



Word Learning in Two Modalities

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Abstract

The analysis of accuracy revealed a significant interaction between presentation modality and meaning modality. Accuracy in the nonword-picture condition was at ceiling and thus, significantly greater than accuracy in the nonword-definition condition and nonsign-picture condition. Analysis of response times found the main effect of meaning format to be statistically significant. Participants were significantly slower when meaning was presented as a definition compared to when it was presented as a picture. These results suggest that meaning associations with novel signs are learned equally fast and accurate as those associated with novel words. Additionally, they suggest that people recall imageable meanings faster than definitions. Finally, results also indicate that typically functioning adults maintain a robust ability for learning word-picture associations likely developed in childhood.

Key Words: word learning, signs, sign language

Introduction

People continue to learn new words throughout life. Children recognize about 10,000 words at age five (Law, Mahr, Schneeberg, & Edwards, 2017). By the time they are twenty, they will know about 42,000 words (Brysbaert, Stevens, Mandera, and Keuleers, 2016). Early in life words are learned from exposure, and where available, from picture books. Later, words may be learned incidentally, by inferring meaning from a conversation or within a text, or by specifically studying the word with its definition for a class. However, a majority of research on language development has focused on the acquisition of spoken words, but there has been limited research investigating the acquisition of signed words especially in adults. In fact, most studies examining the acquisition of American Sign Language (ASL) have focused on grammar, despite the potential difficulties associated with words encoded with hand-shape, hand-movement, and hand location, rather than sound sequences (Quinto-Pozos, 2011). Word learning is not only learning a symbol, (i.e., the sound sequence or sign); the meaning must also be acquired. Despite the fact that most meanings are learned as definitions, it is unknown whether meanings are learned faster when they are presented as words or pictures, such as those in the picture books of young

children. These gaps in the literature are surprising considering the popularity of ASL as a foreign language option in high schools and universities around the country (Quinto-Pozos, 2011). The current study is a first step toward addressing these gaps.

Iconic and Symbolic Gestures/Signing

Signs vary in how directly their meaning can be determined by their shape and movement and include both iconic gestures and symbolic gestures. Iconic signs convey semantic information through handshapes or motions that are directly related to the intended meaning (McNeill, 2001). Specific examples of iconic signs within ASL include the sign for “eat” and “drink” because these signs mimic the literal actions of eating and drinking. For example, the ASL sign for eating is a pinched handshape, with fore-fingers touching the thumb of the same hand, bringing this pinched handshape to one’s mouth. The sign for drinking in ASL is a C-handshape, mimicking a cup being brought to the mouth and tipped backwards.

In contrast, symbolic signs have an arbitrary relationship with the intended meaning. For example, the sign “more” is symbolic and can be described as a pinched handshape, with four fingers touching the thumb of the same hand, on both hands, then bringing the hands together by tapping fingers. In fact, the signs for eat, drink, and more are among the most commonly used by parents teaching their infants ASL (Kirk, Howlett, Pine, & Fletcher, 2012). The current study focuses exclusively on symbolic signs.

ASL as a Second Language

A majority of research on adults learning American Sign Language (ASL) is focused on the acquisition of the grammar, rather than the lexicon. This is a relevant issue because there has been a growth in acceptance of ASL as a foreign language course across the United States, leading to a substantial increase in high school and college students taking ASL courses (Quinto-Pozos, 2011). With this increase in adults learning ASL, there needs to be an increased understanding of ASL vocabulary acquisition. However, sign language cannot be learned and taught in the same ways as oral second languages.

Second language acquisition in spoken language differs from second language acquisition in visual languages. In typical introductory books for spoken languages, a word or concept is taught by providing the word written in the second language, next to the word in the first language, followed by the meaning of the word (second language → first language). This is the case for textbooks teaching spoken languages such as Spanish, French, and Russian (Anderson &

Dolidon, 2020; Newell, et al., 2010; Zubakhin, 2019). More clearly, learning a second language as an adult typically consists of memorizing written word translations from the first language into the second language. This learning process is not applicable to American Sign Language. Since ASL is an exclusively visual language with no written form, in order to teach signs, words and concepts are presented in written English accompanied by the motions of the sign presented through one or more pictures (Newell, et al., 2010). This is clearly not ideal. Therefore, the best way to study word learning in a signed language may be through the use of videos, as in the current study.

