



Acquiring English as a second language via print: The task for deaf children



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ABSTRACT

Only a minority of profoundly deaf children read at age-level. We contend this reflects cognitive and linguistic impediments from lack of exposure to a natural language in early childhood, as well as the inherent difficulty of learning English only through the written modality. Yet some deaf children do acquire English via print. The current paper describes a theoretical model of how children could, in principle, acquire a language via reading and writing. The model describes stages of learning which represent successive, conceptual insights necessary for second/foreign language learning via print. Our model highlights the logical difficulties present when one cannot practice a language outside of reading/writing, such as the necessity of translating to a first language, the need for explicit instruction, and difficulty that many deaf children experience in understanding figurative language. Our model explains why learning to read is often a protracted process for deaf children and why many fail to make progress after some initial success. Because language acquisition is thought to require social interaction, with meaning cued by extralinguistic context, the ability of some deaf individuals to acquire language through print represents an overlooked human achievement worthy of greater attention by cognitive scientists.

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1. Introduction

A major component of schooling is the quest to learn to read. Deaf children take 3–4 years (or more) longer than hearing children to develop minimal reading ability, and the average deaf adult has a reading level of 4th grade (Goldin-Meadow & Mayberry, 2001; Harris & Beech, 1998; Hoffmeister, 1996). A frequent explanation cites deaf children's reduced access to English phonological structures (see reviews in Luckner, Sebald, Cooney, Young, & Muir, 2006; Marschark & Harris, 1996; Musselman,

2000; Paul, Wang, Trezek, & Luckner, 2009; Wang, Trezek, Luckner, & Paul, 2008). Poor phonological awareness is considered the largest impediment to reading for hearing children (Stanovich, 2000; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Deaf children's reading problems have been conceptualized as a more extreme version of reading difficulties in hearing children (Paul et al., 2009). However, phonological awareness has only a modest relationship to reading skills in deaf children, according to a meta-analysis (Mayberry, del Giudice, & Lieberman, 2011). Because many profoundly deaf children recover little, if any, useable speech information, they face the obstacle of being asked to read English without knowing the grammar, words, or sounds of the language. On this account, when these profoundly deaf children become successful readers, it is because they learned the English language from print forms. Current theories of second language acquisition by

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children do not endorse or even discuss the possibility of learning a language exclusively from print. This achievement needs to be more widely understood.

Many authors have endorsed the view that deaf children frequently learn English from print (Charrow & Fletcher, 1974; Goldin-Meadow & Mayberry, 2001; Johnson, Liddell, & Erting, 1989; Kuntze, 1998; Marschark & Harris, 1996; Musselman, 2000; Perfetti & Sandak, 2000; Singleton, Supalla, Litchfield, & Schley, 1998; Supalla, Wix, & McKee, 2001; Wilbur, 2000). But few have noted that learning a language from print, if it is possible beyond some exceptional cases, expands what scholars understand as a normal human achievement. How deaf children could, in principle, learn a language from only print exposure has not been examined from any perspective. The current paper addresses this omission in the research literature.

Theories of language acquisition, while diverse, agree that social interaction is necessary for children to learn both a first and a second language (e.g., Bates, 1976; Fillmore, 1991; Halliday, 1975; Lee, Mikesell, Joaquin, Mates, & Schumann, 2009; Long, 1981; Vygotsky, 1978). Children are believed to learn implicitly and procedurally (Dornyei, 2009; Tomasello, 2003). They first understand the communicative intent inherent in a situation, and then map their comprehension of linguistic meaning to words and phrases (Fillmore, 1991; Halliday, 1975; Krashen, 1985). Even older children and adults rarely learn a second or foreign language fluently from only classroom instruction (Schumann, 1997). It is thus not surprising that no research asks whether children who do not yet read in any language can acquire a language only from textual materials.

It is widely known that profoundly deaf individuals do become proficient readers and writers of English (Lane, Hoffmeister, & Bahan, 1996). Deaf adults commonly report that they learned English via reading (Dalby & Letourneau, 1991). This raises the question of how this is done, and what it tells us about reading, language and deafness.

We first briefly review theoretical positions on why learning a language from print is difficult. We describe how deaf educators have responded to this problem by trying to expose deaf learners to English before they encounter print, and why these methods (including English-based signing systems and lip-reading) have been unsuccessful in improving the average reading level of deaf children and adults. We then present our model of how English could, in principle, be learned from print, for children who come to the task with a strong foundation in a signed language. The task facing deaf children is then compared to three tasks that are well-studied in hearing children: reading in a first language, learning a second language, and reading in a second language.

1.1. Views on the difficulty of acquiring a language from print

There are two main difficulties in learning a language from print. The first is mastering a second or foreign language in a classroom setting. Hearing children rarely succeed at this at any age and especially not before age 12 (Garton, Copland, & Burns, 2011). Note that this failure

contrasts with children's success at learning in an immersion context (Marinova-Todd, Bradford Marshall, & Snow, 2000). The other challenge is to learn a second/foreign language only from written materials, with little possibility of practicing the language outside of print. There is no literature about hearing children accomplishing this, outside of savant cases (Smith & Tsimpli, 1995).

The low success of classroom foreign language instruction is consistent with theorists' view that learning a language is impossible if it does not include social interaction (or at least observing comprehensible exchanges, see Ellis, 1999). Speech act theorists argue that language isn't simply a vehicle for communicating (Austin, 1962). Utterances are social gestures which accomplish interpersonal goals such as sharing, connecting, promising, apologizing, arguing, and joking. It has long been assumed that these are acquired primarily by observing and practicing these acts. Humans learn language not to learn vocabulary or grammar, but to achieve practical goals (Lee et al., 2009; Tomasello, 2003). Achieving these goals brings social rewards; social rewards propel attention to language input and fuel the desire to communicate (Paradis, 2004; Schumann, 1997).

The key advantage of learning via interaction is that the triangulation of context, language and the need to infer speakers' goals closes the gap left by the weakness of inductive learning. Second language acquisition theorists have been especially forceful on this point. Krashen (1985) argued that second language learners can only learn if their input is "comprehensible." By this he meant that learning occurs when the meaning of utterances can be inferred from on-going social interaction and mapped to the accompanying words, phrases and grammatical constructions. While this may seem obvious, it has been customary to posit innate knowledge or learning biases as the necessary constraints on induction. Krashen's arguments were necessary in the 1980s to counter the common practice of expecting immigrant children to learn English by sitting in a classroom pitched to their native speaking peers. Although the majority of immigrant children do learn rapidly in English-only immersion programs, these children receive social interaction in English from peers and adults inside and *outside* of the classroom.

Extending these ideas, Long (1996) articulated the interaction hypothesis. Learners infer the meaning of utterances from on-going social interaction, which includes the constraints of the nonlinguistic context and speakers' goals, as mentioned above. Being engaged in a conversation allows speakers to negotiate meaning. Speakers are highly sensitive to communication failures. They actively repair communication problems and learn from paraphrases and restatements made by conversational partners. Active participation has the advantage of allowing the learner to make their own requests for clarification, but observation of peers' communication, where observers can infer speakers' intentions, is also highly valuable for learning (Ellis, 1999).

How would these theorists regard deaf children's learning of English via print? Some theorists might concede that only one domain of language is learned, the aspects of language related to conveying information via print. These

theorists could note that the difficulties deaf learners experience in acquiring English from print is itself evidence for the interaction hypothesis.

To imagine how someone could learn a foreign language from reading, rather than inferring meaning from social context, think of scholars learning ancient Greek. Such learning begins with translation to a well-known language, to obtain a basic vocabulary, then explicit instruction to learn about grammar and vocabulary differences, and finally intensive reading with a dictionary to avoid the mine fields posed by words' polysemy structure and figurative uses.

When discussing deaf readers' problems, we will repeatedly encounter variants on these issues. Chief among them are the benefits of translation to an L1, but also deaf children's difficulties understanding idioms and even common phrases where one word is used in a non-literal manner (e.g., *look over* to mean SKIM, Payne & Quigley, 1987). Consider trying to grasp *give up* (found in even beginning reading books) to mean ACQUIESCE, if one has mapped GIVE to the concept of transferring possession.

The foregoing review suggests reasons to be skeptical that children who have very little access to spoken English will be able to learn English via print. Indeed, this may be why many educators of the deaf have insisted that deaf children be exposed to some form of English before they encounter print (Bornstein, Saulnier, & Miller, 1984; Marschark & Harris, 1996; Mayer & Akamatsu, 1999; Mayer & Wells, 1996; Paul, 1998). These views are described in the next section.

1.2. Options for learning some English prior to print exposure

The dominant view of educators of the deaf is that deaf children don't have to learn English only from print, because they already know some English from speech training (lip reading) and/or exposure to an English-based signing system (Bornstein et al., 1984; Marschark & Harris, 1996; Mayer & Akamatsu, 1999; Mayer & Wells, 1996; Paul, 1998; Wang et al., 2008). For children with a profound (and many with a severe) hearing loss, oral training and lip-reading have a low success rate and it has proven difficult to predict which learners will succeed (Dodd & Campbell, 1987; Harris & Moreno, 2006; Kyle & Harris, 2010; Picou, Ricketts, & Hornsby, 2011). Note that the small number of deaf children who are able to acquire English from speech training will be in a different starting place than the learners we assume in our descriptive model.

