASL is essential in the development of language and literacy skills in Deaf children. These findings are supported by previous studies on early exposure to ASL and language deprivation in Deaf children (Chamberlain & Mayberry, 2000; Hall, 2017; Henner et al., 2018; Hrastinski & Wilbur, 2016). This understanding is important given that the benefits of L1 proficiency also mean greater access to world knowledge, increasing funds of knowledge, which, in turn, can support the association between two languages, especially between the language user and the language within the text (Koda, 1995).

Next, a series of correlational analyses revealed, as expected, that each language-comprehension skill correlated with the other skills significantly. However, when adding age and parental hearing status into the analysis, age was a significant variable only for children with hearing parents. Two possible explanations for this result are as follows. First, the groups were not evenly distributed in number or age. There were fewer Deaf children whose parents were Deaf overall, and only a small number of them in the older ages (there were only seven from age 16 to 18, in contrast to 38 Deaf children of hearing parents). Second, it is possible that age is not as significant as language skills in determining higher-level comprehension skills. While age was not a significant predictor of performance for Deaf children of Deaf parents, ASL vocabulary and ASL syntactic abilities correlate significantly with literal and inferential comprehension in both participant groups. These findings echo other language studies in monolingual and

bilingual contexts (Cain & Oakhill, 2014; Mokhtari & Niederhauser, 2012; Oakhill & Cain, 2012; Proctor et al., 2010; Sparks et al., 2012) in the sense that vocabulary knowledge and syntactic abilities each has a positive association with higher-level comprehension skills.

Regression analyses were then carried out to determine the role of lower-level language-comprehension skills for literal and inferential comprehension. While ASL vocabulary significantly predicted literal comprehension, ASL syntax significantly predicted literal comprehension but only for Deaf children of hearing parents. It is possible that the effect of ASL syntax was evidenced in them because they did not have adequate ASL vocabulary knowledge, with scores averaged 20% lower than Deaf children of Deaf parents; therefore, pushing them to access their syntactic resources to make assumptions about the ASL texts. As for inferential comprehension of ASL text, both ASL vocabulary and ASL syntactic knowledge are important predictors. These understandings are somewhat in line with other studies on vocabulary and syntactic abilities toward reading comprehension in spoken language (Mokhtari & Niederhauser, 2012; Oakhill & Cain, 2012; Cain & Oakhill, 2014; Uccelli & Paez, 2007).

Moreover, for inferential comprehension, analysis revealed that while neither age nor parental hearing status had a significant effect on accuracy, ASL vocabulary and ASL syntactic abilities were each significant predictors of accuracy. The findings in this study parallel findings from studies of English and other languages in that inferential skills can be informed by vocabulary knowledge and syntax (Hogan et al., 2011)

As predicted, we found that lower-level language skills, specifically ASL

vocabulary and ASL syntax, predicted higher-level language-comprehension skills. This understanding parallels other studies on both monolingual and bilingual children in which vocabulary and syntax contribute to higher-level skills (Silva & Cain, 2015), which, in turn, promote the development of children's comprehension skills in an L2 (Cummins, 2000; Edele & Stant, 2016; Hogan et al., 2011; Mokhtari & Niederhauser, 2012; Proctor et al., 2010; Sparks et al., 2012).

Furthermore, this study offers a new insight regarding the relationship between comprehension skills in ASL and English. A correlational analysis of the relationship between Deaf children's performance in ASL-text comprehension and SAT-10 reading comprehension in English revealed a statistically significant correlation. Although further research is necessary to illuminate the relationship, the findings in this study suggest the possibility of interdependence between L1 text comprehension skills in ASL and L2 reading comprehension skills in English. This study extends findings from previous studies in relation to proficiency in L1 and its role in L2 learning (Proctor et al., 2010; Scott & Hoffmeister, 2017).

Limitations

This study found a positive correlation between lower-level and higher-level language-comprehension skills in ASL, and a relationship between ASL comprehension and English comprehension. There are, however, several limitations within the current study. First, this study did not control for cognitive ability, such as working memory, non-verbal reasoning, and processing skills. It may be possible that the results would be

different had we included the evaluation of participants' cognitive abilities. Second, we did not account for the full range of individual participant demographics, including race/ethnicity, in this study. Previous studies have found a difference in performance on ASL language measures based on race/ethnicity (Henner, 2015; Scott, 2015). It is critical that future research evaluates the effects of race/ethnicity on ASL-text comprehension to better understand the needs of marginalized members of Deaf communities to support the development of their language-comprehension skills.

