2008

ENGLISH READING ABILITY IN YOUNG DEAF SIGNERS AN INVESTIGATION OF SENTENCE COMPREHENSION

Kathy N. Maxwell
Western University

ENGLISH READING ABILITY IN YOUNG DEAF SIGNERS: AN INVESTIGATION OF SENTENCE COMPREHENSION

(Spine title: English Reading Ability in Young Deaf Signers)

(Thesis format: Monograph)

by

Kathy N. Maxwell

Graduate Program in Psychology

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

School of Graduate and Postdoctoral Studies
The University of Western Ontario
London, Ontario, Canada

THE UNIVERSITY OF WESTERN ONTARIO
SCHOOL OF GRADUATE AND POSTDOCTORAL STUDIES

CERTIFICATE OF EXAMINATION

Supervisor	Examiners
Dr. Marc Joanisse	Dr. Ken McRae
Supervisory Committee	Dr. Greg Moran
Dr. Ken McRae	Dr. Anne Barnfield

The thesis by

Kathy Nicole Maxwell

entitled:

English Reading Ability in Young Deaf Signers: An Investigation of Sentence Comprehension

is accepted in partial fulfillment of the
requirements for the degree of
Master of Science

Date_____

_____
Chair of the Thesis Examination Board

Abstract

We performed a detailed investigation of the robust correlation between ASL and English reading ability in 54 deaf students aged 7;3 to 19;0. Skilled and unskilled signers were assessed on four English sentence structures (actives, passives, pronouns, reflexive pronouns) using a four-alternative forced choice sentence-to-picture-matching task, providing a window into how ASL skill is related to English sentence comprehension. Of interest was the extent to which proficiency in L1 provided a foundation for L2 learning as predicted by Cummins' developmental interdependence hypothesis. Skilled signers outperformed unskilled signers on all sentence types. Error analysis indicated greater word recognition difficulties in unskilled signers. Syntactic structures mapping directly from L1 to L2 were more accurately understood than structures mapping in less obvious ways, consistent with MacWhinney's unified competition model. Our findings provide evidence that increased ASL ability supports English sentence comprehension at the levels of individual words and syntax.

Keywords: deaf, American Sign Language (ASL), English, reading, sentence comprehension, word recognition, syntax, passives, pronouns, developmental interdependence hypothesis, Unified Competition Model.

Acknowledgements

I would like to thank the following individuals for their part in the success of this endeavor. Anyone who has attained a master's degree in his or her life knows that you certainly do not do it on your own.

First and foremost I would like to thank my advisor Marc Joanisse whose support and guidance are second to none. Marc's quick ability to switch focus means that you can stop him in the hall, drop by his office unannounced, or question him at the Grad and know that he is always ready to engage in your query. He is an advisor in all the ways that you would hope for, and a whole lot more because of his genuine concern, open mind, and comical spirit.

I would like to thank Cathy Chovaz McKinnon for providing feedback on the experimental design, helping us gain access to our participants and for her continued support and interest. I owe a huge thanks to Tim Mallach for his work on the ASL videos; and to my peer-mentors Deanna Friesen and Elizabeth McLachlan, for their direction and encouragement at every stop along the way.

My lab mates Amy, Aneta, Erin, Randy, Jeff and Lisa provided feedback, advice, guidance and (thankfully) diversions that made even the most stressful days bearable. A handful of excellent research assistants and friends from other labs at Western also contributed in their own way to this project.

Finally, I believe it is most fitting to thank my family, especially Evan, Mom, Dad, and Tracy for their quiet support and unconditional love.

Table of Contents

List of Tables

List of Appendices

English Reading Ability in Young Deaf Signers: An Investigation of Sentence Comprehension

Learning to read English is a difficult task for most members of the deaf population. ASL does not have its own orthographic coding system, nor is written English an orthographic code for ASL. Thus, a deaf individual who is learning to read English is literally learning a foreign language through a modality that is only partially accessible (i.e., through orthography but not phonology). Together these factors make learning to read a daunting task for most deaf individuals, evidenced by reading abilities that are typically well below those of their hearing counterparts (Goldin-Meadow & Mayberry, 2001).

One of the principal explanations for these low reading levels is that deaf individuals lack access to the phonological code of written language (Transler, Gombert and Leybaert, 1999; Beech & Harris, 1997). Hearing individuals learn spoken English through the auditory modality prior to learning to read, and subsequently learn to map the written word onto their knowledge of this spoken code using grapheme to phoneme correspondences (Adams, 1990). Thus, when a hearing reader sees a word on the page they have access to the word's orthographic form and can compute the phonological form, both of which provide access to meaning. This access to phonology allows hearing readers to parse written words into their individual phonemes making the semantics of even unfamiliar words accessible through decomposition. Deaf readers on the other hand are thought not to experience phonological processing of the text due to their inexperience with the auditory mode of English, and thus must rely strictly on

orthography to access word meaning. This results in a reliance on a whole-word recognition strategy of reading where matches between orthography and meaning are memorized, in contrast to the decomposition strategy available to hearing readers (Beech & Harris, 1997). Although there is evidence to suggest that some higher-achieving deaf readers have some access to phonology (Hanson & Fowler, 1987; Nielsen & Luetke-Stahlman, 2002) it is most certainly the case that reading disabilities in this population stem from an inability to effectively access the sounds of spoken language.

Although learning to read is difficult for all deaf individuals some are better at it than others, for reasons that are not always transparent. ASL proficiency has been repeatedly shown to be the single best predictor of English reading outcomes in the deaf population. Strong and Prinz (1997) compared ASL signers with low, medium and high signing ability on English proficiency. English proficiency was operationalized as a composite score of various English comprehension and production tasks. ASL proficiency was also established using a composite score of several comprehension and production tasks. They found that ASL skill was significantly correlated with English ability, such that the high ability group outperformed both the medium and low ability groups, and the medium ability group outperformed the lowest ability group. The authors present this finding as evidence that increased levels of ASL ability lead to increased English proficiency. Padden and Ramsey (1998) drew similar conclusions defining English ability via a collection of subtasks from the Stanford Achievement Test (adapted for deaf participants). Several others (Hoffmeister, 2000; Goldin-Meadow & Mayberry, 2001, Mayberry, Lock & Kazmi, 2002) have reported similar findings, where ASL proficiency is correlated with English reading outcomes. These studies all examine the

relationship between ASL and English in a relatively broad sense, using general comprehension and production tasks spanning a range of language abilities. In contrast, a finer-grained investigation that specifically examines English syntactic comprehension, including the types of errors made by deaf signers has not yet been reported. Our goal in the present study is to investigate in a more detailed manner whether ASL proficiency predicts learning specific elements of English grammar, or whether it is limited to a more basic transfer like vocabulary learning.

