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Testing the Development of Linguistic Knowledge in Adult Naïve Learners of American Sign Language

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The present study was designed to investigate the ways in which notions of semantics and phonology are acquired by adult naïve learners of American Sign Language (ASL) when they are first exposed to a set of simple signs. First, a set of ASL signs was tested for nontransparency and a set of signs was selected for subsequent use. Next, a set of semantically related English words and a set of phonologically related English words were generated and paired with each of the signs selected earlier. In the experiment reported here, participants were taught pairs of sign–English word translations. Subsequently, they were then engaged in a translation recognition task in which foils were semantically related, phonologically related, or completely unrelated to the corresponding translations. Interference in performing the recognition task (i.e., the foil conditions) indicated that participants had encoded various features of the sign–word combinations after a single learning session. Results are discussed with regard to bilingual memory representations as well as to ASL acquisition.

THIS STUDY BUILDS ON THE RESEARCH ON the development of various levels of linguistic representation in bilingual memory. Over time, two hypotheses with differing views on the structure and representation of more than one language in memory have been described: a *word association* model and a *concept mediation* model (see Figures 1 and 2). The first model predicts that beginning bilinguals access second-language (L2) words via their first-language (L1) lexicon (Kroll & Stewart, 1994). In contrast, the second model predicts that beginning language learners access concepts corresponding to L2 words and then mediate through the conceptual store to access the L1 translations of the L2 words (as in Altarriba & Mathis, 1997). The *word association* hypothesis assumes that there is a direct link between the L1 and L2 whereby the novice bilingual associates the new L2 word with known L1 vocabulary. Thus, a novice bilingual learns a new word in the L2 by associating it with its L1 translation and then referring to a conceptual store for meaning. Altarriba and Mathis (1997) administered a timed translation recognition task to English monolingual participants who had learned a set of English–Spanish translations within the course of their experiment. When the choice offered for the correct translation pair during a subsequent test phase included an unrelated word, an orthographically or semantically similar word (foils), or the correct word, the slowest response time occurred with the foils. The slower response time indicates that the novice bilinguals associated the new L2 word with the known L1 lexicon in determining the correct choice for the target word. The *concept mediation* hypothesis assumes that there is no direct link to the L1 lexicon, but translation of L2 occurs by accessing a common semantic store that both L1 and L2 lexicons share. Slower response time

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FIGURE 1
Word Association Model (Reproduced from Altarriba, 1990; originally taken from Potter, So, von Eckardt, & Feldman, 1984)

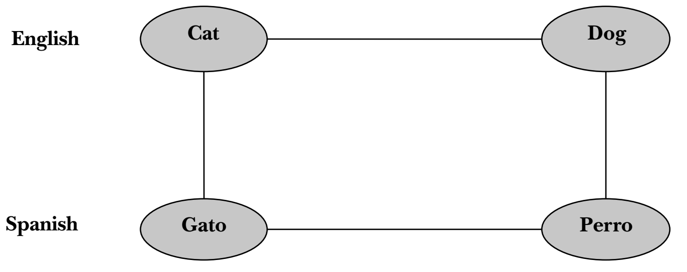
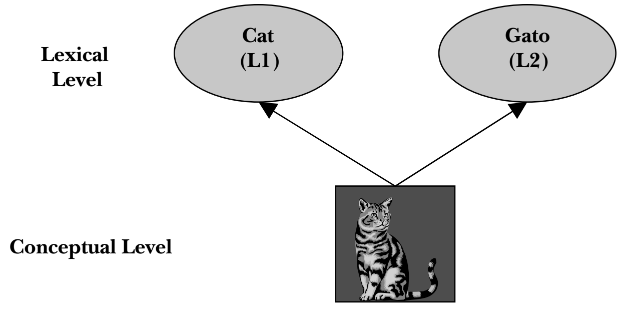


FIGURE 2
Concept Mediation Model (reproduced from Altarriba, 1990; originally taken from Potter et al., 1984)



for semantically similar words, for example, is evidence of this direct access to a conceptual store.

