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The Development of Antonym Knowledge in American Sign Language (ASL) and Its Relationship to Reading Comprehension in English

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It is unknown if the developmental path of antonym knowledge in deaf children increases continuously with age and correlates with reading comprehension, as it does in hearing children. In the current study we tested 564 students aged 4–18 on a receptive multiple-choice American Sign Language (ASL) antonym test. A subgroup of 138 students aged 7–18 took the Stanford Achievement Test reading comprehension test. The results showed that antonym knowledge depended more strongly on age for deaf children with deaf parents than for deaf children with hearing parents. This indicates more developmentally typical acquisition for deaf children with deaf parents, consistent with early natural language exposure. Multiple regressions demonstrated that ASL antonym knowledge eliminated the advantage of deaf parents for reading. This establishes a language effect of ASL on reading comprehension in English.

Keywords ASL; reading comprehension; antonyms; deaf; language delay

Introduction

At an early age, antonyms are part of a child's lexicon. Antonyms represent a strong case of the principle of lexical contrast (Clark, 1987), which proposes that any new word that is acquired must contrast in meaning with other words. The acquisition of antonyms requires knowledge of relationships among words and thus has been fruitfully used as an indicator of both breadth and depth of vocabulary knowledge (Paul & O'Rourke, 1988). Thus, the study of antonyms is

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a useful tool to learn about aspects of vocabulary knowledge beyond vocabulary size.

Vocabulary knowledge in general positively relates to reading comprehension (e.g., Baumann, Edwards, Boland, Olejnik, & Kame'enui, 2003; Davis, 1942; Ouellette, 2006). In recent years it has been shown that vocabulary knowledge in the first language (L1) also supports reading comprehension in the second language (L2) for spoken languages (e.g., de Villiers & Masek, 2013; Lindsey, Manis, & Bailey, 2003; Miller et al., 2006; Proctor, August, Carlo, & Snow, 2006). For example, Proctor et al. (2006) tested 135 bilingual Spanish–English students. They showed that, when controlling for language of instruction (English versus Spanish), English decoding skill, and English oral language proficiency (all effects of L2 proficiency), the effect of vocabulary knowledge in Spanish (L1), as measured by the Woodcock Picture Vocabulary test (Woodcock & Muñoz-Sandoval, 1995), was significant. These results are important for the current study as the authors compared vocabulary knowledge with other variables: Spanish language alphabetic knowledge, fluency, and listening comprehension on the performance of English reading comprehension. The authors suggest that vocabulary knowledge serves as an adequate proxy for background knowledge, interpretation, and comprehension monitoring.

The first goal of the present study is to investigate the developmental trajectory of antonyms in American Sign Language (ASL). For our second goal, we then use antonyms as a measure of ASL proficiency and explore how it supports English reading comprehension.

Background to the Study

The Development of Antonyms

Antonyms constitute a unique class of words as they represent both breadth and depth of vocabulary knowledge. They represent breadth (or size; Ouellette, 2006) of vocabulary knowledge as each antonym is represented by a specific word. Individuals who know more words can make inferences and integrate information into coherent thoughts more easily than those with smaller vocabulary sizes (Sénéchal, Ouellette, & Rodney, 2006). Thus, breadth of vocabulary contributes building blocks for more complex language skills and higher-order thinking skills. A child who knows more antonyms usually knows more words and his vocabulary size is larger (Ouellette, 2006). Depth of vocabulary knowledge refers to the number of meanings, different usages of a word, and relationships between words (Johnson, 2001; Paul & O'Rourke, 1988). The knowledge of opposites, presented by the antonymous relationship between two words, elaborates the meaning of each individual word and is thus part of vocabulary depth (Ouellette, 2006).

In production, children use antonyms in robust and creative ways at early ages (e.g., Clark, 1972; Doherty & Perner, 1998; Jones & Murphy, 2005). In comprehension, children understand antonyms before the age of 4 years (Doherty & Perner, 1998). Jones and Murphy (2005) did not find a firm correlation between antonyms children hear in the input[1] and the antonyms they produce. The authors suggested that the process of learning antonyms and how to use them is associated with cognitive development. Thus, knowledge of antonyms provides evidence for cognitive development and the representation of this knowledge in the language. However, little is known about the acquisition of antonyms in sign languages, including ASL.