English-based signing systems were developed to replace failed oral/aural methods. The majority of deaf children with hearing parents usually begin with an oral training strategy. Those children who do not benefit from oral training may then be moved to a signing strategy (usually an English-based sign system; Moores, 2001). In an English-based sign system, such as Signed English (SE), signers string together separate signs, each corresponding to either a word or a morpheme in English, following English word order (Luetke-Stahlman, 1999). These signs in English word order are presented simultaneously with

spoken English providing the impression that it represents English.

If deaf children could acquire some knowledge of English in a different modality (via signs following the spoken language word order), they would know at least some English grammatical and morphological structure prior to exposure to print (Bornstein et al., 1984; Mayer & Wells, 1996). This reasoning was compelling to deaf educators around the world and many countries developed signed versions of their spoken languages (Signed Dutch, Signed French, Signed Greek, etc.). These are widely employed in school systems; parents are encouraged to use these at home rather than learn a natural sign language (Bornstein et al., 1984; Hamilton, 1983).

The high hopes for manual languages based on spoken languages were not achieved (see Allen, 1986; Israelite, Ewoldt, & Hoffmeister, 1992; Liddell & Johnson, 1992). Although more research on this topic is needed, few deaf children become proficient in non-natural sign systems (Emmorey, 2002; Supalla, 1991, 1992). The main drawback is that gestures of the hands and limbs are only 1/4 as fast as using the vocal apparatus (Hoffmeister, 1996; Supalla, 1991). When each morpheme in a spoken language must be gestured with an individual sign, the result is a lengthy sequence of hand movements that exceeds human short-term memory and processing abilities (Oller, Oller, & Badon, 2010; Supalla, 1991). In contrast, sign languages allow several morphemes to be produced with a single gesture, since motion, hand-shape, and position in the signing space, meaning can be executed simultaneously (Emmorey, 2002; Liddell, 1980; Sandler & Lillo-Martin, 2006; Talmy, 2003).

Another drawback of signing systems based on spoken languages is that deaf children modify the input, rendering it more like natural signed language (Gee & Goodhart, 1988; Hoffmeister, 1996; Singleton, 1989; Singleton et al., 1998; Supalla, 1989). When simultaneously presenting spoken language and SE (and other invented systems), signers frequently omit morphemes for function-words or elide them into the sign, thus obscuring their status as separate morphemes. Modifying the input to make signing more efficient means that learners do not acquire the structure of English, thus defeating the goal behind the design of SE as English in the gestural modality (Hoffmeister, 1996).

2. English as a second language via print: a descriptive model

2.1. Our descriptive and explanatory goals: understanding reading success and failure

Our model describes how deaf children could, in principle, learn English as a second language from only print exposure. We refer to this as a descriptive model because it lists steps deaf children take in obtaining meaning from print and how these can result in satisfactory reading and writing ability.

Our model does not describe an ideal method for teaching deaf children how to learn English or how to read; the

ideal method remains to be elucidated. These are instead the steps that we have observed deaf children following while learning to read, often under non-optimal conditions such as poor signing in the classroom and lesson plans adapted from curricula for hearing children. Indeed, one of our goals is to describe the problems deaf children have in learning to read, and why the journey to literacy is often protracted, with some children making little progress over the course of years (Marschark & Harris, 1996; Trezek, Wang, & Paul, 2009). An example of this is the debate over the difficulty deaf children have with non-literal language, discussed next.

2.1.1. Example: The barrier of words' polysemic variations

Deaf children's difficulty understanding figurative language has been discussed in much the same way in works that span decades (e.g., Iran-Nejad, Ortony, & Rittenhouse, 1981; McAnally, Rose, & Quiqley, 1994; Trezek et al., 2009). Payne and Quigley (1987) examined deaf and hearing children's comprehension of verb particle constructions such as *look over* to mean 'skim' vs. the concrete meaning of looking visually across and above. Compared to hearing children, deaf children's understanding of idiomatic meanings was impaired and showed little variation across age groups. Rittenhouse and Kenyon (1990, p. 323) commented on how "'professional intuition' has led those who teach the deaf to conclude that the use of figurative language does not often come spontaneously for deaf children, as it does for hearing children." The suspicion that deaf children suffer from a specific deficit in metaphorical comprehension was ultimately set aside after it was shown that deaf children could understand idioms with coaching. Rittenhouse and Kenyon (1990) reported that deaf children aged 13–16 (reading level ranged from 2nd grade to 6th grade) were able to learn the meaning of English idioms from watching deaf actors performing skits depicting the idiomatic meanings, with classroom discussion following the skits. Watching the skits led to better learning than simply extending classroom discussion. This is consistent with findings that deaf children's academic performance improves with experiential (and contextual) learning (Quinsland & Van Ginkel, 1990). Deaf children's comprehension of figurative language in English also correlated with their English language skills and general cognitive abilities (see discussion in McAnally et al., 1994).

What is missing in these discussions about deaf children's "strong inclinations to respond literally" (McAnally et al., 1994: 197) is the barrier posed by words' idiomatic variations, when one must learn a language from print. Classroom teachers and parents typically emphasize concrete meanings: *look* means to use the eyes and *over* signals a location. These simple mappings initially assist deaf children in making sense of print words, but soon the simple mapping concept itself becomes the problem. Idioms and verb particle construction like *give in* and *throw up* (VOMIT) are found in books at the very beginning level. Indeed, cognitive linguists claim that even the most basic expressions are metaphorical (Lakoff & Johnson, 1980). Presenting these lexical forms in SE exacerbates the difficulty of appreciating the meaning of these English word combinations.

Deaf children learning sign language naturalistically have little problem with metaphorical extensions, since natural sign languages use these as much (if not more, Talmy, 2003) than do spoken languages. For example, the 3CL hand-shape (three fingers pointing out, palm down) is a classifier used to refer to vehicles, but can also refer to FEET as in rooster or bird feet and can refer to WALK-BY-FEET in upright animals (humans, bears, etc.). This hand-shape is extended metaphorically to mean SELFISH, with the 3CL shape bent to mime an eagle gripping something and not letting go.

What is provocative and worthy of scholarly study is why common English expressions like *take the bus* are acquired seamlessly during naturalistic learning but present a hefty obstacle when deaf children attempt to attach meaning to the individual English words represented via print. We will return to this point later.

2.2. Overview of the model

Our model of how deaf children learn to read is most applicable to profoundly deaf children who have learned a natural sign language from birth. These are deaf children of deaf parents and those hearing parents who learn ASL when their deaf children are young. The model can in principle be extended to those taught using a signing system based on spoken language. For convenience we refer to learners' native language as ASL, and the language of print as English. Nevertheless, our model is intended to be broadly applicable to deaf children growing up wherever a deaf community has a well developed sign language, and where success in school is dependent on reading. Finally, it is worth noting that we will mostly avoid describing what deaf children do with print as 'reading' since that term is so closely associated with mapping graphic forms to oral language (see discussion in Perfetti & Sandak, 2000).

We describe three stages, culminating with proficiency in obtaining meaning from print.

Stage 1: Mapping translation equivalents.

Stage 2: From words to sentences: simple translation breakdown.

Stage 3: Use ASL to learn English via print in a bilingual learning mode.

After presenting the model, we compare it to models and views of the reading process in hearing children reading in a first and a second language.

2.3. Stage 1: Mapping translation equivalents

In the beginning stages of interacting with print, deaf children who have good signing skills will acquire first the print forms that correspond to conceptually simple, frequently used ASL signs and phrases (see Hermans, Knoors, Ormel, & Verhoeven, 2008). Parents typically teach these mappings by signing a word such as CAT or GIRL and then pointing to printed words *cat* and *girl*, as could happen when viewing a child's picture book.

Frequency of occurrence is crucial for successful mapping, but the relevant frequencies are not the frequencies that naturally occur in the spoken environment or even in the written environment. Deaf learners must depend on adults to be in a teaching mode, and to sign and point to a printed word. Thus the frequency of print–sign pairings explicitly provided by adults will be more important than what is available in the environment.

Exceptions to this are illuminating. The visual environment does contain print–form pairings that can be acquired without explicit teaching. In our experience with deaf children in the US, we have observed early acquisition of the print forms for *cereal*, *popcorn*, *candy*, *cookie*, and *potato chip*. Packaging for these desirable foods are visually salient and contain both print words and pictures. We have observed parents providing the sign for these English words while pointing to the words on the packages, thus providing an opportunity for fast mapping of a word–concept pairing. The desirability of these foods for children, combined with the visual accessibility of the print–picture pairings, means that these print forms are acquired earlier than would be expected from their actual English print frequency or their ASL frequency.

Table 1 provides examples of the ASL–English mappings that deaf children acquire, in approximate order of ease of acquisition. We base these estimates of acquisition order on our past observations of deaf children learning to read, combined with our characterization of the underlying constraints on learning these mappings. Prime among these is the translatability of the English forms into ASL.

With increasing exposure to print, learners begin to make more complex mappings as they confront words or sentences which are not easily translatable to ASL. Complex mapping is required when several ASL signs must be assembled to create a meaning similar to an English word or when only one ASL ‘sign’ is needed for understanding an English phrase; an example is *do not know* which in ASL is conveyed using a single ‘sign.’ Note that ‘signs’ can range in size from a single morpheme as in “CAT” to multimorphemic forms as in the sentence HE-GIVE-TO-HER.