Bilingual research empirically testing theories from second language acquisition (SLA) has not generally included data on adult acquisition of a visual–spatial L2, such as American Sign Language (ASL). No studies to date have tested the acquisition of ASL signs by naïve learners using a timed procedure that captures the implicit learning of those signs, even though a recent review by Rosen (2008) indicates that there is tremendous growth in the study of ASL as a foreign language, particularly among secondary school students in the United States. Further, the experiments that have been carried out to examine various characteristics of the representation of ASL signs did not provide for a context in which the time allotted for the access and retrieval of a newly acquired sign was constrained, indicating the automatic processing of the sign. However, neurobiological research in ASL has confirmed that visual–spatial language processing is essentially the same as oral–aural language processing (Emmorey, 2002; Emmorey et al., 2003; Horwitz et al., 2003). The overall similarities in processing between ASL and spoken English suggest that novice ASL bilinguals may represent the new signs in the L2 via the same mechanism that functions for bilinguals learning a second spoken language.

Therefore, a fundamental question remains open in this area of research study: To what extent are the memory processes involved in learning ASL signs in the context of L2 learning similar to, or different from, those involved in learning an oral–aural language? Are signs processed like words in spoken languages?

The aim of the current study is threefold. First and foremost is the aim to uncover the characteristics of word representation that are acquired when an adult first learns ASL sign vocabulary. Knowing the levels of language representation (e.g., phonological, semantic) that are acquired and how best they can be acquired may inform training methods for learning ASL as an L2. Second, the work is aimed at investigating the representation in memory of newly acquired signs under situations that would promote the automaticity of the access of that information. Using an interference paradigm that will be described later, it was possible to determine whether semantic or phonological information was encoded early in the learning of ASL signs without the possibility of elaborative processes that can be engaged in untimed response tasks. Third, the present work is aimed at testing a hypothesis put forth by Kroll and Stewart (1994) regarding the conceptual or semantic development that occurs when one first learns an L2. More will be said about this final aim in the next section.

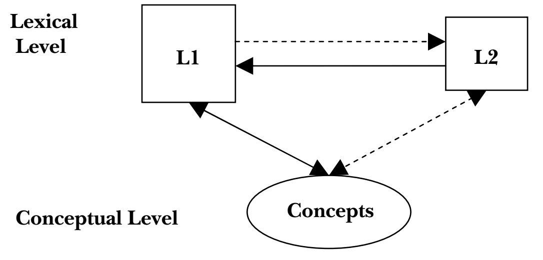
THE CURRENT STUDY

This study investigates a specific part of what adult naïve learners of ASL learn when first exposed to the English equivalents of 28 simple ASL signs. The study investigates only receptive skills and the levels of representation acquired early in learning. The study is not about learning ASL itself; rather, it investigates what automatic mental representations or associations are acquired when adults unfamiliar with a visual language first "learn" the verbal translations of some signs. The theoretical models of bilingual memory representation studied by both Kroll and Stewart (1994) and Altarriba and Mathis (1997) are tested in the current study on the memory of novice students of ASL.

In merging aspects of both the word association model and the concept mediation model of bilingual memory, Kroll and Stewart (1994) proposed a model (i.e., the revised hierarchical model) that describes the asymmetrical links that appear to be present in bilingual language representation as well as a model that accounts for the differences reported in the literature on translation direction (see Figure 3). This model contains mental lexicons for the L1 as well as an L2. The L1 mental lexicon is depicted as larger than that of the L2 because it is assumed that the bilingual would have a larger vocabulary in his or her native language than in the L2. The link between the L1 and concepts appears to be bidirectional and very strong. As a person acquires an L2, especially later in life, L2 words would be integrated into memory by developing a pathway that is attached to the lexicon of the L1 (an idea emerging from the original word association model). Finally, the connection between the L2 and concepts is illustrated as being weak. However, it has been suggested that this link increases in strength as the bilingual becomes more proficient or fluent in his or her L2 (a notion derived from the earlier concept mediation model).

