Modeling Reading Vocabulary Learning in Deaf Children in Bilingual Education Programs

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The acquisition of reading vocabulary is one of the major challenges for deaf children in bilingual education programs. Deaf children have to acquire a written lexicon that can effectively be used in reading. In this paper, we present a developmental model that describes reading vocabulary acquisition of deaf children in bilingual education programs. The model is inspired by Jiang’s model of vocabulary development in a second language (N. Jiang, 2000, 2004a) and the hierarchical model of lexical representation and processing in bilinguals (J. F. Kroll & E. Stewart, 1988). We argue that lexical development in the written language often fossilizes and that many words deaf readers acquire will not reach the final stage of lexical development. We argue that this feature is consistent with many findings reported in the literature. Finally, we discuss the pedagogical implications of the model.

The ultimate goal of language learning in bilinguals is fluent and accurate expression in both languages. In general, bilingual children seem to acquire the two languages with relative ease. There is little evidence that acquiring two languages from birth causes severe language delays in the development in one or even both languages (De Houwer, 2006), with the exception of early vocabulary development (Bialystok, 1988; Doyle, Champagne, & Segalowitz, 1978; Rosenblum & Pinker, 1983). In the end, the majority of bilingually raised children will be able to speak in, read in, write in, and listen to both languages with a native-like proficiency.

For deaf children who are raised with two languages, with one spoken language and one sign language, setting up this bilingual system is much more complicated. First, they have restricted access to the spoken language as a result of their hearing impairment. Deaf children have to acquire spoken languages mainly through the visual channel, for example, through speech reading. Antia and Levine (2001) point out that learning a spoken language tends to be a slow process for deaf children and that this requires exceptional efforts by the child and his or her parents. As a consequence, the spoken language development of deaf children is usually delayed when compared to hearing children (see Blamey, 2003, for an overview). Second, many deaf children have limited sign language input as their parents, family members, and teachers usually do not have fluent signing skills. Hearing parents often start to learn sign language themselves when the deafness of their child has been detected. Spencer and Lederberg (1997) point out that hearing adults are limited in their ability to respond intuitively to deaf children due to their limited signing skills. At early ages, many deaf children of hearing parents will be delayed in the acquisition of sign language (Bornstein, Saulnier, & Hamilton, 1980; Boudreault & Mayberry, 2006; Herman, Woolfe, & Woll, 2006; Hermans, Knoors, & Verhoeven, in preparation; Hoiting, 2005; Mayne, Yoshinago-Itano, Sedey, & Carey, 2000; Moeller, 2000; Spencer, 2004; Spencer & Harris, 2005). In other words, setting up a bilingual system is much more difficult for deaf children. Many of them will not acquire native-like skills in one of the languages.
When deaf children are still in the middle of acquiring both languages, they have to start learning another language skill that is also very difficult for most of them: reading. Reading studies with deaf children have shown, time and again, that deaf children lag far behind their hearing peers (Allen, 1986; Conrad, 1979; Holt, 1994; Karchmer & Mitchell, 2003; Wauters, van Bon, & Tellings, 2006). The reading difficulties that deaf children encounter are most likely related to delays in the acquisition of the spoken language. Reading is a process that is dependent on the language that provides the basis of the writing system, especially during the early stages of acquisition (Perfetti & Sandak, 2000). In these early stages, hearing children learn that written and spoken words consist of smaller elements, letters and sounds (phonological and orthographic awareness), at least for children who learn an alphabetic language. Phonological awareness and orthographic awareness are important prerequisites for mastering the alphabetic principle (Stanovich, 1986), the principle that individual letters map onto individual sounds. Children must be able to decode, independently (without the support of their parents or teachers), the meaning of the many unknown words they are bound to encounter during reading. Mastering the alphabetic principle will turn out to be a very powerful mechanism that enables children to learn reading vocabulary by mapping these new written word forms onto known spoken word forms, especially in regular languages.

Clearly, the effectiveness of this alphabetic principle necessarily depends upon the vocabulary available in the spoken language. Several studies have revealed the relationship between vocabulary and reading proficiency for young hearing children (Dickinson, McCabe, Anastapoulos, Peisner-Feinberg, & Poe, 2003; Snow, Tabor, & Dickinson, 2001). Subsequently, when children have arrived at the stage where they can successfully derive the meaning of words from the context, the alphabetic principle will eventually help them to acquire more spoken language vocabulary. In other words, spelling to sound regularities may not only help children to build up a written word lexicon but eventually the spoken word lexicon as well. In sum, for hearing children, phonological awareness, phonological decoding skills, and spoken language vocabulary are very important predictors of reading development (Adams, 1990; Castles & Coltheart, 2004; Dickinson et al., 2003; Snow et al., 2001). Spoken languages serve as the basis to acquire written languages. In theory, spoken languages are for deaf children also the most optimal platform to learn to read (Perfetti & Sandak, 2000).

However, as stated before, the spoken language development of deaf children is delayed compared to hearing children (Blamey, 2003). Deaf children are not only faced with the task to learn how to read but to learn a new language as well (Hoffmeister, 2000; Marschark & Harris, 1996). For instance, deaf children have smaller spoken language vocabularies than hearing children (Blamey, 2003; Boekel, van Eeten, Overgauw, & Quak, 2006; Geers & Moog, 1989; Moores & Sweet, 1990). Learning new written words often means learning new words in the language. It is then not surprising that the deaf readers who can read very well outperform poor deaf readers on several skills, most interestingly including vocabulary (Harris & Moreno, 2006). Deaf children also need to master the alphabetic principle to learn new written words. However, the hearing loss has a severe impact on their phonological awareness (see for a review, Corcoran-Nielsen & Luetke-Stahlman, 2002) and their phonological decoding skills (Adams, 1990; Miller, 2005; Ormel, Hermans, Knoors, Verhoeven, & Hendriks, in preparation; Transler, Leybaert, & Gombert, 1999). Thus, many deaf children will not master these two important prerequisites for reading vocabulary learning for hearing children: large spoken language vocabularies and good phonological skills. As a consequence, most deaf children will not be able to exploit the natural relations between the spoken and written forms of a language.

The realization that deaf children cannot rely upon their spoken language skills when they start learning to read has now been widely acknowledged. It has also resulted in quite a different approach in bilingual programs toward the education of deaf children in general and toward teaching deaf children to read in particular (Evans, 2004; Israelite, Ewoldt, & Hoffmeister, 1992; Mahshie, 1995; Padden & Ramsey, 2000). Within (many) bilingual education programs, teachers enhance and exploit their pupil’s sign language skills to develop their reading skills. As a scientific
underpinning, proponents of bilingual education models have often referred to the Linguistic Interdependence model proposed by Cummins (1981). This model postulates a common proficiency underlying skills in all languages and that skills acquired in a first language can be used to acquire (transfer to) a second language. Similarly, proponents of bilingual programs have argued that there is a commonality in reading and signing. Therefore, skills acquired through learning sign language can also be used in learning to read (Cummins, 2006; Israelite et al., 1992; Rodda, Cumming, & Fewer, 1993, but see Mayer & Akamatsu, 1999; Mayer & Wells, 1996). For instance, Cummins (2006) has recently proposed that conceptual knowledge, metacognitive and metalinguistic knowledge/strategies, and specific linguistic elements (e.g., fingerspelling and initialized signs) can transfer from a sign language to a spoken language.

