Empirical Article

The Relationship Between the Reading and Signing Skills of Deaf Children in Bilingual Education Programs

Daan Hermans  
Pontem, Nijmegen, The Netherlands

Harry Knoors  
Viataal, Sint Michielsgestel, The Netherlands
and Radboud University Nijmegen, Behavioral Science Institute, The Netherlands

Ellen Ormel  
Radboud University Nijmegen, Behavioral Science Institute, The Netherlands and Pontem, Nijmegen, The Netherlands

Ludo Verhoeven  
Radboud University Nijmegen, Behavioral Science Institute, The Netherlands

This paper reports on one experiment in which we investigated the relationship between reading and signing skills. We administered a vocabulary task and a story comprehension task in Sign Language of the Netherlands and in written Dutch to a group of 87 deaf children from bilingual education programs. We found a strong and positive correlation between the scores obtained in the sign vocabulary task and the reading vocabulary task when age, short-term memory scores, and nonverbal intelligence scores were controlled for. In addition, a correlation was observed between the scores in the story comprehension tasks in Sign Language of the Netherlands and written Dutch but only when vocabulary scores for words and signs were not taken into account. The results are briefly discussed with reference to a model we recently proposed to describe lexical development for deaf children in bilingual education programs (Hermans, D., Knoors, H., Ormel, E., & Verhoeven, L., 2008). In addition, the implications of the results of the present study for previous studies on the relationship between reading and signing skills are discussed.

Learning to read is vital for individuals to participate in society, even more so when those individuals are deaf. But, as pointed out by Marschark and Harris (1996), the deaf child who graduates from high school reads, on average, at the same level as an 8- to 9-year-old hearing child (Allen, 1986; Conrad, 1979; Karchmer & Mitchell, 2003). Wauters, van Bon, and Tellings (2006) reported very similar results in a reading comprehension study, with 464 deaf children from primary and secondary education schools in the Netherlands.

Many studies have investigated why learning to read is so problematic for deaf children. These studies have revealed that deaf readers have difficulties with many subskills that are required for reading. Paul (2003) notes that deaf children have problems with text-based skills like word identification (see also Harris & Beech, 1998; Merrills, Underwood, & Wood, 1994; Wauters et al., 2006), vocabulary (Kelly, 1996; Marschark, 1993; Marschark, Lang, & Albertini, 2002; Paul, 1996, 1998), and morpho-syntax (Berent, 1996; Kelly, 1996; King & Quigley, 1985) and with reader-based skills like working memory (Lichtenstein, 1998, Marschark & Mayer, 1998, but see Boutla, Supalla, Newport, & Bavelier, 2004), metacognition (Kelly & Mousley, 2001), and prior knowledge (Jackson, Paul, & Smith, 1997). Although most of these studies have shown weaknesses of deaf children in many skills that are required for reading, the interplay and the causal relations between these skills have not yet been revealed (but see Kelly, 1996).

In the mid-1990s, bilingual–bicultural programs were developed and implemented in special schools (Israelite, Ewoldt, & Hoffmeister, 1992; Knoors, 2007; Mason & Ewoldt, 1996). One of the motivations for the development of these programs was the observation that deaf children of deaf parents outperform...
deaf children of hearing parents in academic achievement and reading skills (Kusche, Greenberg, & Garfield, 1983; Meadow, 1968; Strong & Prinz, 1997, 2000; Stuckless & Birch, 1966). That observation has triggered a claim of bilingual–bicultural programs regarding the role of sign language in the acquisition of literacy by deaf children. Proponents of bilingual–bicultural programs have argued that, if a sign language is well established as a first language (L1), the acquisition of L2 English literacy can be achieved without the involvement of English in its primary form (Israelite et al., 1992; Mason & Ewoldt, 1996). As a scientific underpinning, they referred to the “Linguistic Interdependence” model proposed by Cummins (1981) that postulates the existence of a common proficiency underlying all languages. Cummins has argued that skills acquired in a first language can transfer to a second language. Likewise, proponents of bilingual–bicultural programs have argued that there is a commonality in reading and signing skills and that skills acquired through learning a sign language can facilitate the acquisition of reading skills (Israelite et al., 1992; Rodda, Cumming, & Fewer, 1993).