In Kuntze’s (2004) studies of deaf children signing while reading, Kuntze observed incorrect interpretations of English polysemies. For the English phrase *look for these*, learners often produced distinct signs for LOOK and FOR, rather than the single ASL sign TO-SEARCH-FOR. This suggests that learners were mapping English words in a one-to-one correspondence mode, and is also an example of the difficulties posed by polysemies found in English verb–particle combinations.

During Stage 1, learners may attend to initial letters more than interior letters. Marlon Kuntze (2004) has observed translation errors such as providing the ASL sign WHITE even though the printed form was *while*. The first author’s deaf daughter claimed that the print words *nuclear*, *nucleus* and *neutral* had the same meaning, which she claimed were all the same as the ASL sign for NEUTRAL. Apart from anecdotal observations of visual errors, surprisingly little is known about deaf children’s early representations of English words. Research is needed on how words and orthography is mentally represented for beginning deaf readers.

Near the end of Stage 2, learners automate the mappings from simple English phrases to ASL phrases. Automating mappings frees up mental resources, allowing more complex learning strategies to be pursued (Birch, 2002; Grabe, 2009). These complex strategies will be necessary to handle the more complex mappings represented in the section of Stage 2 of Table 1.

2.4. Stage 2: From words to sentences: simple translation breakdown

The success of the initial mapping procedure of Stage 1 is illusory because English words cannot be directly mapped to words/signs in any another language or indeed to single nonverbal concepts. The difficulty is that the most frequent words in English are also those with the most idiosyncratic polysemy structure. We have observed learners who did well with simple mappings to ASL become confused by structures like *take the bus* and *run up the bill*. The print word *take* is typically initially mapped to its most concrete sense, meaning gain possession. *Take the bus* to school must thus logically mean to carry a toy bus to school. *Run up the bill* makes no sense; the phrase must actually be *run up the hill*.

We have observed deaf parents functioning as reading mentors for their children at this stage. They can draw on memories of their own struggles to understand the idiosyncratic word combinations and difficult polysemy structure of English and can use ASL to explain the similarities and differences between the two languages (see Stage 3 below). Teachers who are fluent in ASL can also help explain the difficulties of English grammar and polysemy. However, students who do not have good first-language skills will struggle to learn from the abstract discussions that accompany this type of explicit instruction. There is the potential for frustration to set in, with the consequence of loss of interest in learning from print. However, even those growing up in an ASL-rich home with deaf parents report the early stages of learning to read as bewildering. Given the survey question, *Please elaborate on how your attitude toward reading has changed (or not) throughout your life* one deaf doctoral student wrote, *I understand the importance of it, but it was never that much fun for me* (Caldwell-Harris & Hoffmeister, unpublished data).

As they puzzle over English polysemy, at this stage learners are also working to extract the sub-lexical regularities that are part of English orthographic patterns. A third task is noticing (and wondering about) function words and English morphological variations. Grappling with complex mappings affords learners the opportunity to realize that English has unique methods for conveying meaning that need to be learned on their own, not as translations from ASL. Learners who succeed at successfully interpreting some larger word combinations are then in a position to process print in a bilingual learning mode.

2.5. Stage 3: Bilingual learning mode

When deaf learners have been successful in their prior encounters with English print, they are able to profit from Cummins’ (1981) comparative learning process. A bilingual

Table 1
Examples of ASL forms mapped to print expressions, in order of ease of translatability.

Description of what needs to be mapped	English print forms (in italics)	ASL gloss, notes or explanation (ASL forms glossed in all capitals)
<i>Stage 1: Mapping translation equivalents</i>		
ASL single signs mapped to English single print forms	<i>boy, girl, shoe, man, eat</i> (basic level concepts)	ASL single signs
ASL compound signs mapped to English single print forms	<i>brother, sister</i> (basic level concepts)	Compound signs: MALE + SAME means BROTHER
ASL single signs mapped to English phrasal verbs	<i>go in, go away, go out, get down, get out, etc.</i>	English phrasal verbs can map to simple signs for ENTER, LEAVE, ESCAPE, etc.
ASL compound nouns mapped to English compound nouns	<i>high-chair, peanut butter</i> (subordinate level concepts)	BABY + CHAIR; PEANUT + BUTTER
As above, except ASL verb notions are complicated enough to be expressed with independent hands; only one hand is active (marked); considered to be sentence level	<i>Read a book</i>	The hand indicating READ is active, with the fingertips pointing to the eyes and moving up and down, but not touching palm of the other, unmarked hand, which uses a flat hand shape, indicating BOOK
As above, except both hands are active and marked, sentence level	<i>X hit Y</i>	Two handed classifiers; Verb notions expressed through movement with hands moving independently; hands + location convey agent + patient relationship
ASL simple classifier frames mapped to English single word or verb + noun sequences, lexical level	<i>soup</i> (signed as the verb EAT/SPOON + BOWL)	classifier for thick-curved instrument brought repeatedly to the mouth
<i>Stage 2: From words to sentences: simple to complex translation breakdown (examples pose difficulties)</i>		
Mapping from English sentences to ASL classifier frames	<i>X meet Y, X hit Y</i>	MEET, HIT is signed with two classifiers; hands signify agent and patient
English polysemous <i>take</i> can't be mapped to GAIN POSSESSION	<i>X takes the bus to school</i>	X GET INTO VEHICLE, VEHICLE TRANSPORTS (from SOURCE to LOCATION)
English verb particle construction can't be mapped word-for-word	<i>look over, throw up, give in, take over, run up the bill</i>	English phrasal verbs convey concepts at odds with the concrete meaning of the main verb
Passive particle <i>by</i> can't be mapped to NEAR BY in ASL	<i>X hit by Y</i>	The semantic notion of 'by' (near by) is expressed by relationship of both hands represented by classifiers; no explicit marker for "agent" exists in ASL.
English noun <i>car</i> must be mapped to ASL classifier VEHICLE or HANDLING CL ("A"-hand to temple with twist)	<i>Dad drove to meet mom. Mom got into the car and they drove off</i>	DAD DRIVE-BY-CAR MEET MOM. MOM CONTAINER-GET-IN. THEY-TWO GO-AWAY (DRIVE-AWAY).
<i>Stage 3: Use ASL to learn English via print in a bilingual learning model (can now succeed)</i>		
Map ASL phrases to non-dominant senses of English polysemous words	English <i>run</i> has been previously mapped just to ASL verb JOG or RUN-RACE (with handshape L)	<i>Run a factory, run a meeting</i> , now mapped to ASL phrases OPERATE, MANAGE, etc.
ASL simple sign frames mapped to English idioms	<i>kick the bucket, piece of cake</i>	ASL simple sign frames such as DEAD, EASY
ASL complex sign frames mapped to English idioms	<i>get a move on, jog someone's memory, commit something to memory</i>	HURRY + GO, REMIND SOMEONE. MEMORIZE ("A" hand to temple with twist)
ASL frames that draw on grammatical devices for role shift and discourse markers are mapped to English embedded structures	Mental verbs such as <i>think, desire, want</i> are cognitively complex in both languages	ASL embedding and clause markers are indicated by shoulder shift, eyebrows raising and eye gaze signifiers

learning model will enable learners to understand why many words lack translation equivalents. Learners will understand that single words usually do not map to single signs or even simple sign combinations, but that phrases must be mapped to phrases. They can understand that the diverse meanings of English polysemous words are not always related. They will be able to infer the meaning of new words from context. They will readily try to understand print meaning, by bringing in background knowledge, using ASL morphosyntactic knowledge and metalinguistic knowledge, and narrative skills gained from story telling in ASL (Czubek, 2006).

At this stage, deaf learners will be in a position to use reading to improve their English knowledge, just as hearing children do when learning English as a second language (as discussed in the next section, Grabe, 2009; Krashen, 1989, 2004). However, we are not claiming that at this stage deaf children can learn English like any hearing teenager who improves a second or foreign language via

reading. Deaf children continue to be disadvantaged compared to hearing L2 learners because deaf learners lack the option of practicing English outside of reading and writing (with the exception of texting, see below).

In the next section we review how our description of the task facing deaf children compares to L1 reading, L2 learning, and L2 learning from reading. We then present evidence for our model, and discuss how it could be tested and refined.

3. Comparing our model to accounts of L1 and L2 reading

Our model provides no role for English phonology and emphasizes the necessity of learning sign language. It is thus at odds with a view developed by Peter Paul over the last 15 years, which states that deaf children learn to read in a qualitatively similar manner to hearing children

(see reviews in Paul & Lee, 2010; Paul et al., 2009). However, if deaf children have residual hearing and/or can make use of speech via lip reading or cueing techniques, then phonological abilities could become important. We suspect that these deaf children will lie on a continuum between hearing children and deaf children who cannot obtain usable information from speech.

Paul et al. (2009) have argued that phonological abilities in English are necessary for deaf children to develop satisfactory English reading abilities. In criticizing the contrary view of Allen et al. (2009), Paul et al. (2009, p. 346) wrote, “The article by Allen and colleagues struck us in that (a) much of the response does not refer to current theoretical views of reading, and (b) no alternate hypothesis is offered to counter the qualitative-similarity hypothesis...” Our model provides an alternative hypothesis. In the next section, we review current theoretical views of reading, and then situate our model with respect to these views.