The acquisition of ASL vocabulary for deaf children is similar to that of vocabulary in spoken languages for hearing children at early ages (e.g., Anderson & Reilly, 2002). Anderson and Reilly (2002) described the development of the productive vocabulary size of 110 deaf children between 8 months and 3 years of age. Less is known about the development of ASL vocabulary during school years. However, based on the results from Anderson and Reilly (2002), it is suggested that the development of antonyms in ASL should be similar to that in spoken languages. Some researchers have reported that deaf students are delayed in their knowledge of antonyms (Moeller, Osberger, & Eccarius, 1986; Monreal & Hernandez, 2005). For example, 93 Spanish deaf students ages 9–20 achieved scores of only 17% correct on an antonym task in Spanish (Monreal & Hernandez, 2005). In this study, antonym comprehension was tested using written Spanish. Participants had to choose the antonym of the prompt from among four options. One interpretation of these results is not that deaf participants do not know antonyms, but rather they do not know Spanish. Similar results are found in production studies. For example, Moeller et al. (1986) tested 116 deaf students ages 7.5–20 years old on the Woodcock Johnson Psycho educational test battery (Woodcook & Johnson, 1977), which includes antonyms. Oral or signed responses to printed words were measured. The participants in all age groups showed delay in their performance compared to age-equivalent scores. To the best of our knowledge, there is no test or study that has used a sign-to-sign method to evaluate antonym knowledge in a sign language, including ASL. Thus, it is unknown if deaf students are delayed in antonym knowledge.

It is important to note that in most receptive tasks that assess a child's vocabulary knowledge the child is provided with a word or a sign and has to select a picture that matches its meaning from a set of pictures. This is true, for example, for the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) for spoken languages; the British Sign Language vocabulary test (Mann & Marshall, 2012), and the receptive vocabulary test for German Sign Language (Wildemann, 2008) for signed languages. In contrast, as mentioned above, the task used in the current study is a sign-to-sign matching receptive task assessing both sides of the equation of the antonyms knowledge. The task aims to explore the developmental path of antonyms comprehension in ASL throughout the school years (ages 4 to 18). This is the first study in which a vocabulary antonym task has been tested on a large age range of deaf children in any signed language.

There are two main reasons for choosing an antonym receptive task as a measurement of antonym knowledge. The first reason relates to the type of task, as receptive vocabularies represent larger knowledge than productive vocabularies across a range of learners, including deaf children (Woolfe, Herman, Roy, & Woll, 2010). Using a receptive task thus maximizes the potential for each child to demonstrate antonym knowledge. The second reason relates to the advantage of using depth of vocabulary knowledge as a predictor for reading comprehension. Antonyms represent depth of vocabulary knowledge, a measure found to be a better predictor of reading comprehension in monolinguals compared to breadth of vocabulary knowledge (Ouellette, 2006). The importance of the relationship between vocabulary knowledge and reading comprehension in deaf students is further discussed in the following section.

The Relationship Between Language Knowledge in a L1 and Reading Comprehension in a L2 in Deaf Children

In the deaf population, the median reading level of young deaf adults graduating from high school is 8 years below the average of their hearing peers (Kelly & Barac-Cikoja, 2007). Part of the explanation for this delay is related to poor proficiency in English for deaf students, which is caused by decreased auditory-language input (e.g., Allen et al., 2009; Bochner & Bochner, 2009; Knoors & Marschark, 2012; Luckner & Cooke, 2010; Paul, 2000). It is important to note that, within the deaf population, the range in levels of English achievement is wide and many deaf learners do achieve levels of English proficiency that are not different from those of their hearing peers (see, e.g., Toscano, McKee, & Lepoutre, 2002). However, many other deaf students do not achieve high levels of English proficiency. Those who are born to hearing parents and are not exposed to a sign language (e.g., ASL) at an early age cannot be described as native users of the sign language (see, e.g., Mayberry & Lock, 2003). The delay in their spoken language shows patterns of language performance similar to L2 learners (Berent, Kelly, & Schueler-Choukairi, 2009, 2012; Bochner & Bochner, 2009). Thus, many deaf individuals can neither be described as native users of the spoken language of the hearing community nor as native users of a sign language.

The current study focuses on a subgroup within the deaf population, deaf children with deaf parents (DCDP). Being raised by deaf parents means that deaf children are exposed to a natural language from birth. They thus attain language milestones without delay, similarly to hearing children exposed to spoken language. Because of this, parental status as deaf or hearing can be used as an indication of signing ability and of language ability more generally. When comparing the sign language skills of DCDP as a group with the sign language of deaf children of hearing parents (DCHP) as a group, those with hearing parents lag behind deaf children with deaf parents (e.g., Hermans, Knoors, & Verhoeven, 2009; Mayer & Leigh, 2010; Novogrodsky, Fish, & Hoffmeister, 2014). One reason for this lag is believed to be the weaker L1 skills of DCHP (Dickinson & McCabe, 2001).