The available evidence is consistent with the Linguistic Interdependence theory. The theory predicts that (language) skills that have been acquired through learning a sign language will facilitate the acquisition of reading. In other words, the theory predicts a positive (and causal) relationship between signing and reading skills. In several recent studies, such a positive relationship between signing skills and readings skills has been observed (e.g., Hermans, Knoors, Ormel, & Verhoeven, submitted; Hoffmeister, 2000; Mann, 2006; Niederberger & Frauenfelder, 2005; Padden & Ramsey, 2000; Parisot, Dubuisson, Lelievre, Vercaigne-Menard, & Villeneuve, 2005; Strong & Prinz, 1997, 2000), although spoken language skills were neither measured nor controlled for in these studies. In addition, in none of these studies evidence for a “causal” relationship between signing skills and reading skills was established.

Although the Linguistic Interdependence theory can account for the positive correlation between reading and signing skills, we think that the theory in its present form has three major shortcomings. First, the theory does not really give us much insight in why, how, at which (linguistic) levels, and under what circumstances transfer from a sign language to a written language is observed. In other words, we think the model is not sufficiently specific in its explanation on how signing skills transfer to written languages. We think that an understanding of how and why transfer between sign languages and written languages occurs is vital, not only to increase our understanding of why so many deaf children have reading problems but also to work towards a method to improve their reading skills.

Second, the Linguistic Interdependence model has difficulties in accounting for the average reading achievements of deaf children in bilingual education programs. Despite the introduction of bilingual education programs, the reading skills of deaf children do not seem to have improved substantially in the last two decades (Bagga-Gupta, 2004; Heiling, 1995; Wauters et al., 2006). Why is that the case? The positive relationship between reading and signing skills that have been observed in the studies mentioned above seems to imply that bilingual education programs should have led to significant improvements of the reading skills of deaf children. However, that is not what the empirical data reveal. One possible explanation to this apparent paradox is that bilingual education programs may have underestimated the role of spoken languages in the acquisition of written languages (Paul, 1998). As pointed out by Mayer and Akamatsu (1999), sign languages and spoken languages may both play equally important but different roles in the acquisition of written languages by deaf children. Whereas bilingual education programs may have provided the optimal conditions under which deaf children can exploit their sign language proficiency to acquire written languages, the programs may have neglected the potentially beneficial role of spoken languages. In our opinion, any model of reading acquisition of deaf children should acknowledge and explain the roles of both languages in the acquisition of written languages.

Third, we think the model does not adequately capture the learning conditions under which deaf children in bilingual programs acquire a written language. Deaf children learn a written language without having full access to the spoken form of that language. They also learn to read and write in reading instructional practices in which their proficiency in another language, sign language, is usually exploited. For instance, teachers in many bilingual education programs cultivate associations between signs and words to teach deaf children new reading vocabulary.
This technique has been referred to as chaining by Padden and Ramsey (2000). Padden and Ramsey found that teachers in reading instructional practices explicitly linked written words, fingerspelling, and signs together (see also Evans, 2004; Humphries & MacDougall, 2000). They describe an example in which a teacher, in a lesson about volcanoes, in rapid succession first fingerspelled the word “Vulcano,” then pointed to the word written on the blackboard, and finally made the sign. This chaining technique is one example of the many techniques that teachers in bilingual education programs use to exploit deaf children's knowledge in sign language during reading vocabulary learning (Prinz & Strong, 1998). In this paper, we will refer to techniques that exploit children's lexical knowledge in sign language as sign-based reading vocabulary instructional techniques. The use of such techniques in reading instructional practices presumably has an impact on how written words are stored in the mental lexicons of deaf children and how deaf children can access and use these words in reading and writing. To illustrate, in a reading lesson in a bilingual education program for deaf children in the Netherlands, an 8-year-old girl was asked to read aloud the Dutch sentence “Sonja loopt naar de stoel!” (Sonja walks to the chair). As she attempted to read the sentence aloud, the girl made a mistake. She produced the incorrect sentence “Sonja loopt naar de zitten” (Sonja walks to the “to sit”). There is at least one aspect to this reading aloud error that is very intriguing. The noun “chair” and the verb “to sit” are not only semantically similar but also phonologically very similar in Sign Language of the Netherlands (SLN). It seems, therefore, likely that SLN was somehow involved in the production of this error (for very similar errors in the writings of deaf adults, see McCoy, Pennington, & Suri, 1996a, 1996b). Thus, the conditions under which deaf children acquire written languages are unique and will have an impact on how written words are stored in the mental lexicons of deaf children. As pointed out by Chamberlain and Mayberry (2000), any model of reading acquisition for deaf children should acknowledge these conditions.

In this paper, we present a model that describes only one aspect of reading acquisition of children in bilingual education programs: reading vocabulary learning. Deaf children have to develop a written lexicon that contains the appropriate semantic, syntactic, morphological, and orthographic information for each of the words they learn. The construction of such a written lexicon is a vital part of learning to read, as words are the building blocks of languages (Dijkstra & van Heuven, 2002). For hearing children in the early stages of reading acquisition, information about the morphological, semantic, and syntactic specifications of each word are already present in the lexical entry of the spoken word, and this information becomes automatically available when children use the alphabetic principle to encode a new written word. Thus, hearing children only have to incorporate the orthographic information into the lexical entry of the spoken word (or assuming that there are separate lexicons for spoken and written language, they have to copy the information from the spoken to the written lexicon).

For deaf children, reading vocabulary acquisition is an uphill challenge. Most of them do not have a well-established spoken word lexicon they can rely upon. They have to construct a new lexical entry for many of the written words they are being taught. Deaf children usually only have access to the linguistic specifications of the translation equivalent in sign language. How will deaf children set up a written language system, when the syntactic, the semantic, and especially the morphological specifications of the spoken word equivalents are not already available? We think that understanding this issue is vital to help us understand why deaf children have difficulties in learning to read. In what follows, we will present a model of reading vocabulary acquisition for deaf children. The model acknowledges the important roles of both languages in the acquisition of reading vocabulary. The model is strongly inspired by Jiang’s psycholinguistic model of vocabulary learning in a second language (Jiang, 2000, 2002, 2004a, 2004b) and by monolingual and bilingual models of speech production and perception (De Bot, 1992; De Bot & Schreuder, 1993; Hermans, 2000; Kroll & Stewart, 1988; Levelt, 1989; Poulisse & Bongaerts, 1994). We will first present and discuss Jiang’s developmental model of adult vocabulary learning in a second language (L2). Next, we discuss why we think the core features of this developmental model for adult L2 learning also apply to deaf children.
who are learning a written language. We then present an adapted version of Jiang’s developmental model for deaf children and discuss evidence that supports this model. Finally, we will discuss some of the pedagogical implications of the model.