3.1. L1 reading

Because L1 readers know the target language, theories emphasize the cognitive processes in manipulating print (Grabe, 2009). These include phonological awareness, matching print to oral vocabulary, and the integration of bottom-up and top-down information. The first two are not relevant to profoundly deaf readers, according to our model. Below we briefly review the evidence on whether deaf children need to have knowledge of English print sounds to be successful readers.

3.1.1. Is knowledge of English sound structure helpful?

The literature on whether English phonology is necessary or helpful for deaf children’s reading is highly contested (e.g., Allen et al., 2009; Locke, 1978; Paul et al., 2009). Correlations between phonological skills and reading ability emerge in some studies but not others (see review in Kyle & Harris, 2010). When correlations are found, their interpretation is ambiguous. Consider a study by Harris and Beech (1998). These authors tested 24 deaf prereaders, aged 4–6, to determine what skills would predict reading ability one year later, after introduction to print. Reading ability correlated with children’s prereading scores on phonological awareness ($r = .43$). However, the highest predictor was speech intelligibility ($r = .57$). This suggests that what facilitated reading wasn’t phonological awareness itself, but being able to acquire knowledge of English, via residual hearing (see also Harris & Moreno, 2006). Consistent with this, in a meta-analysis, Mayberry et al. (2011) found that phonological skills predicted only 11% of the variance in reading ability, but language ability predicted 35% of the variance in reading ability (see also Belanger, Baum, & Mayberry, 2012).

Further illumination on this debate was offered by Kyle and Harris (2010). In their three-year longitudinal study, the relationship between phonological awareness was not apparent until children were older. This provides empirical evidence for a proposal from Goldin-Meadow and Mayberry (2001) and Musselman (2000) that “deaf children’s phonological abilities develop mainly as a consequence of learning to read rather than being a

prerequisite... [T]he relationship between phonological ability and learning to read in deaf children may be fundamentally different from the relationship observed in hearing children...” (Kyle & Harris, p. 240).

3.1.2. The relevance of other aspects of L1 reading

As reviewed above, the emphasis (in L1 models of reading) on phonological awareness and matching print to oral vocabulary is a point of difference with our model. However, the process of integrating bottom-up and top-down information is something all readers need to do. For example, according to the interactive compensatory model (as reviewed in Grabe, 2009), there are many automatic processes, but if any of them are slowed, other processes will compensate to allow comprehension to continue. Similarly, in the verbal efficiency model, efficient word recognition skills free up cognitive resources. A high degree of reading skill means less dependence on context. In the compensatory-encoding model, the comprehension system continually uses compensatory strategies to counter inefficiencies; metacognitive processes are essential (as reviewed in Grabe, 2009).

These ideas can be most readily applied to deaf children’s literacy from the perspective of learners who are acquiring their English knowledge at the same time as engaging with print. We thus conclude that models of L1 reading are not pertinent to the population of deaf readers who have no or minimal English knowledge when they first try to gain information from print.

3.2. L2 reading

Theories about reading in a second language focus on how L2 reading may be hindered or helped by the L1–L2 writing system differences or similarities. The L2 writing system may differ from the L1 writing system in left-to-right directionality, alphabet knowledge, or orthographic depth (Koda, 2007). L2 learners may be struggling with the grammar and vocabulary of their L2. L2 learners may also lack cultural knowledge relevant to reading texts in L2, which hinders the bridging inferences necessary for learning vocabulary from context (Gibbons, 2002).

An umbrella question is whether second language reading should be characterized as a reading problem or a language problem (Carrell, 1991). An early theory, Cummins’ (1979, 1991) interdependence hypothesis, emphasized transfer: language skills and reading skills transfer from the first language, and thus successful L2 reading are crucial. But other theorists argued that in many cases, L2 reading success ends up depending primarily on L2 language skills (Carrell, 1991). The contemporary view is that there is no privileged knowledge source; reading in a second language is difficult enough that individual readers will benefit from recruiting any and all resources. If L1 reading skills and general language skills are strong, then learners can rely on transfer from L1. If L1 linguistic ability is weak, efficient L2 reading can be improved by enhancing both L1 and L2 language skills (Cummins, 1991).

If deaf children who are beginning to learn English via print are regarded as on a continuum with other L2 readers, they are at the extreme end of some continua. They

are at the extreme low end of amount of prior L2 knowledge and amount of prior L1 reading experience (none). They also do not have the option of practicing their language via print outside of reading. For these reasons, deaf learners are mostly unlike children learning to read in a second language.

3.3. Reading for foreign language learners

Once deaf learners have moved beyond the beginning reading stage, they overlap in important respects with hearing teens or adults who are trying to improve their ability in a foreign language via reading.

Being agile in making inferences about vocabulary, grammar and cultural background is the key ability for improving one's language knowledge via reading. However, written context is not as rich or helpful as the context provided during social interaction (Nagy, 1997). Ellis (1999) found that many of the inferences learners made from written context were incorrect. He estimated that successfully guessing from context requires learners to know about 19 out of 20 words in a text. Coady (1997) estimates that learners will need a vocabulary of between 3000 and 5000 words in order to infer the meaning of new words from written text. Furthermore, a single encounter with an unfamiliar word in context seldom reveals more than a fraction of the word's full meaning. These limitations have led many foreign language instructors to favor using a teaching strategy which blends social interaction, learning from reading, and explicit instruction (Ellis, 2005; Hunt & Beglar, 2005).

One relevant insight is that foreign language learners lack the vocabulary and grammatical knowledge to recruit schema-based learning, which facilitates gaining meaning from text (Gibbons, 2002). Those with poor language skills often encounter a "beginners' paradox" in which difficulty guessing words from context discourages reading; this restricts further vocabulary growth (Hunt & Beglar, 2005). This beginners' paradox is a common occurrence with deaf children.

Ideas from the literature on reading in a foreign language are clearly of central importance for understanding deaf children's difficulty in making progress with English print. We will thus continue to mine insights from the literature on foreign language learning, while noting that reading experts do not advocate only (or even primarily) learning a language from texts (Gibbons, 2002). Deaf learners are thus at a disadvantage compared to hearing foreign language learners because they cannot benefit from social interaction (unless a social medium like texting is used).

3.3.1. Drawing on a first language

The literature on reading for language learning emphasizes drawing on L1 resources. McLaughlin et al. (2000) argued that many second and foreign language learners have a unique bilingual reservoir of cross-language skills to draw on when engaged in L2 literacy tasks. The stronger their first language, the better positioned learners will be to use world knowledge and strategic knowledge to obtain meaning from text and learn vocabulary and grammar from context.

Bernhardt (2010) has written about the difficulty that teenagers and adults have when they try to learn from upper-register texts written in their second/foreign language. Scholarly writings and even newspaper editorials include sophisticated morphosyntax, vocabulary and cultural references. Bernhardt advocates that instructors draw on whatever resources learners have from their first language, whether it is actual literacy ability, or an understanding of complex oral narratives. For deaf learners with strong ASL skills, their L1 resources can be their understanding of ASL narrative structures, such as in family story-telling or ASL theatrical performances (Czubek, 2006).

3.3.2. The difficulties of polysemy and idiomatic language

Numerous authors have noted that polysemy is difficult for classroom foreign language learners (e.g., Nagy, 1997). Foreign language learners frequently translate L2 words to L1, which yields the benefit of rapid understanding at the cost of misunderstanding polysemous variations. Classroom learners also learn new words via explicit instruction, which employ overly simplistic definitions, as noted above. Foreign language learners also lack opportunities for correcting wrong mapping by negotiating meaning during conversation. In contrast, learning via social interaction allows the learner to associate common collocations and idioms with specific situations, which then can be recalled and used to guide both production and comprehension on future occasions. Native speakers are often surprised when they reflect on what the components of a frequently used collocation mean individually.

On the plus side, foreign language learners are helped in understanding homonyms, idioms, figurative language, and metaphorical extensions by understanding these phenomena in their L1. Realizing or being told that a word has a different meaning is necessary but not sufficient for learning. We have experienced deaf children not being able to understand that *take the bus* means being transported via bus, even with explicit instruction.

The problems of idiomatic and polysemic variation are clearly compounded for deaf children learning to read English from print because they are young to be learning a foreign language. They may not have a well-developed L1 with which to grasp concepts of homonymy and idiomaticity. Furthermore, polysemic variation stands in direct opposition to the insight that allowed deaf children to first make sense of marks on paper, which is that these marks are not inert things, but stand for specific meanings.

A final reason why words' idiomatic and polysemic variations pose a larger obstacle when learning a language via print is that the spaces between words reifies words. This encourages readers to identify meanings with words, rather than mapping from word sequences to meaningful situations as occurs during naturalistic learning. In Payne and Quiqley's (1987) study using idiomatic verb particle combinations, deaf children had more difficulty with items like *get your toy down from the shelf* than with *get down your toy from the shelf*; presumably because *get down* is easier to conceptualize as a unitary concept; note also that the meaning of this word order has a more direct translation into ASL.

It is worth noting that languages vary in their orthographic conventions. English writes verb particles separately from their roots (*clean up, turn off*), which is not the case for all languages. Deaf children learning Turkish from print may find some mappings easier in highly regular, agglutinative Turkish, for example.

Detailed curricula that improve foreign language learners' understanding of English polysemies and general vocabulary depth now exist (McLaughlin et al., 2000) and can in principle be adapted for deaf learners.