Further limitations are the sample size in this study and the wide age range. Deafness is a low-incidence disability, and this study had a relatively large sample for the Deaf population, as many studies include fewer than 50 Deaf participants (Scott, 2015). Nevertheless, a larger sample would enable further generalization. Finally, this study specifically examined a subpopulation of Deaf children who were educated in a school setting where ASL use was emphasized. Therefore, it is important to acknowledge that findings from this study are limited to a certain sample of Deaf children and cannot be fully generalized, as the majority of Deaf children are in mainstream settings. Future studies should control for the use of ASL in early language development regardless of parental hearing status prior to enrolling in K-12 education to investigate whether early exposure to ASL supports the development of language-comprehension skills in both ASL and English.

Conclusion

In summary, this study provides evidence that ASL-text comprehension is analogous to traditional printed text in that it relies on language-comprehension skills in

ASL. Furthermore, ASL-text comprehension ability is correlated with English reading comprehension ability. With this study, we can begin to think about ASL text comprehension as a set of literacy skills among Deaf children. This notion is of paramount importance, as many Deaf children continue to leave high school with poor comprehension skills in both ASL and English (Hrastinski & Wilbur, 2016, Luckner et al., 2006; Scott & Hoffmeister, 2017).

This study has implications for instruction. The majority of instruction for Deaf children is informed by lower-level skills in ASL and English, such as phonological awareness, speechreading, and English in a visual but artificial way — but with less stress on higher-level skills (Harris, Terletski, & Kyle, 2017; Scott & Hoffmeister, 2017). It is possible that Deaf children's below-average English literacy skills are at least partially the result of a lack of understanding of ASL text comprehension as a set of literacy skills

Since Deaf children learn through both ASL and English, they should also be expected to demonstrate the capacity to process and comprehend textual information in ASL. However, because until now there have been limited research-based assessments of ASL comprehension (Haug, 2008), there is still much to be explored in the arena of ASL as a set of literacy skills. With this study, we can now begin to delineate the underlying language skills that contribute to overall ASL comprehension in Deaf children. The findings from this study offer us new insight in that supporting Deaf children in the development of English comprehension skills can be mediated through supporting their ASL comprehension skills. Moreover, there may be positive bilingual pedagogical

implications in understanding different language comprehension skills in ASL. Finally, this study provides additional support for the idea that Deaf children need early exposure to ASL texts, which lead to more literacy experiences and better comprehension skills across languages.

CHAPTER V

CONCLUSION

This chapter summarizes the findings of the two studies and provides an interpretation and implications of the results, including limitations, of each study. The chapter concludes with a synthesis of the outcomes, including next steps and pedagogical implications.

Summary of the Two Studies

There were two major goals in this dissertation: First, to develop a new, reliable, and valid assessment that probes Deaf children's literal comprehension and inferential comprehension when perceiving ASL texts; and, second, to investigate the relationships between language-comprehension skills that contribute to overall comprehension in ASL, as well as the relationship between ASL comprehension and reading comprehension in English.

Since there was no standardized comprehension assessment in place that taps Deaf children's comprehension of ASL text through literal and inferential constructs, the first study described the development of a new assessment instrument, ASL-CMP, that measures Deaf children's ASL-text comprehension skills. This study included a report of the psychometric properties to confirm the reliability and validity of the new task.
For the second part of the study, I used the newly developed standardized ASL-Text Comprehension task and information about ASL vocabulary and syntax skills retrieved from the ASLAI (Hoffmeister et al., 2015). We were able to obtain measures of Deaf

children's overall ASL vocabulary knowledge, which was a composite score of three different ASL vocabulary tasks, and their ASL syntactic abilities based on one of the ASL syntax tasks from the ASLAI (Hoffmeister et al., 2015). Furthermore, prior to taking the test, schools provided pertinent data regarding our participants, including their English reading-comprehension scores. Deaf children's reading-comprehension scores from the Stanford Achievement Tests, Hearing Impaired (SAT-HI) (Pearson, 2003) were used as a measure of their reading-comprehension skills in English for the second study.