**Jiang’s Model of Reading Vocabulary Acquisition by Adult L2 Learners**

Jiang (2000) identified two important differences in the learning conditions of children who acquire a first language (L1) and adults who acquire a second language. First, adult L2 learners often learn the second language in (classroom) environments in which the input is less contextualized. That makes it more difficult for L2 learners to extract and integrate lexical meanings. Second, adult learners already have a well-established conceptual and lexical system available that can and will assist L2 word learning. These two unique learning conditions are at the heart of the developmental model for adult L2 learning proposed by Jiang (2000).

The model assumes that representations in the mental lexicon are specified in terms of form information (orthographic and phonologic), morphological information, syntactic information, and semantic information (see Levelt, 1989). These different properties of words are represented in the two components of a lexical entry: the lemma and the lexeme. As is shown in Figure 1, the morphological and phonological/orthographic specifications comprise the lexeme of a lexical representation, whereas the syntactic and semantic specifications constitute the lemma of a lexical representation. Thus, the lemma contains a word’s semantic and syntactic specifications, for example, its meaning and its syntactic category. The lexeme contains a word’s formal and morphological specifications, for example, different morphological variants of a word, its spelling, and/or its pronunciation. Once a lexical entry is opened during language production or comprehension, all the information stored in the lexical entry automatically becomes available to the reader, writer, listener, or speaker.

Lexical development in the L2 proceeds in three separate stages (see Figure 2). In the first stage of development, the word association stage, L2 learners recognize the meaning of L2 words within the existing semantic structure that is closely tied to the L1. Adults learn to remember words by making associations between L2 words and their L1 translation equivalents. In representational terms, the entry of the L2 word is registered in the mental lexicon. The entry contains only L2 form information; the morphological, syntactic, and semantic specifications are empty. The L2
word form is connected to its L1 translation equivalent. Connections have not yet developed between the L2 system and the conceptual system. As a consequence, the comprehension (and production) of L2 words necessarily involves the L1 system.

The continued coactivation of the L2 word form and the lemma structure of its L1 translation equivalent, which assist the use of the L2 word in production and comprehension, will eventually lead to significant changes in the representation and processing of the L2 word. The continued exposure leads to the transfer of the semantic and syntactic specifications of the L1 lemma into the empty lemma space of the L2 word. As a consequence, the L2 word is now directly connected to the conceptual system and access to the meaning of the L2 word does not necessarily involve the L1 language system anymore. However, as the connections between the L2 word and the conceptual system are still very weak, activation of the L1 will assist access to the meaning of the L2 word. The lexical entry of the L2 word does still not contain its morphological specifications.

In the third stage, the full integration stage, all of the words’ properties are specified in the mental lexicon. Lexical development is complete. Strong lexical links have developed between the L2 system and the conceptual system. As a consequence, the L1 system is no longer involved in the recognition of L2 words. However, Jiang (2000) argues that lexical development for most words in adult language L2 learners will stop at the second stage. The second stage, the lemma mediation stage, becomes the default state of L2 lexical processing in adult learners.

Jiang (2000) points out that the L2 words that an L2 learner has acquired can be in different stages of development. It is L2 lexical representations that must become autonomous, not the L2 learner. At a given moment in time, some of the L2 words that an adult has learned are in the first stage of development, whereas other acquired L2 words are in the second or even the third stage of development. This view on lexical development is also shared with other models of language acquisition, for instance, the Restricted-Interactive model of reading (Perfetti, 1991). Perfetti distinguishes between a functional and an autonomous lexicon. Whereas lexical representations in the autonomous lexicon support fast and automatized word recognition, lexical representations in the functional lexicon not yet have sufficient quality (precision and redundancy). As a consequence, processing written words from the functional lexicon requires more attentional efforts. As pointed out by Perfetti, a question like “Is this child an automatic decoder?” is not quite the right question to ask. Instead, the right questions to ask are “How large is the autonomous lexicon?” and “How large is the functional lexicon?” Very similarly, for adult L2 learners, the appropriate question to ask is “How large are the sets of L2 words that are in the first, second and third stages of lexical development?”

Jiang (2000, 2002, 2004a, 2004b) reports a series of findings that supports his developmental model of vocabulary acquisition. For instance, Chen and Leung (1989) found that highly proficient bilinguals rely upon conceptual mediation, whereas beginning bilinguals rely upon lexical associations during L2 word recognition and translation (see also Kroll & Curley, 1988). Furthermore, Jiang (2004b) reports a performance insensitivity to the plural morpheme in English of L1 Chinese learners of ESL, although these learners exhibited clear knowledge (competence) of these structures in English. This finding supports the notion that morphological information at the second stage of development is not integrated in the mental lexicon, and that it will not be activated automatically during reading comprehension. In addition, Jiang (2002, 2004a) reports semantic transfer effects for L1 Chinese and L1 Korean ESL learners (see also Thierry & Wu, 2007; Zughoul, 1991). These semantic transfer effects are consistent with Jiang’s claim that L1 semantic information is copied into the lexical entry of the L2 word. In other words, the model can account for many results that have been reported in the second language acquisition and bilingual literature.

The Application of Jiang’s Model to Reading Vocabulary Learning by Deaf Children

In the next section, we will apply Jiang’s model to reading vocabulary learning of deaf children. The application of Jiang’s model may not seem very straightforward, and it will probably raise more than one question. For instance, does the model apply to all
deaf children, regardless of their proficiency in sign language and/or spoken language? In addition, can an adult model of L2 vocabulary learning be applied to reading vocabulary learning of deaf children? And finally, to what extent and how do instructional practices in bilingual education programs have an impact on how deaf children acquire new reading vocabulary?

To start with our answer to the first question, the model clearly does not apply to all deaf children. The reading vocabulary model assumes that, initially, children create associations between lexical representations in the L1, sign language, and lexical representations in the written language. Therefore, deaf children must be proficient in sign language. More specifically, we propose that the model will only apply to deaf children whose sign language is their most dominant language. Note that this does not necessarily imply that they must have parents who are native signers. Deaf children must, at least, have had sufficient access to the grammar and lexicon of a sign language for a couple of years prior to the start of reading instruction.

