Published in final edited form as:
Lang Cogn Process. 2013 March 1; 28(3): 261–271. doi:10.1080/01690965.2011.620374.

When does Iconicity in Sign Language Matter?

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Abstract

We examined whether iconicity in American Sign Language (ASL) enhances translation performance for new learners and proficient signers. Fifteen hearing nonsigners and 15 proficient ASL-English bilinguals performed a translation recognition task and a production translation task. Nonsigners were taught 28 ASL verbs (14 iconic; 14 non-iconic) prior to performing these tasks. Only new learners benefited from sign iconicity, recognizing iconic translations faster and more accurately and exhibiting faster forward (English-ASL) and backward (ASL-English) translation times for iconic signs. In contrast, proficient ASL-English bilinguals exhibited slower recognition and translation times for iconic signs. We suggest iconicity aids memorization in the early stages of adult sign language learning, but for fluent L2 signers, iconicity interacts with other variables that slow translation (specifically, the iconic signs had more translation equivalents than the non-iconic signs). Iconicity may also have slowed translation performance by forcing conceptual mediation for iconic signs, which is slower than translating via direct lexical links.

Keywords

American Sign Language; iconicity; translation; bilingualism

Due to the nature of the visual-gestural modality, sign languages display a high degree of iconicity, i.e., a resemblance between linguistic form and meaning (e.g., Mandel, 1977; Taub, 2001; Pietrandrea, 2002). Although spoken languages contain iconic words that sound like their referents (e.g., onomatopoetic words), most phenomena are not easily depicted with sound. In contrast, the visual three-dimensional modality of sign languages allows for iconic expression of a wide range of basic conceptual structures, such as object and human actions, movements, locations, and shapes (Taub, 2001). For example, the ASL verbs STIR, DRINK, and EAT[1] all resemble the actions that they denote.

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[3]To investigate whether the observed results might be influenced by age differences between the groups, a subset of the six youngest participants in the fluent signer group (mean age=25,8; sd= 3.3) and the oldest in the non-signer group (mean age=23.5; sd=2.9) ($p = .22$) was selected for separate analyses. ANOVAs for each task revealed the same effects and further showed the iconicity effect was not significantly modulated by the age of participants.

[1]By convention, signs are represented by translation equivalents written in capital letters.

Iconicity is likely to play an important role in some aspects of linguistic behavior, such as metaphor creation (and interpretation), novel sign formation, and of course, sign poetry. However, iconicity and especially how the transparency between the form and its referent influences signed language processing has been and is still one of the aspects of signed language research that has generated much active debate. Some researchers argue that although adult signers may be aware of the iconic properties of signs, and in fact they may exploit them when the communication situation requires it (e.g., signing to a person with no sign language knowledge or to a signer of a different sign language), iconicity is an attribute of signs that is not linguistically relevant for language processing (e.g., Klima & Bellugi, 1979; Newport & Meier, 1985). Others assume that sign languages are basically iconic, that is, the link between form and meaning is so prevalent and robust that there is no level of strictly meaningless units in sign language (e.g., Armstrong, Stokoe, & Wilcox, 1995). Although an absence of meaningless phonological units in sign language is not supported by most models of sign language phonology (Brentari, 1998; Liddell & Johnson, 1989; van der Hulst, 1993; Sandler & Lillo-Martin, 2006), the evidence regarding whether iconicity plays an important role in sign language comprehension and production is mixed.

On one hand, several studies suggest that iconicity does not aid sign vocabulary learning in children. Iconic signs are not learned first and are not over-represented in the early vocabularies of ASL-learning children (e.g., Anderson & Reilly 2002; Orlansky & Bonvillian, 1984). In addition, other studies have shown that iconicity has no effect during on-line sign language processing for adults. For example, Poizner, Bellugi, and Tweney (1981) showed that iconicity has no effect on immediate short-term memory recall: iconic signs were remembered as accurately as non-iconic signs. Bosworth and Emmorey (2010) found that iconic signs were not recognized more quickly or accurately in a lexical decision task and that iconicity did not boost semantic priming. Further, iconic and non-iconic signs are similarly impaired with sign language aphasia (Marshall et al., 2004), and the production of iconic and non-iconic signs engages the same language-related neural regions (Emmorey et al., 2004). Further, iconic and non-iconic signs are equally affected during tip-of-the-finger states (parallel to tip-of-the-tongue states in which the person knows the meaning of the word but cannot retrieve the phonological form; Thompson, Emmorey, & Gollan, 2005). These studies suggest that iconicity does not play a significant role in linguistic processing.