The First Study: The Development of a New ASL Text Comprehension Task

To establish the reliability and validity of the new ASL-Text Comprehension task, we conducted a series of analyses to evaluate the suitability of the new assessment, such as the quality of the task, including design, items, and domains. The first step of the study was to develop testing material. A team of researchers and educators were involved in the development of six different ASL texts inspired from various resources, including the two well-known reading measures, Houghton Mifflin and the Qualitative Reading Inventory. We then developed five questions for each ASL text. Following a pilot study on seven Deaf native bilingual ASL and English users, we revised the items that had below 85% accuracy and reduced the number of ASL texts from six to three. Second, we asked three Deaf teachers to identify the types of questions in the task to ensure that the questions were literal and inferential. Next, we tested the revised task on 356 Deaf children from age 8 to 18. Cronbach's alpha and IRT analyses were carried out using scores from the Deaf children with deaf parents to evaluate each literal domain and inferential domain, as well as the items within each domain. Although the overall internal

consistency was acceptable, there were problems with three items: two items within the literal-comprehension task and one item in the inferential-comprehension task. Questions 6 and 7 in the literal construct, and Question 10 in the inferential construct, did not demonstrate acceptable discriminability in that they did not help us differentiate between strong and poor ASL comprehenders (discriminability value = < .20) (Taib & Yusoff, 2014). For further analyses on Deaf children, these three questions were removed.

A correlational analysis was then carried out between the two domains. As predicted, literal and inferential domains were positively correlated with each other. Finally, we conducted regression analyses on the full group of Deaf children to confirm the predictive validity of the task, using participant age, participant group (Deaf parents and hearing parents), and question type as predictors. What we found in our analyses confirmed reliability and validity, as well as our expectations regarding age, type of question (literal and inferential question), and the effect of parental hearing status as predictors of comprehension in ASL. Our assumptions about performance on the task in general were informed by previous studies (Chamberlain & Mayberry, 2000; Hall, 2017; Hermans et al., 2008; Pettit, 1974; Proctor et al., 2010; Scott & Hoffmeister, 2017; Sparks et al., 2012). We conducted the ASLAI test, including the ASL-Text Comprehension, on 356 Deaf children (demographic information of the participants in this study is in Chapter 3). We found substantive differences in performance on the ASL-CMP based on age, type of question (literal and inferential), and parental hearing status. Accuracy for both literal and inferential questions improved with age. Second, the literal domain had significantly higher accuracy than the inferential domain. Finally, children

with hearing parents had lower accuracy than children with deaf parents in both literal and inferential domains.

When exploring the relationships between the stated predictors for literal comprehension and inferential comprehension independently, two possible interaction terms were detected: an interaction between age and parental hearing status, and an interaction between question type and parental hearing status. We ran the model with both interaction terms added, but found no evidence of effect; therefore, the model without an interaction term was the better fit. This outcome suggests that the valid model is the one that includes age, parents, and type of question as predictors. These findings are in alignment with previous studies on both monolingual and bilingual learners, as well as studies on reading-comprehension issues in relation to language-comprehension skills (Hall, 2017; Henner et al., 2018; Hogan et al., 2011; Scott & Hoffmeister, 2017; Silva & Cain, 2015; van Gelderen et al., 2007).

In summary, the ASL-Text Comprehension task contains reliable and valid items, and there was evidence that children with early exposure to language performed better on higher-level language-comprehension skills than children with later exposure to ASL. ASL text comprehension can likely serve as a foundation for English literacy. Thus, future studies should consider diverting from the overgeneralization of reading development theories drawn from spoken-language research in Deaf children's early language development and start exploring the possibilities of ASL in the development of literacy skills in Deaf children.

The Second Study: The Interrelationships Between ASL Vocabulary, ASL Syntax, ASL Literal Comprehension, and ASL Inferential Comprehension and the Overall Relationship Between ASL Comprehension and Reading Comprehension in English.