Quinto-Pozos (2011) explains the importance of videos for learning sign language. He points out that, in recent years, due the advanced development of technology, ASL learners have benefited substantially from the use of high-quality recorded videos because they allow learners to review signs in motion to master learning. Furthermore, this researcher asserts that linguistic similarities and differences of visual and spoken languages may potentially impact pedagogy (Quinto-Pozos, 2011). For example, there is little to no research focusing on whether hearing adults attempting to learn sign language are presented with unique challenges due to having to master a manual phonological system that uses hand shapes, movements, and signing space (Quinto-Pozos, 2011). This current research attempts to bridge gaps in this area through comparing the impact of using visual (manual) signs versus sound to represent words on the learning of associated meanings in typically functioning adults.

Learning Meanings

When contrasting introductory language books for children with ones intended for adults, there is a fundamental difference in the way in which meaning is presented. In language learning books for children, simplistic images are typically used to represent the meaning of the word (American Education Publishing, 2009) In fact, children 12-24 months of age can point and label pictures independently (Lanza & Flahive, 2012). Further, research in children with disabilities suggests that learning word picture associations are easily acquired in children and the ability evidently persists into early childhood (Capone & McGregor, 2005; Ganz et al., 2015; Özçalışkan et al., 2017). However, in introductory language books for teens and adults, written definitions of words are typical (Humbach, 2007). In fact, Brown & Thiesson (2018) point out that pictures are used to represent meaning exclusively when teaching children who are just developing language or adults with language deficits like aphasia. It is unknown whether this

early skill of learning word meaning from pictures remains intact in adults, given their many years of learning word meanings through definitions. The current study attempts to determine whether the modality in which meaning is presented has an impact on learning the associated word. This topic is specifically relevant to second language acquisition in typically functioning adults, as results may help maximize the language learning potential of these adults, who are characterized as being past the critical period of language that is associated with early childhood.

The current study investigates word learning by breaking down the fundamentals of word learning tasks into two issues: (1) the role of modality of communication (oral versus signed words) and (2) modality of presentation of semantic information (words versus pictures) in word learning tasks. This study examines both accuracy and speed of recall of newly learned pairings words and meanings.

Method

Twenty-five English-speaking individuals who had been speaking English from at least age 5, who were unfamiliar with any signed language, and had no diagnosed learning impairment or cognitive disability participated in this study. Bilingual individuals were not excluded in this study. Participants were college students recruited from the University of Florida research participant pool, who had no exposure to any sign language training. Participants volunteered to participate, self-reported their eligibility for the study, and received no monetary compensation.

This experiment included 28 sets of stimuli, equally divided between novel and archaic tools as well as novel and archaic animals.



Novel and archaic tool



Novel and archaic animal

Figure 1. Example pictures of an archaic tool and an unusual animal or plant.

Each stimulus set consisted of an auditory nonword, a novel sign (nonsign, that is, not a real sign in ASL), a short-written definition, and a picture. Each participant saw an item from each of

the 28 stimulus sets, which were divided into four subsets of 7 stimuli (3-4 animals and 3-4 tools) each. The four subsets were counterbalanced across four presentation conditions: nonword + written definition, nonword + picture, nonsign + written definition, nonsign + picture. Thus, there were 24 lists. The nonwords had one syllable and had no more than two consonant sounds before and after the vowel (e.g., stonk, brank, sote). The purpose of this phonological shape was simplicity and homogeneity. Nonsigns were designed to follow this same format. Both nonwords and nonsigns were repeated twice in short videos. Videos of nonwords and nonsigns were of similar lengths (about 1200 ms.). Definitions were comprised of 5-8 words with 1-2 adjectives before a noun and a prepositional phrase following the noun (e.g., a white, furry animal with long, red ears; a long flat tool for removing wallpaper). Pictures illustrated the entities described in the definitions. Pictures were visually complex and required similar scanning to the written definition stimuli.

Procedure

The experiment was presented on a touch screen monitor. Stimuli and assessments were presented using Direct-RT and MediaLab (Jarvis, 2012). Each block consisted of three training epochs during which the 7 stimuli in a condition were randomly presented for a total of 21 training trials, followed by a multiple-choice test. Each training trial had four steps: 1) 500 ms fixation, 2) The video of nonword being spoken twice or a nonsign being performed twice (1200 ms), 3) A short spacer (250 ms), and 4) The definition or picture presented statically for 3000 ms.