Good ASL skills correlate with L2 reading comprehension (Chamberlain & Mayberry, 2000; Hermans, Ormel, & Knoors, 2010; Hoffmeister, 2000; Lichtenstein, 1998; Miller et al., 2012; Strong & Prinz, 1997). A growing literature examines how ability in vocabulary, syntax, and phonology influences reading comprehension, as described in the next section.

Vocabulary Knowledge

Knowledge of signed language vocabulary correlates with knowledge of the print vocabulary of a spoken language (Hermans, Knoors, Ormel, & Verhoeven, 2008; Hermans et al., 2010; Strong & Prinz, 1997). Strong and Prinz (1997) found that deaf children with higher facility in ASL outperformed children in the lowest ASL ability level in English literacy, regardless of age and IQ. Fish, Hoffmeister, and Thrasher (2005) found a positive correlation between scores on a test of rare ASL vocabulary and scores on a test of English reading comprehension. In a meta-analysis, Mayberry, del Giudice, and Lieberman (2011) found that in eight studies where vocabulary was measured, it predicted 35% of the variance in reading ability. These studies suggest that vocabulary knowledge in a sign language can contribute to reading skill in a spoken language, despite the difference in language modality, and can thus serve as an L1 mediator of development in an L2 (here, English reading).

Syntactic Knowledge

Syntactic knowledge also predicts reading comprehension (Chamberlain & Mayberry, 2008; Miller et al., 2012). For example, Chamberlain and Mayberry (2008) found that skilled deaf adult readers of English scored higher on a test of ASL syntax. The authors further demonstrated that ASL syntactic ability contributed unique variance to their English reading performance when the effects of nonverbal IQ, exposure to print, and ability in Manually Coded English (i.e., visual communication methods expressed through the hands that attempt to represent the English language and generally follow the grammar of English) were statistically controlled.

Phonological Knowledge

For deaf readers the question of the relationship between phonological awareness and reading needs to be explored from two angles: first, whether the hearing threshold level of deaf readers mediates phonological awareness and, second, what other language components affect reading for deaf readers if phonological awareness is not a predictor of reading achievement. The first question was tested by Kyle and Harris (2006), who found that phonological awareness in English was significantly correlated with reading ability in deaf students only if hearing loss was not controlled. They suggested that phonological awareness and reading can be mediated by hearing level in deaf children. A child with more severe hearing loss will have lower scores on phonological awareness tasks and on reading tasks. Some studies that tested the second question found that phonological decoding ability[2] of the spoken language is not a predictor of reading comprehension for deaf readers (Mayberry et al., 2011; Miller et al., 2012). Miller et al. (2012) found that the variance in reading comprehension of deaf children from four orthographic backgrounds (Hebrew, Arabic, English, and German) cannot be related to their phonological decoding skills in the spoken language. Their results showed that the most skilled readers among the 213 tested participants did not perform better on the decoding tasks than did the less skilled readers. In contrast, syntax and semantic knowledge did explain the variance in reading comprehension of the deaf readers in their study. In their meta-analysis, Mayberry et al. (2011) found that phonological coding skills and phonological awareness abilities predicted only 11% of the variance in reading ability in deaf participants. These results suggest that phonological knowledge in the spoken language is not a prominent mediator of reading comprehension for deaf readers.

Evidence for the importance of L1 sign language for deaf students comes also from studies showing that sign language knowledge is activated during the reading process (Morford, Wilkinson, Villwock, Piñar, & Kroll, 2011; Ormel, Hermans, Knoors, & Verhoeven, 2012). Morford et al. (2011) tested 11 deaf adults who were proficient in ASL on a judgment task of written words. The participants judged word pairs that were semantically related more quickly when the form of the ASL translation was also similar compared to word-pairs that were semantically unrelated and the form of the ASL translation was similar. The authors suggested that deaf readers activate the ASL translations of written words in English even under conditions in which the ASL translation is neither present perceptually nor required to perform the task. Ormel et al. (2012) found similar results in 40 deaf children in Grades 3–6. Although the task in this study did not involve reading, it supports the assumption of automatic activation of the signed modality in comprehension tasks. In this study, children were presented with picture pairs for which the sign translation equivalents varied with respect to overlap of the phonological structure of the sign and sign iconicity. Deaf children showed relatively longer response latencies and more errors to nonmatching picture pairs with sign translation that had strong sign phonological structure relations (inhibitory effect) than nonmatching picture pairs without sign phonological structure relations. This effect was not found for hearing children, suggesting that the inhibitory effect found for the deaf children can only be attributed to the bilingual activation of their sign language knowledge. These results provide evidence for interactive cross-language processing in deaf children.