One advantage of the revised hierarchical model is that it accounts for several findings that have been reported in bilingual studies, such as faster translation in the L2–L1 direction, category interference that occurs only during L1–L2 translation (Kroll & Stewart, 1994), and larger priming effects in the L1–L2 direction than in the L2–L1 direction (e.g., Altarriba, 1992; Gollan, Forster, & Frost, 1997). In addition, the model attempts to show how changes in a person's proficiency in the L2 will change the way in which lexical and conceptual information is accessed (i.e., greater proficiency in the L2 allows a greater amount of conceptual information to be available). Although this may be true to some extent, it has been argued that new words in an L2 may not be stored in just the lexicon of the L2 but rather represented as both a lexical and conceptual entry if the words were acquired in an environment in which both form and meaning were emphasized (see Altarriba & Mathis, 1997). Further, it is possible that the conceptual aspect of some words may not be stored in a common conceptual store for both languages, simply because there are some items that may represent language-specific

FIGURE 3
Revised Hierarchical Model (Adapted from Kroll & Stewart, 1994)



Note. L1 = first language; L2 = second language.

concepts and, therefore, direct translations in the opposing language do not exist (Altarriba, 2000).

Altarriba and Mathis (1997) questioned the revised hierarchical model of Kroll and Stewart (1994), which suggests that nonfluent bilinguals rely on lexical association early in SLA and only later on concept mediation. As mentioned earlier, Altarriba and Mathis tested Kroll and Stewart's model with monolingual English speakers who were taught Spanish for the first time. Altarriba and Mathis designed a set of experiments to investigate the acquisition of the link between conceptual memory and the L2, hypothesizing that it could develop as early as the first encounter or first learning session with the new language. Kroll and Stewart had claimed that this link developed over an unspecified length of time and remained relatively weak. Altarriba and Mathis chose a translation recognition paradigm aimed at measuring the interference that would be caused by the presentation of L1–L2 (English–Spanish) pairs that were in some way similar, but not identical, to the true translations. They theorized that individuals would be slower to respond (slower response times [RTs]) to English–Spanish pairs that were either orthographically or semantically similar to the true translations (i.e., foils) that had been acquired during the learning session of their experiment. In the translation recognition task, they indeed found that both monolingual and bilingual participants had slower RTs to the foils. They concluded that orthographic and semantic information is automatically coded early in the process of SLA. In other words, the meanings of words in the new language were represented in the learner's conceptual store as early as the first learning session. Could similar results be found in a "cross-modal" bilingual environment?

Because Altarriba and Mathis's (1997) SLA hypotheses and conclusions are based on experimental data from oral–aural languages, assumptions cannot be made as to whether these hypotheses will function in the acquisition of all L2s, spoken and visual. Therefore, one of the aims of the present study was to investigate what adults naïve to ASL learn when first exposed to signs and their English meanings. The current study hypothesizes that hearing, English-speaking adults learning ASL would also encode semantic, as well as lexical, information early in the learning process. However, as the study's focus was a visual language as the L2 acquired, hypothesizing about orthographically similar words between the two languages had to be altered. Instead, the hypothesis concerned English words that were phonologically similar to the correct translation. Adult students of ASL should have slower RTs when the English words are phonologically similar to the correct translations than when the English words are unrelated to the translations. A semantic condition was also included, as in Altarriba and Mathis.

To test these hypotheses, an experiment was designed that included learning and testing phases. First, participants viewed a videotape of ASL signs and heard the signs' English equivalents. After the participants studied the signs and their translations, we needed to determine if the participants had "learned" the corresponding English words. Second, the participants were tested on their "learning." They viewed the same list of signs and heard an English word from one of the test conditions, paired with each sign. They had to determine whether the word was or was not the English translation they had learned for the sign. It was expected that interference in processing would occur for the foils that were semantically and phonologically similar to the correct translations that the participants had learned in the study phase of the experiment if the participants had indeed accurately encoded the visual, phonological, and semantic referents for each sign.

METHOD

Participants

Undergraduate introductory psychology students ($n = 48$, average age = 19.8) from the University at Albany, State University of New York participated in this experiment for course credit. The participants had normal or corrected-to-normal visual acuity and had no known hearing limitations. When they were asked before the experiment, the participants said they had no knowledge of finger spelling or ASL. Additionally, the participants were also asked about their knowledge of ASL at the conclusion of the experiment. This practice of asking participants about their language background both before and after an experiment has been used previously, as it has been found that, on occasion, the act of performing the experiment brings to mind a forgotten memory of their exposure to ASL or other languages (see, e.g., Altarriba & Mathis, 1997). The participants received partial course credit. At the end of the experiment, a brief language history questionnaire was administered to ensure that they were naïve to ASL. Mean self-ratings on a 10-point scale revealed native fluency in English at 9.3. Percent of the day English was spoken was 92.3. Questionnaire results revealed no exposure to, or knowledge of, ASL or any other signed language (see Appendices A and B).