Models of second language learning make predictions about the role of first language (L1) proficiency in determining second language (L2) outcomes, and are useful in understanding how deaf children come to learn written English. Cummins' (1979) developmental interdependence hypothesis of second language learning proposes that L2 learning is dependent on the degree to which the individual has learned L1 before extensive exposure to L2 begins. Accordingly, for primarily unilingual children to effectively learn L2, it is essential that the link between real world concepts and L1 lexical items first be concretely established. Premature introduction of L2 can have subtractive effects on L1 proficiency, as well as the absence of gains in L2 proficiency. For deaf children this means that they must have a firm understanding of lexical items in ASL in order to learn the lexical items for those same concepts in English.

A second theory of L2 learning that is helpful in explaining the way in which deaf signers learn written English is MacWhinney's Unified Competition Model (2005). The model is an elaborated version of the Competition Model (MacWhinney & Bates, 1989), and specifies the interdependence hypothesis to include transference between languages at specific levels of comprehension. MacWhinney proposes that in initial attempts at L2

comprehension, learners infer that L2 properties map directly onto L1, regardless of actual fit, and this is evidenced at four levels of comprehension: auditory processing, lexical knowledge, grammatical role decoding and meaningful interpretation. For the purposes of our study, we focus on the latter three levels since transference (or lack thereof) in auditory processing is not central to the link between ASL and English.

Transference in lexical knowledge takes place when the conceptual overlap between lexical items in L1 and L2 is high. For ASL learners of written English this means that new English words should be more easily learned in cases where the English word can be directly mapped onto a known ASL sign for the same concept. For instance the deaf child should quickly recognize the English word 'cow' once s/he understands its direct correspondence to the ASL sign COW (ASL sign glosses are presented in uppercase). Indeed this entails reliance on L1 as an intermediary between the lexical item in L2 and the concept itself. Both MacWhinney and Cummins agree then; L2 concept formation is facilitated by concrete knowledge of the concept in L1.

MacWhinney's last two levels of comprehension, grammatical role decoding and meaningful interpretation, can be conceptualized at once as sentence comprehension. While the importance of individual word recognition is key, the task of understanding a full sentence goes well beyond assigning meaning to the words that make up the sentence. In order to become a successful reader, an individual must also understand the syntactic constructions of the language. Transference in sentence comprehension can be described as the extent to which the rules that govern the syntactic structure of a sentence in L1 are applicable to L2 structures. Thus, there may be degrees to which English syntactic constructions transfer to ASL. To examine this more closely, we consider deaf

children's comprehension of four sentence types in this study, two of which are thought to map quite clearly from L1 to L2 (actives and reflexive pronouns) and two for which the mapping between languages is less clear (non-reflexive pronouns and passives).

A reflexive pronoun in English takes the form, *himself, herself, itself* and so on. The ASL version of the reflexive employs a handshape that represents the idea of 'selfness'. This handshape is articulated in the direction of the referent to imply reflexivity, e.g., HIMSELF, HERSELF, MYSELF and so on. Thus the reflexive pronoun is marked in a very similar way, by use of 'self', in both languages. Non-reflexive pronouns also exist in both ASL and English. Like reflexives, non-reflexive pronouns in English refer back to an earlier antecedent that is indicated by a different word at an earlier point in a sentence (e.g., *him* refers back to *John* in the sentence, "John said that Alice hit him"). In contrast, ASL pronoun use relies on the spatial nature of signs such that reference is made by pointing to the exact location in which the entity was previously set up in physical space. All possible referents occupy their own unique position in the signing space, therefore indexing the antecedent of a pronoun is non-ambiguous in ASL (Isenhath, 1990).

As described above, English pronoun and reflexive use does not directly map onto their ASL counterparts. While ASL uses spatial cues to bind a pronoun or reflexive to its antecedent, in English this is achieved through a syntactic relationship, as described below. These differences may make comprehension of English pronouns difficult for deaf readers. The most prominent description of the structure of pronouns comes from Chomsky's Binding Theory (Chomsky, 1981). Two key principles dictate how pronouns are used: Binding Principle A states the structural relationship ('c-command') by which

reflexive pronouns are bound to local antecedents. For instance it explains why *mother* is an acceptable antecedent to *herself* in sentence (1) but not (2)

(1) The girl says the mother$_i$ washes herself$_i$[1].

(2) The mother says the girl$_i$ washes herself$_i$.

Principle B of Binding Theory concerns how non-reflexive pronouns are bound to an antecedent outside of this c-command relationship. For instance it explains why *father* is an acceptable antecedent to *him* in sentence (3) but not (4).

(3) The father$_i$ says the boy pushed him$_i$.

(4) The boy$_i$ says the father pushed him$_i$.

There is some evidence that typically-developing children with normal hearing show knowledge of Principle A earlier and more consistently than knowledge of Principle B (Deutsch, Koster and Koster, 1986; Chien & Wexler, 1990; van der Lely & Stollwerck, 1996). For instance, Deutsch, Koster and Koster (1986) investigated comprehension of both types of pronoun sentences in Dutch-speaking children. The results indicated that comprehension of non-reflexive pronouns was consistently delayed compared to comprehension of reflexive pronouns. The authors argue that the difference between the two constructions may lie in the fact that while reflexive pronouns are governed by a rule that indicates where the anaphor must be indexed, non-reflexive pronouns are governed by a rule that disallows local binding, but does not indicate where the pronoun ought to be indexed. Chien and Wexler (1990) report similar findings in English speaking children. They observed that knowledge of reflexive pronouns was well established in children 6;0 and older. Children were slower to learn non-reflexive

[1] Similarly indexed words are 'bound' syntactically, denoting they have the same referent.

pronouns, however. Even at six-and-a-half years old, children continued to produce errors on these sentence types, which the authors interpret as indicating that they had not yet learned to bind non-reflexive pronouns to the correct antecedents. On the classical Binding Theory this would suggest that children learn Principle A before Principle B.

The data on the acquisition of bound pronouns point to separate developmental trajectories for the two types of pronouns with comprehension of the reflexive pronoun sentences developing earlier than that of non-reflexive pronouns. Of interest was whether a similar trajectory is observed in deaf children. The next section reviews the literature on active and passive sentence constructions in English, but first a note about passives in ASL.

The second syntactic manipulation of interest in this study involved the active/passive alternation in word order. This is of interest since ASL allows for relatively free word order. However, demands for clarity and efficiency in ASL (a process called economization; Isenhath, 1990) mean that signers tend to focus production on content, exclude function words, and minimize the use of word orders that add unnecessary lexical items and ambiguity to utterances. Indeed in both English and ASL the most typical way to express a transitive relationship is S-V-O. Note that there are reports of passive-like constructions in ASL, where a signer takes on the role of the object of the sentence, thereby shifting focus toward the object (Janzen, O'Dea & Shaffer, 2001). Consider a picture where a girl is punching a boy in the face. In order to explain what is happening in the picture, the signer sets up the girl on the right (with body facing slightly left) and the boy on the left (with body facing slightly right). The signer then reassumes the position of the girl and produces a punching motion in the direction of

the boy, then quickly switches *to become the body of the boy while the signer's oncoming fist is understood to be that of the girl's*. The italicized portion of the above sentence where the boy is looking towards the oncoming fist from the direction of the girl might be taken as an equivalent to the English passive: "the boy was punched by the girl". While this shift in focus is what we consider to be a passive in English, when it is used in ASL there is much set up before the production of the passive-like formation. That is, the passive-like construction does not stand alone as a full sentence but rather is part of the sentence that serves to emphasize focus on the object at a particular point within the sentence. A true ASL equivalent of the English passive construction is difficult to positively identify and has gone largely unmentioned in studies of ASL acquisition. Since it does not compare well to English passives it seems reasonable to assume that the mapping between the constructions (if ASL does in fact have such a construction) in the two languages is non-obvious at best.