To summarize, the results from different tasks and from different sign languages indicate that signs are activated during reading and during comprehension tasks. Thus sign language knowledge contributes to reading comprehension despite the difference in language modality.[3]

There is accumulating evidence that sign language functions as a linguistic basis of reading development for deaf children who use sign language as their dominant language. In the current study we tested a large number of deaf children on an ASL antonyms task. Because this task represents depth of vocabulary knowledge, it should thus be a good predictor of reading comprehension, following findings with spoken languages (Ouellette, 2006). In addition, three other possible mediators of reading performance were investigated: (a) parental hearing status as a mediator of the sign language input that the child receives, (b) age as a developmental mediator, and (c) gender as a control mediator.

We tested several hypotheses in the present study. The first prediction focused on the development of antonyms. We hypothesized that deaf children (both DCDP and DCHP) would show age-related development on the antonyms task. The second prediction focused on the difference between the two parental groups. We hypothesized that the DCDP group will outperform the DCHP group on the antonym task. The third prediction focused on the relationship between antonyms and reading comprehension. Prior work has found that DCDP have an advantage over DCHP on language tasks (Hermans et al., 2009; Novogrodsky et al., 2014). Many scholars have attributed this to the cognitive and linguistic benefits of early language exposure. Further, in hearing children, age is a very strong predictor of reading comprehension as it represents language ability (Keenan, Betjemann, & Olson, 2008). We predicted that age will contribute unique variance of reading proficiency consistent with the literature on hearing children. ASL will predict additional unique variance in reading proficiency and once ASL knowledge is statistically equated, parental hearing status will not explain additional unique variance in reading proficiency. Last, based on previous literature, gender will not explain additional unique variance of reading proficiency (Hogrebe, Nist, & Newman, 1985).

Method

Participants

The data were collected from 564 deaf students between the ages of 4 and 18 years (see Table 1) from various sites across the United States. The participants were grouped by parental hearing status: 122 DCDP were exposed to ASL by at least one deaf adult from birth and were thus considered to be native signers and 442 DCHP who were first exposed to ASL-using deaf adults upon entering the education system. It is important to note that, although the DCDP group is small in comparison to the DCHP group, it represents 22% of the sample, whereas in the population at large, only 5–10% of deaf children are born to deaf parents (Mitchell & Karchmer, 2004). Participants were further divided into age groups combining 2 years together in order to have at least 10 DCDP in each of the age groups (Table 1).

Materials

The antonyms task used in this study is a video-based, receptive multiple-choice subtest of the ASL Assessment Instrument (Hoffmeister, Greenwald, Bahan, & Cole, 1989). Here we briefly reviewed the design of the task. The antonym stimuli were initially constructed by four native signers to vary in difficulty level, including easy antonyms (e.g., LIGHT, DARK) and slightly harder ones (such as CLEAR and VAGUE; see example in Figure 1). A group of 25 native signers scrutinized antonym pairs to ensure they were indeed antonyms and also confirmed the relationship between each prompt and its foils. The 13 antonym

Table 1 Number of participants by age, gender, and parental hearing status

Age	4–5		6–7		8–9		10–11		12–13		14–15		16–18		Total
Gender	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
DCDP	8	8	16	9	9	13	4	6	12	5	11	11	2	8	
Total	16		25		22		10		17		22		10		122
DCHP	9	13	30	31	35	20	33	30	50	34	36	30	44	47	
Total	22		61		55		63		84		66		91		442

Note. M = male, F = female, DCDP = Deaf Children of Deaf Parents, DCHP = Deaf Children of Hearing Parents.

pairs included eight pairs of adjective antonyms and five pairs of verb antonyms. Each of the 13 stimulus items consisted of a prompt (1), the target (a), and three other possible response options: a semantic foil (b), a phonological foil (c), and an unrelated foil (d). The semantic foils are semantically related to the prompt. For example, DARK[4] (b) is not an antonym of VAGUE (1) but is semantically related to it. The phonological foils differ in 1 to 3 phonological features (hand shape, movement, location, or palm orientation) from the prompt. For example, the signs ATTRACT and WANT used in the test differed only in hand shape. The choice of which features differed was equally distributed across movement, location, and palm orientation, while hand shape feature differences only played a role in two foils. The task was piloted on 10 deaf adults with deaf parents. The final task questions were selected from those items that achieved 90% correct or better performance.