Materials

Sign Selection. Twenty-eight signs were selected that abided by the following four criteria: (a) simple or monomorphemic, (b) frequently used, (c) visually dissimilar from each another, and (d) not transparent. We relied on two beginning ASL teaching texts and two ASL dictionaries as the source for simple and frequently used signs (Humphries, Padden, & O'Rourke, 1980; Smith, Lentz, & Mikos, 1988; Sternberg, 1994; Stokoe, Casterline, & Croneberg, 1965). We wanted to select a list of signs that were completely distinct from one another in terms of all parameters, including movement, shape, and position. In other words, if two signs varied from each other on a single parameter, we excluded those items from our final list of signs. This ensured that the signs on the list were visually dissimilar. The English translations of signs on the list were all concrete nouns.

A native deaf signer was videotaped signing the list. Videotaping a native signer is the ASL equivalent to having a native English speaker say English words. The signer's mean signing time per word was 1,260 milliseconds. The English speaker's mean time for each word was 534 milliseconds. Therefore, it was determined that a 5,000-millsecond interval between each sign would give participants adequate time to see the sign, hear the English word, and respond as required. A 5-second interval was also the preferred elapsed time between signs in recall and recognition tests in other published works (Bonvillian, Rea, Orlansky, & Slade, 1987; Bower & Karlin, 1974; Cochran, McDonald, & Parault, 1999). There was no sound on the videotape.

Next we needed to be sure the chosen signs were not transparent. Thirty participants with no knowledge of ASL or experience with finger spelling and from the same pool as the subsequent experiment were then asked to guess the English translations for the signs. Two participants correctly guessed two different signs. These signs were eliminated from the list. This ensured that the remaining signs were not transparent—that is, their translations were not easily guessed—and, thus, these signs were used in the ensuing experiment.

Creating Semantic Associates. The English translations for the 28 signs selected were then presented to 30 participants who did not take part in the earlier norming study or in the subsequent experiment. They were asked to write down the first word that came to mind next to each of the English words. All of the words that the participants wrote were tabulated to find the word most frequently associated with the target word on the list. Only exact wording was tallied (i.e., not plurals for singular words or derivations of our words on the list). For example, for "shoe" people wrote "sock" and "socks," which were counted as two different words. Thus, the most frequently reported word for each target word was used as the semantic associate for these items. As the participants were from the same pool as those who would perform the subsequent experiment, these association norms would presumably reflect the knowledge of the participants in the experiment proper.

Design and Apparatus

The experiment required words in four test conditions: (a) the target words (i.e., the English words the participant learned for the videotaped signs); (b) words unrelated to the target words; (c) words semantically related to the target words; and (d) words phonologically related to the target words. The unrelated items were made up of words of approximately the same length and frequency as the signs' English equivalents (Kučera & Francis, 1967). Mean word length and mean word frequency for the words in all four conditions are listed in Table 1. *t*-Tests indicated no significant differences across conditions for either frequency or length (all $ps > .05$). The phonologically related condition was constructed of rhyming words (Fergusson, 1985; *Webster's*, 1987). Sample stimulus items include the following: Targets: apple, cookie; Unrelated: thigh, paddle; Semantic

TABLE 1
Word Length and Frequency Means and Standard Deviation for Four Test Conditions

Condition	Means	*SD*
	Length	
Target	5.08	1.38
Unrelated	5.08	1.38
Semantic	4.71	1.30
Phonological	5.21	1.35
	Frequency	
Target	90.29	117.95
Unrelated	88.75	112.43
Semantic	77.79	81.96
Phonological	83.33	136.50

Foil: pie, sweet; Phonological Foil: chapel, rookie. Thus, the words that corresponded to the target "apple" in each condition included "thigh," "pie," and "chapel." The set can be derived for "cookie" in the same way from the examples provided earlier (see Appendix C for a complete listing of items).

The videotape of the 28 common ASL signs created previously was used in the current experiment. Four signs and four English words, each from a different test condition, were isolated for use during the practice phase. The remaining 24 English words for each condition (i.e., the English translations for the sign, the unrelated words, the semantically related words, and the phonologically related words) were counterbalanced across four experimental lists such that 6 words from each condition appeared only in one list. Each list had a different set of six words from each of the four conditions. To familiarize participants with the test procedure, the four practice signs and words were shown and heard at the start of each test phase. Everyone received the same practice items.