In English, passives have the explicit function of bringing the object into focus by moving it to the beginning of the sentence. English passives take on three forms including truncated, where the subject is omitted (e.g., the food was delivered), non-reversible, where the subject and object cannot logically be substituted for each other (e.g., the lamp was broken by the boy), and reversible, where the subject and object can be logically substituted for each other (e.g., the girl was pointed at by the man). Various studies have shown that these forms differ with respect to when they are acquired in English-speaking children. Baldie (1976) showed that while comprehension of actives was fully established in hearing English children by age 3;0, non-reversible passives and truncated passives took more time to develop with high levels of accuracy occurring

between 3;6 – 3;11. High levels of accuracy on reversible passives on the other hand was not demonstrated until the 6;6 – 7;6 range. Baldie argued that the early development of non-reversible and truncated passives relative to reversible passives could be explained in terms of lexical knowledge. In the case of non-reversible and truncated passives, the meaning of the sentences can be determined strictly based on knowledge of the individual words without the need for syntactic comprehension. These sentence types, along with pragmatic knowledge about the world, leave no room for object ambiguity. Reversible passives on the other hand are more easily confused due to subject/object ambiguity; these sentences offer no pragmatic cues as to subject/object identification and require the use of syntactic knowledge for accurate comprehension.

While acquisition of lexical items and basic sentence structures develop rapidly in the early stages of language learning, the development of syntactically complex structures like the reversible passive takes time. Although children's early linguistic capabilities are largely lexical in nature, their development of abstract syntactic structures that makes their language more consistent with the adult version is a function of their exposure to those structures (Savage, Lieven, Theakston & Tomasello, 2003; Vasilyeva, Huttenlocher & Waterfall, 2006). Deaf children's exposure to passive constructions is limited by two factors: their lack of access to spoken instances of English passives, and by their continued exposure to elementary level reading materials (due to their delayed reading skills) where the instance of passive sentences is minimal (Vasilyeva, Huttenlocher & Waterfall, 2006). This exposure disadvantage might leave deaf individuals at a relative disadvantage for learning English passives.

Consistent with this, English passives do appear to be difficult for deaf readers. As discussed above, hearing children tend to perform well on all three forms of passive constructions (truncated, non-reversible, reversible) by around seven years of age (Baldie, 1976); in contrast, deaf children still had not mastered the passives at 18 years of age (Power & Quigley, 1973). Power & Quigley also found that, like young hearing children, deaf readers tend to mistakenly believe that passives conform to S-V-O (active) word order. They further suggest that deaf children who are able to comprehend passive forms rely heavily on the word 'by' as an indicator of the passive voice. Since truncated passives imply but do not explicitly mention a subject, there is no 'by' in the sentence, leaving deaf readers without their cue to the passive voice in truncated passive sentences. This distinction highlights a specific strategy that deaf individuals may use to gain access to a difficult English syntactic structure.

Rationale of present study

Our study examined the robust relationship between ASL and English reading ability with respect to how ASL proficiency facilitates sentence comprehension in school-age individuals who are deaf. We investigated the level of analysis at which deaf readers comprehend English sentences using four English sentence constructions (actives, passives, reflexive, and non-reflexive pronouns). We also examined error patterns in responses, which allowed us to tease apart simple word identification strategies from more complex syntactic strategies. Based on the developmental interdependence hypothesis and the Unified Competition Model presented above, we broadly predicted that skilled signers should show more proficient reading outcomes than unskilled signers for at least two reasons that relate to increased L1 ability. First, increased ASL ability

should facilitate English reading ability in a concrete manner: transference of lexical items should allow for comprehension of individual English words. Second, increased ASL ability should facilitate English reading abilities in an abstract manner, allowing for the decoding of syntactic constructions in L2. More specifically, we examined the key assumption from the developmental interdependence hypothesis, that L2 proficiency develops as a function of L1 proficiency, and examined the ways in which L1 proficiency constrains L2 learning with the Unified Competition Model in mind. Thus, we examined whether skilled signers would show better overall reading outcomes than unskilled signers. We further examined the abstraction of linguistic ability from L1 to L2 by assessing whether skilled signers would be more accurate on more syntactically complex English sentences than unskilled signers.

We were also interested in whether unskilled signers would tend to make errors that indicate poor word recognition and syntactic parsing skills while skilled signers would tend towards syntactic parsing errors only. This finding would be consistent with the Unified Competition Model such that even when syntax becomes an obstacle skilled signers continue to use their lexical knowledge to approach the correct answer. Further in line with the Unified Competition Model, we expected passive sentences to be particularly difficult for all deaf readers, since there is no obvious analogue in ASL, and exposure to English passives is limited in the deaf population.

Additionally, we were interested in the extent to which the progression of syntactic development by the deaf signers mirrored that of a younger hearing group who were also acquiring these same constructions. This descriptive analysis allowed us to provide some insights into whether the deaf individuals' pattern of English syntactic

development was fundamentally altered from that of normal hearing children's, or merely delayed.

Lastly, we were interested in alternative hypotheses relating to hearing threshold and IQ that might explain why some deaf children are better at learning English. For this reason our sample of deaf children included a wide range of abilities in order to better capture the breadth of skills within the population.

Method

Participants

Participants were 52 deaf students recruited from Schools for the deaf in London, Ontario (n = 22) and Milton, Ontario (n = 30) ages 7;3 to 19;0. Both schools adhered to the "Bi-Bi" (Bilingual-Bicultural) philosophy of instruction. As such, the language of instruction at both schools was a mix of ASL and written English. All students used ASL to communicate on a daily basis and had a hearing loss greater than 45 dB.

A group of ten English-speaking children with normal hearing, ages 8;2 to 8;11, were also assessed on the English reading tasks. All of the hearing children spoke English as their first language and none had hearing problems of any kind (as assessed by parental report). Hearing participants were recruited through a participant volunteer database and tested in our lab at the University of Western Ontario.

Informed consent was obtained from a parent or guardian prior to testing, and participants assented to the testing sessions. Recruitment and testing procedures were approved by the University of Western Ontario Office of Research Ethics, Non-medical Review Board.