Of the 564 participants, a subgroup of 138 students aged 7–18 (37 DCDP and 101 DCHP) took the Stanford Achievement Test–Reading Comprehension test (SAT-RC; Traxler, 2000) in addition to the antonym task.

Testing Procedures

The antonyms task was administered to small groups of participants by deaf researchers, with videotaped instructions and two demonstration items presented by a native signer. Participants then viewed two practice items followed by the 13 test items. For each item, the video presented the stimulus followed by the four response choices. Participants were instructed to select the response that best reflected the opposite of the prompt. An example of a question from the response booklet is presented in Figure 1, corresponding with (1) here:

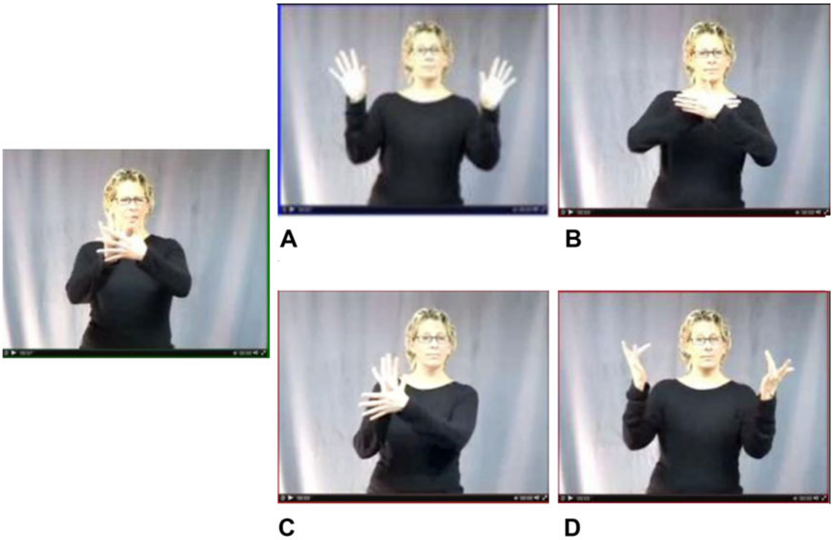

Figure 1 On the left: VAGUE A. CLEAR B. DARK C. MOVIE D. LIGHT (in weight).

1. Prompt: *VAGUE*

(a) Target: *CLEAR*
(b) Semantic foil: *DARK*
(c) Phonological foil to the prompt: *MOVIE* (differs in movement and palm orientation from the prompt)
(d) Unrelated foil: *LIGHT* (in weight)

Results

Hypothesis 1: Knowledge of Antonyms Will Increase With Age

Participants performed better on the task with age ($r = .34$, $p < .000$; Figure 2). In the DCDP group, a maximum average correct performance of 81% was achieved at the age of 16–18 years. For the DCHP group, development was more gradual, with a maximum correct performance of 56% at the age of 16–18 years, which is equivalent to the achievement of 6–7 to 8–9-year-old DCDP (Figure 2). The correlation between age and performance was moderate for both DCDP group ($r = .57$, $p < .0001$) and DCHP group ($r = .39$, $p < .0001$), however, it was higher for the DCDP compared with the DCHP.

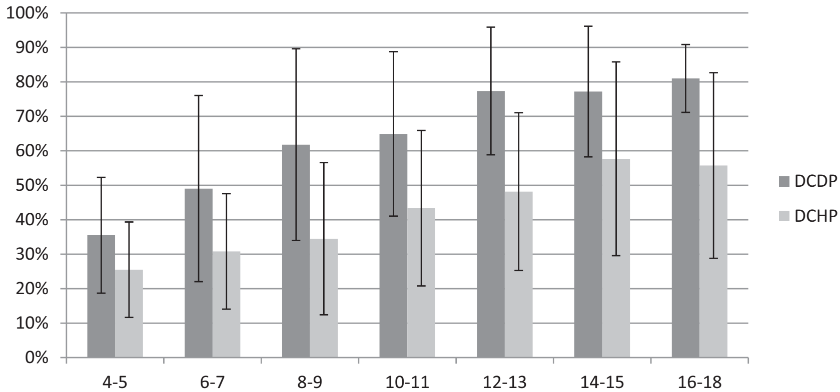

Figure 2 Average correct performance (%) as a function of age and parental hearing status.