However, Mayer and Wells (1996) and Mayer and Akamatsu (1999) provided several arguments against the view that Cummins’ Linguistic Interdependence theory can be used as a justification for the bilingual–bicultural approach to reading acquisition. They showed that too many assumptions that have to be fulfilled before transfer is possible according to the Linguistic Interdependence theory are not met in the reading acquisition situation of deaf children. They conclude that American Sign Language (ASL) and English should be considered from the perspective that both may play different roles in the literacy development of deaf children. Cummins (2006), in turn, has argued that the Linguistic Interdependence theory does allow for transfer of conceptual knowledge, metalinguistic strategies, and specific linguistic elements like initialized signs and finger spelling.

The empirical data, quite interestingly, do show that there is a strong and positive relationship between signing and reading skills (Chamberlain & Mayberry, 2000; Hoffmeister, 2000; Mann, 2006; Padden & Ramsey, 2000; Parisot, Dubuisson, Lelievre, Vercaingne-Menard, & Villeneuve, 2005; Prinz, 2002; Strong & Prinz, 1997, 2000). For instance, Strong and Prinz studied the relationship between the signing skills and the reading skills of a group of 155 deaf children between 8 and 15 years old. They found a strong correlation between signing skills and reading skills, even after age and nonverbal intelligence were partialled out. In general, deaf children with good signing skills were also the better readers. Although a strong correlation between reading and signing skills was observed in several different studies, one important question still remains unanswered: What is the locus of the relationship observed in these studies?

One possibility is that the locus of the relationship is the lexical level. We recently proposed a developmental model of reading vocabulary learning for deaf children in bilingual education programs (Hermans, Knoors, Ormel, & Verhoeven, 2008). The model is depicted in Figure 1. The model assumes that many written words deaf children learn go through three different stages before they eventually contain the appropriate semantic, syntactic, morphological, and orthographic specifications. Here, we will focus only on the first stage of lexical development, the word association stage. The model assumes that children will initially understand the meaning of new written words within the preexisting language and conceptual systems. For deaf children who are dominant in sign language, this implies that they will understand the meaning of written words within the preexisting sign language system. Thus, deaf children initially remember written words by creating associations between written words and their translation equivalents in sign language. If deaf children indeed automatically understand the meaning of written words within the preexisting sign language system, this implies that they will understand the meaning of written words within the preexisting sign language system. Thus, deaf children initially remember written words by creating associations between written words and their translation equivalents in sign language. If deaf children indeed automatically understand the meaning of written words within the preexisting language and conceptual systems, lexical knowledge in sign language will have an impact on reading vocabulary learning. For instance, the quantity of acquired signs will to some extent determine how successful deaf children are in learning new reading vocabulary. In other words, it is indeed quite possible that reading and signing skills are related at the lexical level.

Another possibility is that reading and signing skills are related at higher levels of processing. Chamberlain (2001) administered a story comprehension task in ASL and in written English to 35 adults.
Approximately half the adults performed at a near-native level on the ASL story comprehension task. Chamberlain found that most of the adults with a high level of proficiency in ASL read at 8th grade level or above. In contrast, most of the adults who had a low level of proficiency in ASL read at 4th grade level or below. In other words, the relationship between ASL and reading skills may also be localized at the level of text structure.

The aim of the present study was to look more closely at the relationship between reading skills and signing skills. One of our aims was to determine whether there is a relationship between vocabulary scores in Sign Language of the Netherlands (SLN) and in written Dutch. For that purpose, we administered a sign vocabulary task and a reading vocabulary task to a group of deaf children in bilingual education programs. In addition, we investigated whether there is a relationship between story comprehension skills in SLN and in written Dutch. For that purpose, story comprehension tasks in SLN and written Dutch were administered. Finally, we investigated how background variables like parental hearing status (PHS) and language preference (LP) affect the performance of children on the vocabulary and story comprehension tasks in SLN and in written Dutch.
Experiment

