How does iconicity affect sign language learning?

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Introduction

Signed languages display rampant iconicity. Many signs have visual features that resemble their referents. This iconicity appears to be facilitated by signed languages' use of the visual modality, which permits more aspects of referents to be mapped to the form of signs than to words in spoken languages (Taub, 2001; McNeill, 2008; Ortega, 2012). Current views about language are dominated by the idea of arbitrary connections between linguistic form and meaning, and tend to downplay the role of iconicity (Perniss et al. 2010). But Perniss et al. (2010) showed that iconicity is a far more prevalent property of human languages than currently recognized, and language users (both signers and speakers) exploit iconicity in language processing and language acquisition. How the transparency between the form and its referent influences signed language processing, comprehension, and production has been and still is one of the aspects of signed language that has generated much active discussion. A number of developmental studies have shown an advantage in learning iconic rather than arbitrary form-meaning mappings (Brown, 1980; Campbell et al., 1992). But, there are other studies that suggest that iconicity does not aid sign vocabulary learning, and has no effect on immediate short-term memory recall (Anderson & Reilly, 2002; Poizner, Bellugi, and Tweney (1981)). In the present study, we examined how exactly iconicity affects sign language learning in novel signers.

Signed languages are spontaneously-arising natural languages that exhibit linguistically complex structures and are able to convey abstract concepts. Signed languages are interesting to study because they can help us to examine those aspects of language structure which are similar across human languages from those that result from the modality in which the language is expressed. Studying iconicity in signs is important for its potential role in the acquisition of a sign language. A common misconception is that signs are iconically self-explanatory, or even that they are pantomime. Many signs are arbitrary and bear no resemblance to their referent, but even so, sign language naturally allows for more iconicity than a spoken language does. Some signs do resemble their referents in some way, but there can be form mismatches because the hands often represent things that are not hands. This iconic relation is not pure identity, so iconicity might not help the intuitive mapping as much as once thought.

On one hand, there are many studies that suggest that iconicity aids learning. A study by Baus, Carreiras, & Emmorey (2012) found that iconicity appears to help L2 learners learn new signs in American Sign Language (ASL). In this study, they had hearing non-signing participants perform a translation recognition task and found that iconicity aids memorization of signs in early learners. After learning a set of iconic and arbitrary (non-iconic) signs in ASL, participants were asked to produce forward and backwards translations (English-ASL and ASL-English) and to match word-sign equivalents while their response times and accuracies were measured. In both tasks participants were faster and produced fewer errors for iconic than non-iconic signs. The findings from this study support the argument that there is a facilitatory advantage of iconicity that makes sign learning easier.

However, at present it is unknown exactly what part of the process of learning iconicity might help. We predict two possible advantages of iconicity that help people learn new signs. The first advantage is in the Initial Guess (Advantage 1). Iconic co-speech gestures accompany spoken languages, which may mediate iconic sign learning. Although users of spoken languages are accustomed to processing language in the auditory modality, they may be able to take advantage of this iconicity in their gestures to expedite their sign language learning because of their intuitions about the alignment of form and meaning. Hearing non-signers might have the intuition that signs are iconic in some way, so this bias helps when they are exposed to iconic signs for the very first time and guess them correctly in the initial guess. The second advantage is in the Rate of Learning (Advantage 2). Because of the more transparent mapping between form and meaning, iconic signs might be easier to learn and remember over time than non-iconic signs are. By examining the sign learning process in terms of these two Advantages, we can determine how iconicity affects learning in more detail.

On the other hand, there are studies suggesting that there is a disadvantage of iconicity for new learners. An account proposed by Ortega (2012) suggests that iconicity may impede the processing and production of phonological detail in sign learning. In this study, he found that hearing non-signing participants doing sign repetition and generation tasks articulate more accurately when the signs overlap with their own gestures, and worse when iconic signs have less overlap with their own gestures. He argues that the inaccuracy to produce some of the exact phonological constituents of iconic signs could be explained in terms of gestural interference. He interprets these findings as evidence that “non-signers process iconic signs as gestures and that in production, only when sign and gesture have overlapping features will they be capable of producing the phonological components of signs accurately” (Ortega, 2012).

Speakers of spoken languages produce spontaneous gestures when talking, and these tend to be iconic (can adopt the form of a referent to facilitate communication) and “echo” the co-occurring speech. Iconic signs and speakers’ co-speech gestures are similar in the sense that they are both iconic, but different in the sense that signs have particular phonological details that affect the meaning, where gestures allow for much more variability and do not have strict grammatical and phonological rules. Signs in ASL are characterized by their major phonological parameters: handshape, movement, location, and palm orientation (Stokoe, 1960). Non-signers are unaware of the strict set of phonological rules of ASL, so encoding the phonology of iconic mappings might be especially difficult for them. Ortega suggests that when non-signers are first viewing iconic signs, they can access their iconic features (arguably via their expertise in perceiving iconic gestures) and ignore the exact sign phonological structure. When asked to imitate iconic signs, they only retained their memorable iconic elements but disregarded their exact phonological components (Ortega, 2012). He also argues that arbitrary signs, in contrast, cannot be mapped onto a familiar gesture making them less memorable, and so their sign components actually have to be processed more accurately, and are thus reproduced more accurately (Ortega, 2012). Ortega's (2012) findings support the argument that there may be gestural interference in the production of iconic signs by hearing non-signers, and that they might process iconic signs as gestures which might impede phonological encoding of new iconic signs and be a disadvantage to learning.

Another way that iconicity can impede some aspect of language use is in language processing speed. Thompson et al. (2010) did a study that investigated the extent of iconicity effects for British Sign Language signers during language processing with a phonological decision task in which the meaning of the sign was irrelevant. They had Deaf signers decide if iconic and non-iconic signs involved straight or curved fingers. Their results show that iconicity is a significant predictor of response latencies and accuracy, with more iconic signs leading to slower responses and more errors. They concluded that meaning is activated automatically for highly iconic properties of a sign, and this leads to interference before making form-based decisions (Thompson et al., 2010). This disadvantage of iconicity demonstrates that its' effects pervade the entire language system, arising automatically even when access to meaning is not needed for the task.