Hypothesis 2: The DCDP Group Will Outperform the DCHP on the Antonym Task

From ages 6–7 and up, the DCDP group performed significantly better than the DCHP group. As the target comparison here was the two parental status groups in each age, a *t* test with a Bonferroni correction for multiple comparisons was used, with seven comparisons, for $p < .01 =$ **, $p < 0.01/7 < .0014$ and for $p < .05 =$ *, $p < 0.05/7 < .007$. The DCHP group performed at chance level at the ages of 4–5 and the DCDP group performed above chance level at this age with no significant difference between the two groups, $t(36) = 2.01$, $p = .052$, compared with $p < .007$. At all the following ages the DCDP groups performed significantly better than the DCHP groups with large effect sizes for all age groups (Table 2).

Hypothesis 3: Age and ASL Performance Will Predict Reading Comprehension

The third hypothesis was confirmed. Age and ASL performance correlated with reading scores and both explained unique variance of the reading comprehension scores. Correlation was calculated between age and reading scores for both DCDP and DCHP groups. As can be seen in Figure 3, Spearman *r* correlation between age and reading scores was higher for the DCDP group compared to that of the DCHP group ($r = .67$; $r = .37$, $p < .0001$, respectively). Figure 3 illustrates the reason for this: in the DCHP group, the reading scores are highly variable and do not cluster as tightly around the trend line as is the case for the DCDP group.

Table 2 Comparison of average percentage correct on the antonym task between the two parental hearing status groups for each age group

Age	N	DCDP	DCHP	t-test	Effect size
6–7	61	49%	31%	$t(84) = 3.79^{**}$	.80
8–9	55	62%	34%	$t(75) = 4.54^{**}$	1.12
10–11	63	65%	43%	$t(71) = 2.79^{*}$	.95
12–13	84	77%	48%	$t(99) = 4.94^{**}$	1.40
14–15	66	77%	58%	$t(86) = 3.03^{**}$	.79
16–18	91	81%	56%	$t(99) = 2.93^{*}$	1.23

Note. $^{*}p < .05$, $^{**}p < .01$. Effect size measured by Cohen's d. According to Cohen (1988), an effect size of 0.2 is a small effect, an effect size of 0.5 is a medium effect, and an effect size of 0.8 is a large effect. DCDP = Deaf Children of Deaf Parents; DCHP = Deaf Children of Hearing Parents.

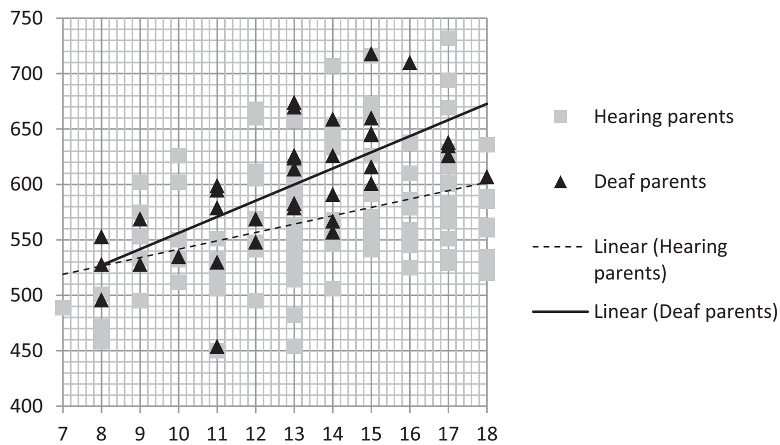

Figure 3 Correlation between age (years) and reading scores (SAT-RC).

In addition, Spearman r correlation between performance on the antonym task and reading scores was significant for both DCDP and DCHP groups (r = .65; r = .55, $p < .0001$, respectively).

We further compared the four possible mediators of reading performance: age, performance on the antonym task, parental hearing status, and gender. Stepwise regression analysis indicated that, while ASL knowledge, as represented by scores on the antonyms task, explained unique variance in reading comprehension scores, parental hearing status was not significant (Table 3). In

Table 3 Antonym, age, parental hearing status, and gender as predictors of reading scores

	Zero-order correlation		Multiple regression			
	r	*p*	*b*	*β*	R^2	*p*
Antonym	.60	< .000	1.21	.54	.35	< .000
Age	.41	< .000	6.64	.37	.10	< .000
Parents	.22	= .01	Parental status excluded during multiple regression			
Gender	.11	= .18	Gender excluded during multiple regression			

Note. Antonym refers to score on the Antonym test; Parents is a binary variable corresponding to parental hearing status. Sample size was 122 deaf children with deaf parents; 422 deaf children with hearing parents.

addition, ASL explained more of the variance of the reading comprehension ($R^2 = .35$) than did age ($R^2 = .10$) (Table 3).