Method

Participants. Eighty-seven deaf children, 50 boys and 37 girls, from five special schools for deaf children in the Netherlands participated in the present study. All children had a hearing loss more than 80 dB on the best ear (unaided), had normal nonverbal intelligence, and did not have additional known handicaps. All children were diagnosed with deafness before the 3 years of age. Ten children had one or two deaf parents, and 24 children had a cochlear implant. Most of the classroom teachers were hearing. They used SLN or Sign-Supported Dutch (SSD) as the language of instruction in the classroom. Although there are differences between the bilingual education programs across the different schools in the Netherlands, all of the children received language instruction in SLN for a couple of hours a week. These lessons were given by a (deaf) specialized SLN teacher. Most of the SLN teachers had specific expertise (i.e., had a Bachelor of Education degree) in teaching SLN as a language to deaf children. In the Netherlands, many deaf children enroll in a specialized preschool program from the age of 2 or 3. Most of the deaf children who participated in the experiment started in (pre-) kindergarten. The mean age of the deaf children during test administration was 10;11 (minimum = 8;6, maximum = 12;11).

All of the children in the present study had a minimum of 4 years of experience in SLN. The teachers were asked to fill in a language questionnaire for each of their pupils. Teachers were asked to indicate whether a child preferred SLN, SSD, spoken Dutch, or another language in the communication with teachers and deaf children. According to their teachers, most children (n = 47) preferred to use exclusively SLN in the communication with teachers and deaf children, whereas 25 children preferred SSD. The remaining 15 children preferred a combination of SLN and Dutch (n = 1), SLN and SSD (n = 11), or SSD and Dutch (n = 3). Note that such estimation of LP does not imply that deaf children are dominant in that particular language; it presumably also reflects different factors, like the language proficiency of their teachers, classmates, friends, and parents. Teachers also answered questions about the language use at home. They indicated that a wide variety of language combinations were used for the 87 deaf children who participated in this study. In 16 families, SLN was exclusively used in the communication between parents, siblings, and the deaf child, and in 22 families, only SSD was used. In 15 families, spoken Dutch was the language that was used predominantly. In the remaining 33 families, a combination of SLN, other sign languages, SSD, spoken Dutch, and other spoken languages were used. In one family, the language use at home was unknown. Finally, teachers filled in 12 questions about the language proficiency of their pupils in spoken Dutch. They estimated the receptive and expressive spoken language skills of the children on various linguistic levels (phonology, vocabulary, morphology, syntax, and story comprehension) on a five-point scale.1

Materials

Reading skills. Reading skills were measured using two tests, a reading vocabulary test and a written story comprehension test. These tests were taken from the Taaltest Alle Kinderen (TAK-R), a test battery for the assessment of Dutch spoken language skills of hearing children developed by Verhoeven and Vermeer (2001) and adjusted to a written format. The psychometric properties were only available for the original spoken test. In the vocabulary test, children saw a written word and four pictures on a computer screen. They were instructed to select the picture that matched the written word in meaning. The vocabulary task consisted of 96 items.

In the story comprehension task, children read six written stories, one at a time. The stories in the reading comprehension task were of increasing complexity. After children had read the stories, they were asked to answer four questions about the story. The questions were also presented on the computer screen. Most of the questions were open questions. The children were free to choose the modality in which they responded. Most of the children responded to the questions in SLN. They received one point for each of the 24 questions they answered correctly. Test scores were not corrected for guessing. Some of these questions
referred to information literally mentioned in the stories. Other questions were either the so-called gap-filling or text-connecting questions (Cain & Oakhill, 1999).

**Sign language skills.** Two sign language tests were administered: a receptive vocabulary test and a story comprehension test. The tests were developed and administered as part of the development of an assessment instrument for SLN (Hermans, Knoors, & Verhoeven, 2008). In the vocabulary test, children saw a sign on a computer screen that was followed by four pictures. Children were instructed to select the picture that matched the sign in meaning. The vocabulary task consisted of 61 items. In the story comprehension task, children saw five stories in SLN, one at a time. The stories were of increasing complexity. After each of these stories, children had to answer four questions about the story. These questions were also presented on a computer screen. The children were instructed to answer the questions in SLN. Most of the questions were open questions. They received one point for each of the 20 questions they answered correctly. Again, test scores were not corrected for guessing. Like in the story comprehension task in SLN, some of the questions referred to information literally in the stories. Other questions were gap-filling or text-connecting questions.