There’s a conflict in the current sign language literature, because it is unknown whether iconicity helps or hurts learning. There’s a gap in the existing iconic advantage studies suggesting that more detail is needed to determine at which stage of learning iconicity might help. There are also some studies arguing the exact opposite - that iconicity does not aid learning - and these need to be compared with the advantage studies more closely in order to determine the effects that iconicity has on new learners of signed languages.

So what exactly about iconicity influences sign learning? The present study proposes to replicate and extend the Baus et al. (2012) iconicity advantage findings using a similar learning paradigm with a novel population of hearing non-signers, in order to examine the effects of iconicity on the learning process more closely. Our questions for this study are: Will the form-meaning mapping be easier to encode initially when iconicity is presented (Advantage 1)? Will iconicity help in the duration of learning by speeding the acquisition of iconic mappings (Advantage 2)? Is there a downside to iconicity during recall? In order to asses these questions; our study consisted of two tasks.

First, participants trained on a translation recognition task multiple times for a given set of signs. In all conditions, all of the signs are in actuality iconic ASL signs, but half of them were taught with a non-iconic meaning, to control for any differences in meaning that the two categories might have. This controls for a confound in the Baus et al. (2012) study, which used distinct sets of signs in the iconic and non-iconic conditions—ASL signs that were actually iconic or not, respectively. This is confounding because the signs in the two conditions are different in a variety of ways, including the complexity, learnability, and identity of their forms and meanings. As a result, effects could be due to any of these uncontrolled confounding factors rather than to the iconicity or arbitrariness per se of the mappings.

Participants were presented with signs in blocks until their accuracy is 100% in two consecutive blocks. This allowed us to evaluate their initial success and the rate of increase in their success over the course of exposure. In each trial, participants saw one English word and one sign and had to indicate whether the word was the correct gloss for that sign. Feedback was given and thus the participants learned the mappings over time. Reaction time and accuracy data were collected in order to measure onset, slope, and ultimate achievement of accuracy over the blocks of learning.

If iconicity does affect sign learning, then we should see shorter time to criterion for signs assigned iconic meanings and longer time to criterion for signs assigned non-iconic meanings, in line with what was found by Baus et al. (2012). One hypothesis (H1) is that participants will successfully guess iconic sign-gloss pairings better than non-iconic ones. In that case they should be more accurate for iconic pairings from the onset (Advantage 1). A second hypothesis (H2) is that learners will acquire iconic signs more quickly over the entire training period. This would predict a steeper slope for learning of iconic pairings than non-iconic pairings from block to block (Advantage 2). Null effects for any measure would indicate that iconicity does not affect the rate of sign acquisition, but rather that previous findings are due to uncontrolled differences between signs that are in actuality iconic and non-iconic.

Then, the participants performed a two-alternative forced choice phonological recall task where they saw two phonologically similar signs and had to pick one that matches an English word. New videos with a different signer were recorded for this task. In each triad, the gloss and one of the signs were drawn from the training items. The other was a foil, which was created to look identical to the first sign, except for a minimal change that made it look more like a possible gestural representation of the sign’s true iconic meaning. This task was designed to investigate the possibility that some iconic signs in ASL have phonological similarities with gestures which may interfere with the mapping and thus make iconic sign learning more difficult. It's aimed to test the hypothesis (H3) that phonological details will be less precisely encoded for iconic than non-iconic signs, indicating a disadvantage of iconicity for learning. This hypothesis predicts that participants will be more likely to (incorrectly) pick the foil when presented for a sign that they learned as iconic, because they will not have correctly encoded all of the phonological details due to gestural overlap in what they think an iconic sign should look like and their own iconic gestures. If this is the case, then we can determine that these similarities between sign and gesture are what make some iconic signs harder to process, learn, and recognize. An alternative hypothesis (H4) is that iconicity leads to improved phonological encoding of signs. In this case, we would expect participants to (correctly) select the real iconic sign more often than the foil, relative to their accuracy for non-iconic signs.

Experiment 1

Participants

40 participants participated in this experiment in exchange for course credit in psychology and cognitive science classes at UCSD. They are all native English speakers with no prior exposure to signed languages.

Materials

For the training task, 32 sign-English gloss pairs were selected for high iconicity from a ratings list (Emmorey & Berlove). Stimuli were rated for meaning transparency on a scale of 1-7 by a separate group of participants with no knowledge of ASL (0 = no meaning, 7 = absolutely strong/direct meaning).The iconic signs chosen for this study were rated as having more transparent meaning, and all are above 3.5. The mean of signs in the database, including non-iconic signs, is 3.29. Stimuli were presented in approximately 2-3 second video clips, with the same fluent signer presenting all signs.

For the phonological recognition task, a different non-fluent signer performed the same 32 signs used in the training task, and also performed foil distractors that varied phonetically to appear more similar to English co-speech gestures. The phonology for these foils were decided on the basis of a prior study, where a separate group of 6 naïve participants were presented with 74 English glosses and asked to produce a gesture that they think represents each word. These gestures were then used to modify the original signs to create the foils. The foils were created by systematically changing as few phonological parameters of the original signs as possible to look more similar to the normed gestures (see Appendix).

In order to get from 74 to 32 signs, we had the same 6 participants guess the meaning of each sign by typing an English word. Their guesses were then coded on a scale of 0-4 of how close the guess was to the correct meaning (4 being blank/wrong and 0 being exactly correct). All 32 signs used in the experiment were below 1 on the guessability scale, indicating low guessability by non-signers. The participants then saw each sign and its correct meaning, and we had them rate on a scale of 1-7 how recognizable each sign is now that they know the meaning (1 being very poor and 7 being very good). All 32 signs were above 3.0 on the recognisability scale, indicating high recognisability by non-signers.