Procedures

The deaf children were tested individually in a private room in their school, over two sessions. Session one consisted of ASL and English reading tasks, and took approximately 40 minutes to complete. Session two consisted of a hearing assessment and a test of nonverbal intelligence (TONI-3; Brown, Sherbenou & Johnsen, 1997). For some of the children, hearing assessment and TONI-3 scores were available on file at their school. In these cases the children were only assessed on session one. Note that this study was part of a larger research project that investigated the factors influencing English and ASL proficiency in deaf children, and included some additional tasks not reported here (Maxwell & Joanisse, 2008).

Stimuli for the language tasks in session one were presented via a 12-inch Macintosh PowerBook or a 13-inch MacBook computer placed directly in front of the seated participant. The researcher sat next to the participant and recorded responses on prepared score sheets. As described below, all language tasks were receptive in nature, and therefore the experimenter was not required to interpret children's signs. However the experimenter was a fluent signer and was able to answer any questions that arose during the sessions. Sequence of task presentation was held constant across participants, in the order indicated below.

Language measures. Three receptive sign language proficiency tasks were administered. We used receptive ASL tasks to maximize comparability to written English comprehension, which is itself a receptive task. Target stimuli for the vocabulary, lexical decision and sentence comprehension tasks are listed in appendices (Appendix A through Appendix C respectively).

In the *ASL Vocabulary Task*, participants saw four pictures (one target picture and three distractors) arranged into each corner of the computer screen. A video clip appeared at the center of the screen, depicting a native signer producing an ASL sign. The participant was asked to point to the picture that correctly matched the sign. The researcher provided feedback on four practice items, 16 test items followed without feedback.

In the *ASL Sign Decision Task*, participants saw pairs of video clips, each depicting a single ASL sign. In each pair, one clip contained a true ASL sign; the other contained a permutation of that true sign making it invalid. Incorrect foils were created by changing either the handshape, point of articulation or movement feature of the valid sign (Klima & Bellugi, 1979). In this task the participant was asked to point to the correct sign in the pair. The researcher provided feedback on four practice items, 18 test items followed without feedback. One of these items contained a potentially ambiguous sign pair, and was removed from analyses.

In the *ASL Story Comprehension Task*, participants viewed videos of short stories, each of which was followed by five multiple-choice comprehension questions. The stories and questions were adapted from items in Form A of the Gray Oral Reading Test version 4 (GORT-4, items 1, 2, 4, 6 & 8; Wiederholt & Bryant, 2001), originally a test of reading comprehension. All stories and subsequent questions were presented in ASL, so that the task focused exclusively on sign language comprehension. To begin each trial, the signer presented a short story. Signed instructions indicated that the story could not be repeated—participants had only one opportunity to become familiar with each story. At the end of each story, five new ASL clips appeared on screen; at the center was a video of

a question pertaining to the story, and at each corner was a video presenting one of four possible answers. The question and possible answers were played in succession thereby allowing participants to see all of the options. Participants responded by pointing to the video depicting the correct answer. Participants were allowed to view the question and the possible answers as many times as they wished; only the story itself was restricted to one viewing. Prior to the test items, participants viewed a practice story complete with questions and potential answers, to ensure that they understood the task. Feedback was provided during the practice story and questions only. The length and difficulty of the stories progressed steadily, and the task was terminated early if a participant answered incorrectly to four or more questions on any one story.

Of primary interest in this study was the degree to which overall receptive ASL proficiency is related to English sentence comprehension. To this end, we constructed a composite score of ASL ability by calculating the average proportion of items correct across all three tasks, with all tasks weighted equally. This composite score was then used to group participants as high or low achieving ASL signers (henceforth skilled and unskilled signers).

In the *English Sentence Comprehension Task* participants were presented with four pictures (one target picture and three distractors) arranged into each corner of the computer screen. At the same time, a written English sentence appeared across the center of the screen in 44 point sans serif font, without obstructing the pictures. Picture stimuli were cartoon illustrations depicting transitive actions (e.g., washing, pinching, pointing) being performed by humans or other animate creatures (e.g., dogs, cats, turtles). The participant's task was to read the sentence and point to the picture that correctly depicted

it. The researcher provided feedback on four practice items, 16 test items followed without feedback. Both deaf and hearing children participated in this task whereas only the deaf children participated in the previously described ASL measures.

The English sentence comprehension task was designed to assess comprehension of four types of syntactic constructions: active, passive, pronoun and reflexive pronoun sentences. Each construction was presented four times throughout the task. Items were designed so that both proportion correct and proportion of error types could be analyzed. There were two types of errors represented on each slide: 'near-misses' (at a rate of .25 per slide) and 'other-misses' (at a rate of .50 per slide). A near-miss was a picture that had more in common with the target than the two other-misses, and was therefore closer to the correct response than the other error type. While a near-miss still constituted an error, selection of this particular type of error demonstrated comprehension at a more complex level than was evidenced by the selection of the other-misses (as explained in the next section). Other-misses depicted relationships between the characters that were further removed from the target sentence. Errors of this type illustrated a weak understanding of written English. It might be useful to think of the error analysis in terms of educated guesses, which would result in mostly near-misses, versus guessing at random which would result in a proportional mixture of near- and other-misses.

A near-miss took on two different forms in this experiment depending on which type of sentence was presented. In the case of active and passive sentences, a near-miss was one in which the patient and the agent were switched (i.e., a word order error). For example, in a sentence that read, "The mother washes the girl" (or in the passive sentences, "The girl is washed by the mother") the near-miss would be the picture that

instead showed the girl washing the mother. Near-misses on the pronoun sentences depicted a misinterpretation of the Binding Principles (i.e., a binding error, Chomsky, 1981). For example in a sentence that read, "The mother washes her" the near-miss was a picture that showed the mother washing herself as opposed to the mother washing the girl (vice versa for the reflexive pronoun sentences).

Other-misses always depicted more gross departures from the given sentence, and depending on the sentence, included depictions of characters that were not mentioned, characters that represented gender-pronoun mismatches or by pictures that depicted a self-orienting action when an other-orienting action is required (or vice versa).

Hearing and nonverbal intelligence measures. Measures of hearing ability and nonverbal intelligence (NVIQ) were obtained in session two, which took approximately 15 minutes to complete. Hearing children also completed the NVIQ portion of session two.

Pure-tone hearing thresholds were obtained at 500, 1000, 2000 and 4000 Hz using a standard audiometric procedure (ANSI, 2004). For the purpose of statistical analyses we computed an overall hearing threshold for each child by averaging across all four frequencies. We also averaged across the 500 and 1000 Hz levels, and the 2000 and 4000 Hz levels to obtain low and high frequency thresholds respectively. In our analyses, we operationalized hearing threshold as the lowest dB acuity in the better ear within each frequency range (overall, low, high). NVIQ was assessed using Form A of the Test of Nonverbal Intelligence, version 3 (TONI-3; Brown, Sherbenou & Johnsen, 1997). This test was specifically designed to eliminate the confound of verbal ability in assessing intelligence, thus it was the ideal intelligence measure for our study.