Discussion

We investigated how knowledge of antonyms develops across the school years and whether knowledge of antonyms in an L1 (ASL) predicts reading comprehension proficiency in an L2 (English), as is the case for spoken languages.

The Development of Antonym Knowledge

With increasing age deaf children perform better on ASL antonyms, with even the youngest signers performing at above-chance levels on our sign-to-sign task, which is consistent with findings from spoken languages indicating understanding of antonymous relationships at an early age before the beginning of elementary school (Doherty & Perner, 1998). This refutes the claim of prior researchers that deaf children are delayed in antonym development compared to hearing children (Monreal & Hernandez, 2005; Moeller et al., 1986). Rather, the current results suggest that age-appropriate language development is important to antonym development and that studies finding deaf children to be delayed in this vocabulary domain likely included deaf children with delayed language. The current results indicate that acquiring antonyms has a similar developmental path regardless of the language modality.

The second characteristic of ASL development relates to the importance of the amount of input at an early age. In the current study, DCDP outperformed DCHP at most ages, including the oldest age group. This result extends prior findings that showed delayed acquisition of ASL of DCHP as a group compared to DCDP as a group (Hermans et al., 2009; Mayer & Leigh, 2010; Novogrodsky et al., 2014).[5] Luckner and Cooke (2010) explain the differences in vocabulary size among young children as a result of the quantity and quality of language input to which they have been exposed during the first few years of life. What is noteworthy in the current findings is documenting that the gap persists into the beginning of adulthood, namely, ages 16–18 in our sample.

In spoken languages, antonyms are acquired before synonyms (Charles, Reed, & Derryberry, 1994; Doherty & Perner, 1998), suggesting that the relationship of words with opposite meanings is easier to understand than that of words with similar meanings. To determine if this is true for signers of ASL, the current results were compared with Novogrodsky et al.'s (2014) study of synonym knowledge, which was also an ASL sign-to-sign matching task. At elementary school ages, the native signers (DCDP) performed better on the antonym task than on the synonym task (36% versus 18% at ages 4–5; 49% versus 37% at ages 6–7; 62% versus 54% at ages 8–9). This is what is predicted by the principle of lexical contrast (Clark, 1978), which states that learners are motivated to learn new words that differ in meaning from known words, meaning that synonyms are relatively difficult to acquire.

Language and Reading Comprehension

The finding of a relationship between vocabulary knowledge and reading comprehension confirms prior findings with deaf readers (Fish et al., 2005; Hermans et al., 2008; Hermans et al., 2010; Mayberry et al., 2011; Strong & Prinz, 1997). The importance of vocabulary knowledge in an L1 for reading comprehension in an L2 has been emphasized by Proctor et al. (2006). They showed that, controlling for L2-English abilities, the effects of vocabulary knowledge in L1 Spanish was stronger on English reading ability relative to the other L1 variables of alphabetic knowledge, fluency, and listening comprehension. The current results are in line with Proctor et al. (2006) in showing that vocabulary size in a sign language relates to reading comprehension in an L2. This adds evidence to the puzzle of bilingualism and how L1 abilities influence reading in L2: The L1 vocabulary effects on L2 reading comprehension are supramodal.

In the current study, language was measured with just one vocabulary test. It would be useful to evaluate the relationship between different aspects of an L1 like ASL and reading comprehension of English. We suggest comparing various measures of vocabulary, syntax, morphology, and phonology. Comparing these components would add another profitable step in understanding the relations between signed languages and reading comprehension.

Although the current study did not test the effect of the spoken language on reading, it is important to understand how this ability relates to reading comprehension in the case of deaf readers who sign. Even when sign language is the dominant communication modality, there are cases where deaf signers use oral language to some degree. Vermeulen, van Bon, Schreuder, Knoors, and Snik (2007) tested the reading comprehension and visual word recognition skills of 50 deaf children who had been using a cochlear implant (CI) for at least 3 years. The visual word recognition score included scores of two lexical decision tasks based on silent reading. The first task included a list of words and pseudowords and the participant had to cross out as many pseudowords as possible in 1 minute. The second task consisted of pairs containing a word and a pseudoword and the participants had to mark one item as nonexisting.[6] The CI learners were compared to deaf children without a CI and to hearing children. While the reading comprehension performance of the CI group was significantly better than that of the no-CI group, word recognition scores did not explain the improved reading of the CI group. The authors explained the difference in reading comprehension skills between the deaf children with and without CIs as due to the auditory access to spoken language of the CI group. They mention the contribution of receptive vocabulary knowledge as an important factor in the causal chain. Interestingly, 74% (37/50) of the participants came from schools for the deaf in the Netherlands. These data suggest another possible factor as an intermediary of reading comprehension, that is, Sign Language of the Netherlands (SLN). The contribution of SLN to reading comprehension was not tested in the Vermeulen et al. (2007) study and is thus a hidden factor in that study. Our results suggest that sign language proficiency of the participants in the Vermeulen et al. study might have explained part of the variance of the reading achievement. This assumption is supported by findings that present benefit from bimodal input (signed and spoken) for deaf children (Giezen, 2011; Knoors & Marschark, 2012). The nature of the relationships among L1 (a sign language), L2 (a spoken language), and reading comprehension requires additional study.