The videotape of the 28 signs was then reordered into four randomly selected orders using Media 100's digital nonlinear editing system. With the GoldWave audio program, the 96 test English words, 24 words in four conditions, plus 8 words used for practice were entered into the computer. The words were cued so that they would be heard after the sign began but before the sign ended. To standardize how the signs were presented to the participant, Liddell's (1984) description of sign phonology was employed. In his description, a sign can begin with either a MOVEMENT (M) or a HOLD (H) at a stationary location. Signs can also end with either an M or an H. For example, the sign for FATHER is HMH. In the sign for FATHER, the first movement to the forehead is not relevant to sign formation. In the sign, the first and last contacts of the thumb on the forehead are HOLDS, with the intervening MOVEMENT. (Note that another sign form for FATHER is the thumb contact HOLD on the forehead without MOVEMENT but with other fingers wiggling.) While seeing FATHER on videotape, the participant heard the English word "father" after the initial H but before the M. The participant heard the English word as the signer's palm began traveling toward her face. The English word was completed before the signer's thumb came to rest on her forehead. Hearing the English translation at the same moment in each sign's articulation was crucial for accurately recording RT. Therefore, the words were cued to be heard just after the initial M or H, as the signer was transitioning to the following H or M of the sign.

A program developed using SuperLab Pro software was used to record elapsed time between the onset of the English word and the participant's response. The signs for the experiment were presented on a video monitor, and the words were heard over speakers on either side of the monitor and linked to a laptop computer.

Procedure

All participants were assigned a random number and were tested individually. The first phase of the experiment in which the participants studied the signs and their English translations was the acquisition phase. Participants were seated in front of the video monitor to watch 28 signs one by one and hear their English translations. They were asked to try their best to learn the English translations for the 28 ASL signs. Within the same 5-second interval for each sign, the participants heard the sign's English translation twice. The videotape was repeated twice in the same order, so the participants saw the signs twice and heard the English translations four times. Then the participants were asked to check what they had learned by viewing the same 28 signs, without translations, in a different order and saying aloud the English word they remembered for the sign. At the end of the viewing without the audio, we read aloud the errors and omissions the participants had made in naming the English translations and provided the accurate sign and spoken translation for items the participants had missed. Then the participants viewed the list of 28 signs again but in a different order. The English words and their corresponding signs were repeated once again. This study test process was repeated in full, until the participants reached 100% accuracy. When the participants named the translations for the signs 100% correctly, they went on to the testing phase of the experiment. To limit the duration of the experiment, participants were excused from the experiment if they did not reach 100% accuracy after half an hour of study. On this basis, 3 individuals were excluded from finishing the experiment and 3 new participants were added to maintain the group number at 48.

Following the acquisition phase, the participants were given a 3-minute intervening task, which included counting backward by 4s from 534. This task diverted the participants from thinking about the acquisition phase and actively engaging in rehearsal. The 3 minutes also allowed us to set up the computer for the test phase.

The second phase of the experiment, in which the participants decided if the word they heard was the translation they had learned for the sign, was the testing phase. On the monitor, the participants saw each of the 28 signs again in yet a different order paired with hearing an English word. (Four of those signs formed the practice trials that were then followed by the remaining 24 signs divided equally among the following four conditions: correct target, semantically related, phonologically related, and unrelated.) Each participant viewed a single experimental list in random order. The participants were told to press a designated "yes" or "no" key on the laptop keypad indicating whether the word they heard was or was not the word they had learned for the sign on the video monitor. They were to make their decisions as quickly and as accurately as possible. The participants were given 1,500 milliseconds to respond. At the beginning of the test phase, four signs each with an English word were presented as practice trials to familiarize the participants with the test procedure. Then the actual test proceeded.

As mentioned earlier, at the end of the experiment, the participants were asked four questions about sign recognition (see Appendix B) and answered a brief language history questionnaire. None of the participants was found to have had prior experience with ASL or any other signed language.