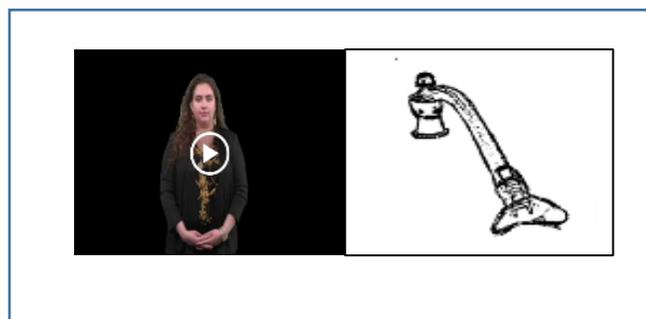


Figure 2. Sample training trial

Following all 21 trials in a block, a multiple-choice test assessed learning. This multiple-choice test was structured similarly to a training trial for the first three steps, but in step 4 a two by two grid appeared on the screen containing either four short definitions or four

pictures, depending on the block, as shown in figure 3.

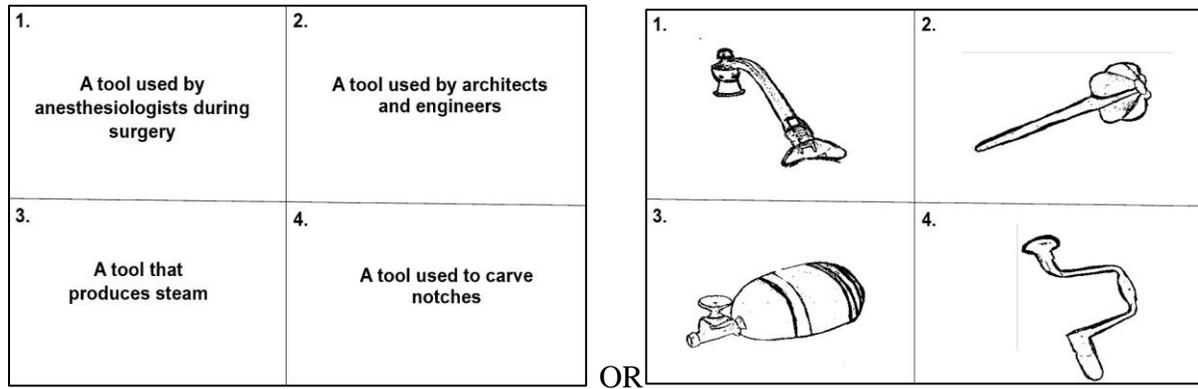


Figure 3. Sample of multiple choice stimuli for assessing learning when meanings were presented as definitions or pictures.

Participants touched the definition or picture they believed was associated with the stimulus presented in step 2. Accuracy and response times collected from the test. The order of presentation of the 4 blocks was randomly assigned by the computer. Therefore, the location of the correct answer varied randomly within each block, ensuring the answer was not appearing in a predictable pattern.

Results

The analysis of accuracy revealed a significant interaction between presentation modality and meaning modality ($F(1,24)=5.851$, $p=0.024$, partial eta squared= 0.196), illustrated in Figure 4 and Table 1. In regard to accuracy, people were uniformly at ceiling with nonword to picture mapping to the point where there was no variability across the number of participants. We explored the interactions between presentation and meaning modality. Accuracy in the nonword-picture condition was significantly greater than accuracy in the nonword-definition condition ($t(24)=2.295$; $p=0.031$), as well as accuracy in the nonsign-picture condition ($t(24)=2.449$, $p=0.022$). This stems from the fact that participants were at ceiling in the nonword-picture condition. There were no other significant comparisons (all $p>0.082$).

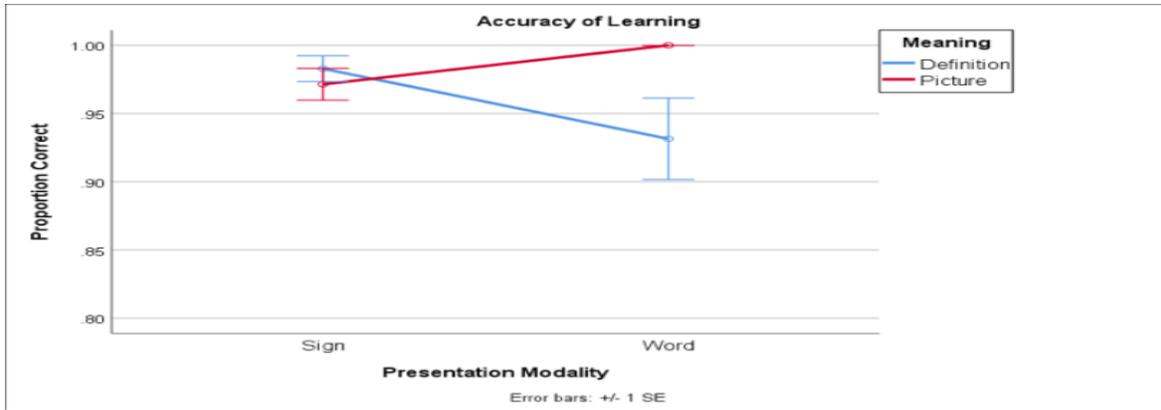


Figure 4. When words were presented as signs, accuracy was similar whether meanings were presented as definitions or pictures. When oral words were paired with pictures, accuracy was at ceiling, and when oral words were paired with definitions, accuracy was significantly lower.