L1 English reading group

Typical English sentence comprehension ability was established from the results of the hearing group. This allowed us to situate proficiency patterns found in the deaf signers within the context of how these abilities develop in children with normal hearing. This also helped assess how experiential and environmental differences (especially hearing status and exposure to language) influence reading ability.

Results

To examine the influence of ASL skill level on reading English sentences, deaf children were divided into high- and low-achieving signer groups (skilled and unskilled signers). Group membership was determined using a median split on the ASL composite scores. Group characteristics are presented in Table 1. We noted that six out of the 52 participants had a deaf parent at home; two of the six fell into the unskilled signer group with the other four falling into the skilled group. The groups did not differ on age, $t(50)= 0.13, p = .86$. However, there was a small but significant difference between the two groups on NVIQ, $t(50) = 2.44, p < .05$. In order to ensure this difference was not driving our effects, we partialed out NVIQ scores in all relevant analyses.

We compared the skilled and unskilled signers' accuracy on the sentence comprehension task (Table 2) using a two-way mixed ANCOVA for the effects of group (skilled vs. unskilled) and sentence-type (active, passive, pronoun, reflexive pronoun) controlling for TONI-3 percentile rank. This revealed a main effect of group, $F(1, 49) = 16.24, p < .001$, a main effect of sentence type, $F(3, 147) = 14.09, p < .001$ and a significant interaction, $F(3, 147) = 2.93, p < .05$. We were particularly interested in comparing the rates of performance on each sentence type across groups. Post hoc tests

Table 1. Mean (SD) group characteristics.

	Skilled signers (n=26)	Unskilled signers (n=26)	Hearing Children (n=10)
Age (yy;mm)	12;09 (2.03)	12;10 (3.07)	8;06 (0.03)
TONI-3 percentile	46.42 (26.78)[a]	29.00 (24.75)	39.70 (1.60)
ASL Composite (/58)	43.50 (4.25)[a]	31.81 (5.24)	
Vocabulary (/16)	14.92 (0.90)[a]	10.92 (1.76)	
Sign Decision (/17)	16.88 (0.33)[a]	15.35 (1.72)	
Story Comprehension (/25)	11.69 (4.09)[a]	5.54 (2.72)	
Hearing threshold (dB)	90.46 (11.56)	90.03 (8.65)	
low frequencies (dB)	87.10 (13.48)	86.33 (8.75)	
high frequencies (dB)	93.81 (11.89)	93.98 (11.24)	

Note. [a]Skilled group significantly greater than unskilled group, $p < .05$.

Table 2. Proportion correct (mean, SD) for each sentence type, by group.

	Skilled signers	Unskilled signers	Hearing children
Active	.93 (.18)*[a]	.64 (.33)*	.98 (.08)*
Passive	.25 (.33)	.18 (.23)	.55 (.31)*
Pronoun	.62 (.28)*[a]	.35 (.34)*	.43 (.12)*
Reflexive	.82 (.26)*[a]	.48 (.34)*	.98 (.08)*
Total	.65 (.19)[a]	.41 (.21)	.74 (.10)

Note. *Significantly above chance, $p < .05$; [a] skilled group significantly greater than unskilled group, $p < .05$.

revealed that skilled signers outperformed unskilled signers on active, $F(2, 193) = 14.05$, $p > .001$, pronoun, $F(2, 193) = 12.23$, $p > .001$, and reflexive sentences, $F(2, 193) = 19.12$, $p > .001$, but not on passives, $F(2, 193) = 0.77$, $p = .50$.

Further, we examined groupwise performance on each sentence type using one-sample t-tests that compared accuracy rates to a chance level of .25. The skilled signers performed significantly above chance on active, $t(25) = 19.22$, $p < .001$, pronoun, $t(25) = 7.66$, $p < .001$, and reflexive pronoun sentences, $t(25) = 11.11$, $p < .001$, but not on the passive sentences, $t(25) = .00$, $p = 1.00$. The unskilled group showed the same pattern, performing significantly above chance on actives, $t(25) = 6.18$, $p < .001$, pronouns, $t(25) = 2.38$, $p < .05$, and reflexive pronouns, $t(25) = 3.48$, $p < .01$, but not on passive sentences, $t(25) = -1.49$, $p = .15$.

We also compared the types of errors that deaf children made on the sentence comprehension task (Table 3). Across all sentence types, the skilled signers averaged a greater number of near-misses than other-misses, $t(25) = 5.77$, $p < .001$; in contrast, the unskilled signers were no more likely to produce near-misses than other-misses, $t(25) = 1.63$, $p = .12$.

Additionally, we were interested in the comparison between active and passive proficiency, and reflexive and pronoun proficiency within groups. Planned comparisons revealed that actives were significantly easier to comprehend than passives for both the skilled, $t(25) = 9.55$, $p < .001$, and unskilled groups, $t(25) = 5.04$, $p < .001$. Likewise, reflexives were significantly easier to comprehend than pronouns for both groups, $t(25) = 4.04$, $p < .001$, and, $t(25) = 2.16$, $p < .05$, skilled and unskilled respectively.

Table 3. Average number of near- and other-miss errors (mean, SD) for each sentence type, by group.

	Skilled signers		Unskilled signers		Hearing children	
	Near	Other	Near	Other	Near	Other
Active	0.27 (0.72)	0.00 (0.00)	0.54 (0.81)	0.88 (1.18)	0.00 (0.00)	0.10 (0.32)
Passive	2.46 (1.21)[a]	0.54 (0.71)	1.96 (1.11)	1.31 (0.79)	1.40 (0.84)[a]	0.40 (0.84)
Pronoun	0.92 (0.89)	0.62 (0.94)	0.96 (0.92)	1.65 (1.26)	1.70 (0.68)[a]	0.40 (0.52)
Reflexive	0.35 (0.75)	0.38 (0.70)	0.65 (0.80)	1.42 (1.06)[b]	0.00 (0.00)	0.10 (0.32)
Total	4.00 (2.02)[a]	1.54 (1.73)	4.12 (1.37)	5.27 (3.17)	3.10 (0.99)[a]	1.00 (1.33)

Note. [a]Near-misses significantly greater than other-misses, $p < .05$, [b]other-misses significantly greater than near-misses, $p < .05$.

We investigated group hearing thresholds to ensure that they were not responsible for the association we found between ASL and reading ability in our deaf groups (Table 1). There was some variability among individual participants' hearing acuity: one child fell within the moderate hearing loss range, 41-60 dB; 17 children fell within the severe loss range, 61-90 dB; and 30 fell within the profound loss range, 90+ dB (hearing assessment data was unavailable for the remaining four deaf children in the study because their school records did not contain this information, and we were not able to test them ourselves due to absenteeism on session two testing days). However, the groups did not differ on low, $t(46) = 0.24$, $p = .82$, high $t(44) = 0.48$, $p = .96$, or overall hearing thresholds, $t(44) = 0.14$, $p = .89$.