Design

Each participant learned half of the signs (16) paired with their true iconic meanings, and the other half with pseudo-random assignments of meanings, making them non-iconic. To make the non-iconic mappings we did a pair-wise switch where all 32 words were randomly assigned into pairs, and then we shuffled the meanings. The randomized assignments were then checked to make sure that the non-iconic meaning did not still look iconic in the sign. Participants were assigned to one of two lists, such that across participants, each sign was associated with its true, iconic meaning half of the time (see Figure 1). This design – having the same signs and glosses in each condition (iconic and non-iconic) – controls for any aspects of the forms or the meanings of the signs that could potentially affect learning.

Item	Sign	List 1 Gloss	List 2 Gloss
1		**ELEPHANT (iconic)**	**CAT (non-iconic)**
2		**CAT (iconic)**	**ELEPHANT (non-iconic)**
3		**GIRAFFE (non-iconic)**	**FISHING (iconic)**
4		**FISHING (non-iconic)**	**GIRAFFE (iconic)**
32	…	…	…

Figure 1: List design (stills of video clips from Emmorey & Berlove).

In this first task, training proceeded in blocks so that we could analyze both accuracy from the outset and learning over time. Every participant saw all 32 signs in one block, with either a correct or incorrect gloss for each sign, presented in random order. If a sign was presented with the correct gloss in the first block, then in the second block we would present it with an incorrect gloss, and vice versa. After two blocks, the participant would be presented with their own accuracy percentage from the most recent two blocks. Training continued until a participant met criterion (100% accuracy) for both types of signs in two consecutive blocks.

After criterion was reached, the participant took a 10 minute break (participants either sat in the lab lobby or performed a short McGurk effect experiment in a separate room) and then moved on to the phonological recognition task. This was a two-alternative forced choice task, where one English gloss was presented, followed by two video clips of signs presented sequentially. The order of the two sign clips was counterbalanced, and participants saw the 32 triads only once. In each triad, the gloss and one of the signs was drawn from the training items, and the other sign was a matched foil.

Procedure

In training task trials, participants were presented with a word for 1000 ms followed by a video clip of a sign (see Figure 2). After each sign, participants were instructed to press one of two buttons to say if the English word matched the meaning of the sign or not. Auditory feedback was presented 200 ms after each response, either a buzz for an incorrect response or a bell for a correct response. After another 1000 ms, a central fixation cross appeared to mark the start of the next trial. After every two 32-sign blocks, each participant was shown their own accuracy percentage. Reaction time and accuracy were collected for each sign-word pair presented. Accuracy after the first block and slope of accuracy over time were calculated.

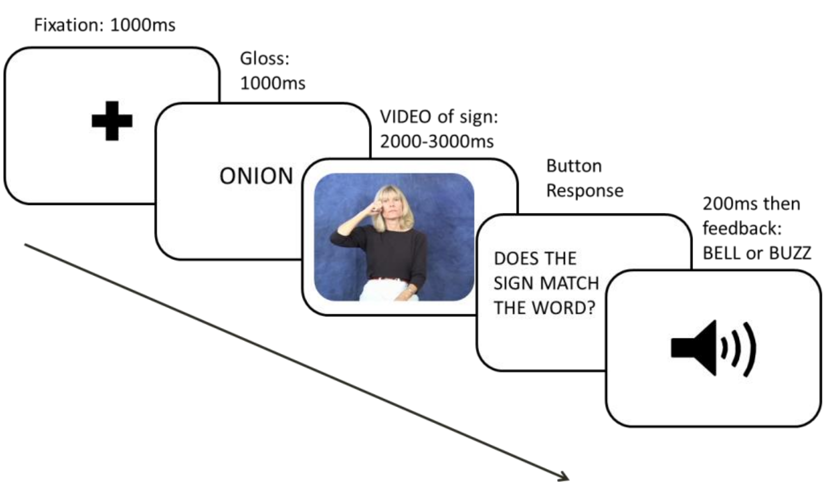

Figure 2: Training translation recognition task trial structure.

In the phonological recognition task, the participant saw an English gloss and two video clips of a sign and a foil. Then were instructed to press one of two buttons to indicate which of the two signs matched the gloss (see Figure 3). After another 1000 ms, the stimulus disappeared and a central fixation cross appeared to mark the start of the next trial. Reaction time and accuracy were measured for each trial and participants saw the set of 32 glosses with pairs of signs and foils once.

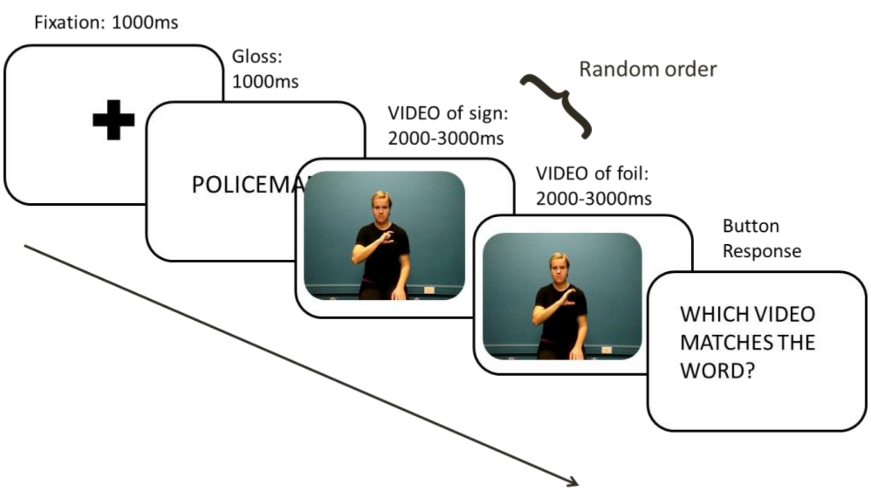

Figure 3: Phonological recognition task trial structure.

