How the Hands Cue the Mind: The Effects of Iconicity and Enactment on Sign Language Acquisition

Laura M. Morett (morett@pitt.edu)
Department of Psychology, University of Pittsburgh
210 S. Bouquet Street, Pittsburgh, PA 15260 USA

Abstract

Iconicity is a powerful cue to symbolic meaning. However, it is unclear from previous research whether language learners benefit from iconicity. Prior research indicates that the motor system supports language acquisition, suggesting that iconicity expressed via this modality may be particularly salient. The present study investigates the effects of iconicity and enactment on the acquisition of American Sign Language by hearing adults. The results reveal that enactment enhances sign learning in general, but fail to show that iconic signs are learned more effectively than non-iconic signs. As such, they indicate that the motor system—but not iconicity—plays a key role in sign language acquisition.

Keywords: Second language acquisition, sign language, mental imagery, embodied cognition.

Introduction

Sign language is the only type of natural language that is comprehended and produced exclusively in the visuospatial modality. Given that the visuospatial modality allows for greater isomorphism between symbols and their referents than the auditory modality, it follows that sign language should be more iconic than spoken language, and there is evidence that this is indeed the case (McNeill, 2005; O'Brien, 1999). Thus, although hearing speakers are accustomed to processing language in the auditory modality, they may be able to take advantage of this iconicity to expedite their learning of sign language. If iconicity plays a pivotal role in sign language acquisition, learners should be able to acquire sign languages more quickly and effectively than they learn spoken languages. Moreover, learners should be able to learn iconic signs and expressions more efficiently than lexical items that are not iconic.

Unlike spoken language, which is articulated primarily with the mouth and vocal tract, sign language is articulated with the hands and body. As such, another factor that may play an integral role in the acquisition of sign language is the engagement of the motor system. Theories of embodied cognition posit that representations of language are inherently perceptual, and are encoded and retrieved via the body's sensorimotor system (Barsalou, 1999). 4Thus, these theories would predict that enacting signs—especially those that are iconic—allows sign language learners to tap directly into these perceptually-based representations, thereby facilitating their recall and comprehension. If the motor system does contribute significantly to sign language acquisition, learners should recall iconic signs better than non-iconic signs due to the isomorphism between the visuospatial properties of motor representations of signs and their referents.

Iconicity and Language Acquisition

Meaningful hand movements, including gestures and signs, vary on the basis of several qualities, including conventionalization, semiosis, and relationship to speech. In order to show how different types of hand movements relate to one another on the basis of these characteristics, Adam Kendon and David McNeill (1992) developed a continuum, which is illustrated below in Figure 1. At one extreme of the continuum lies sign language, which is highly conventionalized, segmented and analytic, and occurs in lieu of speech. At the opposite extreme lies gesticulation, which is unconventionalized, global and synthetic, and occurs concurrently with speech. Although iconicity is not plotted on this continuum, it can be inferred that, due to its global and synthetic (i.e., holistic) nature, gesticulation is highly iconic, whereas sign is the least iconic of the hand motions.

It is important to note that iconicity varies within and between sign languages. Much of this variation can be explained by ontogenetic development. There is evidence that the home sign of individual deaf children as well as pidgin sign languages created by communities of deaf children are generally more iconic than conventionalized sign languages (Kendon, 1980; Senghas, Kita, & Özyürek, 2004). Moreover, even within highly-conventionalized sign

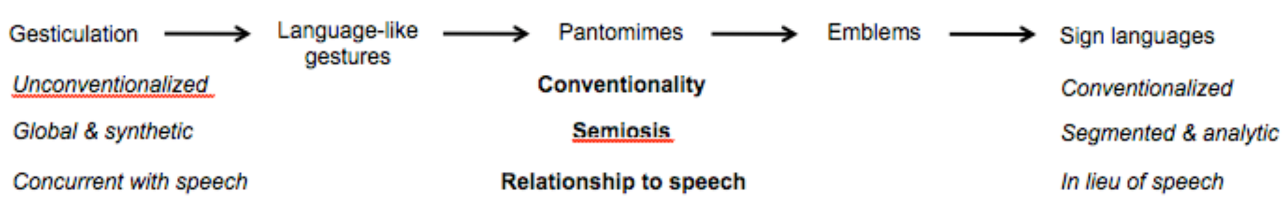


Figure 1: Kendon's continuum, as characterized by McNeill (2005).

languages, recently-coined signs are more iconic than signs that have been in the language longer (Frishberg, 1975). This is likely the case because signs are initially based on referents' affordances, which become obfuscated through inter-generational transmission of signs.