Hearing children

Finally we examined the pattern of performance in the hearing children who were well-matched for NVIQ with both the skilled, $t(34) = .70$, $p = .49$ and unskilled groups, $t(34) = -1.18$, $p = .25$. These children performed above chance on all four sentence types: actives, $t(9) = 29.00$, $p < .001$, passives, $t(9) = 3.09$, $p < .05$, pronouns, $t(9) = 6.22$, $p < .001$ and reflexive pronouns, $t(9) = 29.00$, $p < .001$. In addition planned comparisons revealed that like the deaf children, actives were easier to comprehend than passives $t(9) = 4.30$, $p < .01$, and reflexives were easier to comprehend than pronouns, $t(9) = 11.00$, $p < .001$. These children also showed a similar error pattern to the skilled signers, marked by a significantly greater number of near-miss than other-miss errors overall, $t(9) = 3.84$, $p < .01$.

Discussion

Previous studies of deaf children show a correlation between ASL and English reading ability (Prinz & Strong, 1998; Hoffmeister, 2000; Goldin-Meadow & Mayberry, 2001). The purpose of this study was to gain a better understanding of the details of this relationship, especially as it relates to some aspects of English syntax. Earlier studies indexed English proficiency using various methods that gauge overall English comprehension and production abilities (Strong & Prinz 1997; Padden & Ramsey 1998; Hoffmeister, 2000). These studies assessed broad language abilities and did not look specifically at the finer-grained details of proficiency on English grammar. We used a comprehension measure adapted from studies of syntactic abilities in hearing children to specifically examine comprehension of word order and pronoun binding in English. This method allowed us to relate our findings directly to specific types of syntactic constructions, thereby providing a more detailed analysis of how sign proficiency affects English reading ability.

As predicted, there was a strong association between ASL proficiency and English sentence comprehension, with skilled signers outperforming unskilled signers. More importantly, our data suggest this divergence tends to vary as a function of the type of English syntactic structure. Skilled signers showed a quantitative advantage marked by higher proficiency scores overall, as well as a qualitative advantage marked by rates of error types as discussed below. These results are consistent with theories of L2 language acquisition that highlight the importance of L1 proficiency at both the lexical and syntactic levels.

Both the developmental interdependence hypothesis and the Unified Competition Model predict that concrete word learning in L2 is dependent on concrete word knowledge in L1. Could it be the case then, that the link between ASL and English is simply due to differences in English word recognition skills across the two groups? If so, some children might have shown poorer sentence comprehension due to an inability to recognize the constituent words of a sentence, rather than a frank difficulty in sentence parsing. To examine this, we considered the rates of error types across group. Two types of errors were considered: near-misses and other-misses, which distinguished between parsing and word recognition errors, respectively. Our conceptualization of near-misses differed by sentence type. For active and passive sentences, a near-miss error was marked by the selection of a picture that represented a reversal of thematic roles (i.e., reversing the subject and object). In pronoun and reflexive pronoun sentences a near-miss error was marked by the selection of a picture that represented a misapplication of the Binding Principles (Chomsky, 1981), such that a pronoun or reflexive was bound to the incorrect noun phrase. Thus, near-miss errors indicated that children were able to correctly recognize the words in a sentence but were unable to correctly parse the sentence's syntactic form. In this sense, near-misses reflected a certain degree of sophistication in English ability in spite of an error being committed. Other-miss errors were marked by the selection of a picture that included an actor who was not mentioned in the sentence; characters that represented gender-pronoun mismatches; or by the selection of a picture that depicted a self-orienting action (e.g., a girl pinching herself) when an other-orienting action (e.g., a girl pinching a boy) was appropriate (or vice versa). We viewed these types

of errors as evidence that sentences were being misinterpreted due to a more basic difficulty affecting single word recognition.

So do some children show poorer sentence comprehension scores due to an inability to recognize the words of a sentence? The answer seems to be no, for the skilled signers, but yes, for the unskilled signers. The unskilled signer group made both near- and other-miss errors in equal proportion, while skilled signers made significantly more near-miss than other-miss errors. This tendency towards near-miss errors by the skilled signers indicates that even when syntax becomes an obstacle, they continue to use their lexical knowledge to approach the correct answer. This observation was most relevant for the passive sentences, where accuracy rates were similar across the skilled and unskilled groups. Although the overall sum of errors was balanced for the two groups on the passive sentences, the specific type of errors made by each group was not. The tendency for the skilled group to make near-misses reveals a reliance on lexical knowledge in sentence processing that is not mirrored by the unskilled group. The unskilled signers tended to make both other-miss and near-miss errors at equal rates, indicating that the information gathered from the sentence was severely impoverished. This mix of errors reflects a more general difficulty in interpreting who and what is being represented in the sentence, in addition to a syntactic parsing problem. From the error analysis, we conclude that poor ASL proficiency has negative outcomes for English sentence comprehension at both the syntactic and the individual word level.

The observed pattern of sentence comprehension accuracy harkens back to the idea of transference. The Unified Competition Model contends that ease of L2 sentence comprehension depends on the extent to which L2 constructions map onto L1

constructions. There was a common gradient of difficulty across the sentences types for both skilled and unskilled signers: sentences that mapped more directly from L2 to L1 (actives and reflexive pronouns) were easiest to comprehend, those that shared semantic form but not linguistic form (pronouns) were somewhat more difficult to comprehend, and those that portrayed linguistic constructions that appear in L2 but are questionable in L1 (passives) were the most problematic.

Thus far, the ease of mapping theory explains the data accurately. However, on this account, we should only expect to see increased comprehension in the skilled signer group on the easier sentence types (actives and reflexive pronouns) where mapping is straightforward. In fact what we see are benefits for the skilled signers not only on actives and reflexive pronouns, but also on pronouns. In addition to the ease of mapping theory, we argue that increased proficiency in L1 offers the learner a more significant advantage by establishing an abstract set of representations that enhances L2 ability even in cases when the construction in L1 and L2 is not identical. Skilled signers experienced increased comprehension not only on those sentences that easily map from L1 to L2, but also on those sentences for which the mapping between languages is not straightforward (pronouns). This increased ability allows for comprehension beyond the one-to-one mapping of lexical items and syntactic structures, consistent with the theory that first language proficiency supports learning a wide range of second-language skills (Cummins, 1979, 1983) including both lexical and syntactic abilities, extending across linguistic modalities.

While we did find support for the linguistic interdependence hypothesis across the active, reflexive and pronoun sentences, with skilled signers outperforming the unskilled

signers, we did not find support for this hypothesis on the passive sentences. We are not the first to report passive construction difficulties in the deaf (Power & Quigley, 1973). The fact that the skilled signers failed to outperform the unskilled signers on these sentences can be explained by deaf children's limited exposure to this structure in addition to the general difficulty with which this construction is learned even by hearing children. Given equivalent exposure times there is reason to believe that deaf children will catch up (Rinaldi & Caselli, 2008). Even though ASL proficiency does provide support for abstract linguistic understanding, without sufficient exposure to a given syntactic structure, comprehension of that structure cannot be expected to develop at a natural rate.