In a 3-year longitudinal norming study, the sign vocabulary and story comprehension task were administered to a group of 330 deaf children between 4 and 12 years old from bilingual education programs. To assess the reliability of the sign language tests, Cronbach’s alpha coefficients were computed for each age-group. The alpha coefficient for the different age-groups varied between .95 and .97 (average .96) for the sign vocabulary task and between .86 and .91 (average .88) for the story comprehension task.

We were quite limited in the possibilities to assess the validity of the SLN tests given that there are currently no other SLN tests available for deaf children in primary education. However, it was possible to determine to what extent theoretically known relationships between characteristics of children and language acquisition were present in our longitudinal data. We decided to look at the effects of three variables that are known to affect (sign) language acquisition: “age,” “gender,” and “parental hearing status.” We found that “age” correlated significantly with the scores on the sign vocabulary ($r = .72, p < .001$) and SLN story comprehension task ($r = .76, p < .001$). In addition, we found that girls outperformed boys on both tasks. Finally, deaf children of deaf parents outperformed deaf children of hearing parents. The observation of reliable effects for each of these three variables adds to the validity of the tests, in our view, although it is clear that a more extensive investigation of the psychometric properties of the instrument is eventually required.

The iconicity of signs (and the grammar of sign languages) has been found to complicate the construction of sign language assessment instruments in general and the development of sign vocabulary tests in particular (Jansma, Knoors, & Baker, 1997; Tolar, Lederberg, Gokhale, & Tomasello, 2008). The main threat in sign vocabulary tasks is that children can correctly guess the meaning of unknown signs on the basis of their phonological properties. When constructing the materials for the sign vocabulary task, we employed two basic strategies to reduce the effects of iconicity. First, for many of the 61 items used in the vocabulary task, the form of the sign resembled the form of the objects depicted by some of the foil pictures (the pictures that did not match the meaning of the sign). Second, the correct pictures were drawn from such a perspective that the form of the sign resembled the form of the object(s) in the picture as little as possible. To investigate to what extent iconicity still constituted a real threat, the vocabulary task was administered to a group of 30 hearing children (from 5th to 7th grade), with no proficiency in SLN. The mean percentage of correct responses was 36%. Although these hearing children still scored significantly above chance (25%), the average scores are relatively low in comparison to the scores of hearing children that have been reported in the literature (73% reported by White & Tischler, 1999, and 61%–72% reported by Jansma et al., 1997).

**Short-term memory capacity.** We also administered a short-term memory (STM) task for signs and for written words. Gathercole (1999) has pointed out there is an intimate and well-established relationship between STM capacity and vocabulary learning (but
As STM capacity may be a cognitive skill that underlies vocabulary skills in both languages, it should be controlled for when the correlation between the vocabulary scores is investigated. The STM-span task for signs comprised a maximum of 18 items. We presented children with 18 sequences of increasing length (2, 3, 4, 5, 6, or 7 signs). There were three test items at each of the six sequence lengths. A total of 42 signs were selected for the STM-span task. The 42 signs were all very common signs, and we assumed the children had acquired these signs. On each occasion, deaf children saw a series of signs on a computer screen, with a pause of 500 ms between every sign. They were instructed to repeat the signs in the same order. If children failed to respond correctly on three successive occasions, test administration was terminated. The STM-span task for written words also comprised a maximum of 18 items. The same 42 words were used for the written STM-span task (though never in the same order). We presented deaf children with 18 sequences of increasing length (2, 3, 4, 5, 6, or 7 words). Again, there were three test items at each of the six sequence lengths. In this task, a series of words was presented on a computer screen (see Figure 2a). After 5 s, the words disappeared from the screen and appeared in a different order below the original words (Figure 2b). Children were instructed to put the words back to their original places using the computer mouse. We chose this response format for the STM task for written words in order to prevent problems that may occur with a verbal written response. When children failed to respond correctly on three successive items, test administration was automatically terminated.

**RAVEN-CPM.** The RAVEN-CPM was administered as an index for the abstract reasoning skills, or nonverbal intelligence, of the children. The RAVEN-CPM consists of 36 items.