Obviously, it is quite plausible that iconicity may facilitate the acquisition of signs, due to its isomorphism with the visuospatial properties of the referent. Nevertheless, research has failed to provide conclusive evidence that children learn iconic signs more readily than they learn arbitrary signs. One study of the acquisition of American Sign Language (ASL) by congenitally deaf children showed that only 30% of these children's first 10 signs are iconic, and that this number increases to only 34% at 18 mos. (Orlansky & Bonvillian, 1984). Another study (Miller, 1987) showed that 3-year-old hearing children unfamiliar with ASL were unable to reliably select the correct referent of iconic signs on the Peabody Picture Vocabulary Test, a standardized, forced-choice measure of vocabulary development (L. M. Dunn & Dunn, 1997). Taken together, these findings suggest that both deaf and hearing children are unable to use signs' iconicity to associate them with their referents, thereby facilitating sign language acquisition.

Related work examining gesture comprehension has provided insight into the question of why young children are unable to associate iconic hand movements with their referents. One study showed that, by 26 months of age, children were able to associate iconic gestures with objects with similar affordances, even though they were unable to do so at 14 mos. of age (Namy, 2008). Another, more recent study demonstrated that 4-year-olds were better able than 2-year-olds to learn object labels associated with iconic gestures, but that both age groups learned object labels associated with arbitrary gestures at a comparable rate (Marentette & Nicoladis, 2011). Although this study also showed that 4-year-old children treated iconic gesture as an action associate rather than a label, 2-year-olds were not tested. The seeming inconsistency between the results of these two studies can be explained by the fact that the objects' affordances were demonstrated to children in the earlier study, but not the more recent study. Thus, this work demonstrates that children who were able to effectively associate iconic gestures with corresponding objects understand the relationship between them, allowing these children to use gesture as an embodied aid in word learning.

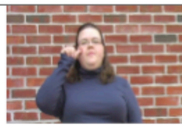
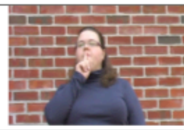
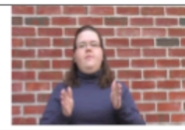
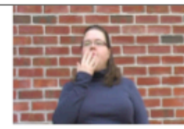
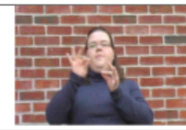
To date, no published research has examined whether the iconicity of sign language facilitates its acquisition by adult learners. However, there is evidence that adults unfamiliar with sign language can effectively guess the meanings of highly iconic signs, even when their referents are metaphorical (O'Brien, 1999). Work has also shown that adults are able to learn words from a novel spoken language accompanied by representative iconic gestures more effectively than words presented as speech only or words accompanied by non-representative iconic gestures (Allen, 1995; Kelly, McDevitt, & Esch, 2009). Given that adults understand the correspondences between object affordances and iconic hand movements—including signs—it follows that they should be better able to learn highly iconic signs than arbitrary signs.

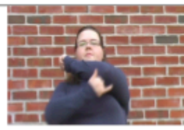
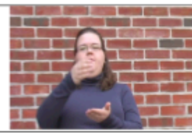
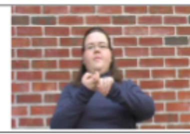
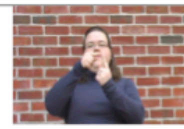
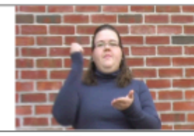
Enactment and Language Acquisition

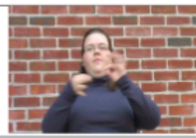
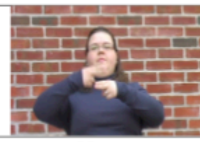
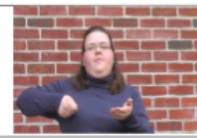
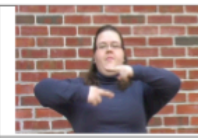
Aside from being more iconic than spoken language, sign language is also more embodied than spoken language. Because the hands and parts of the body other than the vocal tract and face play a larger role in sign language than in spoken language, sign language engages the motor system to a greater degree than spoken language. This engagement of the motor system likely produces memory traces that are richer and more multimodal than those produced by spoken language, providing learners with additional recall cues.