On the other hand, there is growing evidence suggesting that iconicity can impact performance on language tasks (see Perniss, Thompson, & Vigliocco (2010) for review). For example, Thompson, Vinson, and Vigliocco (2009) reported that iconicity aids lexical retrieval in a sign-picture matching task (see also, Grote & Linz, 2003; Ormel, Hermans, Knoors, & Verhoeven, 2009). Signers decided whether a sign and a picture referred to the same object, and the iconic relationship between the sign and the picture was manipulated. For example, the beak of a bird is depicted in the ASL sign BIRD, and this property is salient in a picture of a bird's head in profile, but not in a picture of a bird in flight. Response times were faster when the property that was iconically depicted in the sign (e.g., the beak of the bird) was highlighted in the corresponding picture. Ormel et al. (2009) found the same facilitatory iconicity effect using a similar task with deaf children. In addition, Thompson, Vinson and Vigliocco (2010) found that iconicity influenced reaction times in a sign-phonological decision task. Deaf signers were required to indicate whether the "active" fingers in a sign were straight or curved. In this case, they found an inhibitory effect of iconicity: it took longer for signers to make the handshape decision for iconic than for non-iconic signs. Because the task did not require explicit access to semantics, Thompson et al. (2010) interpreted this inhibitory effect as reflecting automatic access to iconicity, which interfered with the form-based decision.

Despite the lack of agreement on how iconicity influences lexical and memory processing in highly proficient signers, several studies indicate that hearing adult second language learners rely on iconicity to remember signs during the initial stages of learning (Campbell, Martin, & White, 1992; Lieberth & Gamble, 1991; Luftig & Lloyd, 1981). Second language learning adults are better able than children to recognize the relationship between the form of a sign and its referent, and they may encode this relationship as part of the lexical semantics of the sign. However, iconicity only influences learning when learners can identify the mimetic motivation for the signs. For example, Klima and Bellugi (1976) showed that iconic attributes are not sufficient to reach comprehension of the meaning by naïve hearing speakers (see also Thompson, et al. (2010) for a lack of difference between iconic and non-iconic signs in the phonological decision task for hearing non-signers).

In the present work, we examined the role of iconicity in lexical processing by exploring whether iconicity facilitates lexical translation performance for either new learners or highly proficient ASL-English bilinguals. Lexical translation provides an appealing way to gauge the role of iconicity in language processing because of the involvement of the conceptual memory system when performing the task (Kroll & Stewart, 1994). In order to translate a word, associations between the input (source language) and the output (target language) lexical systems (*word-word associations*) and associations through the conceptual system (*conceptually mediated translation*) are both utilized in word translation. However, the extent to which lexical associations or conceptual mediation are involved seems to be determined by several factors, such as L2 proficiency (Kroll & Curley, 1988), the characteristics of the words to be translated (e.g., imageability; de Groot, 1992), and the amount of training on translation tasks (de Groot, 1997; Macizo & Bajo, 2005).

We hypothesize that for new sign language learners, iconicity will strengthen the link between form and meaning, and thus iconic signs should be easier and faster to learn and to translate. Moreover, if strong connections between lexical and conceptual representations for iconic signs are maintained and automatically accessed for proficient English-ASL bilinguals, then iconicity should also enhance their translation performance. On the contrary, if iconicity-related connections become less relevant for lexical processing when a high level of proficiency has been attained, then iconicity should have no impact on translation accuracy or speed.

Method

Participants

Fifteen hearing adults (12 women; mean age = 20.9 years) with no knowledge of ASL and fifteen hearing proficient signers (13 women; mean age = 36.1 years) participated, and all had normal hearing. Four signers were exposed to ASL from birth by Deaf parents, and eleven learned ASL in late childhood or adulthood. All used ASL on a daily basis, and eleven were interpreters.

Materials

Twenty-eight ASL verbs (14 iconic and 14 non-iconic) were selected (see Appendix for the list of stimuli). Stimuli were rated for meaning transparency on a scale of 0 – 3 by a separate group of ten participants with no knowledge of ASL (0 = no meaning; 1 = weak meaning, 2 = moderate or fairly clear meaning, and 3 = absolute strong/direct meaning). The non-iconic signs were rated as having little or no meaning (mean = 0.73), and the iconic signs were rated as having more transparent meaning (mean = 1.57). All the iconic signs resembled actions made by manipulating objects (see Figure 1 for examples). The meanings for an

average of 81% of the iconic signs were correctly guessed by these participants, while only 1.4% of the signs in the non-iconic condition were correctly identified.