3.3.3. More research needed on "the power of reading"

Grabe (2009), Hunt and Beglar (2005), Ellis (1999, 2005) and other researchers recommend that for efficient L2 reading to develop, learners need extensive exposure to written input. The most vocal theorist on this topic is Krashen (1989, 2003, 2004), who argued in his book *The Power of Reading* that free voluntary reading "may be the most powerful educational tool in language education" (Krashen, 2003, p. 15). With reading for learning and pleasure, readers acquire vocabulary and grammar implicitly, from the passage meanings.

Correlational studies reveal that heavy readers have superior literacy development compared to light readers. Krashen (2004) references Malcolm X and Richard Wright as having made impressive gains in vocabulary by self-selected reading; other case histories have revealed individuals whose growth in literacy and language is attributable to free reading. These examples (and the studies discussed in Krashen, 2004) are consistent with the needs of deaf children to be able to improve their knowledge of English vocabulary and grammar via reading. However, the studies cited by Krashen about improvements from free voluntary reading are from teenagers and adults, not children. Future research could investigate the age ranges at which deaf students, with different language learning histories (e.g., ASL as a first language vs. English-based sign) are able to benefit from sustained voluntary reading.

3.4. Support for our model from the literature on reading in a foreign language

3.4.1. The benefit of a strong first language

The literature on reading in a foreign language provides four reasons why deaf children's ability to gain information from print benefits from a highly developed first language.

1. Learners' first language functions as the symbol system to which English print forms can be mapped.
2. A strong first language gives access to the semantic, cultural and world knowledge necessary for schema-based inferencing, considered a crucial aspect of reading.
3. A strong first language functions as the medium for explicit instruction, considered necessary by L2 experts when L2 learning is restricted to textual materials in the classroom.
4. A strong first language can be used as a model for understanding metalinguistic concepts such as synonymy, polysemy, morphology and grammar (see Nunes, Burman, & Bell, 2009).

3.4.2. Why deaf children stall while learning to read

The literature on L2 reading helps explain why deaf children can become stuck for several years in Stage 2, which we called, "From words to sentences: simple translation breakdown." One of these is the problems that come from narrowly mapping L2 words either to L1 words, or to specific nonverbal concepts (e.g., *take* means to gain possession). The second is the lack of social interaction, meaning reduced rewards from successful communication. Classroom learners report low enjoyment of foreign language class and many say that they remember almost nothing from even years of classroom study (Garton et al., 2011). This is consistent with low interest in reading that educators have long observed in deaf children learning in traditional/typical classroom settings.

4. Evidence for the model

Below we describe the self-report, observational and correlational studies whose findings are broadly consistent with our model.

4.1. Self-reports and studies of successful readers

4.1.1. Learning English from print

Evidence for the broad claim that English is learned as an outcome of reading comes from reports of deaf adults, such as those in Dalby and Letourneau (1991), and parents. For example, Rachel Coleman, wrote about her daughter: "Her first language is American Sign Language. She has learned English as a second language through reading and writing" (Coleman, 2012, p. 36). Deaf professionals including Marie Philip, Gabrielle Jones, Ben Bahan, Marlon Kuntze and others have also discussed with us their experience of learning English via print (see also discussion in Musselman, 2000; Pinar, Dussias, & Milford, 2011; Wilbur, 2000).

We have informally collected self-reports from deaf students enrolled in classes under our supervision that support two key aspects of our model: successful readers benefited from strong ASL skills and from English-learning mentoring by sign-proficient parents. These students recall initially translating print words to their ASL equivalents, and then spending considerable time learning the idiosyncrasies of English grammar and polysemy structure. Many have reported that their English reading comprehension improved with sustained reading over years of practice, continuing into high school and beyond.

4.1.2. Knowledge about spoken language phonology not necessary

Deaf educator Gabrielle Jones (2012) reported that when she learned Chinese and Russian as foreign languages, she skipped aspects of the lessons that focused on sounds and concentrated on learning the meaning of the print forms. Jones noted that deaf adults can often learn to read fluently in a foreign language more quickly than hearing learners. This is because they are able to concentrate on print and do not need to divide their time in

learning both spoken and written forms (see similar report in Friday, 2012).

In her dissertation, Jones (2012) observed deaf students in China learning Chinese from writing. Although their teachers (both hearing and deaf) tried to teach them about the sounds for Chinese words, the deaf children typically ignored this aspect of the lessons. They used their strong visual skills to encode the shape and structure of Chinese characters, and mapped these to meaningful information components. The deaf teachers observed by Jones were more likely than hearing teachers to emphasize morphological characteristics of Chinese characters, rather than characters' phonological radicals. This suggests that the deaf teachers were sensitive to what information in Chinese characters would be most helpful for recovering meaning for their deaf learners.

4.2. Evidence for direct mappings between print words and signs

Hermans et al. (2008) found evidence of print-sign co-activation occurring in deaf Dutch children in the early stages of developing proficiency in reading Dutch (note that their paper includes a model of vocabulary acquisition in deaf children that shares some similarities to ours). This is consistent with mapping print forms to native sign language as proposed in Stage 1 of our model. Indeed, Morford, Wilkinson, Villwock, Piñar, and Kroll (2011) asked deaf adults to judge whether written word pairs were similar in meaning. Judgments were faster when the ASL translation equivalents of the written words used similar hand-shapes. ASL signs thus appear to be activated even for fluent English readers, consistent with related findings that the native language is activated when hearing adults read in their second language, as discussed by Morford et al. (2011). DiPerri (2004) concluded that some deaf children believe that print is a format for writing ASL; this is consistent with Stage 1 (mapping print forms directly to ASL).

4.3. Research on using ASL for explicit instruction of English knowledge

Case studies exist of classroom programs that have used ASL as the language for instructing students in learning English via print (Gibson, Small, & Mason, 1997; Prinz & Strong, 1998). An ASL Models Program where trained deaf adults using ASL were paired with hearing teachers at the Scranton State School for the Deaf was embedded within the school program and lasted seven years until the school closed. Students who participated in the program for more than 5 years made significant gains in their ASL knowledge and in reading scores (Hoffmeister, Greenwald, Czubek, & DiPerri, 2003). Abrams, Weinstock, and Erting (1996) describe a preschool class where deaf and hearing teachers co-teach, using a whole-language approach to build student ASL vocabularies and written English skills. Delana, Gentry, and Andrews (2007) report the success of bilingual-bicultural instruction in east central Texas and consider the challenges of establishing these “bi-bi programs” in areas where no large deaf community exists.

Supalla's Signs of Success has reported enhanced English literacy using ASL as the medium of instruction (Supalla et al., 2001). Supalla and colleagues employ reading instruction based on ASL written graphemes for reasons similar to what we have recounted in the current paper. The Signs of Success program does not use any auditory or sound-based training, but helps learners understand English print visually. In the first stage of this curriculum, illustrations of objects are used together with illustrations of signs. Learners are then taught a writing system using graphemes that represent ASL phonological components (hand-shape, movement, location) to convey ASL sentences in print. In a subsequent stage, learners are exposed to hybrid texts where English print words are written with the ASL graphemes, in ASL word order. In the final stage, the ASL graphemes are replaced with the English gloss for the ASL grapheme combinations. Supalla and colleagues have also developed a dictionary-style resource book. Students can use the ASL graphemes to look up what they intend to communicate, to find the necessary English words. The resource book is organized via hand shapes and movement, making the look-up processes intuitive for ASL signers. Without this type of resource book, students in the typical classroom must ask a teacher for the translation of an ASL phrase.

Luckner et al. (2006) reviewed the literature on what teaching strategies facilitate English literacy and deaf children. Several of the strategies with the largest effect sizes are compatible with our model, such as explicitly teaching vocabulary, providing high interest literature, and teaching students how to translate ASL into written English (also see Akamatsu & Armour, 1987). Cannon, Easterbrooks, and Fredrick (2009) documented increases in print vocabulary recognition following an intervention pairing math expository books with signing of the content via a DVD.

4.4. Correlations between ASL and reading ability

Numerous studies documented correlations between ASL ability and English reading (Fish, Hoffmeister, McVey, & Clinton, 2006; Fish, Hoffmeister, & Thrasher, 2005; Hoffmeister, 1996, 2000). ASL ability is a strong predictor of English reading proficiency regardless of parental deafness or hearing status, with ASL measured using a synonyms/antonyms test and a test of knowledge of rare ASL vocabulary (Fish et al., 2005, 2006). Deaf students who had more cohesive and fluent ASL narratives scored better on tasks of reading and writing (Strong & Prinz, 2000). In a study of deaf children in the Netherlands, knowledge of signed language vocabulary also correlated with print vocabulary (Ormel, Hermans, Knoors, & Verhoeven, 2012). Niederberger (2008) found that fluency in French Sign Language was highly correlated with reading skill.

Mayberry and colleagues compared deaf adults who acquired ASL from birth (native deaf ASL users) with late-deafened individuals who acquired English from birth (acquired a hearing loss later than 5 years of age). These groups had better sign language skills than deaf adults who were born deaf and did not learn to sign until a later age (Boudreault & Mayberry, 2006; Mayberry, 2007; Mayberry & Lock, 2003; Mayberry, Lock, & Kazmi, 2002).