**Procedure**

Children were tested individually. All tests were administered by a group of 19 third- and fourth-year students who were trained to become sign language interpreters or sign language teachers. Children were instructed in SLN. The children were tested in two or three sessions that lasted between 20 and 40 min.

**Results**

**Data Analysis**

In the analyses of the data, we assumed that (i) skills in the stronger language (the sign language) affect skills in the weaker language (the written language), (ii) low-order skills (vocabulary skills) affect high-order skills (story comprehension skills), and (iii) STM skills affect vocabulary skills (see also Figure 3). These assumptions have implications for our data analysis. When we compute the relationship between sign and word vocabulary scores, this relationship will be corrected for the STM scores for words and signs. Similarly, to study the strength of the relationship between story comprehension skills in SLN and in written Dutch, this relationship will be corrected for the sign and reading vocabulary scores. Note that this procedure will result in relatively conservative estimations of the strength of the relationships. We will return to these assumptions in the general discussion.

![Figure 2](image-url)  
**Figure 2** Item presentation (2a, left) and response screen (2b, right) in the short-term memory task for words.
The relationship between sign vocabulary and reading vocabulary. Figure 3 shows a schematic representation of some of the results we observed in this experiment. Appendix A gives a more extensive overview of the results of the correlational analyses of the present study. As shown in Figure 3, the correlation between the STM-span test for signs and the sign vocabulary test was .42 ($p < .01$), whereas the correlation between STM span for words and word vocabulary test was .46 ($p < .01$). Next, the partial correlation between the scores obtained in the written and the sign vocabulary task was examined. This analysis showed that the correlation was .40 ($p < .01$), after age (in months), RAVEN-CPM scores, and STM-span scores for words and signs were partialled out.

Table 1 lists the results as a function of the hearing status of the parents and the language preference (LP) of the children. Analyses of variance were conducted on the scores in the two vocabulary tasks, the STM tasks for signs and words and the RAVEN-CPM with PHS as between-subject factor and Age in months as a covariate. These analyses revealed main effects of PHS in the sign vocabulary task ($F_1 (1, 87) = 9.51, p < .01$) and the reading vocabulary task ($F_1 (1, 87) = 5.90, p < .05$). Deaf children of deaf parents scored significantly higher on both vocabulary tasks than deaf children with hearing parents. Finally, the main effect of PHS did not reach significance in the STM-S task ($F_1 (1, 87) < 1$), the STM-W task ($F_1 (1, 87) < 1$), and the RAVEN-CPM task ($F_1 (1, 87) < 1$).

Analyses of variance were conducted on the scores obtained in different tasks, with LP as between-subject factor and Age in months as a covariate. The main effect of LP was significant in the sign vocabulary task ($F_1 (1, 87) = 8.26, p < .01$). Deaf children who preferred exclusively SLN scored significantly higher than deaf children who did not exclusively prefer SLN. No differences were found in the reading vocabulary task ($F_1 (1, 87) < 1$), the STM-S task ($F_1 (1, 87) = 1.79, p > .1$), the STM-W task ($F_1 (1, 87) < 1$), and the RAVEN-CPM task ($F_1 (1, 87) = 1.39, p > .1$).

Table 1 also lists the results for the nine children who performed above the 90th percentile in the reading vocabulary task in the present study in comparison to the 78 other children. The nine children who performed above the 90th percentile in the reading vocabulary task also scored significantly higher on the sign vocabulary task ($F_1 (1, 87) = 5.91, p < .01$) and the STM-S task ($F_1 (1, 87) = 6.16, p < .01$) but not on the STM-W task ($F_1 (1, 87) = 2.27, p > .01$) and the RAVEN-CPM task ($F_1 (1, 87) < 1$).