The second question concerned the applicability of an adult model of L2 vocabulary learning to reading vocabulary learning of deaf children. Jiang’s model describes the acquisition of a second spoken language by adult learners. These adults are learning a second spoken language in the presence of a well-established L1 lexical system and a conceptual system. In contrast, when deaf children are learning a written language, they are still in the middle of acquiring sign language. In addition, most deaf children have some spoken language skills when they start reading. However, there are also several important similarities between deaf children who acquire a written language and hearing adults who acquire a second (spoken) language. First, new L2 words (hearing adults) and new written words (deaf children) are learned in the presence of an existing conceptual system and a lexical L1 system. The acquisition of the L1 may not be completed for deaf children, but our main point here is that the written language is learned in the presence of an L1 system. Like second language learners, deaf children may rely on this system when they learn reading vocabulary. Second, both groups learn the first language in a naturalistic setting in which the input is often (or should be) highly contextualized. In other words, the L1 is predominantly learned in situations that are functionally meaningful for learners. When children acquire new L1 words/signs, they learn words/signs and concepts at the same time. As a result, the meaning and form of words/signs are often inseparable. However, the L2 (adults) and the written language (deaf children) are often learned in a classroom. The challenge within this environment is often not to learn a new written or spoken word but to remember it. As a consequence, it becomes very difficult for adult L2 learners or deaf children to extract the semantic, syntactic, and morphological specifications of new words. In other words, we think that the same unique learning conditions that Jiang identified for adult second language learners are also found in the situation of deaf children who are learning a written language. We, therefore, think that Jiang’s model of vocabulary acquisition can be applied to the acquisition of reading vocabulary by deaf children in bilingual education programs.

The third question concerns the impact of the educational programs deaf children are enrolled in on lexical development. This question has two dimensions. First, how is the concept of “bilingual education” implemented in education programs? In contemporary bilingual education programs, the goal of bilingual education is predominantly viewed as dual language mastery and access to both (deaf and hearing) cultures (Bagga-Gupta, 2004). Both languages are viewed as being essential for the academic achievements of deaf children. Although this rather broad definition of bilingual education is the key principle in many programs, there are also major differences between the education programs. One of these differences concerns the view of educators on the role of spoken language skills in bilingual education programs. To illustrate, in (some of the) bilingual education programs in the Netherlands, Norway, and the United States, spoken language skills are neither strongly focused upon nor strongly de-emphasized. In contrast, in (some of the) bilingual education programs in other countries (for instance Sweden, United States, and Canada), spoken language skills are regarded as playing no role in the conceptualization of bilingual education (Bagga-Gupta, 2004).
second dimension concerns the view of these bilingual education programs on the acquisition of reading and writing skills. Prinz and Strong (1998) identified five different instructional approaches that are used in bilingual education programs in the United States to teach children the written English. Bagga-Gupta notes that a sixth variant is used in bilingual education programs in Sweden. In five of these approaches, sign language skills are (to some extent) exploited to teach deaf children written language. Nevertheless, these five programs exploit different techniques to bridge the gap between sign language skills and written language skills (sign glossing, sign writing, chaining, fingerspelling, and translation). Both dimensions, the view on bilingual education and the specific techniques that are chosen in reading instructional practices, will presumably have an impact on lexical development. We will return to this issue later on in this paper. In the next section, we will present our adaptation of the model of reading vocabulary proposed by Jiang.

A Model of Reading Vocabulary Acquisition for Deaf Children

For deaf children, lexical development in written languages is bound to be as complicated as lexical development in adult second language learners when we consider sign language-dominant deaf children who are in bilingual education programs. In theory, these deaf children can exploit both their sign language and their spoken language skills during reading vocabulary learning. However, many deaf children have small spoken language vocabularies and poor phonological skills when reading instruction starts in grade one (Blamey, Sarant, & Paatsch, 2005; Boekel et al., 2006). Boekel et al. investigated the spoken language skills of a group of 135 children from bilingual schools in the Netherlands. They found that 6- and 7-year-old deaf children had an average delay in vocabulary development in spoken Dutch of, respectively, 46 and 54 months compared to age-matched hearing children. In addition, the recognition of the spoken words that deaf children do know is a slow and effortful process, as the connections between the lexical spoken language system and the conceptual system are weak. In other words, deaf children will not be able to effectively exploit associations between written and spoken words to remember new written words when reading instruction starts.

In the first stage of lexical development, deaf children create associations between written words and signs (see Figure 3). In this stage of lexical development, the lexical entry of the written word is registered in the mental lexicon. The entry contains only orthographic information; the morphological, syntactic, and semantic specifications are empty. Access to the meaning of written words necessarily involves the sign language.

The lemma of the sign language translation equivalent of the written word is involved in the use (comprehension/production) of the written word. The continued coactivation of the lemma of the sign and its written translation equivalent will eventually lead to changes in the representation of the written word, signaling the second stage of lexical development. The syntactic and semantic specifications of the L1 lemma are copied into the lexical representation of the written word. Written words are now directly connected to the

![Figure 3](image-url) A model of lexical development for deaf children.
conceptual system. The sign language system is no longer necessarily involved in the recognition of written words but it will facilitate written word recognition. The morphological specifications of the written words are still empty.

In principle, there is a third stage in lexical development. In this stage, the lexical entry contains the appropriate semantic, syntactic, and morphological specifications. The written word is strongly connected to the conceptual system, either directly or through connections with the spoken language system. Although connections may still exist between lexical entries in the sign language system and the written language system, connections will no longer be strong enough to support fast and automatized lexical access. As pointed out by Jiang (2000), fluent and accurate expression of one's thoughts (and comprehension of other people's thoughts) in a language can only be achieved when that system does not rely upon another (different) language system.

The written words that deaf children have learned can be in different stages of development. Whereas some of the (more recently) acquired words may still be in the first stage of development, other words may be in the second or even third stage of development. However, we think that many written words deaf children in bilingual education programs acquire will not reach the third and final stages of development. The lemma mediation stage becomes the default state of lexical processing in reading.

In the next sections, we will present evidence in support of the model. The evidence will be directed toward several core features of the model. The model assumes that children create associations between written words and signs. Any reading instructional practice that exploits deaf children’s lexical knowledge in sign language, like chaining, should be a very effective technique to teach children new reading vocabulary. Thus, the first feature of the model is that sign-based reading vocabulary instructional techniques should help children to build up a reading vocabulary. The second feature is that deaf children recognize written words via the sign language system in the first two stages of lexical development. The third feature is that some of the specifications within the lexical entry of the written word are empty or are specifications from the sign language. The last feature is that the development of many written words will stop at the second stage of development for deaf children in bilingual education programs.

Do Sign-Based Instructional Techniques Help Deaf Children to Acquire Reading Vocabulary?