The late learners in the ASL group had both poor ASL and lower English reading ability. Mayberry concluded, “Early acquisition of sign language as the L1 supports later learning of a spoken language as the L2 (in its written form). Likewise, early acquisition of a spoken language as the L1 supports later learning of a sign language as an L2” (Mayberry, 2007, p. 547; see also Cummins, 2006).

4.5. *The superior academic achievement of deaf children born to deaf parents*

Deaf children born to deaf parents typically outperform children born to hearing parents on many academic measures, including reading achievement (Brasel & Quigley, 1977; Israelite et al., 1992; Kampfe & Turecheck, 1987; Moores, 2001). This superior performance is often attributed to the inherent advantage of language acquisition from birth resulting in language fluency prior to entering school (Corina & Singleton, 2009; Gerner de Garcia, 2003). Our model provides a fuller explanation for why English literacy is facilitated by having deaf parents. Simply, deaf parents provide their children with more of the ingredients described in our model. These ingredients include pairing English print words with the equivalent ASL signs, helping with problems in English such as English polysemies, and teaching meaning sets and other ways to move beyond mapping simple translation equivalents. When their children grapple with English in a bilingual learning mode, many deaf parents remember and share examples of problems and solutions they had when they struggled to learn English via print.

But having deaf parents is not necessary for achieving satisfactory English reading ability. In one sample of deaf children age 4–18, multiple regression was used to determine factors predicting reading ability. The association between ASL and reading comprehension was so strong that it statistically eliminated the advantage of having deaf parents (Hoffmeister, Novogrodsky, Caldwell-Harris, Fish, & Benedict, 2013). For this sample, what mattered for reading comprehension was not having deaf parents, but having good ASL skills.

In Kyle and Harris' (2010) longitudinal study (reviewed earlier) three factors predicted higher reading abilities: better levels of hearing, being diagnosed early, and having deaf parents. This suggests that two primary pathways exist for deaf children to learn to read (as has been suggested by Gerner de Garcia, 2003). One is having sufficient hearing (or lip-reading abilities) to learn at least some English before print is encountered. The other is what is conferred by having deaf parents, which includes strong L1 signing skills, which, we propose, facilitates learning English as a second language via print.

5. Testable components of the model

At all 3 of the proposed stages of our model, experimental, observational and retrospective self-report studies are called for. It is imperative to learn more about how deaf learners mentally represent print and whether and how this changes during learning. Our model states that deaf

students are at risk for getting stuck when the lexical mapping strategy is no longer sophisticated enough to handle English grammar and polysemy. How frequent is this? What learner and teaching variables mitigate or exacerbate stagnation in the reading process? The rough rank-ordering in Table 1 can be tested: is rank-order of acquisition of English forms influenced by ASL frequency and transparency of the ASL–English mapping?

We have proposed that strong ASL skills are necessary, but we also noted that the direct mapping strategy quickly becomes an obstacle after initial success. This could suggest to some readers that first mapping from print to a different known language is not helpful. But what are the alternatives? Can children learn that the print form *cat* means the same as the concept CAT if mentors simply point to a picture and a word, without using language to explain the symbolic relationship? Hearing children who do not yet read usually do not spontaneously understand that printed forms refer to concepts, even with pointing, if verbal explanation of a relationship is omitted. However, this remains an empirical question that could be investigated by trying to teach deaf children or non-literate hearing children the meaning of print forms without accompanying language, by miming or using pictures.

Our model proposes that success occurs when deaf learners engage with English in a bilingual mode, by using their L1 to discuss English as an object of study. Research can investigate whether learners do use their L1, and how much mapping occurs to L1 vs. to conceptual structures. Do students benefit from discussions of how ASL and English share some similar word orders in simple sentences and have similar pronominal systems? Do they benefit from using ASL for contrastive language analysis? For example, is it helpful to explain the concept of grammatical exceptions by referring to examples of ASL exceptions?

A testable prediction of our model is that profoundly deaf children in the early stages of learning English do not resemble any other category of learners, but that the distinctiveness of deaf readers diminishes as their proficiency improves. We predict that when deaf readers are reading in a bilingual learning mode (what we have called Stage 3), their reading strategies increasingly resemble hearing foreign language students (as proposed by Charrow & Fletcher, 1974).

5.1. *Can texting ground English in social interaction?*

Theorists consider language learning most likely to occur when learners understand speakers' intentions from the communicative context (Krashen, 1985). Texting via mobile devices can facilitate interaction in real time, thus allowing some of the learning from context that occurs during normal conversation. However, context accompanying texting is still impoverished compared to face-to-face social interaction. This suggests that texting will be most useful for learners who already have basic English language knowledge, as discussed in the section above on learning a foreign language via reading. For those learners, communicating via mobile devices can be a rewarding way to build vocabulary, grammar, and pragmatic understanding. We have already observed deaf teenagers improving

their writing via texting (e.g., RH's deaf daughter). Future work can systematically examine literacy gains from texting.

6. Conclusions

Learning a language in childhood from printed material is difficult but possible with a strong first language and parental and educational support. Deafness per se is not the cause of the average 4th grade reading level, since deaf children who grow up with ASL as a native language achieve an average 8th to 9th grade reading level (Israelite et al., 1992). According to our descriptive model of how deaf children learn to read, they initially map print forms to their ASL meanings, then grapple with nontransparent mappings as they build up their vocabulary, and finally engage with print in a bilingual mode, building their knowledge of English through reading. Our model implies that many more deaf children could become proficient readers if school systems used ASL as the medium of instruction or an innovative system like Supalla's Signs for Success (Supalla et al., 2001) rather than adapting the L1 curriculum used for hearing children (Lane et al., 1996).

The already difficult process of acquiring language from print is compounded greatly for those children who have low or variable sign exposure before arriving at school. Without a strong first language, children will be required to map print words to whatever symbolic structures they have been using to communicate, or to nonlinguistic concepts. It seems plausible that these students would be able to map some print forms to concrete concepts, but that many will stagnate at Stage 2. It would be useful to investigate whether and how often some deaf students can become good readers without a strong L1 (see Mayberry, 2007; Mayberry & Lock, 2003).

Aside from educational and humanitarian concerns (Grosjean, 2001), how and under what circumstances a second language can be learned via print is an important scientific question. Further investigation of this topic has the potential to broaden our understanding of resilience in the human language and reading systems.

References

- Abrams, M., Weinstock, J., & Erting, L. (1996). Surround them with language. *Perspectives in Education & Deafness*, 14, 12–15.
- Akamatsu, C. T., & Armour, V. A. (1987). Developing written literacy in deaf children through analyzing sign language. *American Annals of the Deaf*, 132, 46–52.
- Allen, T. E., Clark, M. D., del Guidice, A., Koo, D., Lieberman, A., Mayberry, R., et al. (2009). Phonology and reading: A response to Wang, Trezek, Luckner, and Paul. *American Annals of the Deaf*, 154, 338–345.
- Allen, T. (1986). Patterns of academic achievement among hearing impaired students: 1974 and 1983. In A. N. Schildroth & M. A. Karchmer (Eds.), *Deaf children in America* (pp. 161–206). San Diego, CA: College-Hill Press.
- Austin, J. L. (1962). *How to do things with words*. Oxford: Clarendon Press.
- Bates, E. (1976). *Language and context: The acquisition of pragmatics*. London: Academic Press.
- Belanger, N. N., Baum, S. R., & Mayberry, R. I. (2012). Reading difficulties in adult deaf readers of French: Phonological codes, not guilty! *Scientific Studies of Reading*, 16, 263–285.
- Bernhardt, E. B. (2010). *Understanding advanced second-language reading*. New York, NY: Routledge.
- Birch, B. (2002). *English L2 reading: Getting to the bottom*. Mahwah, NJ: Lawrence Erlbaum.
- Bornstein, H., Saulnier, K. L., & Miller, R. (1984). *The signed English starter*. Washington, DC: Gallaudet University Press.
- Boudreault, P., & Mayberry, R. I. (2006). Grammatical processing in American Sign Language: Age of first-language acquisition effects in relation to syntactic structure. *Language and Cognitive Processes*, 21, 608–635.
- Brasel, K. E., & Quigley, S. P. (1977). The influence of early language and communication environments on the development of language in deaf children. *Journal of Speech, Language and Hearing Research*, 20, 95–107.
- Cannon, J., Easterbrooks, S., & Fredrick, L. (2009). Vocabulary instruction through books read in ASL in English language learners with hearing loss. *Communication Disorders Quarterly*, 31, 98–112.
- Carrell, P. L. (1991). Second language reading: Reading ability or language proficiency? *Applied Linguistics*, 12, 159–179.
- Charrow, V. R., & Fletcher, J. D. (1974). English as the second language of deaf children. *Developmental Psychology*, 10, 463–470.
- Coady, J. (1997). L2 vocabulary acquisition: A synthesis of research. In J. Coady & T. Huckin (Eds.), *Second language vocabulary acquisition: A rationale for pedagogy* (pp. 225–237). New York: Cambridge University Press.
- Coleman, R. (2012). My two cents: Cochlear implants. In *The endeavor: A publication for families and professionals committed to children who are deaf and hard of hearing, Fall 2012*. Published by the American Society for Deaf Children.
- Corina, D., & Singleton, J. (2009). Developmental social cognitive neuroscience: Insights from deafness. *Child Development*, 80, 952–967.
- Cummins, J. (1979). Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research*, 49, 222–251.
- Cummins, J. (1981). The role of primary language development in promoting educational success for language minority students. In California State Department of Education (Ed.), *Schooling and language minority students: A theoretical framework* (pp. 3–49). Los Angeles: Evaluation, Dissemination and Assessment Center, California State University.
- Cummins, J. (2006). The relationship between American Sign Language proficiency and English academic development: A review of the research. Unpublished manuscript. <<http://www.aslthinktank.com/files/CumminsASL-Eng.pdf>>.
- Cummins, J. (1991). Language development and academic learning. In L. Malave & G. Duquette (Eds.), *Language, culture and cognition* (pp. 161–175). Clevedon: Multilingual Matters.
- Czubek, T. A. (2006). Blue Listerine, parochialism, and ASL literacy. *Journal of Deaf Studies and Deaf Education*, 11, 373–381.
- Dalby, K., & Letourneau, C. (1991). Survey of communication history of deaf adults. Paper presented at the biennial meeting of the Association of Canadian Educators of the Hearing Impaired, Calgary, Alberta.
- Delana, M., Gentry, M., & Andrews, J. (2007). The efficacy of ASL/English bilingual education: Considering public schools. *American Annals of the Deaf*, 152, 73–87.
- DiPerri, K. (2004). ASL phonemic awareness in deaf children. Unpublished doctoral dissertation, Boston University.
- Dodd, B., & Campbell, R. (1987). *Hearing by eye: The psychology of lip-reading*. Mahwah, NJ: Lawrence Erlbaum.
- Dornyei, Z. (2009). *The psychology of second language acquisition*. Oxford, UK: University Press.
- Ellis, R. (1999). *Learning a second language through interaction Amsterdam*. John Benjamins Publishing Company.
- Ellis, R. (2005). Principles of instructed language learning. *System*, 33, 209–224.
- Emmorey, K. (2002). *Language, cognition, and the brain: Insights from Sign Language research*. Mahwah, NJ: Lawrence Erlbaum.
- Fillmore, L. W. (1991). Second-language learning in children: A model of language learning in social context. In E. Bialystok (Ed.), *Language processes in bilingual children*. New York: Cambridge University Press.
- Fish, S., Hoffmeister, R., & Thrasher, M. (2005). Knowledge of rare vocabulary in ASL and its relationship to vocabulary knowledge in English in Deaf children. Presented at the IASCL conference, Berlin.
- Fish, S., Hoffmeister, R., McVey, R., & Clinton, L. (2006). Bilingualism in two modalities: The relationship between L1 vocabulary in ASL and L2 reading abilities in English in Deaf children. In *Proceedings of the 31st annual Boston University conference on language development*. Brookline, MA: Cascadilla Press.
- Friday, L. (2012). Tory's story: Archaeology buff, language lover, and BU's only deaf freshman. Boston University Today. <<http://www.bu.edu/today/2012/torys-story/>> Downloaded 30.04.12.