Table 1.

Summary of Descriptive Statistics- Accuracy in Presentation and Meaning Modality

Presentation Modality	Meaning Modality	
	Definition	Picture
Nonword	0.931 (0.149)	1 (0)
Nonsign	0.983 (0.047)	0.971 (0.058)

Analysis of response times found the main effect of meaning format to be statistically significant ($F(1,24)= 93.261$; $p<0.001$; partial eta squared=0.795). Participants were significantly slower when meaning was presented as a definition compared to when it was presented as a picture. There were no other significant comparisons.

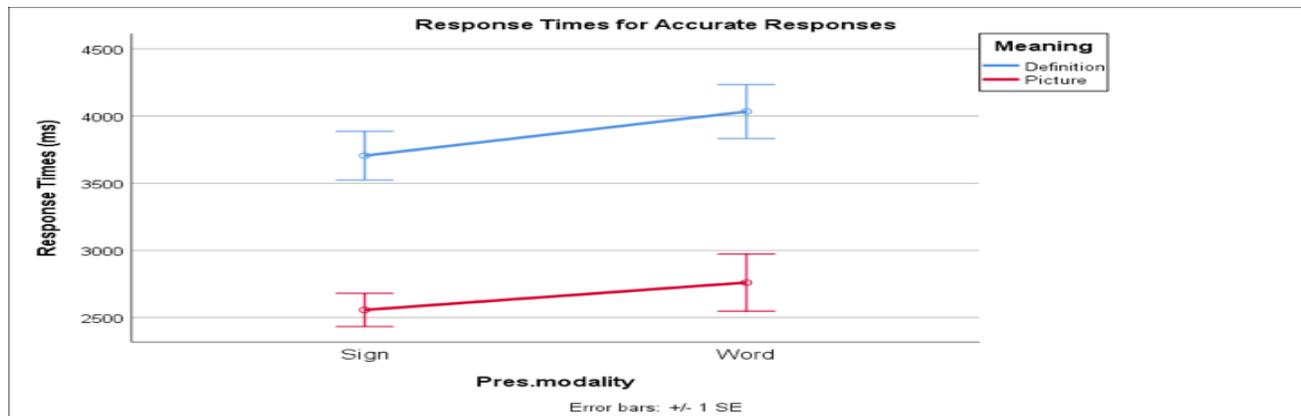


Figure 5. Recall times were faster when meanings were presented as pictures than as definitions.

Table 2.

Summary of Descriptive Statistics- Response Times in Presentation and Meaning Modality

Presentation Modality	Meaning Modality	
	Definition	Picture
Nonword	4114 (1156)	2761(1067)
Nonsign	3709 (909)	2568 (629)

Discussion

This study examined the effects of differences in modality on word learning. The first research question investigated how the modality of word presentation (nonword vs. nonsign) impacts the learning of an associated meaning. It was hypothesized that participants would learn associations between nonwords and meanings faster than between nonsigns and meanings due to the cultural emphasis on verbal language and the power of the phonological loop. The second research question addressed how the modality of a meaning presentation (picture vs. written definition) impacted learning of an associated word.

Addressing the first research question, unexpectedly, there was no main effect of presenting the word as a visual nonsign or an auditory nonword on the learning of the associated meaning impacting either accuracy or response times. This is important because learning associations

between unknown oral words and meanings is a well-practiced skill for college students. However, these students had no previous experience with signed languages, yet their accuracy and response times for the pairings of sign and meanings were similar to those for oral words. This supports the idea that college-aged adults, who are far past the critical period for language learning, can still quickly create associations between meanings and symbols, whether those symbols are novel signs or novel words.

The second research question, investigating whether there was an effect of whether the modality of meaning presentation on the learning of an associated word, demonstrated that there was no significant overall effect of meaning presentation (picture vs. written definition) on accuracy of learned associations. In contrast, the meaning modality significantly impacted response times. People were slower to identify a written definition stimuli than a picture stimuli when paired with a word, even though both types of meaning required visual scanning. There are at least two potential reasons why this may be the case. First, the participants may have been unsure of the definition of words. In this case, participants may have read each complete definition, because they did not immediately recall the correct answer.