In the second study, there were two goals. The first goal was to identify whether lower-level language skills, ASL vocabulary and ASL syntax, are important indicators of higher-level language skills, ASL literal and inferential comprehension. I was interested also in whether the lower-level skills in ASL were as important for higher-level comprehension, as has been demonstrated in other language studies (Hogan et al., 2011; Proctor et al., 2010; Sparks et al., 2012). The second goal was to examine the relationship between ASL comprehension and reading comprehension in English.

For the first part, the results were derived from 251 participants. The other participants were removed as there were some missing values on some of the variables in this study (demographic information of the participants in this study is in Chapter 4). Descriptive statistics and *t*-tests were performed to detect comparative differences between deaf children of deaf parents and deaf children of hearing parents. As expected, the results of the *t*-tests displayed statistically significant differences across measures, including age between the two groups, deaf children of deaf parents and deaf children of hearing parents. A series of correlational analyses was then carried out to determine whether all the language-comprehension skills, including the three vocabulary tasks, ASL Antonyms, ASL Synonyms, and difficult ASL vocabulary were correlated. Results of the Pearson correlation were that all the tasks are significantly correlated, including the three vocabulary tasks. Therefore, for further analyses, the three vocabulary tasks became one

composite score, ASL vocabulary knowledge.

Finally, I carried out a linear regression analysis. I wanted to find the predictive weight of ASL vocabulary and ASL syntax in each literal and inferential comprehension. Furthermore, age and parents were added to the model, since they have both been found to be significant factors in other language development studies (Henner, 2015; Silva & Cain, 2015). Since I wanted to know the effect of various lower-level skills on literal and inferential comprehension as two separate outcome variables, several models were built.

In the first series of regression analyses, accuracy on literal comprehension questions was the dependent variable, while age, parents, ASL vocabulary knowledge, and ASL syntactic abilities were the predictor variables. The results showed that age and participant group have no significant effect on literal comprehension, but parental hearing status does have a significant effect on ASL vocabulary and ASL syntax. However, the model revealed that the residuals followed the normal distribution weakly. Therefore, based on exploratory data analysis that implied a possible interaction effect of ASL syntax and parents, the interaction term was then added to the model. The results indicate statistically significant effects of age, ASL vocabulary, and the interaction term of ASL syntax and parents toward literal comprehension. An ANOVA analysis was then carried out to compare the two models for literal comprehension, one without the interaction term and the other with the interaction term. The results reveal that the model improved significantly with the interaction term. Finally, a post-hoc analysis using pairwise comparison was conducted to determine the interacting factors to fully understand the nature of the interaction. I found that syntactic knowledge was a significant predictor of

literal comprehension for children of Deaf parents but not for children of hearing parents. The findings that ASL vocabulary was found to be significant for both DD and DH suggest that ASL vocabulary may be sufficient for literal comprehension.

Finally, a regression analysis was performed with accuracy of inferential comprehension set as the dependent variable and all the said variables as predictors. The results reveal that ASL vocabulary and ASL syntax have statistically significant effects on inferential comprehension in both DD and DH, which thereby suggests that making inferences is dependent on both ASL vocabulary knowledge and ASL syntactic abilities.

The final models revealed that ASL vocabulary knowledge is the strongest predictor of literal and inferential comprehension. This finding should be of no surprise as several studies to date in relation to vocabulary knowledge and reading comprehension have found to show that vocabulary is a strong predictor of reading comprehension (Cain & Oakhill, 2014; Oakhill & Cain, 2012; Tannenbaum, Torgesen & Wagner, 2006). While ASL syntax was found to be important for Deaf children of hearing parents for literal comprehension, it is not statistically significant in Deaf children whose parents were Deaf. It can be inferred that those who already have sufficient ASL vocabulary knowledge to access the information in ASL should be expected to perform well on literal comprehension. ASL syntax was found to be a significant predictor of inferential comprehension for both participant groups. This finding implies that inference-making relies on not just vocabulary knowledge, but also on the ability to employ contextual information in the sentence to construct inferences with accuracy. This finding is supported by other studies regarding syntactic abilities toward higher-level

comprehension (Cain & Oakhill, 2014; Cain & Oakhill, 2007; Edele & Stant; 2016; Mokhtari & Niederhauser, 2012; Perfetti, Landi & Oakhill, 2005).