Results

In Experiment 1, 6 participants did not finish the training task in the allotted experiment time (60 minutes), leaving 34 participants to be used in data analysis. The original Baus, Carreiras, & Emmorey (2012) study found that iconicity does in fact aid memorization of new signs. Our training task results had the potential to replicate or fail to replicate this finding, and additionally showed the learning curves over time for each type of mapping (iconic or not) that showed when iconicity affects learning. H1 predicted that participants would perform significantly better for the iconic mappings in the first block. The onset accuracy for the non-iconic mappings is predicted to be lower, because non-iconic signs do not have strong referent mappings between form and meaning, and thus they are harder to learn. We first assessed differences in accuracy during the first block by performing a paired two sample t-test on mean accuracy in the first block of learning as a function of iconicity (see Figure 4). Results showed a significant effect of sign type, with iconic signs having higher accuracy in the first block ($t(32) = -19.93$, $p < 0.0001$).

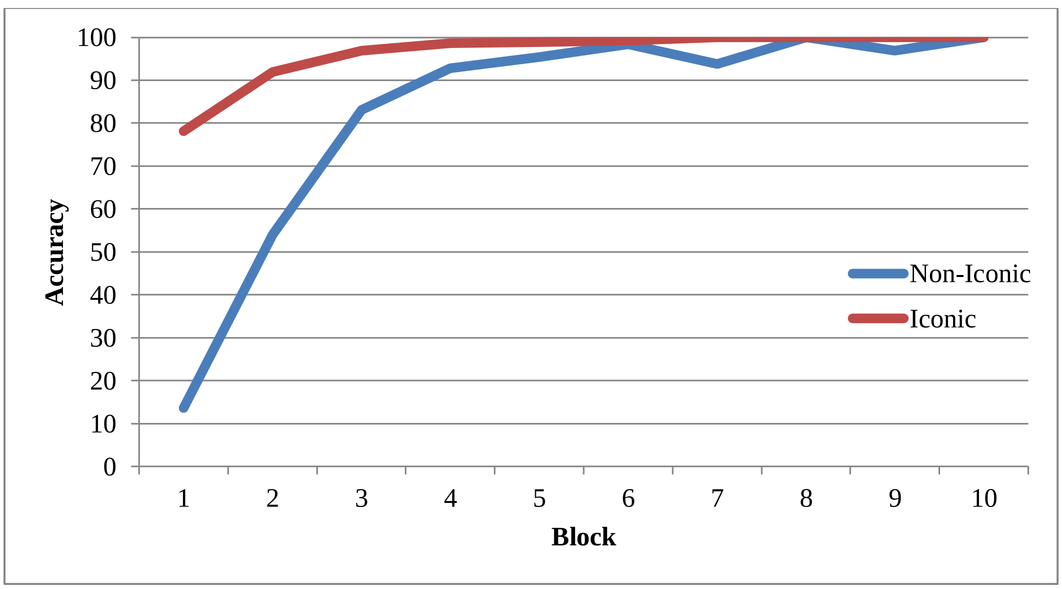

Figure 4: Participant accuracies over all 10 blocks of training task. Participants performed significantly better for the iconic mappings in this very first block (Advantage 1: Initial Guess).

Advantage 2 suggests that learners will acquire iconic signs more quickly over the entire training period, because iconicity strengthens the link between from and meaning. H2 predicted a steeper slope for learning of iconic pairings than non-iconic pairings from block to block. In order to test this, we need to compare the two sign type accuracies in the second block. In order to have both of these start at the same baseline, we want to look specifically at only the signs that were guessed incorrectly in block 1, and not use the rest. For each participant, we removed the items that were guessed correctly in block 1. Some participants did not make any mistakes on iconic trials in block 1, leaving us with 13 participants who did make mistakes on iconic trials in block 1. These 13 participants were used in the H2 analysis. We assessed differences in accuracy during the second block by performing a paired two sample t-test on mean accuracy in the second block of learning as a function of iconicity (see Figure 5). Results showed a significant effect of sign type, with iconic signs having higher accuracy in the second block as well ($t(11) = -3.17$, $p < 0.004$).

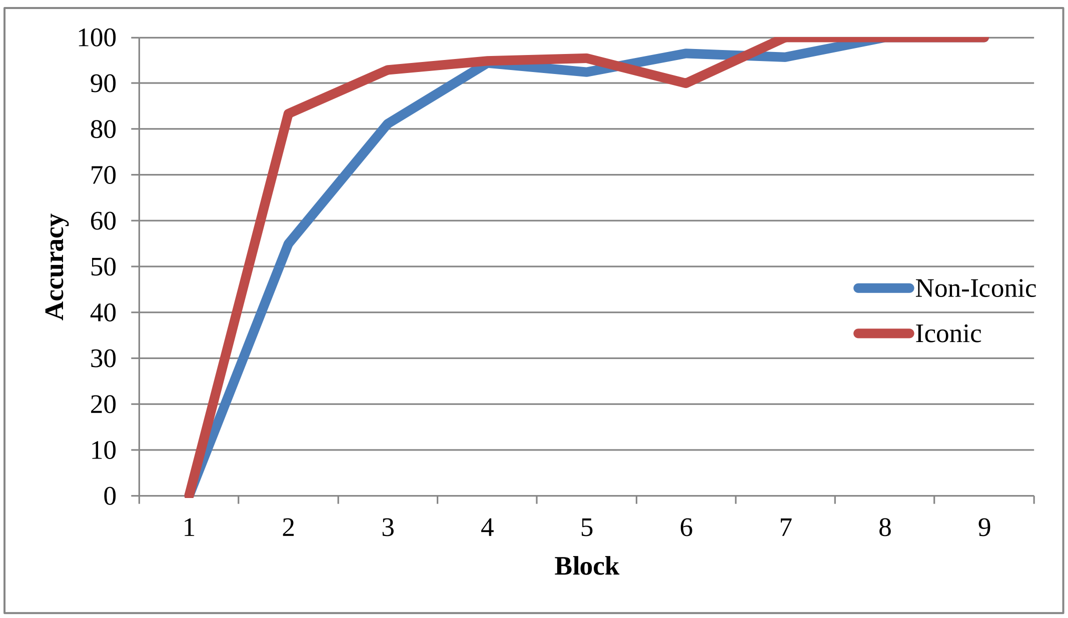

Figure 5: Participant accuracies over all 10 blocks of training task (adjusted, N=13). Participants performed significantly better for the iconic mappings in the second block when looking at signs they guessed incorrectly in the first block (Advantage 2: Rate of Learning.)