The relationship between story comprehension in SLN and written Dutch. We first computed the correlation between the vocabulary scores and the story comprehension scores in SLN and written Dutch, with age (in months) and RAVEN-CPM scores partialled out. The correlation between vocabulary scores and story comprehension scores was .58 ($p < .01$) for SLN and .75 ($p < .01$) for written Dutch (see Figure 3). Next, the correlation between the comprehension scores for written and signed stories was computed. The observed correlation was significant ($r = .51, p < .01$) with age (in months) and RAVEN-CPM scores partialled out, but failed to reach significance when age (in months), RAVEN-CPM scores, and the vocabulary scores for signs and words were partialled out ($r = -.01, p > .1$).
Table 1 lists the results as a function of the hearing status of the parents and the LP of the children. Analyses of variance were conducted on the scores for story comprehension in SLN and written Dutch, with PHS as between-subject factor and Age in months as a covariate. These revealed main effects of PHS for story comprehension in SLN ($F_{11, 87} = 9.76$, $p < .01$) and in written Dutch ($F_{11, 87} = 5.83$, $p < .05$). Deaf children of deaf parents scored significantly higher on both story comprehension tasks compared to deaf children with hearing parents.

Analyses of variance were conducted on the scores for story comprehension in SLN and written Dutch with LP as between-subject factor and Age in months as a covariate. The main effect of LP was significant for story comprehension in SLN ($F_{11, 87} = 6.31$, $p < .05$) but not in written Dutch ($F_{11, 87} < 1$). Deaf children who preferred exclusively SLN scored significantly higher on the story comprehension task in SLN than deaf children who did not exclusively prefer SLN.

Table 1 also lists the results for the 10 children who performed above the 90th percentile in the reading comprehension task in the present study in comparison to the other 77 children. The 10 children who performed above the 90th percentile on the written story comprehension task also scored significantly higher on for the story comprehension task in SLN ($F_{11, 87} = 4.58$, $p < .05$).

Discussion

In this experiment, the relationship between vocabulary and story comprehension skills in SLN and written Dutch was investigated. This experiment yielded several interesting results. First, vocabulary scores for SLN and written Dutch were positively correlated when age, nonverbal intelligence, and STM scores for signs and written words were partialled out. In other words, children with large vocabularies in sign language facilitate the acquisition of reading vocabulary, and not vice versa, this finding then suggests that good vocabulary skills facilitate the acquisition of reading vocabulary.

As we pointed out in the introduction, we recently proposed a model of reading vocabulary learning of
deaf children in bilingual education programs. The model assumes that deaf children interpret the meaning of new reading vocabulary within the existing language and conceptual systems. For deaf children from bilingual education programs who are dominant in sign language, this implies that they will create associations between known signs and unknown reading vocabulary. The results of the present study are consistent with this assumption, but they also raise the question on how children can create these associations. As pointed out by Padden and Ramsey (2000), the relation between signs and written words is arbitrary and needs to be cultivated in reading instructional practices. Padden and Ramsey observed that teachers explicitly linked written words, finger spelling, and signs together to teach children new reading vocabulary. These techniques, referred to as chaining by Padden and Ramsey, are also used by teachers of deaf children in bilingual education programs in the Netherlands. An interesting prediction would then be that the intensity and the quality of sign-based reading vocabulary instructional techniques, like chaining, also determine how successful children are in learning new reading vocabulary. In other words, the present results call upon investigations of the intensity and quality of sign-based reading techniques in reading instructional practices. Such studies are still scarce (but see Padden & Ramsey, 2000), but they are very likely to contribute tremendously to our understanding of deaf children’s acquisition of reading.

We also investigated the relationship between story comprehension skills in SLN and in written Dutch. Analyses revealed that vocabulary scores were strongly correlated with story comprehension scores in SLN and in written Dutch. Story comprehension tasks are generally used to measure skills at the level of text structure only, like the ability to make gap-filling inferences. It is therefore required that vocabulary skills will not strongly affect scores in the story comprehension task. In other words, the vocabulary used in story comprehension tasks must be known and easily accessible to the children. The results suggest that these requirements were not in the present study: vocabulary scores were strongly correlated to story comprehension scores. This correlation was larger in written Dutch ($r = .75$) than in SLN ($r = .58$). Note that the standard deviations were higher in the reading vocabulary task compared to the sign vocabulary task. In other words, the differences in vocabulary among the children tested in the present study were higher in written Dutch than in SLN. As a consequence, reading vocabulary scores will presumably have had a stronger impact on story comprehension in written Dutch than in SLN.