Research examining recall of spoken language has provided evidence that engagement of the motor system during language processing enhances memory encoding and retrieval. For example, when presented with a series of instructions, adults recall more spoken instructions when they act them out than when they repeat them aloud (Svensson & Nilsson, 1989). Moreover, adults are more likely to recall spoken instructions for tasks that they have enacted for a longer time period (30 s.) than those that they have enacted for a brief time period (5 s.) (Cohen & Bryant, 1991), indicating that greater engagement of the motor system produces richer, more robust memories. A separate line of research has provided evidence that adults are more likely to produce sought-after words during speech disfluencies when they gesture than when they keep their hands still (Frick-Horbury, 2002; Frick-Horbury & Guttentag, 1998), indicating that gesture facilitates lexical access. Taken together, the results of all of this work suggests that the enactment of meaningful hand motions during language processing allows speakers to tap into their semantic representations more effectively, thereby promoting language encoding and recall.

There is also evidence that the motor system plays a key role in language acquisition. To this end, research has revealed a tight relationship between motor and language milestones in childhood, demonstrating that the onset of babbling is accompanied by repetitive motor movements (Iverson & Fagan, 2004), and that the transition to two-word speech is accompanied by gesture-word combinations (Capirci, Iverson, Pizzuto, & Volterra, 1996). Furthermore, several studies have shown that children are able to express symbolic meaning via hand motions before speech (Acredolo & Goodwyn, 1988; Bonvillian, Orlansky, & Novack, 1983; Iverson & Goldin-Meadow, 2005), and that children's iconic gesture production predicts their vocabulary development (Rowe & Goldin-Meadow, 2009a, 2009b; Rowe, Özçalışkan, & Goldin-Meadow, 2008). Finally, there is evidence that school-aged children are better able to learn the meanings of novel words from both

ASL Sign					
English	**Adult**	**To answer**	**Box**	**Color**	**To count**
Sign Type	Arbitrary	Metaphorical	Iconic	Arbitrary	Metaphorical

ASL Sign					
English	**Country**	**Cup**	**Friend**	**Goal (objective)**	**Hammer**
Sign Type	Arbitrary	Iconic	Metaphorical	Metaphorical	Iconic

ASL Sign					
English	**To help**	**Message**	**Name**	**Pool (billiards)**	**To roll**
Sign Type	Metaphorical	Metaphorical	Arbitrary	Iconic	Iconic

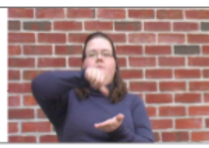
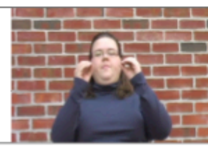
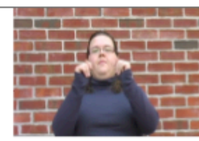
ASL Sign					
English	**Sauce**	**Saw**	**To teach**	**Team**	**To twist**
Sign Type	Iconic	Iconic	Metaphorical	Metaphorical	Iconic

Figure 2: ASL signs and English words used in study, listed by sign type.

their native language and unfamiliar second languages when they enact iconic gestures representing the words' meanings (Tellier, 2005, 2008).

It is important to note that the facilitatory effects of enactment observed in most studies discussed above stem from a combination of embodied action and mental imagery. Furthermore, there is experimental evidence that learning techniques incorporating mental imagery enhance second language vocabulary acquisition (Atkinson, 1975; Atkinson & Raugh, 1975). Aside from investigating the effects of iconicity and enactment on sign language acquisition, a secondary goal of the current study was to disambiguate the roles that embodied action and mental imagery play in sign enactment. As such, the study included conditions that were designed to elicit mental imagery and embodied action in combination, only mental imagery, only embodied action, and neither mental imagery nor embodied action.

To date, no published research has investigated whether enactment facilitates the acquisition of signed second languages by adults. On the basis of previous research, it was predicted that the enactment condition would result in ASL sign acquisition superior to that observed under the other conditions. This prediction stems from enactment's incorporation of both mental imagery and embodied action, and its resulting engagement of both the visuospatial and motor systems.

Method

Participants

Undergraduate students were recruited from the participant pool at the University of Pittsburgh, and received partial course credit in return for participation. All recruited individuals were fluent English speakers[1] and confirmed that they had no knowledge of American Sign Language (ASL) prior to the experiment. Additionally, all recruited individuals had normal hearing and normal or corrected-to-normal vision. 6 individuals were eliminated due to technical difficulties or failure to return for all three sessions, resulting in a final sample of 29 participants (age: $M = 20.79$, $SD = 1.65$; sex: 11 males; 18 females).