- Garton, S., Copland, F., & Burns, A. (2011). Investigating global practices in teaching English to young learners. British Council, Aston University Research Archive. <http://www.teachingenglish.org.uk/sites/teacheng/files/B094%20FINAL%20Aston%20University%20A4%20report_2column_V3.pdf> Downloaded 21.05.12.
- Gee, J. P., & Goodhart, W. (1988). American Sign Language and the human biological capacity for language. In M. Strong (Ed.), *Language learning and deafness* (pp. 48–74). New York: Cambridge University Press.
- Gerner de Garcia, B. A. (2003). Acquisition of English literacy by signing deaf children. *Ponto de Vista, Florianopolis* (05), 129–150.
- Gibbons, P. (2002). *Scaffolding language, scaffolding learning: Teaching second language learners in the mainstream classrooms*. Portsmouth, NH: Heinemann.
- Gibson, H., Small, A., & Mason, D. (1997). Deaf bilingual bicultural education. In J. Cummins & D. Corson (Eds.), *Encyclopedia of language and education. Bilingual education* (Vol. 5, pp. 231–240). Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Goldin-Meadow, S., & Mayberry, R. I. (2001). How do profoundly deaf children learn to read? *Learning Disabilities Research & Practice*, 16, 222–229.
- Grabe, W. (2009). *Reading in a second language: Moving from theory to practice*. Cambridge: CUP.
- Grosjean, F. (2001). The right of the deaf child to grow up bilingual. *Sign Language Studies*, 1, 110–114.
- Halliday, M. A. K. (1975). *Learning how to mean*. London: Edward Arnold.
- Hamilton, L. (1983). *The comprehensive signed English dictionary*. Washington, DC: Gallaudet University Press.
- Harris, M., & Beech, J. R. (1998). Implicit phonological awareness and early reading development in prelingually deaf children. *Journal of Deaf Studies and Deaf Education*, 3, 205–216.
- Harris, M., & Moreno, C. (2006). Speech reading and learning to read: A comparison of deaf children with good and poor reading ability. *Journal of Deaf Studies and Deaf Education*, 11, 89–201.
- Hermans, D., Knoors, H., Ormel, L., & Verhoeven, L. (2008). The relationship between the reading and signing skills of deaf children in bilingual education programs. *Journal of Deaf Studies and Deaf Education*, 13, 518–530.
- Hoffmeister, R. (1996). What do deaf kids know about ASL even though they see MCE? In *Proceedings of deaf studies IV* (pp. 273–308). Washington, DC: Gallaudet University Press.
- Hoffmeister, R. (2000). A piece of the puzzle: The relationship between ASL and English literacy in deaf children. In C. Chamberlain, R. Mayberry, & J. Morford (Eds.), *Language acquisition by eye* (pp. 143–163). Mahwah, NJ: Lawrence Erlbaum.
- Hoffmeister, R., Greenwald, J., Czubek, T., & DiPerri, K. (2003). Establishing a dual language program for deaf children: What is needed? *Paper presented at the annual symposium on language & education of the deaf*. Sioux Falls, SD: Communication Services for the Deaf.
- Hoffmeister, R., Novogrodsky, R., Caldwell-Harris, C. L., Fish, S., & Benedict, R. (2013). ASL vocabulary knowledge eliminates the advantage of Deaf parents for English reading comprehension. *Presented at the 38th annual Boston University conference on language development, November 1–3, 2013*.
- Hunt, A., & Beglar, D. (2005). A framework for developing EFL reading vocabulary. *Reading in a Foreign Language*, 17, 23–59. <<http://www.nflrc.hawaii.edu/rfl/april2005/hunt/hunt.html>> Downloaded 20.11.12.
- Iran-Nejad, A., Ortony, A., & Rittenhouse, R. (1981). The comprehension of metaphorical uses of English by deaf children. *Journal of Speech and Hearing Research*, 24, 551–556.
- Israelite, N., Ewoldt, C., & Hoffmeister, R. (1992). *Bilingual-bicultural education for deaf and hard of hearing students*. Toronto, Canada: MGS Publications.
- Johnson, R. E., Liddell, S. K., & Erting, C. J. (1989). *Unlocking the curriculum: Principles for achieving access in deaf education*. Washington, DC: Gallaudet Research Institute.
- Jones, G. (2012). Cross-cultural and cross linguistic analysis of deaf reading practices in China: Case studies using interviews and classroom observations. Unpublished dissertation. University of Illinois, Urbana Champaign.
- Kampfe, C. M., & Turecheck, A. G. (1987). Reading achievement of prelingually deaf students and its relationship to parental method of communication: A review of the literature. *American Annals of the Deaf*, 132, 11–15.
- Koda, K. (2007). Reading and language learning: Crosslinguistic constraints on second language reading development. *Language Learning*, 57, 1–44.
- Krashen, S. (1985). *The input hypothesis: Issues and implications*. New York: Longman.
- Krashen, S. (1989). We acquire vocabulary and spelling by reading: Additional evidence for the input hypothesis. *Modern Language Journal*, 73, 440–464.
- Krashen, S. (2003). *Explorations in language acquisition and use*. Portsmouth, NH: Heinemann.
- Krashen, S. (2004). *The power of reading: A review of research*. Portsmouth, NH: Heinemann.
- Kuntze, M. (1998). Literacy and deaf children: The language question. *Topics in Language Disorders*, 18, 1–15.
- Kuntze, M. (2004). Literacy acquisition and deaf children: A study of the interaction between ASL and written English. Unpublished doctoral dissertation. Stanford University.
- Kyle, F. E., & Harris, M. (2010). Predictors of reading development in deaf children: A 3-year longitudinal study. *Journal of Experimental Child Psychology*, 107, 229–243.
- Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.
- Lane, H. L., Hoffmeister, R., & Bahan, B. J. (1996). *A journey into the deaf-world*. San Diego: DawnSignPress.
- Lee, N., Mikesell, L., Joaquin, A. D. L., Mates, A. W., & Schumann, J. H. (2009). *The interactional instinct: The evolution and acquisition of language*. Oxford: Oxford University Press.
- Liddell, S. K. (1980). *American Sign Language syntax*. The Hague: Mouton.
- Liddell, S. K., & Johnson, R. E. (1992). Towards theoretically sound practices in deaf education. In *Bilingual considerations in the education of deaf students: ASL and English* (pp. 8–34). Washington, DC: Gallaudet University College for Continuing Education.
- Locke, J. L. (1978). Phonemic effects in the silent reading of deaf and hearing children. *Cognition*, 6, 175–187.
- Long, M. H. (1981). Input, interaction and second language acquisition. In H. Winitz (Ed.), *Native language and foreign language acquisition*. *Annals of the New York Academy of Sciences*, 379, 259–78.
- Long, M. H. (1996). The role of the linguistic environment in second language acquisition. In W. C. Ritchie & T. K. Bhatia (Eds.), *Handbook of language acquisition. Second language acquisition* (Vol. 2, pp. 413–468). New York: Academic Press.
- Luckner, J., Sebald, A., Cooney, J., Young, J., & Muir, S. G. (2006). An examination of the evidence-based literacy research in deaf education. *American Annals of the Deaf*, 150, 443–456.
- Luetke-Stahlman, B. (1999). *Language across the curriculum: When students are deaf or hard of hearing*. Hillsboro, OR: Butte.
- Marinova-Todd, S., Bradford Marshall, D., & Snow, C. (2000). Three misconceptions about age and L2 learning. *TESOL Quarterly*, 34, 9–34.
- Marschark, M., & Harris, M. (1996). Success and failure in learning to read: The special case of deaf children. In J. Oakhill & C. Cornoldi (Eds.), *Children's reading comprehension disabilities: Processes and intervention* (pp. 279–300). Mahwah, NJ: Lawrence Erlbaum.
- Mayberry, R. I. (2007). When timing is everything: Age of first-language acquisition effects on second-language learning. *Applied Psycholinguistics*, 28, 537–549.
- Mayberry, R. I., del Giudice, A. A., & Lieberman, A. M. (2011). Reading achievement in relation to phonological coding and awareness in deaf readers: A meta-analysis. *Journal of Deaf Studies and Deaf Education*, 16(2), 164–188.
- Mayberry, R. I., & Lock, E. (2003). Age constraints on first versus second language acquisition: Evidence for linguistic plasticity and epigenesis. *Brain and Language*, 87, 369–384.
- Mayberry, R. I., Lock, E., & Kazmi, H. (2002). Linguistic ability and early language exposure. *Nature*, 417, 38.
- Mayer, C., & Akamatsu, C. (1999). Bilingual-bicultural models of literacy education for deaf students: Considering the claims. *Journal of Deaf Studies and Deaf Education*, 4, 1–8.
- Mayer, C., & Wells, G. (1996). Can the linguistic interdependence theory support a bilingual-bicultural model of literacy education for deaf students? *Journal of Deaf Studies and Deaf Education*, 1, 93–107.
- McAnally, P. L., Rose, S., & Quigley, S. P. (1994). *Language learning practices with deaf children* (2nd ed.). Austin, TX: Pro-Ed.
- McLaughlin, B., August, D., Snow, C. E., Carlo, M., Dressler, C., White, C., et al. (2000). Vocabulary improvement and reading in English language learners: An intervention study. In *Proceedings of a research symposium on high standards in reading for students from diverse language groups*. Washington, DC: U.S. Department of Education.
- Moore, D. F. (2001). *Educating the deaf: Psychology, principles, and practices*. Boston: Houghton-Mifflin.
- Morford, J. P., Wilkinson, E., Villwock, A., Piñar, P., & Kroll, J. F. (2011). When deaf signers read English: Do written words activate their sign translations? *Cognition*, 118, 286–292.