Prior research has compared hearing children's performance on actives and passives, and pronouns and reflexives (Baldie, 1976; Chien & Wexler, 1990), providing us with benchmarks for making such comparisons in deaf children. We observed a similar pattern of syntactic development across both groups where actives were performed with greater accuracy than passives, and reflexives were performed with greater accuracy than pronouns. Thus even though ASL proficiency has implications for the overall acquisition of English reading ability, it seems to matter less with respect to the precise pattern of syntactic development.

Hearing children

The hearing children performed above chance on all four sentence types. Importantly, they showed the same pattern of syntactic development as both of the deaf groups, with actives being easier to comprehend than passives, and reflexives being easier to comprehend than pronouns. These congruent effects suggest that similar

constraints operate on how deaf and hearing children learn word order principles in English. Additionally, we found that hearing children tended to make more near-miss errors than other-miss errors, a pattern that was mirrored by the skilled signers, but not by the unskilled signers. Thus, the skilled signers reflected the hearing readers in terms of their patterns of syntactic development and error tendencies, suggesting that deaf readers with good signing ability develop along the same path (albeit delayed) as hearing children. While unskilled signers did show the same pattern of syntactic development as both the skilled signers and the hearing group, their development was disproportionately delayed as evidenced by their low accuracy rates, and distribution of error types that departed from the other groups' pattern.

Alternative hypotheses

Three other factors may have played a role in the association between ASL and English reading ability: NVIQ (NVIQ), severity of hearing loss and age differences. Deaf children have been shown to be a particularly heterogeneous group with respect to NVIQ (Marschark, 1993) due to the fact that deafness can be caused by a number of in-utero or perinatal insults (including roseola, meningitis, maternal rubella, anoxia, premature birth and effects of medications) all of which have potential consequences for cognitive development in addition to the resulting deafness. One possibility is that low NVIQ is responsible for difficulty in learning both L1 and L2, which might explain the L1/L2 association we observed. Consistent with this, we did find a small but significant effect of NVIQ on signing ability, such that skilled signers tended to have higher scores than the unskilled signers. This might undermine our assertion that ASL skill significantly predicts English sentence comprehension. However, we controlled for NVIQ in all

statistical analyses of English sentence comprehension. We noted that effects of signing ability remained significant, suggesting that although NVIQ may play some role in predicting signing ability, it is not the sole factor in determining English sentence comprehension ability.

A related concern was whether the groups differed with respect to residual hearing abilities. As is common with samples of deaf individuals, a portion of the students had some residual hearing abilities that may have allowed them to access limited cues from spoken language; for instance low frequency information might allow deaf individuals to detect speech cues such as vowel length. It could be argued that this small amount of access to spoken language could ultimately affect participants' English sentence comprehension scores. However, no group differences were found for low, high, or overall hearing threshold in our sample. Thus, hearing thresholds cannot explain the group-wise differences with respect to English syntactic abilities seen here. We also noted that all but one of our participants for whom we had hearing assessments fell within the severely to profoundly deaf range, such that it is unlikely that these individuals are reliably perceiving any acoustic information relevant to speech.

Finally, it is worth noting that although the two signer groups were not matched on age a priori, the groups were statistically comparable in this respect. Thus, this factor also cannot explain the difference in English reading ability across the high- and low-signing ability groups.

Conclusions

Deaf individuals are generally delayed in learning to read English, performing on average at a fourth-grade level (Goldin-Meadow & Mayberry, 2001). ASL ability has

been shown to be the single best predictor of English reading ability in deaf readers (Goldin-Meadow & Mayberry, 2001, Hoffmeister, 2000; Strong & Prinz, 1997, 2000). We were interested in further examining this known correlation, specifically with respect to English sentence comprehension ability. We examined four syntactic constructions that are known to vary in terms of difficulty in hearing children. Children performed a four-alternative forced choice written sentence-to picture-matching task. We found significant differences between skilled and unskilled signers on sentence comprehension accuracy for active, pronoun and reflexive pronoun sentences in favor of the skilled signers. We also found significant differences in the types of errors committed by each group, which indicated that skilled signers were able to effectively extract more lexical and syntactic information from the sentences than were the unskilled signers. We interpret these results as support for both the Unified Competition Model and the developmental interdependence hypothesis (Cummins, 1979, 1983) where L2 learning depends on L1 proficiency, even across linguistic modalities. Specifically, ASL proficiency in the groups described here was predictive of both English word recognition and English syntactic comprehension abilities.

References

Adams, M. J. (1990). *Beginning to read.* Cambridge, Massachusetts: MIT Press.

American National Standards Institute. (2004). Methods for manual pure-tone threshold audiometry (ANSI S3.21-2004). New York: Author.

Baldie, B. J. (1976). The acquisition of the passive voice. *Journal of Child language, 3,* 331-348.

Beech, J. R., & Harris, M. (1997). The prelingually deaf young reader: A case of reliance on direct lexical access? *Journal of Research in Reading, 20,* 105-121.

Brown, L., Sherbenou, R. J. & Johnsen (1997). *Test of nonverbal intelligence: A language free measure of cognitive ability.* Austin, TX: Pro-Ed, An International Publisher.

Chien, Y.-C., & Wexler, K. (1990). Children's knowledge of locality conditions in binding as evidence for the modularity of syntax and pragmatics. *Language Acquisition, 1,* 225-295.

Chomsky, N. (1981). *Lectures on government and binding: the pisa lectures.* Berlin: Mouton de Gruyter.

Cummins, J. (1979). Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research, 49,* 222-251.

Cummins, J. (1983). Bilingualism and special education: Program and pedagogical issues. *Learning Disability Quarterly, 6,* 373-386.

Deutsch, W., Koster, C. & Koster, J. (1986). What can we learn from children's errors in understanding anaphora? *Linguistics, 24,* 203-225.

Goldin-Meadow, S. & Mayberry, R. I. (2001). How do profoundly deaf children learn to read? *Learning Disabilities Research & Practice, 16*, 222-229.

Hanson, V. L., & Fowler, C. A. (1987). Phonological coding in word reading: Evidence from hearing and deaf readers. *Memory & Cognition, 15*, 199-207.

Hoffmeister, R. J. (2000). A piece of the puzzle: ASL and reading comprehension in deaf children. In C. Chamberlain, J. P. Morford & R. I. Mayberry (Eds.), *Language acquisition by eye* (pp. 143-163). Mahwah, New Jersey: Lawrence Erlbaum Associates Inc.

Isenhath, J. O. (1990). The linguistics of American sign language. *Communication styles.* Jefferson, N.C.: McFarland & company, Inc., Publishers.

Janzen, T., O'Dea, B. & Shaffer, B. (2001). The construal of events: Passives in American Sign Language. *Sign Language Studies, 1*, 281-310.