RESULTS

For each participant, mean response times and standard deviations (*SD*s) were computed for the four conditions (true target, semantic, phonological, and unrelated). After computing *SD*s for each participant's RT in each condition, we found no RTs, or outliers, that exceeded 2.5 *SD*s above or below the mean for each condition. All participants' RTs were included in our analysis. Mean RTs, *SD*s, and error rates for the four test conditions (correct translation, unrelated, semantic, and phonological) for all participants are listed in Table 2. Only data for correct responses were included. An analysis of variance (ANOVA) indicated that the four conditions differed significantly from one another, with $F(3,45) = 27.708$, $MS = 8.620$, $p < .001$. Planned comparisons (Bonferroni corrections were applied) showed that RTs for the semantic and the phonological conditions were virtually the same, with $t(47) = -0.220$, $p >$ .05. However, the RTs for the semantic and phonological conditions compared to the unrelated condition were significantly slower, indicated by $t(47) = 2.363$, $p < .05$ (Cohen's $d = 0.48$) and $t(47) = 2.753$, $p < .01$ (Cohen's $d = 0.56$), respectively. Semantically related foils produced an interference effect suggesting that novices in ASL had formed a conceptual link to the ASL signs. Phonologically related foils produced a slightly larger interference effect, indicating that the participants had learned to associate the newly acquired signs and their phonological representations in English.

TABLE 2
Mean Response Times (Milliseconds), Standard Deviations, and Error Rates (Percentages) for All Test Conditions ($n = 48$)

Condition	RT	*SD*	ER
Target	968	334	1.04
Unrelated	1,127	364	0.69
Semantic	1,195	431	2.08
Phonological	1,202	417	11.81

Note. ER = error rate; RT = response time.

Error data were examined to see if the higher rate of errors in the phonological condition was significantly different from other conditions (see Table 2). An ANOVA indicated that there was a significant difference in error rates across the four conditions, with $F(3,45) = 27.708$, $MS = 4.852$; $p < .001$. Planned comparisons (Bonferroni corrections were applied) revealed that the error rate for the target condition differed significantly from the phonological condition, with $t(47) = -5.698$, $p < .001$ (Cohen's $d = 1.16$). In addition, the error rate for the unrelated condition was significantly different from the phonological condition, with $t(47) = -6.132$, $p <. 0001$ (Cohen's $d = 1.77$). Finally, the error rate for the semantic condition was also significantly different from the phonological condition, with $t(47) = -5.695$, $p < .001$ (Cohen's $d = 1.16$). Appendix D includes a listing of individual items and their corresponding error rates. Note that although only one item in the semantic category produced a significant error rate (i.e., "kids"), several items contributed to the large error rate in the phonological condition. In this later condition, most prominent were the items "fair," "bother," and "fig," corresponding to "bear," "father," and "pig," respectively. Clearly, these kinds of errors of substitution stem from the similarity across items in terms of initial phonemes; thus, as in most situations, whenever manner/place of articulation overlaps across lexical items, errors of recognition and identification are more likely to occur. More will be said later in terms of the implications of these kinds of errors for lexical representation and processing in general.

GENERAL DISCUSSION

The experiments described here were designed to follow the approach of Altarriba and Mathis's (1997) experiments in SLA. When Altarriba and Mathis tested English-speaking monolinguals who had just acquired a set of words in an L2 (Spanish), they found that these participants had encoded both semantic and orthographic aspects of the new words and were able to access this new information when responding to a translation recognition task. Because an interference effect occurred for both conditions, it appeared that monolinguals formed a direct link with lexical and conceptual levels of representation when first learning an L2. In the current study, the results of the experiment on acquiring the ASL signs confirmed that L2 (ASL) conceptual processing (as well as phonological processing of the English translation equivalents) is involved very early in the language acquisition process. Both semantic and phonological interference effects were reported within the current study. It can be assumed, then, that the processes involved in acquiring an L2 as described by Altarriba and Mathis also come into play for adult novices learning a visual language as the L2. Moreover, as reported by Altarriba and Mathis, the current work also indicates that the revised hierarchical model proposed by Kroll and Stewart (1994) should be modified to indicate that conceptual/semantic information can be acquired in the earliest stages of L2 learning. In other words, even after a single learning session, individuals can acquire the knowledge of the meaning of newly learned L2 words—a link that had been purported to take more time to develop, as per the revised hierarchical model.