Language and Parental Hearing Status as Predictors of Reading Comprehension

Our findings showed a higher correlation between age and reading scores in the DCDP group compared to the DCHP group. This result suggests that, when exposure to the L1 is consistent in quantity and quality, as in the case of DCDP, age is a better predictor for reading scores than in the case of the DCHP group, presumably because of the more variable learning histories of the DCHP.[7] However, in the correlation between age and reading comprehension one important factor is missing in the equation, namely the language proficiency of each child. When language ability, as measured by antonym test scores, was included in the equation, regression analysis showed no effect for parental hearing status. Strong and Prinz (1997) found that deaf students with deaf mothers outperformed their deaf peers with hearing parents in reading tests. However, in their study, when levels of ASL ability were equivalent across parental hearing status groups, there were no differences in reading ability. Chamberlain and Mayberry (2008) argued that “skilled [signing] deaf readers are proficient sign language comprehenders” (p. 383). The current results support this position and confirm that, for deaf readers, proficiency in reading comprehension does not depend on parental hearing status, but rather on solid and deep L1 proficiency. Similarly to spoken languages, language is the key for reading comprehension achievement.

Language and Age as Predictors of Reading Comprehension

For typically developing children, age is a strong predictor of reading ability because language ability develops with age, and language is crucial for reading. In deaf children, language ability is not as tightly linked to age because deaf children often experience language delays (Vermeulen et al., 2007; Wauters, Van Bon, & Tellings, 2006). This delay is particularly common for DCHP. Our study established that language remains a good predictor of reading ability in deaf children, even when age is not (as can be seen in Figure 3 for DCHP). These results add to the literature demonstrating that language ability is important for reading ability, even when the modality is different, as in the case of deaf children acquiring ASL as the L1 and English as the L2. An implication of this variability is that some deaf children have reading delays because of language delays (Marschark, Lang, & Albertini, 2002), not because of deafness per se. The current results suggest that intervention strategies for improving reading comprehension should include enhancement of the L1 (the sign language) in addition to the L2.

Conclusion

The acquisition of antonym knowledge in a sign language contributes to the literature on the development of vocabulary knowledge across languages. The developmental language path of antonyms and its relationship to reading comprehension holds for signed languages as well as spoken. The importance of a strong L1 for deaf children is true not only for communication but also as a necessary foundation for reading ability and hence for academic achievement in the L2.

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Notes

1 For example, negated antonyms: "That's not making it clean, that's making it dirty," versus coordinated antonyms: "They're winter shoes that you can wear outside or inside."

2 For example: lexical decision of words and pseudo words (Miller et al., 2012; Mayberry et al., 2011), picture matching of words that match on the level of phoneme and rhyme, word recall of rhyming versus non-rhyming words, manipulating sounds and blending syllables (Mayberry et al., 2011).

3 It is important to note that signs do not prevent auditory speech perception (and related phonological abilities) when this modality is available for deaf readers as in

the case of children who successfully use cochlear implants or hearing aids. For these children, the contrary has been shown, that they can benefit from bimodal input (Giezen, 2011; Knoors & Marschark, 2012).

4 Following convention, all English glosses of ASL signs are written in capital letters.

5 Recent results show this pattern also in the spoken modality: DCDP receiving cochlear implants outperformed DCHP on all measures of spoken Persian, including perception and sentence imitation, suggesting that early L1 in the manual modality supports later L2 skills in the spoken modality (Hassanzadeh, 2012).

6 The second task excludes the possibility of children underestimating their word knowledge or children who are fast and might accept pseudowords, because in this task for every pair the child had to mark one item as non-existing.

7 It is important to note that the current study sample is not a cross sectional sample of deaf children across the US but rather a unique group of children who are exposed to ASL. The relationship between the language of oral deaf students and reading comprehension is a different question that does not involve the L1-L2 relationship.

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