Teachers in bilingual education programs (in the Netherlands) often use sign-based reading vocabulary instructional techniques to teach deaf children reading vocabulary. In an intervention study in the Netherlands, Wauters, Knoors, Vervloed, and Aarnoutse (2001) showed that deaf children benefit from the use of signs during reading vocabulary training. Sixteen deaf children from bilingual education programs between 6;1 and 10;1 years old received reading vocabulary training under different conditions using a within-subjects design. In one condition, the “speech-only” condition, a training trial consisted of the following events: first, a picture was presented on the computer screen and the trainer produced the name of the picture in the spoken language. Next, the printed name of the picture was presented on the computer screen. Deaf children were asked to pronounce the name of the picture. Finally, the trainer repeated the name of the picture in the spoken language. In the “speech and sign” condition, the name of the picture was not only produced by the trainer and the child in Dutch but also in SLN. Wauters et al. found that children remembered the written words more accurately in the speech and sign condition compared to the speech-only condition.

Do Deaf Children Encode Written Words via Their Sign Language System?

The model assumes that the sign language is involved in the recognition of written words in the first two stages of lexical development. Evidence for this assumption has been found in several studies (Mayberry, Chamberlain, Waters, & Hwang, 2005; Ormel, Hermans, Verhoeven, & Knoors, submitted; Treiman & Hirsch-Pasek, 1983). Ormel et al. conducted a word–picture verification task with a group of 10- to 12-year-old deaf children from bilingual education programs.
A written word and a picture were presented on a computer screen, and children had to decide whether or not the word and the picture mapped onto the same concept. Ormel et al. manipulated two properties of the SLN translation equivalents of the written words: (a) the iconicity of SLN translation equivalent and (b) the phonological relationship between the translation equivalent of the written word in SLN and the name of the picture in SLN.

In the “strong iconic” condition, the form and the meaning of the sign translation equivalent of the written word were strongly related. In this condition, children saw, for instance, the written word “ball” next to a picture of a “BALL.” As the relation between the meaning and the form of the SLN sign BALL is transparent, these pairs constituted the stimuli in the strong iconic condition. In the “weak iconic” condition, the relation between the form and the meaning of the sign translation equivalent of the written word was much less transparent (the SLN sign LETTER). Deaf children took less time to correctly press “YES” for word–picture pairs in the strong iconic condition compared to the weak iconic condition. A group of hearing control children without knowledge of SLN was (obviously) equally fast in both conditions.

Ormel et al. also manipulated the phonological relationship between the sign translation equivalent of the written word and the name of the picture in SLN for a proportion of the “NO” responses. In the “SLN phonological” condition, words and pictures were unrelated in Dutch, but the sign translation equivalent of the written word was phonologically related to the name of the picture in SLN. To illustrate, the written word “gans” (goose) was paired with a picture of a “TEACHER.” This pair is unrelated in Dutch (gans [goose]—leraar [teacher]), but the SLN signs “GOOSE” and “TEACHER” are phonologically related. In the “SLN-unrelated” condition, words and pictures were unrelated both in Dutch and in SLN. Deaf children took more time to correctly press NO in the SLN phonological condition compared to the SLN-unrelated condition. Again, the control group of hearing children without SLN knowledge was (obviously) equally fast in both conditions.

In other words, Ormel et al. found that the recognition of written words by bilingual deaf children is affected by properties of their sign language translation equivalents. This finding strongly suggests that deaf children recognize printed words via the sign language system. Similar results were found in a different experimental paradigm by Mayberry et al. (2005). Mayberry et al. conducted a visual lexical decision task with a group of 48 children from bilingual education programs (sign and speech). The children were between 7 and 16 years old. Mayberry et al. manipulated the consistency of the relation between the written English words and their translation equivalents in ASL. The relationship between the English word and its translation equivalent in ASL was either consistent or inconsistent. Mayberry et al. found that beginning deaf readers were sensitive to the consistency of the word–sign relations: beginning readers recognized written English words with consistent sign relations faster and more accurate than written English words with inconsistent sign relations. In contrast, more advanced readers recognized both categories of words equally well. In fact, Mayberry et al. found that the involvement of ASL in English written word recognition did not decrease as a function of age but rather as a function of the reading age of the deaf children.

Morphological, Syntactic and Semantic Specifications in the Entries of Written Words

The model assumes that the morphological specifications in the lexical entries of written words are empty in the first two stages of lexical development. It is only in the final stage of development that lexical entries contain the appropriate morphological specifications. Is there evidence that is “consistent” with the view the morphological specifications are empty for many deaf readers? And more specifically, is there any evidence that “shows” that the morphological specifications of written words are empty?

The assumption that the morphological specifications are empty is consistent with the results of many studies that have revealed the difficulties of deaf children and deaf adults with the morphology of the written language, especially in written language production (Breadmore, Olson, & Krott, 2006; Fabretti, Volterra, & Pontecorvo, 1998; King & Quigley, 1985;
Quigley & King, 1980; Quigley, Wilbur, Power, Montanelli, & Steinkamp, 1976; Schönström, 2006; Tur-Kaspa & Dromi, 2001; Van Beijsterveldt & van Hell, submitted; Wilbur & Quigley, 1975). Although the number of morphological errors of deaf people decreases (descriptively) as a function of their age, deaf adults still produce a large amount of morphological errors in their writings (McCoy et al., 1996a, 1996b). Apparently, morphological errors are very persistent. The model can easily account for this finding as it assumes that the morphological specifications of many written words are empty. Deaf children and deaf adults have to rely upon (general) morphological rules of the written language in their comprehension and production of written language.

Breadmore et al. (2006) reported results that provide more direct evidence in support of the developmental model. They conducted a study on the morphological skills of deaf secondary school children. Breadmore et al. tested a group of 25 deaf children between 11 and 17 years old and a group of reading age-matched hearing children (mean age 8;4). Most of the deaf children were educated in bilingual education programs. In one experiment, children were given a booklet with 33 pairs of line drawings on it. Each pair consisted of one line drawing depicting a single object with English name written under it (SKIRT) and a line drawing depicting multiple objects (SKIRTS) without its English name. Children were instructed to write the English plural under the picture. The plural was regular (FEATHER–FEATHERS), semi-regular (BOX–BOXES), or irregular (MAN–MEN). Breadmore et al. found that deaf children performed equally well on regular and semi-regular plurals compared to reading age-matched hearing children. However, deaf children performed significantly worse on irregular plurals. Our lexical development model can easily account for this finding. Irregular plurals, like the plural “men,” have to be specified in the lexical entry of the word “man.” As that information will generally not be specified in the lexical entry of deaf children who are poor readers, the models predict that deaf children will perform worse compared to reading age-matched hearing children. In contrast, deaf children can produce regular and semi-regular plurals by applying general morphological pluralization rules of English. That deaf children seem to use these general rules was also evident by the many overregularizations (e.g., “deers” for “deer”) that Breadmore et al. observed for secondary school deaf children. In other words, the results obtained by Breadmore et al. fit very nicely into this model of lexical development.