The correlation between vocabulary scores and reading comprehension scores in both languages makes it much more difficult to determine the strength of the relationship between story comprehension skills in SLN and written Dutch. The correlation between the story comprehension scores was strong ($r = .51$) when vocabulary scores were not taken into account but disappeared ($r = -.01$) when vocabulary scores in both languages were taken into account. Theoretically, vocabulary scores should be taken into account when it is assumed that vocabulary knowledge affects reading comprehension, but not vice versa. However, it is questionable to what extent this assumption is actually valid. Children in the upper grades of primary education acquire a large proportion of new reading vocabulary during independent reading. Good reading comprehension skills will help readers to comprehend written texts and will help them to infer the meanings of the unknown written words they encounter during reading. Therefore, if vocabulary scores in SLN and written Dutch are partialled out when the relationship between reading comprehension stories in SLN and written Dutch is computed, this partial correlation is presumably an underestimation of the actual relation between the comprehension skills in both languages. In other words, the actual correlation between story comprehension skills in SLN and written Dutch in this study presumably lies somewhere in between the values of $-.01$ and $.51$.

Although the present study does not give a clear answer on the relationship between reading and signing skills at higher levels of processing, it stresses the importance of measuring and controlling reading and sign vocabulary when the relationship between reading and signing skills is investigated at higher levels of processing. This study, therefore, has implications for the interpretation of the results obtained in previous studies on the relationship between sentence/story...
comprehension skills in sign languages and written languages (Chamberlain & Mayberry, 2000; Hoffmeister, 2000; Padden & Ramsey, 2000; Prinz, 2002; Strong & Prinz, 1997, 2000). In none of these studies, sign and reading vocabularies were taken into account. It remains to be seen to what extent reading and signing skills are related at higher levels of processing.

In the present study, we also ran additional analyses to explore the effects of the hearing status of the parents and the LP of the children. The rationale was that deaf children of deaf parents have an earlier and more intensive contact with SLN and, therefore, should score higher on the vocabulary and story comprehension tasks in SLN. Analyses of variance confirmed this prediction. As skills in both languages were positively correlated, deaf children of deaf parents should also have higher scores on the reading vocabulary and the story comprehension tasks in written Dutch than deaf children of hearing parents. Again, our analyses confirmed this prediction.

We also explored the impact of the LP of children on their signing and reading skills. Again, the rationale was that deaf children who exclusively prefer SLN will be more proficient in SLN compared to deaf children who do not exclusively prefer SLN. Analyses confirmed this prediction. However, deaf children who preferred exclusively SLN did not score higher on the vocabulary and story comprehension tasks in written Dutch. Apparently, high scores on the sign language tasks are not necessarily associated with high scores on the written language tasks. One possible explanation for the absence of a difference in the vocabulary and story comprehension tasks in written Dutch is that both groups of children may differ in cognitive abilities that were not taken into account in the present study, like working memory capacity or skills in spoken Dutch. To illustrate, it is indeed possible that children who do not exclusively prefer SLN in the communication with teachers and classmates have better skills in spoken Dutch. Although we did not administer spoken language tests, we did collect the teacher’s ratings of the spoken language skills of the children. They estimated the spoken language skills of their pupils on various linguistic levels (phonology, vocabulary, morphology, syntax, and story comprehension) on a five-point scale. The ratings of the children’s receptive vocabulary and story comprehension skills in spoken Dutch are shown in Table 2.