The phonological recognition task was designed to test Ortega's (2012) account that gestures interfere with iconic sign processing because of their phonological overlap. There is a potential disadvantage to iconicity for new learners, and H3 predicts that the phonological details of iconic signs will be less precisely encoded than those of non-iconic signs, thus foil signs with small changes should be selected more often for signs learned originally with iconic mappings. H4 predicts a potential advantage of iconicity - that it will lead to improved phonological encoding of signs. In this case, the real iconic signs would be selected more often than the foils, relative to the accuracy for non-iconic signs. This would indicate that there is less gestural interference in iconic sign processing than originally predicted by Ortega (2012), and that iconicity helps to distinguish the phonology between iconic signs and foils.

We performed a paired two sample t-test on mean accuracy in this task as a function of iconicity (see Figure 8). We saw no significant difference between accuracies for this task ($t(32) = 0.06$, $p = 0.95$). Contrary to Ortega's findings and predictions, our data shows that iconicity did not have a negative impact on the participants' ability to recognize fine details of sign. While the difference in accuracies for the two mapping types is not significant, these results do indicate that iconicity does not impede phonological encoding and recall, but it is not a significant facilitator either. Iconicity appears to help the participants distinguish between signs and foils just as well as arbitrariness does.

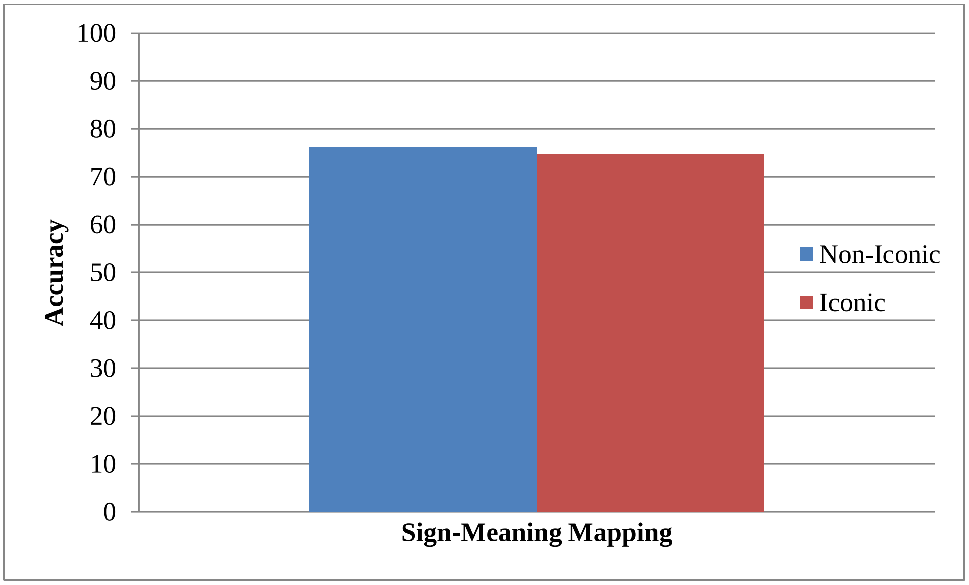

Figure 8: Accuracy in the phonological recognition task. No evidence of a disadvantage due to iconicity.

We also recorded reaction times for each participant in each trial of both tasks. Thompson et al. (2010)'s language processing study showed that iconicity is a significant predictor of response latencies and accuracy, with more iconic signs leading to slower responses and more errors. They concluded that meaning is activated automatically for highly iconic properties of a sign, which can interfere in decision-making. We assessed differences in reaction time during the training task by performing a paired two sample t-test on mean reaction time as a function of iconicity (see Figure 9). Results showed a significant effect of sign type, with iconic signs having faster reaction times ($t(33) = 5.06$, $p < 0.001$). Reponses to iconic signs were faster by an average of 27.37ms. This shows that while iconic signs were more accurately guessed and learned faster in this task, participants were also faster to respond in each trial to iconic signs, contrary to Thompson et al. (2010)'s findings. Reaction times were not significant in the second task (t(33) = 0.77, p = 0.44), but responses to iconic signs were faster by an average of 19.07ms (see Figure 10).

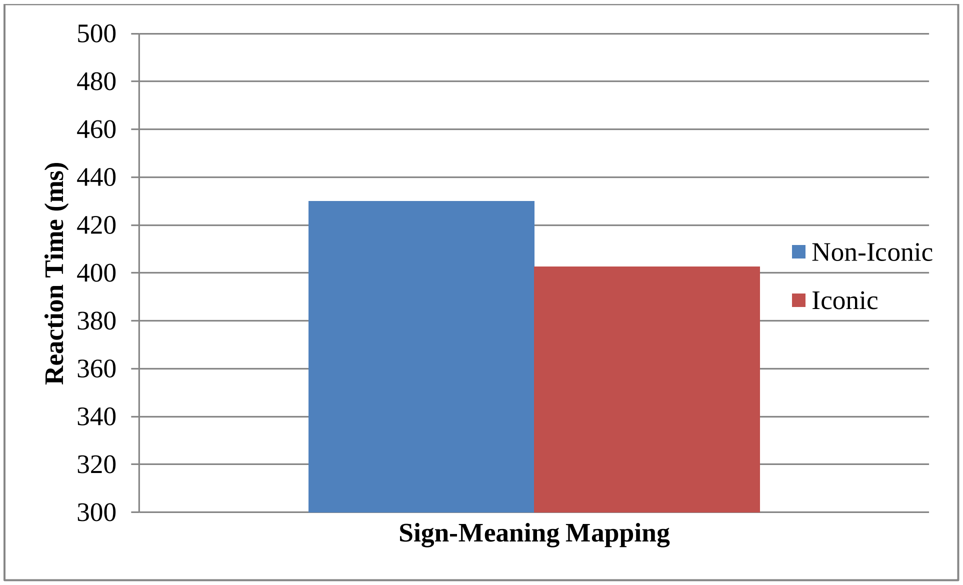

Figure 9: Reaction times in the training task.