Stimuli

Twenty ASL signs and their English glosses were used as stimuli for this research (see Figure 2). Each sign was classifiable into one of the following three types: Iconic, metaphorical, or arbitrary. Iconic signs depicted their

[1] Participants were not required to be native English speakers in order to participate, given that the English glosses of the signs were common words, and should thus be comprehensible to non-native undergraduate students, whose proficiency must be sufficient to comprehend academic English.

referent holistically or metonymically (e.g., pantomiming hammering for *hammer*); metaphorical signs represented the source domain of the conceptual metaphor structuring their referent (e.g., cupped hands moving forward three times, as if conveying an entity of information from the signer to the listener, for *to teach*); and arbitrary signs bore no structural resemblance to their referent (e.g., two fingers from both hands taping one another repeatedly for *name*). The distinctions between these sign types were supported by empirical data collected from a separate group of participants unfamiliar with ASL (O'Brien, 1999), ensuring that they were applicable to the target population of the current study.

A female native signer of ASL was video recorded demonstrating the twenty signs used in this study. The signer was unaware of the goals of the study. Video footage of each sign was segmented and trimmed, yielding stimuli averaging 2.5 s. in duration. Additionally, ambient audio captured during video recording was expunged from the footage, yielding silent stimuli.

Procedure

This experiment consisted of three sessions, the first of which included both a learning and test phase, and the second and third of which included only a test phase. In learning trials, participants were presented with video of a randomly-selected sign (~2500 ms.), and after a 1000 ms. interstimulus interval, were presented simultaneously with the corresponding English gloss as text and audio (2500 ms.). After one additional repetition of this sequence of events, participants performed one of four actions. For words presented in the enactment condition, participants enacted the sign with their own hands; as such, this condition included both mental imagery and embodied action. For words presented in the imagery condition, participants closed their eyes and visualized the sign's referent in their mind's eye without moving their hands; as such, this condition included mental imagery, but not embodied action. For words presented in the motion condition, participants made an X-shaped motion with their dominant hand three times; as such, this condition included embodied action but not mental imagery. For words presented in the comprehension condition, the learning sequence was repeated one additional time, and participants were not explicitly told to do anything; as such, this condition did not include either mental imagery or embodied action. Within each experimental session, each sign was randomly assigned to one of these four conditions in a within-participants design, such that five signs were presented in each condition for each participant. The learning phase consisted of 3 blocks comprising 20 trials apiece (one for each sign), yielding a total of 60 learning trials altogether.

Following the learning phase in the first session, participants were given a 5-minute break, and then completed the test phase. In test trials, upon being presented with English glosses as text and audio, participants were asked to produce the corresponding ASL sign. Participants were instructed to try to recall the sign as best they could, but were told that they could say "skip" to move on if they could not recall a sign. During test trials, participants' signing was recorded by a video camera set approximately 45° to the left of their central viewing point. The test phase consisted of one block of 20 trials (one for each sign). Overall, the first experimental session lasted about 30 minutes.

In order to examine how long-term recall of signs varied by condition, participants returned to the lab for two follow-up sessions held one week and four weeks after the first session. In each of these sessions, participants completed the test phase in the manner described above. Each of the follow-up sessions lasted approximately 10 min. apiece.

Results

Sign recall was quantified using a binary coding scheme (1 = correct; 0 = incorrect/skipped). Total number of signs recalled correctly for each participant and condition were converted into proportions, in order to control for unscorable responses caused by technical errors in running the recall task (which accounted for less than 5% of the data). In order for a sign to be coded as correct, it must have been performed using the same hand (dominant/non-dominant, as specified per participant on a post-experimental questionnaire), and must have had the same hand shape and movements as the correct ASL sign, as modeled by the signer.

To address the question of whether learning condition affects sign recall, proportional data were submitted to repeated measures ANOVAs, using participant and sign as fixed factors. These analyses revealed significant main effects of learning condition, $F_{pp}(3, 87) = 7.16$, $p < .001$, $\eta_p^2 = .29$; $F_{sign}(3, 45) = 14.07$, $p < .001$, $\eta_p^2 = .48$, and recall interval, $F_{pp}(1, 29) = 10.99$, $p = .004$, $\eta_p^2 = .38$; $F_{sign}(1, 15) = 18.16$, $p = .001$, $\eta_p^2 = .55$, but failed to reveal a significant condition-by-interval interaction, $F_{pp} > 1$; $F_{sign} > 1$; see Figure 3. Bonferroni-corrected post-hoc analyses showed greater recall accuracy for signs learned via enactment than via mental imagery ($p = .04$), motion ($p = .06$), and