As stated before, the model assumes that lexical entries contain the semantic and syntactic specifications of the SLN translation equivalents in the second stage of development. Is there any evidence for a transfer of the semantic and syntactic specification of signs into the entries of written words? Evidence for such transfer effects is sparse. The only reported evidence comes from studies in which an existing corpus, which contains the writing samples of ASL-proficient deaf adults from Gallaudet University, the National Technical Institute of the Deaf, the Pennsylvania School for the Deaf and the Bicultural Center, was analyzed on the type of errors deaf adults produce (McCoy et al., 1996a, 1996b; Michaud, 2002; Stark, 2001). McCoy et al. (1996a) report a number of writing errors that show that deaf adults have difficulties with the correct use of written English words that have different meanings (like “other” and “another”) but which share the same translation equivalent in ASL. The model can account for these errors as it assumes that the semantic specifications of the ASL sign are copied into the lexical representation of written words. As a consequence, deaf children and adults will have difficulties in the correct use of words that share their translation equivalents in the sign language.

Is there evidence for transfer of the syntactic specification of signs into the entries of written words? Again, there is some evidence available to support this claim. McCoy et al. (1996a) reported writing errors that suggest that the syntactic specifications of the L1 sign are copied into the lexical representation of the L2 written word. They reported errors like “I am interesting in ASL and I want to learn it.” Again, McCoy et al. note that the written words “interesting” and “interested” share their translation equivalent in ASL. Although it is tempting to consider the writings errors as morphological errors, they are also consistent with the view that the syntactic information of the sign was copied into both lexical entries, “interesting” and
“interested.” In sum, there is some evidence that is consistent with the view that for many deaf people the lexical entries of written words do not contain the appropriate L2 morphological, syntactic, and semantic specifications.

Lexical Fossilization

A final feature of the model is that many words that deaf readers acquire do not reach the final stage of lexical development. Lexical development will fossilize. Again, is there evidence that is consistent with the view that lexical development fossilizes? Obviously, the low average reading levels of deaf children and adults are consistent with the model. In addition, the model can easily account for the persistence of morphological errors in the comprehension and production of written language by deaf adults. But, there are many other models that can easily account for these results.

However, there is some evidence that specifically supports our model of lexical development as far as fossilization is concerned. First, McCoy et al. (1996b) found that approximately 76% (!) of the errors ASL-proficient deaf adults produce in their writings can be attributed to transfer from sign languages to written languages. In addition, there is also evidence that shows that deaf adults still encode written words into sign language. Treiman and Hirsch-Pasek (1983) instructed 14 deaf ASL native adults to make grammatical judgments of written English sentences. Some of the English sentences were tongue twisters when translated into ASL. They found that deaf adults made more errors on the written sentences when those sentences were tongue twisters in ASL. This result shows that deaf adolescents still encode written sentences into ASL. Quite remarkably, only the three outstanding deaf readers (reading scores at 11th grade or higher) did not show this sign similarity effect.

Testing the Model of Reading Vocabulary Learning

As we described in the previous sections, there is evidence available to support the reading vocabulary model for deaf children. In this section, we will describe several possible empirical tests of the model. We will focus on the model's predictions in the first two stages of lexical development, as many written words deaf children acquire do not reach the third stage of lexical development.

For several features of the model, some empirical evidence is available to support the model. For instance, studies in which writings errors of deaf adults and children were analyzed have revealed errors that support the notions of semantic and syntactic transfer (McCoy et al., 1996a, 1996b). However, writing errors are instances of derailments of the language production system and, as such, do not necessarily reflect the error-free process of lexical access in language production or perception (Schriefers, Meyer, & Levelt, 1990). In other words, there is a need for converging evidence from different paradigms that measure error-free language production or comprehension, for instance, online experimental tasks. Jiang (2004a) administered a semantic judgment task in which L1 Korean participants had to decide whether or not pairs of written L2 English words were semantically related (see also Thierry & Wu, 2007). Some of the semantically related English pairs shared their translation equivalent in Korean, whereas other pairs had different translation equivalents in Korean. Jiang found that L1 Korean bilinguals were faster in making the decision when the English words shared a translation equivalent in Korean. Very similarly, we could select pairs of semantically related written words that either share or do not share a translation equivalent in sign language. The model predicts that deaf children from bilingual education programs will respond faster to pairs of semantically related written words that share a translation equivalent in sign language. The model's assumption regarding transfer of syntactic information can also be tested in various different experimental paradigms. For instance, the model predicts that deaf children will detect word substitution errors involving words from different syntactic classes in sentences more slowly and less accurately when these words share a translation equivalent in sign language (or when the translation equivalents of the written words in sign language are phonologically very similar).

The model assumes that deaf children create associations between written words and signs. Therefore, deaf children's lexical sign language skills should
directly affect the acquisition of reading vocabulary. First, deaf children who have acquired large vocabularies in sign language will have fewer difficulties in acquiring new reading vocabulary compared to deaf children who have acquired small vocabularies in sign language. Thus, the quantity of acquired sign vocabulary will predict subsequent development in the quantity of reading vocabulary for deaf children when cognitive variables like spoken language vocabulary, nonverbal intelligence, and short-term memory capacity are controlled for. Second, the model assumes that lexical development in sign languages directly affects lexical development in written languages. There are presumably differences between deaf children regarding lexical development in sign language. For instance, deaf children of deaf parents may have developed more precise semantic representations of signs when compared to deaf children of hearing parents. As this information is copied into the lexical entry of its translation equivalent in the written language, deaf children of deaf parent may develop more elaborate semantic representations of written words as well. In general, the model predicts that the positive and negative effects that are associated with the transfer of information from the L1 (sign language) to the L2 (written language) will vary as a function of the advancement of L1 lexical development.

Impact of Sign-Based Reading Vocabulary Instructional Techniques

Sign-based reading vocabulary instructional techniques are very powerful techniques to teach deaf children the meanings of unknown written words. These instructional techniques enable many deaf children to understand the meaning of new reading vocabulary. However, there are also limitations of such techniques that manifest themselves both in direct vocabulary instruction and in vocabulary learning during independent reading. In direct vocabulary instruction, teachers can exploit children’s acquired lexical knowledge in sign language to teach them the meaning of unknown written words. However, the use of sign-based techniques will often not be sufficient for the development of written words beyond the second stage of lexical development. The transition from the second stage to the final stage of development may take longer than expected, as the inappropriate L1 lemma specifications may block and slow down the integration of the specifications of the L2 into the lexical entry, resulting in lexical fossilization (Jiang, 2000).