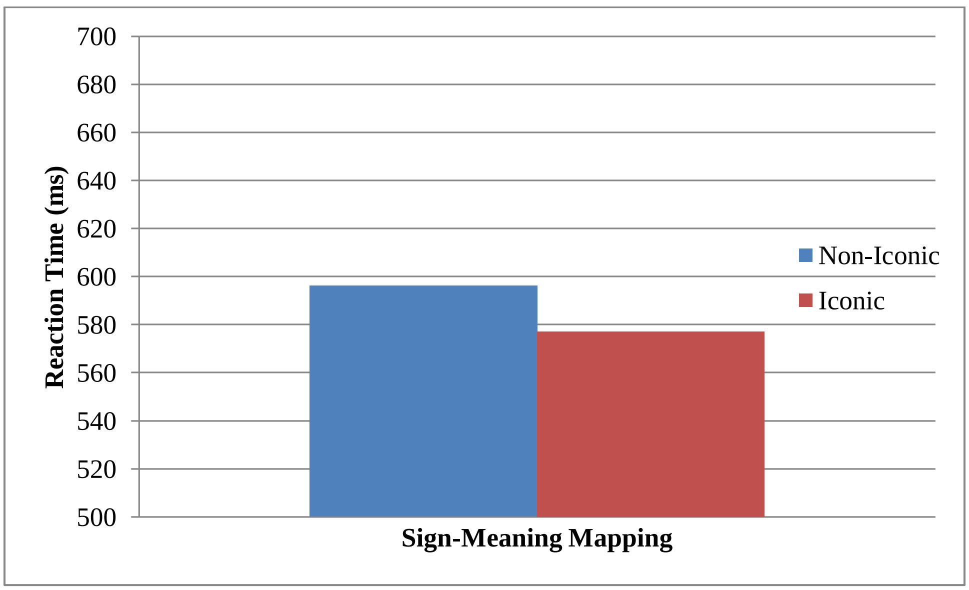

Figure 10: Reaction times in the phonological recognition task.

Discussion

Experiment 1 replicated and expanded upon the iconicity advantage found in Baus et al. (2012). It demonstrated two specific iconic advantages in the Initial Guess and Rate of Learning of iconic over non-iconic signs. The forced-choice task, however, produced no evidence of an iconic disadvantage (contra Ortega, 2012) or advantage. This might be in part due to the type of testing task used: Sign production, as used in Ortega's study, might be more impacted by gesture than sign recognition. Ortega's results may have been an artifact of using actual iconic and actual non-iconic signs, and these could have inherent different phonological features that impact learning and recall of phonological details. The null effect we observed might also be due to the amount of time between the tasks: we implemented a 10-minute interval, whereas Ortega's participants had an interval of 6 months before coming back to do the reproductions.

In the next experiment, we aimed to test the possibility that an iconicity disadvantage may only show up with a longer wait time between tasks. A longer interval might increase effects of gesture knowledge on just-learned signs. In order to test whether the null effect we found was due to a short wait period, we conducted a second experiment that had the exact same design as experiment 1, with another 38 participants; the only difference was that the break was now 30 minutes instead of 10.

Experiment 2

Participants

38 different participants were recruited for this experiment for course credit in psychology and cognitive science classes at UCSD. They are all English speaking with no prior exposure to signed languages.

Materials

The materials from Experiment 1 were used.

Design

All design features of Experiment 1 were the same, except that instead of taking a 10 minute break between the two tasks, participants took at 30 minute break.

Procedure

The same trial structure and measurements were used as in Experiment 1.

Results

Four participants did not finish the training task in the allotted experiment time, leaving 34 participants to be used in data analysis. The training task results of replicate those of Experiment 1, both the iconicity advantage in the initial guess and the learning rate over time (see Figure 11). We assessed differences in accuracy by performing a paired two sample t-test on mean accuracy in each block as a function of iconicity. Results showed a significant effect of sign type, with iconic signs having higher accuracy in the first block ($t(33) = -12.48$, $p < 0.0001$). Results showed a significant effect of sign type, with iconic signs having higher accuracy in the second block as well.

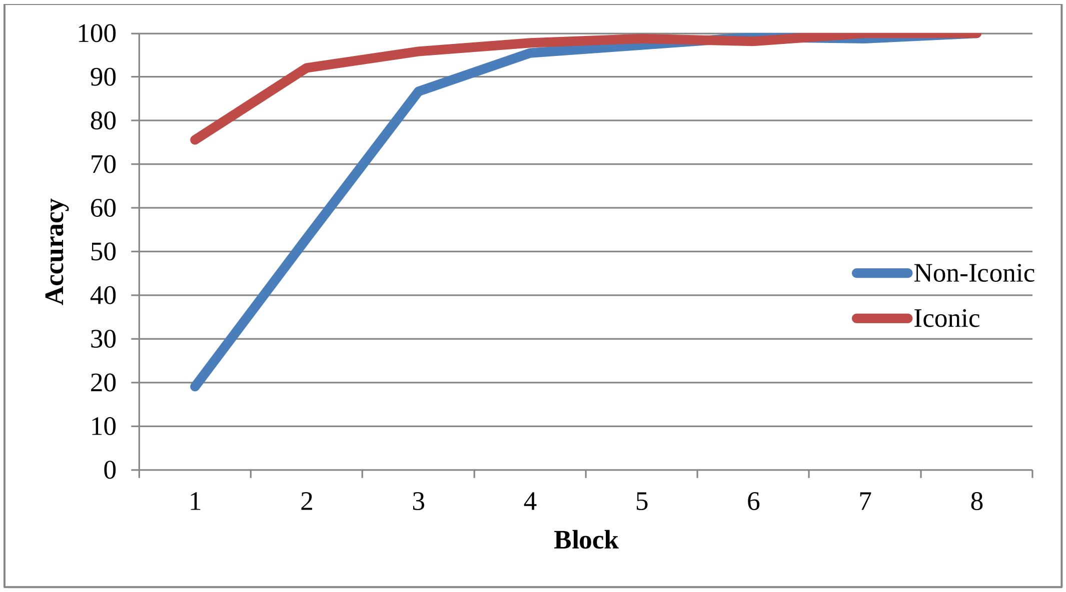

Figure 11: Participant accuracies over all 10 blocks of training task in Experiment 2. Participants performed significantly better for the iconic mappings in this very first block (Iconicity Advantage 1: Initial Guess).