Klima, E., & Bellugi, U. (1979). *The signs of language.* Cambridge, MA: Harvard University Press.

MacWhinney, B. (2005). New directions in the competition model. In M. Tomasello & D. I. Slobin (Eds.), *Beyond Nature-Nurture* (pp. 79-110). Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.

MacWhinney, B. & Bates, E. (Eds.). (1989). *The crosslinguistic study of sentence processsing.* New York: Cambridge University Press.

Marschark, M. (1993). Intelligence and cognitive development. *Psychological development of deaf children* (pp. 128-149). New York, NY: Oxford University Press Inc.

Mayberry, R. I., Lock, E. & Kazmi, H. (2002). Linguistic ability and early language exposure. *Nature, 417*, 38.

Maxwell, K. N. & Joanisse, M. F. (2008). English reading ability in deaf signers of American Sign Language. Manuscript in preparation.

Nielsen, D. C. & Luetke-Stahlman, B. (2002). Phonological awareness: One key to the reading proficiency of deaf children. *American Annals of the Deaf, 147*, 11-19.

Padden, C., & Ramsey, C. (1998). Reading ability in signing deaf children. Topics in Language Disorders. Special Issue: ASL proficiency and English literacy acquisition: New perspectives, 18(4), 30-46

Power, D. J. & Quigley, S. P. (1973). Deaf children's acquisition of the passive voice. *Journal of Speech and Hearing Research, 16*, 5-11.

Prinz, P. M. & Strong, M. (1998). ASL proficiency and English literacy within a bilingual deaf education model of instruction. Topics in Language Disorders. Special Issue: ASL proficiency and English literacy acquisition: New perspectives, 18(4), 47-60.

Rinaldi, P. & Caselli, C. (2008). Lexical and grammatical abilities in deaf Italian preschoolers: the role of duration of formal language experience. *Journal of Deaf Studies and Deaf Education,* in press, doi:10.1093/deafed/enn019.

Savage, C., Lieven, E., Theakston, A. & Tomasello, M. (2003). Testing the abstractness of children's linguistic representations: lexical and structural priming of syntactic constructions in young children. *Developmental Science, 6,* 557-567.

Strong, M. & Prinz, P. (1997). A study of the relationship between American Sign Language and English literacy. *Journal of Deaf Studies and Deaf Education, 2* (1), 37-46.

Strong, M. & Prinz, P. (2000). Is American Sign Language skill related to English literacy? In C. Chamberlain, J. P. Morford & R. I. Mayberry (Eds.), *Language acquisition by eye* (pp. 131-141). Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.

Singleton, J. L., Supalla, S., Litchfield, S., & Schley, S. (1998). From sign to word: Considering modality constraints in ASL/English bilingual education. *Topics in Language Disorders, 18*, 16-29.

Transler, C., Leybaert, J., & Gombert, J. (1999). Do deaf children use phonological syllables as reading units? *Journal of Deaf Studies and Deaf Education, 4*, 124-143.

van der Lely, H. K. J. & Stollwreck, L. (1997). Binding theory and grammatical specific language impairment in children. *Cognition, 62*, 245-290.

Vasilyeva, M., Huttenlocher, J. & Waterfall, H. (2006). Effects of language intervention on syntactic skill levels in preschoolers. *Developmental Psychology, 42*, 164-174.

Wiederholt, J. L. & Bryant, B. R. (2001). *Gray oral reading test, version 4.* Pearson Education, Inc.

Appendix A

ASL Vocabulary Items

Practice items:

BOOK , BASEBALL, WEATHER, HAPPY

Test items:

CANADA, RACCOON, KING, DUCK, COACH, HELICOPTER, LETTER, PANCAKE, PINEAPPLE, STARS, DESTROY, PINK, CHEESE, SNOW, SIT, SKI

Appendix B

ASL Sign Decision Items

Target Sign	Foil Sign		
	Handshape	Point of Articulation	Movement
Practice items:			
APPLE	apple	opposite cheek	apple
BALL	ball	back of hands touch	ball
CLOWN	pig	clown	clown
MAD	mad	shoulder	mad
Test items:			
PLAY	'I love you' hands	play	play
ENCOURAGE	encourage	above/below each other	encourage
ARRIVE	arrive	back of non-dominant hand	arrive
FLOWER	flower	elbow	flower
DISCUSS	tip of index on palm	discuss	discuss
CAT	cat	tip of nose	cat
MOTHER	mother	index contacts chin	mother
TRUST	trust	hands side by side	trust
RELATIONSHIP	'touch' hands	relationship	relationship
PERFECT	'six' hands	perfect	perfect
GUILT	guilt	wrong shoulder	guilt
STICKY	'seven' hands	sticky	sticky
LONDON	London	wrong shoulder	London
BLUE	(this item was removed from the analysis)		
WONDERFUL	wonderful	wonderful	out to sides
BRAG	brag	temples of head	brag
INSTITUTE	'I love you' hands	institute	institute
FANCY	fancy (two-handed)	stomach	fancy

Appendix C

English Sentence Comprehension Items

Practice items:

The man points at the boy. The cat has a baseball bat. The girl sees a football.

The dog bites the cat.

Test items:

Actives

The mother is washing the girl. The turtle hits the bird.

The man is pointing at the boy. The girl is pinching the doctor.

Passives

The bird is hit by the turtle. The mother is washed by the girl.

The boy is pointed at by the man. The girl is pinched by the doctor.

Pronouns

The mother washes her. The doctor pinches her. The man is pointing at him.

The girl washes her.

Reflexive pronouns

The turtle hits himself. The mother washes herself. The boy is pointing at himself.

The girl pinches herself.

Appendix D

Ethics Approval

Office of Research Ethics

The University of Western Ontario
Room 00046 Dental Sciences Building, London, ON, Canada N6A 5C1
Telephone: Fax: Email:
Website: www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. M. Joanisse
Review Number: 116628 **Revision Number:**
Protocol Title: English reading abilities in deaf signers of ASL
Department and Institution: Psychology, University of Western Ontario
Sponsor:
Ethics Approval Date: August 26, 2005 **Expiry Date:** April 30, 2007
Documents Reviewed and Approved: UWO Protocol, Letters of Information & Consent (adult, child) 2005
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Non-Medical Research Involving Human Subjects (REB) which is organized and operates according to the Tri-Council Policy Statementand the applicable laws and regulations of Ontario has granted full board approval to the above named research study on the approval date noted above.

This approval shall remain valid until the expiry date noted above assuming timely and acceptable responses to the REB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the REB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the REB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;

b) all adverse and unexpected experiences or events that are both serious and unexpected;

c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the REB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the REB.

Chair of REB: Dr. Jerry Paquette
Deputy Chair: Susan Hoodnon

Ethics Officer to Contact for Further Information			
☒ Karen Kueneman	☐ Janice Sutherland	☐ Susan Underhill	☐ Jennifer McEwen

This is an official document. Please retain the original in your files.

cc: ORE File