In relation to the above issues of acquisition and development, note that all of the participants in the current study had been exposed to an L2 at some point in their lives (either from birth or through schooling in later years; see Appendix A). Thus, it appears that for the current participants, the acquisition of concepts via sign constituted a kind of "third-language" exposure, although it was not a verbal language, as were their L1s and L2s. Given the briefness of the questionnaire that was used, it is difficult to assess the degree to which the present participants were fluent in their L2 compared to their L1. Thus, although all participants had been exposed to an L2 at some point in their lives, their relative fluency in that language is likely to have varied considerably and is not currently known. Future investigations of the acquisition of ASL signs should examine the extent to which individuals who are exposed to an L2 and who consider themselves truly "bilingual" or "fluent/proficient" in their L2 show different patterns of translation recognition for newly acquired signs. Mode or context of learning and acquisition should also be taken into account in further investigations. Thus, participants' bilingualism may be examined as a variable of interest in future studies of sign acquisition, as this question was not a focus of the current investigation.

The present study provided evidence that conceptual and phonological interference occurs in learning the meanings of ASL signs—a finding similar to that reported for the acquisition of words of a second, spoken language (see, e.g., Altarriba & Mathis, 1997; van Hell & Mahn, 1997). Previous ASL research evidence points to the parallel functioning of visual–spatial and oral–aural languages. For example, signs that look different from one another are identified more quickly than those that look similar to one another. This mimics the *phonological similarity effect* that occurs in spoken languages (see also Emmorey, 2002). In addition, Liddell (1984) illustrated how signs have beginnings, middles, and ends similar to the segments of spoken words, onsets, medial phases, and offsets.

An interesting finding in the current set of results is that the error rates were significantly higher in the phonological condition, as compared to other conditions within the experiment; that is, many more confusion errors occurred when foils were phonologically similar to the true translation. Given that the test pairs in the current case were comprised of a spoken word and a word that was signed, the implication is that the participants accessed the phonological representations of the signed words to the extent that those representations interfered with their ability to reject the incorrect pairing. Theoretically, these data suggest that individuals accessed phonology when not specifically directed to do so in the context of the current study. Phonology was encoded in an implicit manner, as part of the learning of signs, overall. Thus, as current models of bilingual representation have suggested (see, e.g., BIA and BIA+ in Dijkstra & van Heuven, 1998), phonology is often retrieved in the process of understanding newly acquired concepts in an L2—even if it is a signed language. Further, the current data underscore the basic finding in the literature that many auditory confusion errors are derived from words that have phonological overlap and share either place of articulation or manner of articulation, or both. The fact that these phonological representations in the current study stem from the recognition of a signed word is interesting evidence to suggest that phonological confusion errors are not modality-specific (see also Engle, Cantor, & Turner, 1989, for a related discussion).

Although the current study examined translation recognition for newly acquired signs and their English translations, the participants performed a learning task that by its very nature emphasized the phonological and semantic aspects of the association between the English word and its corresponding sign. Although the participants developed these new representations such that they achieved 100% accuracy on a test of their knowledge, it is unclear to what extent different participants might have engaged in their own strategies in learning the signs of interest. Clearly, the possibility that the participants engaged in their own mnemonic strategies to shape their mental representations for the signs and their English counterparts may have affected the way in which this knowledge was learned and encoded for each participant. Future examinations of the acquisition of signs should vary instructions so as to either document the means by which participants actively learn signs or provide concrete instructions as to the types of strategies that should be used (e.g., imagery, context availability) so as to investigate the influence of learning strategy on the ultimate representation of new signs.[1] Moreover, it is important to note here that although the current work focused on the learning of ASL signs, the learning of language, in general, encompasses many more elements that bring together aspects of reasoning, pragmatic usage, contextual influences, and the like (see, e.g., Larsen-Freeman, 2003; van Lier, 2004). Thus, language development is a highly dynamic process, and future work may focus on the acquisition of ASL signs in broader contexts of language, incorporating a more ecological approach to acquisition.

In a related vein, neurological investigations into the hemispheric involvement of imageable concrete signs in ASL, as distinct from abstract lexical forms, continue to raise questions about the different roles imagery may play in ASL and English (Emmorey & Corina, 1993). Most recently, neurobiological evidence also indicates that both signed and spoken languages are generally localized in the same area in the left hemisphere (Corina, Vaid, & Bellugi, 1992; Damasio & Damasio, 2000; Emmorey et al., 2003; Horwitz et al., 2003).