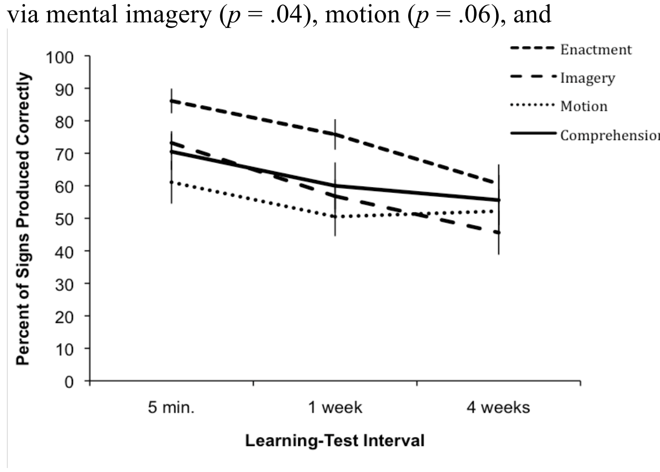


Figure 3: Percent of signs produced correctly by learning condition and recall interval (error bars represent *SE*).

Table 1: Mean number of signs produced correctly by sign type and recall interval.

	Recall interval		
Sign type	5 min.	1 week	4 weeks
Iconic	.74 (.36)	.66 (.24)	.62 (.28)
Metaphorical	.78 (.24)	.55 (.24)	.50 (.29)
Arbitrary	.60 (.26)	.56 (.28)	.44 (.27)

comprehension (p = .05), as well as greater recall accuracy after an interval of 5 minutes than 1 week (p < .01) and 4 weeks (p < .001). These results indicate that enactment facilitates the acquisition of novel signs by hearing adult learners unfamiliar with sign language across both short and long learning-test intervals.

To address the question of whether iconicity affects the learning and recall of ASL signs, sign type (iconic, metaphorical, arbitrary) was entered into a repeated measures ANOVA, using sign as a fixed factor. This analysis failed to reveal a main effect of sign category on recall, $F(1, 17) = 1.13$, $p = .35$, $\eta_p^2 = .12$; see Table 1. This result indicates that, similar to deaf children, hearing adult learners do not benefit significantly from iconicity when learning novel signs.

Discussion

The current study investigated the roles of iconicity and enactment on the acquisition of ASL signs by hearing adult L2 learners. The results revealed that enactment facilitated sign learning more effectively than visualization of sign referents, performance of meaningless hand movements, or simple sign comprehension. However, the results failed to demonstrate that iconic signs are learned more effectively than arbitrary signs. Considered as a whole, these results suggest that enactment enhances ASL sign recall and production in hearing learners through the creation of motorically-rich lexical traces.

Unfortunately, the results of the current study do not provide insight into why adult L2 learners fail to benefit from the iconicity inherent in some signs, and in sign language in general. One possible explanation is that, like children, adults go through a developmental stage in the initial stages of language learning in which they are unable to associate the visuospatial properties of iconic signs with the affordances of their referents. Although adults are generally familiar with the affordances of common objects, it is possible that this inability to associate them with their corresponding signs derives from insufficient linguistic context, rather than from insufficient domain-general knowledge, which has been proposed to explain children's insensitivity to iconicity. When learning their first set of signs, adults unfamiliar with ASL are unable to relate their semantic and phonological properties to other similar signs, which may negate their ability to recognize iconicity. Alternatively, hearing adults' experience with spoken languages, in which iconicity is sparse, may lead them to assume that language is not iconic, causing them to ignore any physical correspondences between signs and their referents. Finally, the novelty of processing language in the visuospatial modality may place a heavy cognitive load on adult L2 learners unfamiliar with sign language, negating any benefits that iconicity may have bestowed. Needless to say, future research is necessary to test between these possibilities and to clarify the cause of this null effect.

The advantage produced by enactment of signs during learning indicates that the motor system plays a key role in L2 lexical acquisition, particularly for sign language. Of note, only *meaningful* motion (i.e., sign enactment)—not arbitrary motion (i.e., X-shaped motions)—enhanced sign acquisition. This result is consistent with embodied theories of cognition, which maintain that the mental representations underlying language derive from meaningful interactions between our bodies and the world (Barsalou, 1999). It is also consistent with work showing that meaningless repetitive motion can disrupt the formation of visuospatial representations (Vandierendonck, Kemps, Fastame, & Szmalec, 2004). The observation that enactment is more effective at promoting sign learning than visualization of referents via mental imagery indicates that meaningful engagement of the motor system results in richer, more robust mental representations of signs, which are more likely to be retrieved successfully, particularly by inexperienced learners.

In conclusion, the results of this study demonstrate that adult L2 learners can take advantage of enactment, but not iconicity, to facilitate their acquisition of sign language. As such, they indicate that the hands cue the mind in sign language acquisition, rather than vice versa, demonstrating the power and depth of the body's cognitive capacity in relation to the acquisition of a novel second language.

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