This would lead to longer response times than quickly scanning for a keyword. Additionally, there are reports in the literature that imageable words are easier to learn. We also cannot rule out that the nature of the definitions contributed to the increased response times. However, this is unlikely since the definitions consisted of only 5-8 total words with 1-2 adjectives before a noun and a short prepositional phrase or clause following the noun. Controlling the definition lengths was done to allow for efficient scanning for keywords during the word retrieval testing. Further, the picture stimuli were also visually complex and required similar scanning to the written definition stimuli. Controlling the definition length was done to allow for efficient scanning for keywords during the word retrieval testing. Further, the picture stimuli were also visually complex and required similar scanning as the written definition stimuli.

In addition, there was a significant interaction between word modality and meaning modality in accuracy learned associations recall. This interaction arose because all participants reached ceiling accuracy, scoring 100% in the nonword and picture condition. The accuracy for this condition exceeded all predictions. This is not to imply that participants in this study performed poorly in the nonword-definition, nonsign-picture, and nonsign-definition conditions, as these individuals still acquired associations with over 93% accuracy in these other three experimental

conditions. The common practice of focusing on picture-naming during early language acquisition is a plausible contributing factor to these results (Lanza & Flahive, 2012). The skills associated with practicing picture-naming lay the foundation for the development of language, listening, and future literacy skills, and apparently, continue to be robust in young adults 20 years later (Lanza & Flahive, 2012). This 100% accuracy may also be partially attributed to the biological proximity of the visual cortex to word naming areas in the temporal lobe, which may have facilitated the rapid development of connections between the representations of the pictures in the visual cortex and the phonological representations of the nonwords in the auditory association cortices (Seikel, et al., 2020). In any case, these findings demonstrate that college-aged word learners are still adept at learning associations between new auditory words and pictures. Further, they illustrate that learning meanings for signs can be nearly as fast and accurate as learning meanings for new oral words.

Limitations and Next Steps

A primary limitation of the study is the small number of items per condition. However, using a completely within-subjects design helped maintain power. Another limitation is the quality of the pictures. This did not impact accuracy at all, considering that one of the picture conditions reached ceiling accuracy, but future replications should employ artist-drawn pictures to ensure uniform quality. Moreover, the definitions should have been better controlled to exclude full clauses and participial constructions. Future replications might also employ eye-tracking to explore the impact of definition-reading on recall times. A final limitation of the study was that there was no maintenance testing. For example, after the entire initial training and testing, we could have pooled all the stimuli and retested participants after a half hour filler task. This would have allowed us to determine the extent to which new words were actually learned rather than just temporarily stored. Therefore, future replications of this experiment should include maintenance testing.

Implications

On a broader scale, the results of this study, demonstrating no negative effects of presenting a word as a sign, can be interpreted as promising news for individuals learning a signed language, whether they are children or adults, because participants were equally as accurate when learning meanings of nonsigns as nonwords. There was no overall advantage in accuracy of learning or recall times for learning auditory words, as might have been expected since none of these

students had any experience with sign. On the other hand, if a typically-developing student wants to take ASL as a foreign language instead of Spanish, for example, because they had trouble learning Spanish in high school and think ASL will be easier, these findings suggest that learning associations between signs and meanings are no easier, or harder, than learning novel sound sequences paired with meanings, which is essentially what learning another language is. On the other hand, people with Auditory Processing Disorder may find learning a signed language to be easier than acquiring another oral language.

In regard to meanings presented through pictures, these results strongly suggest that the ability to associate auditory words with pictures remains robust into early adulthood, a finding that might be useful for designers of second language acquisition textbooks. Moreover, as pointed out above, one of the populations where pictures are used to (re)learn associations between auditory words and pictures is people with aphasia due to stroke. Most people with stroke are over 50, and aging itself may slow the word learning process (Brusbaert, et al, 2016). Thus, replicating the current experiment with individuals with aphasia and age-matched controls might help determine the extent to which aging versus impaired learning mechanisms account for why relearning the names of pictured objects is so difficult in aphasia.

Conclusion

In summary, these results suggest that meaning associations with novel signs are equally as accurate and quick to recall as those with novel words. This indicates that there are seemingly no disadvantageous effects of using signs to represent words in word-learning tasks. Individuals are able to recall the meaning of a learned association equally as well when using signed words as when using auditory words. Results of this experiment also align with findings in psycholinguistic literature, which indicate that people are quicker to recall imageable meanings more quickly than less imageable meanings. Therefore, concepts requiring meaning to be represented through explicit written definitions, rather than an imageable picture, may require longer study and recall times. Finally, this experiment also demonstrated that typically functioning adults maintain a robust ability for learning associations between novel words and novel pictures into adulthood.

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