For the final part of the second study, I carried out a Pearson correlational analysis to determine whether there was a relationship between ASL comprehension and reading comprehension in English. For this part of the study, I was able to use only the 158 participants who had reading scores. The correlation revealed a significant positive relationship between ASL comprehension and reading comprehension in English (r = .66, n= 158, p < .001). However, it is possible that the correlation is mediated by participants' ASL vocabulary knowledge and ASL syntactic abilities. To test this, I conducted a partial correlation. A partial correlation allowed us to remove potentially confounding variables to measure the degree of association between the two variables of interest. I controlled for vocabulary and syntax to examine the relationship between ASL-text comprehension and English-text comprehension. I first did this with 62 participants who had no missing data points on all tasks including the three vocabulary tasks. This analysis yielded a very weak association between the two tasks. But, when I filtered the dataset to examine the missing values, I found that 152 out of 158 had completed one of the vocabulary tasks, the difficult ASL vocabulary task, so I decided to look at that alone since it is highly correlated with all other vocabulary measures. The results showed a significant moderate association between ASL-text comprehension task and SAT-10 reading comprehension after holding ASL vocabulary and ASL syntax constant with (r = .24, p = .001). This suggests that ASL comprehension is significantly predictive of English comprehension.

Limitations

Given that this is a new exploratory study, limitations are inevitable. First, this study did not consider other important factors that contribute to comprehension, such as cognitive skills and social factors. There is evidence of cognitive skills effects on comprehension, such as working memory, inhibition, and processing in wider literature. In addition to cognitive skills, social factors are equally important. To comprehend a text requires intentional attention, and the root of that intention is reliant on one's motivation and purpose. Furthermore, there are strong correlations between social economic status (SES), parents' educational background, and the child's comprehension skills (Hart & Risley, 2003; Ibrahim & Hamann, 2017). Another factor that is absent from this study is decoding skills. Based on the SVR model (Gough & Tunmer, 1986), decoding is as equally important as language-comprehension skills for comprehension; therefore, it would be beneficial to examine Deaf children's decoding skills in ASL. Previous studies suggest that comprehenders who must use resources for decoding can have a negative effect on the meaning-making process when addressing a text. However, it is assumed that the Deaf children in this study had sufficient decoding skills; otherwise, they would not have been able to complete such tasks in the ASLAI. Another limitation of this study is understanding the effect of genre, text structure, and the questions' level of difficulty in ASL on comprehension. However, the limitations within this study can serve as a guide for future studies.

Conclusion

It is not uncommon for Deaf children to leave high school with poor literacy skills in both ASL and English (Hrastinski & Wilbur, 2016; Traxler, 2000), and little research has been conducted on the development of ASL literacy skills in Deaf children (Luckner et al., 2006). Clearly, there is a bias in the current literature in relation to the development of comprehension skills in Deaf children, such that literacy skills can only be developed if they have access to spoken language with a written form (see Harris, Terlektsi, & Kyle, 2017; Mayer & Trezek, 2014). In contrast to relying on auditory input solely for language-comprehension skills, ASL displays many positive benefits for Deaf children in their language development. There is ample evidence demonstrating the relationship between ASL proficiency and its role in English literacy skills in Deaf children (Hall, 2017; Henner, 2015; Henner et al., 2018; Hrastinski & Wilbur, 2016; Hoff, 2013; Scott, 2015; Scott & Hoffmeister, 2017). Furthermore, Deaf children who are exposed to ASL, especially at an early age, exhibit better literacy skills in both ASL and English than those who learned ASL later. This factor should be of no surprise given that ASL is comprised of similar linguistic elements as other languages, such as phonemes, morphemes, vocabulary, and syntax, and be used for reasoning and thought (Bahan, 2006; Boudreault & Mayberry, 2006; Henner, 2016; Valli, Mulrooney, & Rankin, 2011). However, little research has been conducted in the arena of ASL comprehension as higher-level language-comprehension skills.