For the phonological recognition task in Experiment 2, we performed a paired two sample t-test on mean accuracy in this task as a function of iconicity (see Figure 12). We saw no significant difference between accuracies for this task ($t(33) = -1.43$, $p = 0.16$). Even after a 30 minute break between the tasks, there is no apparent advantage or disadvantage of iconicity on sign recognition.

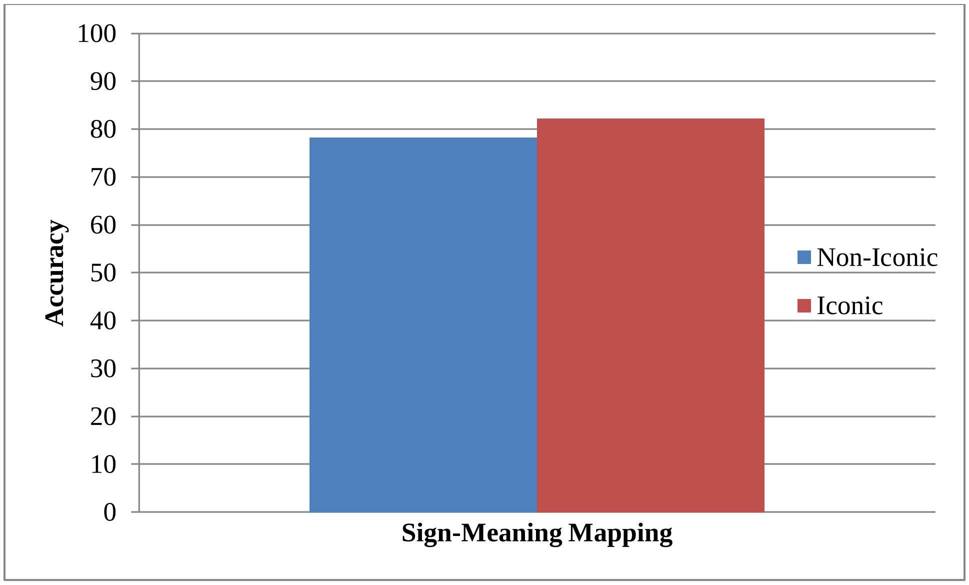

Figure 12: Accuracy in the phonological recognition task in Experiment 2. No evidence of a disadvantage due to iconicity.

We assessed differences in reaction time during the training task in Experiment 2 by performing a paired two sample t-test on mean reaction time as a function of iconicity (see Figure 13). Results showed a significant effect of sign type, with iconic signs having faster reaction times ($t(33) = 3.29$, $p = 0.002$). Reponses to iconic signs were faster by an average of 17.20ms. Reaction times were significant in the phonological recognition task ($t(33) = 2.58$, $p = 0.015$), and responses to iconic signs were faster by an average of 60.69ms (see Figure 14).

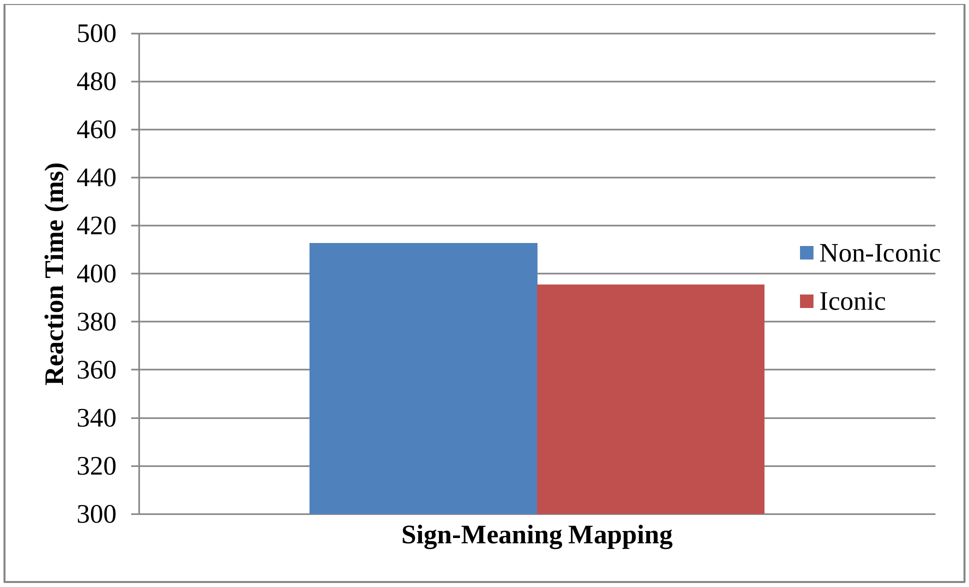

Figure 13: Reaction times in the training task in Experiment 2.