In addition, deaf children must eventually be able to derive the meaning of the unknown words they encounter during independent reading. Hearing children acquire approximately 3000 new words each year during their primary and secondary school years (Stahl, 1999; Stahl & Fairbanks, 1986). As children can acquire a maximum of approximately 400 new words each year through direct instruction, they have to acquire the bulk of the new vocabulary through incidental learning, for instance, through independent reading (Herman, Anderson, Pearson, & Nagy, 1987). As the quantity of reading vocabulary is vital for understanding written texts (Anderson & Freebody, 1981; Perfetti, 1991), deaf children must also be able to decode the meaning of unknown words they encounter during independent reading. Lexical knowledge in sign language will not be very useful when children have to figure out the meaning of unknown written words: there is no (systematic) relationship between the form of signs and their written translation equivalents. In other words, associations between words and signs cannot easily be used in independent reading. Deaf children will usually have to derive the meaning of the written word solely on the basis of information provided by the context. That is a daunting task for deaf children, as successful derivation of the meaning words on the basis of contextual information requires knowledge of approximately 98% of the words in a given text (Hu & Nation, 2000). In other words, although sign-based reading instructional techniques are effective tools to teach children new reading vocabulary, deaf children will have problems developing a reading vocabulary that supports reading, both in terms of the quantity and the quality of lexical representations.

The Role of Spoken Language Skills in Reading Vocabulary Learning

According to our model, the lexical entry contains the written word’s semantic, syntactic, morphological, and
orthographic information in the final stage of lexical development. The written language system is strongly connected to the conceptual system, either directly or through connections with the spoken language system. In theory, the involvement of the spoken language system is very beneficial as it affects three important dimensions of lexical representations: the redundancy, the preciseness, and the quantity (Perfetti, 1991).

First, sublexical and lexical connections between the written and spoken language systems add to the redundancy of lexical representations, especially in regular languages. As the reader can rely upon multiple sources of information during word recognition, redundant lexical representations allow fast and automatized access to the morphological, syntactic, and semantic specifications of individual words (Perfetti, 1991). Fast and automatized access to the appropriate specifications in a word’s lexical entry is necessary to become a good reader (Perfetti, 1985; Stanovich, 1990). In other words, the involvement of the spoken language system can be beneficial to (deaf) readers as it increases the redundancy of lexical representations.

Second, the involvement of the spoken language system can increase the preciseness of lexical representations. Eventually, the written lexicon has to contain the appropriate semantic, syntactic, and morphological specifications for each word. As we pointed out above, children can indeed rely upon their sign language system to acquire the meaning of new reading vocabulary in direct vocabulary instruction. However, they subsequently have to acquire the syntactic and morphological specifications of every written word. In other words, the written words that deaf children acquire necessarily go through these three stages of development. That seems very inefficient to us. In contrast, if deaf children can acquire good spoken language (vocabulary) skills and if they can exploit these skills during reading vocabulary learning, they will be able to bypass the first two stages of lexical development.

Finally, the involvement of the spoken language system can increase the quantity of lexical representations. Deaf and hearing children with good spoken language skills can rely upon lexical knowledge in their spoken language to acquire new reading vocabulary, both during direct instruction and during independent reading. In addition, the interplay between the spoken language system and the written language system will become more bidirectional as children acquire more proficiency in the written language: spelling to sound regularities not only help children to build up their reading vocabulary but also their spoken language vocabulary. The interplay between the written and the spoken language system also allows children to simultaneously acquire words in both modalities during incidental word learning. We think that this mutual reinforcement of lexical growth in both systems is vital for the development beyond the initial stages of language acquisition.

Many deaf children cannot rely upon their spoken language skills during the initial stages of reading acquisition. However, the spoken language system of deaf children will mature in time. In addition, deaf children may acquire knowledge about the spoken language system through intensive exposure to print (Musselman, 2000; Padden & Ramsey, 2000). Thus, the spoken language system might support reading vocabulary learning during the later stages of reading acquisition. The involvement of the spoken language system can be very beneficial as it increases the preciseness, the redundancy, and the quantity of lexical representation in the written language.

**Pedagogical Implications**

In the mid-90s of the last century, bilingual education programs were implemented in special schools for deaf children in many countries (Israelite et al., 1992; Mason & Ewoldt, 1996). These bilingual education programs have given deaf children unique opportunities to develop their skills in a natural sign language and to exploit their sign language proficiency to acquire a variety of academic skills. But despite the promises of bilingual education programs, the average reading skills of children do not seem to have improved substantially in the last decade. In our opinion, bilingual education programs with sign-based reading instructional practices have indeed provided children with the opportunities under which they can exploit their sign language proficiency to acquire written languages.

We have argued that most deaf children must initially rely upon their sign language system to learn the
meanings of written words, as their spoken language system is not yet ready to support the acquisition of the written language when reading instruction starts. Many teachers of deaf children in bilingual education programs have acknowledged this, and they use sign-based instructional techniques to teach deaf children new reading vocabulary. However, learning the meanings of written words is not enough: children have to develop a written lexicon that also contains the syntactic and morphological specifications of each word. We have also argued that spoken language skills are, potentially, very beneficial for the development of a mental lexicon in which the orthographic, morphological, syntactic, and semantic properties of written words are specified. Thus, deaf children may benefit tremendously if not only their sign language skills are exploited in reading vocabulary acquisition but also their spoken language skills. The involvement of the spoken language system will add to the redundancy, the preciseness, and the quantity of lexical representations. In other words, we think both languages can play an important but different role in the acquisition of reading vocabulary.

To be very clear, we think teachers should use sign-based chaining techniques when they teach deaf children in bilingual education programs new reading vocabulary. Words/signs are the building blocks of language, and the acquisition of vocabulary is a crucial aspect of language development. Sign-based reading vocabulary instructional techniques, like chaining, provide teachers with a powerful instrument for teaching children these building blocks of language. In addition, deaf children with little access to spoken languages will, at least initially, automatically understand the meaning of new written words within the preexisting language and conceptual systems, regardless of whether intralingual strategies, interlingual strategies, or extralingual strategies are used in the classroom. Thus, reading instructional programs that exploit deaf children’s lexical knowledge in sign language will facilitate the acquisition of new reading vocabulary.

We have also argued that many written words that deaf children from bilingual education programs acquire will not develop beyond the second stage of lexical development. In this scenario, the right question to ask is which strategies teachers should use to help deaf children to reach the third stage of lexical development. A first necessary step is that deaf children must learn that written languages are not related to sign languages. Hoffmeister and Caldwell-Harris (in preparation) have pointed out that deaf children may have a “naive theory of print.” Deaf children do not always realize that the written language is related to the language spoken by hearing people and unrelated to the sign language. In addition, deaf children have to learn that there are important differences between written languages and sign languages. To illustrate, the relation between the form and the meaning of words is usually arbitrary. In contrast, the forms of many signs are related to their meanings. Children have to be aware of this fundamental difference when they start learning written words (Paul, 1998).