The lessons from the aforementioned studies, including the gaps in current research, became the foundations for this study. Deaf children who learn through ASL

and English should be expected to demonstrate the ability to process higher-level comprehension in both ASL and English. However, because there was no available assessment that examines Deaf children's higher-level comprehension skills in ASL, this dissertation aimed to fill the current gaps.

In doing so, I considered four theoretical models: the simple view of reading (SVR (Gough & Tunmer, 1986), lower- and higher-level language-comprehension skills (Hogan et al., 2011), the linguistic interdependence hypothesis (Cummins, 2000), and the interdependence continuum (Proctor et al., 2010). While the SVR model is an effective way to capture an overall snapshot of an individual's text comprehension in a broad sense, it has its own limitations. For example, it does not inform instruction. This can be problematic for teachers who work with Deaf children especially when many of them are already struggling to employ higher-level language-comprehension skills in English (Harris, Terlektsi, & Kyle, 2017; Kyle & Cain, 2015).

In response to the limitations within the SVR model, Proctor, August, Snow, and Barr (2010) expanded the SVR model to incorporate Cummins' interdependence hypothesis when examining comprehension skills in Spanish bilingual children. Cummins posits that the skills in the L1 facilitate the development of language skills in the L2. Proctor et al's (2010) study confirms that there is a positive relationship between comprehension skills in Spanish comprehension as an L1 and English as an L2. In this dissertation, I proposed a new assessment tool, and then using this tool, I showed that the skills within the language-comprehension domain in ASL are analogous to traditional printed comprehension.

More than 50% of Deaf children across the United States do not receive formal education in ASL, and more than 70% of Deaf children's parents do not communicate with their Deaf children in ASL (Gallaudet Research Institute, 2012). Lastly, the ability to sign does not guarantee that Deaf children will develop the literacy skills they are expected to acquire when leaving high school. Similar to hearing children who speak, ASL knowledge does not in and of itself guarantee print literacy skills. It is also important to consider the development of critical thinking skills, and the ability to employ higher-level thinking skills in ASL.

This dissertation presents not only a new, sound instrument that assesses Deaf children's comprehension skills in ASL through literal and inferential dimensions, but also insights about the relationship between lower-level and higher-level skills in ASL. The findings from this study are in line with previous research. I have demonstrated that the skills required to comprehend ASL texts parallel text comprehension in English, in the sense that ASL comprehension relies on vocabulary knowledge, syntactic abilities, literal comprehension, and inferential comprehension for an accurate construction of meaning (Clarke et al., 2010; Mokhtari & Niederhauser, 2012).

Furthermore, this study has important pedagogical implications. With this new assessment tool, we can begin to evaluate students' progress and growth in the language they are learning and to identify the nuanced differences in skills within ASL language comprehension, as well as understanding the differences between a skilled ASL comprehender and a poor ASL comprehender. These data can then be used to support and guide teachers and practitioners to purposefully design their instruction and intervention

to meet the needs of their students with precision. Finally, the findings from this study provide evidence of a significant correlation between ASL comprehension and English reading comprehension, suggesting an interdependent relationship to be borne out in further studies.

To this end, it can be concluded from this study that ASL text appears to promote literacy experiences in Deaf children, which, in turn, support the development of resources that will facilitate the advancement of literacy skills in both ASL and English. Our understanding of ASL comprehension as a meaning-making practice in Deaf children in academic contexts will not only support the development of Deaf children's comprehension skills in ASL and English, but also expand the current theoretical understanding of ASL text as an avenue to literacy skills. Finally, with the current findings we can begin to think more about how we can capitalize on ASL as a natural language of Deaf children to promote the higher-level thinking skills necessary for advancement in an ever-changing world.