- Musselman, C. (2000). How do children who can't hear read an alphabetic script? A review of the literature on reading and deafness. *Journal of Deaf Studies and Deaf Education*, 5, 9–31.
- Nagy, W. E. (1997). On the role of context in first- and second-language vocabulary learning. In N. Schmitt & M. McCarthy (Eds.), *Vocabulary: Description, acquisition, pedagogy* (pp. 64–83). Cambridge: Cambridge University Press.
- Niederberger, N. (2008). Does the knowledge of a natural sign language facilitate deaf children's learning to read and write? Insights from French Sign Language and written French data. In C. Plaza-Pust & M. L. Esperanza (Eds.), *Sign bilingualism* (pp. 29–50). Philadelphia, PA: John Benjamins Publishing Company.
- Nunes, T., Burman, D., & Bell, D. (2009). Writing a language you can't hear: Profoundly deaf children's representation of morphology in writing. In N. Brunswick (Ed.), *Reading and dyslexia in different orthographies*. New York, NY: Psychology Press.
- Oller, J. W., Jr., Oller, S. D., & Badon, L. C. (2010). *Cases: Introducing communication disorders across the life span*. San Diego, CA: Plural Publishing Inc.
- Ormel, E., Hermans, D., Knoors, H., & Verhoeven, L. (2012). Cross-language effects in visual word recognition: The case of bilingual deaf children. *Bilingualism: Language and Cognition*, 15, 288–303.
- Paradis, M. (2004). *A neurolinguistic theory of bilingualism*. Amsterdam: John Benjamins.
- Paul, P. V. (1998). *Literacy and deafness: The development of reading, writing, and literate thought*. Boston: Allyn and Bacon.
- Paul, P. V., & Lee, C. (2010). The qualitative similarity hypothesis. *American Annals of the Deaf*, 154, 456–462.
- Paul, P. V., Wang, Ye., Trezek, B. J., & Luckner, J. L. (2009). Phonology is necessary, but not sufficient: A rejoinder. *Journal of Deaf Studies and Deaf Education*, 154, 346–356.
- Payne, J.-A., & Quigley, S. (1987). Hearing-impaired children's comprehension of verb–particle combinations. *The Volta Review*, 89(1987), 133–143.
- Perfetti, C. A., & Sandak, R. (2000). Reading optimally builds on spoken language: Implications for deaf literacy. *Journal of Deaf Studies and Deaf Education*, 5, 31–50.
- Picou, E. M., Ricketts, T. A., & Hornsby, B. W. Y. (2011). Visual cues and listening effort: Individual variability. *Journal of Speech, Language and Hearing Research*, 54, 1416–1430.
- Pinar, P., Dussias, P., & Milford, J. (2011). Deaf readers as bilinguals: An examination of deaf readers' print comprehension in light of current advances in bilingualism and second language processing. *Language and Linguistics Compass*, 5, 691–704.
- Prinz, P., & Strong, M. (1998). ASL proficiency and English literacy within a bilingual deaf education model of instruction. *Topics in Language Disorders*, 18, 47–60.
- Quinsland, L. K., & Van Ginkel, A. (1990). Cognitive processing and the development of concepts by deaf students. *American Annals of the Deaf*, 135, 280–284.
- Rittenhouse, R. K., & Kenyon, P. L. (1990). Teaching idiomatic expressions: A comparison of two instructional methods. *American annals of the deaf*, 135, 322–326.
- Sandler, W., & Lillo-Martin, D. (2006). *Sign language and linguistic universals*. New York: Cambridge University Press.
- Schumann, J. H. (1997). *The neurobiology of affect in language*. Malden, MA: Blackwell.
- Singleton, D. (1989). *Language acquisition: The age factor*. Clevedon: Multilingual Matters.
- Singleton, J., Supalla, S., Litchfield, S., & Schley, S. (1998). From sign to word: Considering modality constraints in ASL/English bilingual education. *Topics in Language Disorders*, 18, 16–30.
- Smith, N. V., & Tsimpli, I. M. (1995). *The mind of a savant: Language learning and modularity*. Blackwell.
- Stanovich, K. E. (2000). *Progress in understanding reading: Scientific foundations and new frontiers*. New York: Guilford.
- Strong, M., & Prinz, P. (2000). Is American Sign Language skill related to English literacy? In C. Chamberlain, J. P. Morford, & R. I. Mayberry (Eds.), *Language acquisition by eye* (pp. 131–141). Mahwah, NJ: Lawrence Erlbaum.
- Supalla, T. (1989). *Segmentation of Manually Coded English: Problems in the mapping of English in the visual/gestural mode*. Doctoral dissertation. University of Illinois.
- Supalla, S. (1991). *Manually Coded English: The modality question in signed language development*. In P. Siple & S. Fischer (Eds.), *Theoretical issues in sign language research*. Chicago: University of Chicago Press.
- Supalla, S. (1992). Equality in educational opportunities: The deaf version. In M. Walworth (Ed.), *A free hand: Enfranchising deaf education*. Silver Spring, MD: T.J. Publishers.
- Supalla, S., Wix, T. R., & McKee, C. (2001). Print as a primary source of English for deaf learners. In J. Nichol & T. Langendoen (Eds.), *One mind, two languages: Studies in bilingual language processing*. Oxford: Blackwell.
- Talmy, L. (2003). The representation of spatial structure in spoken and signed language. In K. Emmorey (Ed.), *Perspectives on classifier constructions in sign language*. Mahwah, NJ: Lawrence Erlbaum.
- Tomasello, M. (2003). *Constructing a language*. Harvard University Press.
- Trezek, B. J., Wang, Y., & Paul, P. V. (2009). *Reading and deafness: Theory, research and practice*. Clifton Park, New York: Cengage Learning.
- Vellutino, F., Fletcher, J., Snowling, M., & Scanlon, D. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*, 45, 2–40.
- Vygotsky, L. S. (1978). *Mind and society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.
- Wang, Y., Trezek, B., Luckner, J., & Paul, P. (2008). The role of phonology and phonologically related skills in reading instruction for students who are deaf or hard of hearing. *American Annals of the Deaf*, 153(4), 396–407.
- Wilbur, R. B. (2000). The use of ASL to support the development of English and literacy. *Journal of Deaf Studies and Deaf Education*, 5, 81–104.