A second step for deaf children is to gain knowledge about the structure of the written and the spoken language. Deaf children may start to learn the regularities of the orthographic system when their experiences with reading materials are intensified. Because the orthographic system generally is a reflection of the phonological system of the underlying spoken language, children may gain knowledge about the phonology of the spoken language system as well. Thus, some deaf children acquire knowledge automatically through intensive exposure to print (Musselman, 2000; Padden & Ramsey, 2000). However, teachers may also try to enhance deaf children’s knowledge of the written and spoken language systems. For instance, teachers can use techniques like fingerspelling (Padden & Ramsey, 2000) or visual phonics (Woolsey, Satterfield, & Robertson, 2006) to increase children’s knowledge of the sublexical structures (letters, graphemes/phonemes, and syllables) in the written and spoken languages. In addition, teachers may stimulate children’s knowledge about the orthographic/phonological and morphological structure of the written language by exploiting childrens’ skills in the sign language. For instance, Paul (1998) notes that children can be introduced to the notion of word roots through exercises in which they have to detect similarities in the forms of morphologically related signs. In fact, the acquisition of many morphological and syntactic properties of written languages can be facilitated when
teachers build upon children’s knowledge of sign languages (Paul, 1998).

Another beneficial step for deaf children is the development of spoken language skills. Good spoken language vocabulary skills will facilitate the acquisition of new reading vocabulary. More importantly, children need to develop precise phonological representations (Perfetti, 1991). Precise phonological representations are necessary to exploit sublexical correspondences between written and spoken languages (Leybaert & Alegria, 2003). Speech therapists and teachers may use techniques like cued speech (CS) to enhance children’s comprehension in the spoken language (Alegria, Charlier, & Mattys, 1999; Nicholls & Ling, 1982) and to improve the preciseness of phonological representations (Leybaert, 2000; Leybaert & Alegria, 2003; Leybaert & Lechat, 2001). Leybaert, for instance, found that deaf children who are taught spoken language skills through cued speech (CS) from an early age on had developed precise phonological representations, and used phoneme-grapheme correspondence rules in spelling. In other words, deaf children need to acquire knowledge of the structure of written and spoken languages. The involvement of the spoken language system in reading vocabulary learning can be very beneficial as it increases the redundancy, the preciseness, and the quantity of lexical representations.

In sum, in this paper we have presented a new model of reading vocabulary acquisition for deaf children. In our view, the model provides a new perspective on reading vocabulary learning by deaf children in bilingual education programs. We have argued that many written words deaf children acquire do not reach the final stage of lexical development and that the sign language lemma mediation stage becomes the steady state of processing in many deaf children and deaf adults. We have presented evidence that supports various core features of our model, although it is also clear that we need much more evidence to support our model. Finally, we have also shown that this view on lexical development may reveal new challenges for teachers in bilingual education programs.

Notes

1. Cochlear implants have given profoundly deaf children more access to the spoken language. Several studies have already shown that cochlear implants can lead to an increase of speech perception and production skills, reflected in, for instance, increased receptive vocabularies (Geers, Nicholas, & Sedey, 2003; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000). In addition, deaf children with cochlear implants have been found to perform better on reading tests than deaf children without cochlear implants (Geers, 2003; Vermeulen, van Bon, Schreuder, Koors, & Snik, 2007). The spoken language systems of (some of) the deaf children with cochlear implants can support the acquisition of the written language during the initial stages of reading acquisition. For those deaf children, reading instructional practices should exploit the children’s spoken language skills.

2. Current models of speech production assume that morphological variants of a word are represented in the same lexical entry (Levelt, 1989). For example, the lexical entry “GO” contains the morphological forms “GO,” “GOES,” “GONE,” “WENT,” and “GOING.” All these morphological forms become available once the lexical entry GO is opened in language comprehension or production. Jiang (2000) argues that morphological variants, like GOES, GONE, WENT, and GOING, may not be integrated into the lexical representation of GO for L2 learners but are represented as separate entities in the L2 lexicon instead.

3. We realize that this description of the proficiency of children in sign language and spoken language is rather vague. At this point, it is very difficult to make specific claims about how deaf children’s proficiency in sign languages and spoken languages affect lexical development in written languages. One of the reasons is that we think that lexical development is not only affected by the proficiency of deaf children in both languages but also by reading instructional practices. Thus, lexical development in a written language may be very different for children from different educational programs whose proficiency in sign language and spoken language is comparable. Nevertheless, as pointed out by one of the reviewers, there may be differences between lexical development in sign language within groups of sign language-dominant deaf children. It may turn out to be necessary to look more closely to lexical development in sign languages for various different groups of deaf children.

4. There are obviously important differences between reading instructional practices for deaf children as far as contextualized input is concerned, depending upon the specific view on literacy of a school or an institute (Paul, 1998) and the specific skills and style of a teacher. Some of the special schools for deaf children adhere to a whole-language approach to reading instruction. Although it is now clear that word decoding skills cannot easily be acquired in education programs that exclusively adhere to a whole-language approach (National Reading Panel, 2000), this approach to reading might be very fruitful to help children to overcome lexical fossilization in the long run. Any method that will stimulate deaf children to extract and integrate meanings will eventually help children to overcome lexical fossilization.

5. Figure 3 visualizes the model of lexical development as a model in which words and signs are stored in separate lexicons. This visualization may seem inconsistent with current theories and recent empirical studies reported in the mainstream.
bilingual literature. Most current theories of bilingual representation and processing assume that (spoken and written) words from a bilingual’s languages are stored in one integrated mental lexicon (Green, 1998; Hermans, 2000; Poulisse and Bongaerts, 1994; van Heuven, Dijkstra, & Grainger, 1998). However, we do not intend to make any specific claims about whether words and signs are stored in two separate lexicons or in one integrated lexicon. Our main point is that deaf children have to construct different lexical entries for a particular sign and its translation equivalent in the written/spoken language, regardless of whether the word and sign are stored in one or two lexicons. This assumption is necessary to explain why deaf children are, above chance level, able to select and produce words or signs in the language in which they intend to speak or sign (De Bot & Schreuder, 1993), even though children may still produce many code switches. In other words, we could also have chosen a visualization in which words and signs, tagged for the language they belong to, are stored within one integrated lexicon.

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Language Acquisition and Its Consequences for Sign Language Assessment, Zurich, Switzerland.


Received November 7, 2006; revisions received September 17, 2007; accepted October 13, 2007.