Notwithstanding the linguistic and neurobiological parallels between ASL and the spoken languages of the world, we recognize that the visual modality makes a distinct difference in L2 learning. The current study kept the learning challenge of ASL to a bare minimum (i.e., acquiring the English words for 28 simple signs). Nothing about sign perception was investigated. Clearly, the greater part of understanding how sign-naïve adults learn ASL has to include working memory experiments on what the adult learner processes (i.e., sees, stores, attends to, recalls, etc.) in the visual modality (see, e.g., Wilson & Emmorey, 2003). Experiments on reproducing ASL signs are recommended, as well as experiments with ASL units longer than primarily single monomorphemic signs.

When we analyzed the ways the participants remembered the English meanings during the study phase of the present experiment, another potential area of research became clear. Although the participants studied the English meanings for the signs in the learning part of the experiment, we informally noted evident mnemonics used by two participants, each for a single word. For example, one participant said "father-head" while hearing the word "father" and viewing FATHER, in which the thumb of the open hand shape touches the forehead. Another participant during the study said "funny-nose" when seeing CLOWN, which is made by cupping the nose with one hand. Future experiments on systematically including mnemonics in the study phase might offer insight into another method for teaching ASL as an L2.

The concept mediation model, explained in Altarriba and Mathis's (1997) experiments and in the current study, supports the practice of teaching SLA using contextual units that emphasize the semantic or conceptual representation of a newly acquired word. Many beginning ASL texts already emphasize contextual learning (see, e.g., Smith et al., 1988). Thus, assuming that the acquisition of words in aural and visual languages is similar, researchers can focus on how the visual modality is mentally represented by hearing adults learning a signed language. What is most important to keep in mind is that bilingual research should include oral–aural as well as visual–spatial languages, and as the experiment in this study shows, the concept mediation hypothesis (as well as the modifications of the revised hierarchical model as posed by Altarriba and Mathis) applies to signed as well as to spoken language.

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NOTE

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APPENDIX A

Responses to Language History Questionnaire ($n = 48$)

Mean age in years	19.8
Mean self-rating (10-point scale: 1 = very little; 10 = native-like) on overall English fluency	9.3
Percentage of day English was typically spoken	92.3
Percentage of participants who had been exposed to an L2 other than English from birth (countries of origin included Dominican Republic, India, Iran, Pakistan, and Puerto Rico)	23
Percentage of participants who had been exposed to an L2 other than English later in life, primarily at school (languages included Spanish, Arabic, Hindi, and Farsi but NOT American Sign Language or another signed language)	77

APPENDIX B

Posttest Interview Questions

1. Did you recognize any signs? What signs?
2. Did any of the signs look like the English meanings after you learned them? Which?
3. Did you see any letters in the signs? Explain.
4. Did you notice any relationship between the words you heard on the test and the words you learned for the signs? Explain.

APPENDIX C
Items Included in Experimental Test Conditions

Target	Unrelated	Semantic	Phonological
animal	signal	dog	minimal
apple	thigh	pie	chapel
bathroom	ceremony	toilet	classroom
bear	spot	hug	fair
children	interest	kids	nation
clown	chick	circus	crown
cookie	paddle	sweet	rookie
farm	game	cow	charm
father	ground	mother	bother
girl	land	boy	curl
gold	hero	silver	mold
king	rose	queen	thing
ice	guy	cold	price
liquor	muscle	drink	vicar
machine	station	car	cuisine
meat	ring	steak	street
mirror	butter	image	hearer
movie	fence	theater	navy
penny	beard	copper	jenny
pig	bum	pink	fig
rock	file	hard	lock
school	number	teacher	pool
shoe	bush	socks	few
train	watch	track	brain

APPENDIX D
Error Rates (Percentages) for Individual Items per Target Condition*

Target Condition	
Bear	0.520
Rock	0.520
Unrelated Condition	
Chick	0.345
Hero	0.345
Semantic Condition	
Kids	2.08
Phonological Condition	
Fair	4.23
Bother	3.31
Fig	1.88
Crown	0.479
Nation	0.479
Hearer	0.479
Classroom	0.479
Vicar	0.479

Note. *Items that are not included above were responded to accurately 100% of the time.