Table 2  Mean percentages of correct responses in the Sign-V, the Read-V, the teachers’ estimates of the children’s Spo-V, Sign-S, Read-S, and the teachers’ estimates of the children’s Spoken-S as a function of the hearing status of the parents, the language preference of the children, the reading vocabulary status and reading comprehension status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sign-V</th>
<th>Read-V</th>
<th>Spo-V</th>
<th>Sign-S</th>
<th>Read-S</th>
<th>Spoken-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parental hearing status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deaf (n = 10)</td>
<td>74.0</td>
<td>64.5</td>
<td>3.4</td>
<td>93.4</td>
<td>75.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Hearing (n = 79)</td>
<td>60.4</td>
<td>51.0</td>
<td>3.3</td>
<td>76.4</td>
<td>60.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Language preference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLN (n = 47)</td>
<td>67.9</td>
<td>53.3</td>
<td>3.2</td>
<td>83.5</td>
<td>63.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Mixed (n = 40)</td>
<td>54.9</td>
<td>51.7</td>
<td>3.4</td>
<td>72.2</td>
<td>59.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Reading vocabulary status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average (n = 78)</td>
<td>59.9</td>
<td>48.2</td>
<td>3.1</td>
<td>76.5</td>
<td>58.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Good (n = 9)</td>
<td>79.2</td>
<td>90.5</td>
<td>4.9</td>
<td>93.9</td>
<td>94.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Reading comprehension status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average (n = 77)</td>
<td>60.1</td>
<td>49.0</td>
<td>3.2</td>
<td>76.7</td>
<td>57.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Good (n = 10)</td>
<td>76.3</td>
<td>80.2</td>
<td>4.3</td>
<td>91.0</td>
<td>98.3</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Note. Read-S, the story comprehension scores in written Dutch; Read-V, reading vocabulary task; Sign-S, story comprehension scores in SLN; Sign-V, sign vocabulary; Spoken-S, story comprehension skills in spoken Dutch; Spo-V, vocabulary in spoken Dutch.
words, there may indeed be differences in the spoken language skills of children who exclusively prefer SLN and children who do not exclusively prefer SLN in the communication with teachers and classmates. Table 2 also shows that the children who scored above the 90th percentile on the reading vocabulary task also received higher ratings of their vocabularies in spoken Dutch \( (F_1 (1, 87) = 9.40, p < .01) \). Similarly, the children who scored above the 90th percentile in the story comprehension task in written Dutch also received higher ratings of their story comprehension skills in spoken Dutch \( (F_1 (1, 87) = 15.07, p < .01) \). These findings suggest that the children who have good skills in written Dutch have good skills not only in SLN but also in spoken Dutch. Those skills in spoken Dutch may also have facilitated the acquisition of skills in written Dutch. Alternatively, children may have acquired good skills in spoken Dutch as a consequence of having good skills in SLN or in written Dutch. As it stands, it is not without problems to draw any firm conclusions on the relation between language skills in SLN and written Dutch on the basis of the present study. The results, therefore, demonstrate the necessity of assessing deaf children’s spoken language skills when the relationship between reading skills and sign language skills is investigated.

In sum, we studied the relationship between reading and signing skills in a vocabulary task and a story comprehension task. We found a positive correlation between the scores of children in the vocabulary tasks in SLN and written Dutch. On the basis of the present study, it remains unclear whether signing skills and reading skills are related at the higher levels of processing. Although we observed a positive correlation between the scores in the story comprehension tasks in SLN and in written Dutch, this correlation disappeared when vocabulary scores were taken into account. Finally, the results suggest that children’s spoken language skills should also be assessed in studies on the relationship between reading and signing skills.

Notes

1. Some of the classroom teachers of the deaf children were deaf. In those cases, estimations of children’s proficiency in spoken Dutch were made by the speech therapist of the children.

2. However, it is unclear to what extent these requirements can actually be met in any test situation with (hearing and deaf) children.

References


Appendix

<table>
<thead>
<tr>
<th>Task</th>
<th>STM-S</th>
<th>STM-W</th>
<th>Sign-V</th>
<th>Read-V</th>
<th>Signed-S</th>
<th>Written-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>STM-S</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STM-W</td>
<td>.40**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOC-S</td>
<td>.42**</td>
<td>.32**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOC-W</td>
<td>.32**</td>
<td>.46**</td>
<td>.51**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STO-S</td>
<td>.31**</td>
<td>.26**</td>
<td>.58**</td>
<td>.52**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>STO-W</td>
<td>.28*</td>
<td>.42**</td>
<td>.68**</td>
<td>.75**</td>
<td>.51**</td>
<td>1</td>
</tr>
</tbody>
</table>

Mean percentage of correct responses and standard deviations, and correlations between the scores obtained in the short-term memory tasks for signs (STM-S) and words (STM-W), the sign vocabulary task (Sign-V), reading vocabulary task (Read-V), SLN story comprehension task (Signed-S), and the reading comprehension task (Written-S), with age and Raven-CPM scores partialled out.

\( *p < .05, **p < .01 \).


Received March 26, 2007; revisions received January 27, 2008; accepted February 17, 2008.