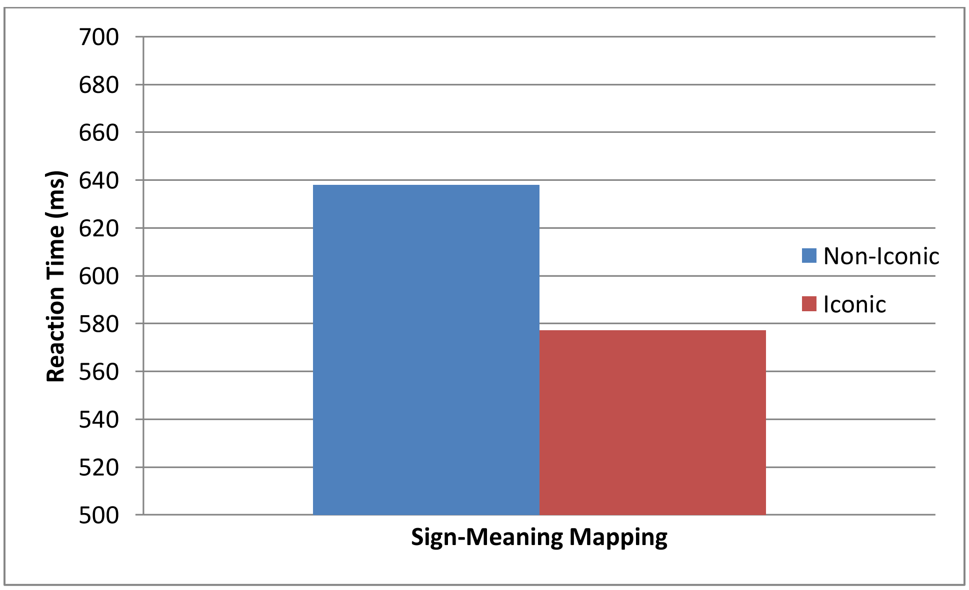

Figure 14: Reaction times in the phonological recognition task in Experiment 2.

Discussion

The aim of this study was to further investigate the effects that iconicity has on sign language learning in non-signers. In the first task of both experiments, we replicated the iconicity advantage found in Baus et al. (2012). We further demonstrated two specific significant advantages of iconicity, in the Initial Guess and in the Rate of Learning. Iconicity strengthens the link between form and meaning when new learners are processing an iconic sign. In the second task of both experiments, we found no evidence of a significant iconicity disadvantage (contra Ortega, 2012). There appears to be no gestural interference that affects participants' abilities to detect phonological differences between signs and foils.

This null effect might in part be due to the type of testing task used in each study. Reproduction might be more impacted by natural gesturing than recognition is, as seen in Ortega (2012). We chose not to have a reproduction task in the current study. In a future study, we could allow the participants to perform the signs along with the training videos, and then test them on the same phonological recognition task. This will test the possibility that actual performance while learning enhances or interferes with phonological encoding and affects accuracies in the second task. We could also replicate Ortega's reproduction task, in order to see whether recalling iconic phonology shows a disadvantage while just recognizing differences in videos does not. The null effect might also be due to the differences in the amount of time between the tasks. 10 and 30 minutes are much different than 6 months, and we had the limitation of a short study, unlike normal language learning experiments that take place over longer periods of time. A future study might look at extending the length of the break even further.

The method of developing materials in this study addresses confounds found in previous language learning designs. Because we used the same signs and English glosses in each condition (iconic and non-iconic), we've eliminated other confounding factors that might themselves be responsible for findings in the current literature.

There are some problems with the current design. The pair-wise switch to make the non-iconic mappings might lead the participants to realize that the iconic and non-iconic meanings are all in pairs. One way to adjust this is to assign the non-iconic meanings in a rotating list of all 32 meanings instead. Another problem with this design is that the participants have to view the signs many times in the training task in order to reach 100% accuracy in two consecutive blocks. Participants saw each video an average of 11.06 times in Experiment 1, and 9.59 times in Experiment 2. This amount of exposure might eliminate the possibility of gestural interference while encoding, especially for the iconic signs, and might be a reason for the null effect seen in the phonological recognition task. In the Training task, they see the English gloss before seeing the sign video. This order of presentation might affect the results because participants might automatically think of a gesture when they see a word, which might skew how they then view and encode a subsequent sign.

Another possible study might investigate manipulating the proportion of iconic to non-iconic mappings in the training task in order to find the optimal proportion for learning. We could then compare this optimal proportion to current proportions in signed languages. We could also consider using bilingual participants (both spoken and signed languages) in order to be able to generalize or find differences in our study's findings.

In sum, our results are consistent with the hypothesis that iconicity aids sign language learning in non-signers, both in the initial guess and in the rate of learning over time. However, the results also indicate that there is no gestural interference happening for iconic signs in the recognition task that manipulated the fine phonology of ASL signs. Given this null effect, more research is needed to investigate the mechanisms and design that give rise to the disadvantages and consequences of iconicity suggested by Ortega (2012) and Thompson et al. (2010).

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Appendix 1. List of phonological changes to signs to make foils

Sign Gloss	Change	Type
ANGEL	Palms face away from shoulders	Palm
ATTENTION	5-open handshape	Handshape
CAT	F handshape is dynamic - open and close 2x	Movement
CLOWN	5 claw grasps 2x	Movement
DRESS	Palms end face down on legs	Location
DUMB	5-closed handshape	Handshape
ELEPHANT	C handshape	Handshape
FISHING	Fists are closer together	Location
GOLF	Fists are touching at the knuckles	Location
HAMMOCK	Palm faces up	Palm
HAT	10-t handshape	Handshape
ICECREAM	O handshape	Handshape
MICROSCOPE	Rotate hands at wrist 2x	Movement
MILK	Open and close motion is also pulled down 2x	Movement
MIRROR	Palm moves closer and farther from face 2x	Movement
NAPKIN	10-t handshape	Handshape
ONION	A handshape	Handshape
PANTS	Hands move up and down 2x over each leg	Movement
PAPER	Hand sweeps towards body	Movement
PIRATE	Palm orientation is so that elbow is out 90°	Palm
POLICEMAN	C handshape with all fingers	Handshape
READ	4-open handshape	Handshape
RIVER	Palms face down, touching	Palm
ROOSTER	5-open handshape	Handshape
SAND	Palms face down	Palm
SHOWER	Hand is over top of head	Location
SOUP	10-t handshape	Handshape
SUSPENDERS	Movement starts from chest down to waist	Movement
TABLE	Non-dominant palm (on bottom) faces up	Palm
TENNIS	S handshape	Handshape
TIE	1-g handshape	Handshape
WHISTLE	1-g handshape	Handshape