APPENDIX

Bridges (2:39 minutes): Expository Text

Transcript:

Visualize yourself walking through the wood, there you reach a trench. You see a rapid river. You begin to wonder how does one walk across the river. You could swim, but that would be dangerous. What if the trench is so deep that you couldn't see the bottom? How then does one walk across a deep gorge? One possible explanation for how all bridges started was when a person saw a fallen tree. The person observed the fallen tree and the concept of a bridge was born. Today, we have many different bridges. For example, we now have many cars and, sometimes, they get stuck in traffic. A bridge is one way to help maintain the flow. When a train passes by, the people in cars have to wait, and that can be annoying. Instead of waiting for the train to pass, we now have bridges that allow the train to pass over us. Similarly, for rivers, how does a car go across the river? What about the train? Or, people walking over the river? Bridges make this possible. Bridges come in different forms depending on the landscape. If the gorge is small, then a small bridge will be built. Some gaps will be a bit longer and deeper, and the bridge will be slightly bigger. But, if the gap is so gigantic, far and deep, then a huge bridge will be built. If a river is just a tiny stream, then there will be a small bridge. A bigger river calls for a bigger bridge. A huge body of water calls for a huge bridge. Not all bridges are designed the same way. Suspension bridges have a deck hung low on vertical suspenders and are usually made for cars to drive on. Some bridges are narrow and are built for pedestrians

only. Some bridges are double decked, so that way they can be bidirectional for cars to travel across. Some bridges can move in certain ways to allow ships to go through. Bridges are useful because they help us arrive at our destinations more quickly.

Questions:

Why is having bridges an advantage? (Inferential)

Why do bridges move in certain ways? (Literal)

Which bridge is designed for pedestrians only? (Literal)

What do you think was the first thing to be used as a bridge? (Literal)

What will happen if there is no bridge? (Inferential)

Photosynthesis (1:36 minutes): Expository Text

Transcript:

Photosynthesis is a process that enables plants to live. Plants are different from animals and people. Plants are rooted in one place. This leads us to ask how plants get food. They get food through photosynthesis. For photosynthesis to take place, it requires three things: sun, water, and carbon dioxide. Carbon dioxide is the air that people exhale. Plants have leaves, and all leaves have pores. Pores allow carbon dioxide to seep in. Plant roots drink water from beneath. The combination of both carbon dioxide and water, along with the sun, produces natural sugar, which provides plants with energy and increases their

greenness. During the last stage of the process, plants emit oxygen, which people and animals breathe. People and animals rely on plants to live.

Questions:

6. Photosynthesis produces all except one, which one? (Literal)

7. What is required for photosynthesis? (Literal)

8. What is photosynthesis? (Literal)

9. Why are animals and people different from plants? (Inferential)

10. What will happen if there is no photosynthesis? (Inferential)

Marva Finds a Friend (2:58 minutes): Fiction Text

Transcript:

Marva finds a new friend. Marva is a little girl. One rainy day, Marva stays in her house. She plays with her doll. Across the room, through a window, she spots something. Marva walks to the window and sees a cat. The cat is wet, gaunt, and scraggy. Marva darts outside and rescues the cat by bringing it inside the house. Wet, thin, cold, Marva dries the cat with a towel. Marva's mom walks in the room and sees the cat, thin and gaunt. She says the cat needs some food and then walks away. Marva looks at the cat and gives it a name. But, before she can give the cat a name, mom returns with a bowl of food. The cat empties the bowl ravenously. Marva tells her mother that she has decided the name for the cat: Cookie. She then goes on to tell her why she named the cat Cookie. "The cat

reminds me of an Oreo, black fur with white paws." Her mother explains to Marva that the cat might belong to someone else, and we found it because Cookie was lost. Marva looks at the cat and says, "I want to keep you." As days go by, Marva plays with and grows to love the cat. Sadly, Marva's mother saw a missing ad in the newspapers that matched the cat. Next day, someone buzzes the doorbell, and Marva looks at her mother and they know someone is here to pick up the cat. When Marva opens the door, she does not expect to see another girl, who looks like Marva. The girl asks if Marva has her cat, only to find that they gave the cat the same name. The girl sees the cat and rejoices in having the cat in her arms again. Marva is saddened by it all, but the mother of the girl who the cat belongs to tells Marva that they live down the street, and that she can come over any time to play with the cat. Marva looks at the girl in the eyes and smiles, for they have become friends.

Questions:

11. What does Marva do when it is raining outside? (Literal)

12. Why does the cat look unhealthy? (Literal)

13. What is Marva's mother's reaction when she sees the cat? (Literal)

14. Why does Marva appear sad when her mother reads the newspaper? (Inferential)

15. What do you think will happen to Marva and the other girl after the story? (Inferential)

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