Signs in each condition were matched for phonological features (number of two-handed signs, handshape types, and movement) and for length (mean = 38.4 frames (1,267 ms) for the iconic signs and 36.6 frames (1,208 ms) for the non-iconic signs). Finally, the ASL signs were rated for familiarity on a scale of 1 (infrequent) to 7 (very frequent) by two fluent hearing ASL signers. The iconic and non-iconic signs did not differ significantly in rated familiarity, $p > .30$ (mean ratings = 3.6 and 4.1, respectively).

The English translation equivalents of the ASL signs in each condition were matched for lexical log frequency (Baayen, Piepenbrock, & Gulikers, 1995), length in phonemes and letters, and imageability (based on Coltheart, 1981; all p's >.05) (see Table 1).

Procedure

In the learning phase, the nonsigning participants were individually taught English translations of the 28 ASL signs (presented in random order). A video clip of each sign was presented on a computer screen followed by the same clip with the English translation printed below. After each presentation, participants repeated the sign as many times as they wanted and then pressed the space bar to see the stimulus again and copied the sign a second time. The learning phase took approximately one half hour, and the experimenter was present to correct nonsigners in their sign productions.

The proper study for both groups of participants began with the translation recognition task. For this task, a video clip of a sign and an English verb were presented simultaneously on a 15 inch Macintosh laptop computer. Both new learners and fluent signers had to decide whether the ASL sign and English word matched, pressing keys marked *yes* or *no*. Reaction times (RTs) were recorded from stimulus onset using Psyscope software (Cohen et al., 1993). Each stimulus was presented twice, once with the correct English verb translation and once with an incorrect translation from the same set of learned materials.

After the translation recognition task, participants performed the two production translation tasks (forward and backward translation directions). For the forward translation task, participants saw a printed English verb on the screen and produced the ASL translation by raising their hand from a button box, which registered RT by stopping the timer. Only those ASL signs correctly signed were considered in the analysis. For backward translation, participants watched a video of a sign and pronounced the English word. Reaction time was measured by a voice onset key from the beginning of the video clip. Order of translation direction was counterbalanced across participants.

Results

Incorrect responses in the recognition task were not considered in the reaction time analyses (7.7% of the data). For the forward translation task (English to ASL), incorrect sign translations, poorly produced signs (i.e., signs that were unrecognizable due to a change in at least one of the phonological parameters composing the sign) or hesitations (i.e., the sign was not produced immediately after raising the hand from the button box) were excluded from the analyses (2.7 % of the data). For the backward translation condition (ASL to English), incorrect spoken responses and responses with hesitations (e.g., "um") were excluded from the analysis (2.4% of the data). Moreover, two items, one from the iconic condition ("eat") and one from the non-iconic condition ("ski"), could not be analyzed because the microphone did not properly trigger the beginning of the word. These items were only excluded from the backward translation condition.

Data from the recognition and translation production tasks were analyzed separately. The forward and backward translation conditions were also analyzed separately because a direct comparison between translation direction is confounded by response modality (sign vs. speech).

Translation recognition task

A 2 × 2 ANOVA with iconicity as the within-participants factor and participant group as the between-items factor was carried out over correct responses[2].

The ANOVA revealed a main effect of group, $F_1(1, 28) = 6.98$, MSE = 38,788.81, $p < 0.01$, $F_2(1, 26) = 109.60$, MSE = 2,246.66, $p < 0.001$. Fluent signers were faster (1,199 ms) than nonsigners (1,335 ms) in recognizing correct ASL-English translation equivalents (see Table 2). There was no main effect of iconicity (Fs <1), but the interaction between iconicity and group was significant, $F_1(1, 28) = 11.86$, MSE = 986.44, $p < .01$, $F_2(1, 26) = 5.46$, MSE = 2,246.66, $p < .01$. As predicted, new learners were faster to recognize iconic than non-iconic sign translations, $t_1(14) = 2.39$, $p < .05$, $t_2(27) < 1$, but surprisingly, fluent signers were slower to recognize iconic sign translations, $t_1(14) = 2.60$, $p < .05$, $t_2(26) < 1$.

The error rate analysis also showed a main effect of group, $F_1(1, 28) = 11.39$, MSE = .010, $p < .01$, $F_2(1,26) = 29.65$, MSE = .004, $p < .001$. Fluent signers made fewer errors (3.3%) than new learners (12%). There was a main effect of iconicity, $F_1(1, 28) = 6.13$, MSE = .003, $p < .05$, $F_2(1, 26) = 3.21$, MSE = .005, $p = .08$; however, this iconicity effect was modulated by a significant interaction with group, $F_1(1, 28) = 9.96$, MSE = .003, $p < .01$, $F_2(1, 26) = 7.59$, MSE = .004, $p < .01$. New learners made more errors for non-iconic than iconic sign translations, $t_1(14) = 3.17$, $p < .01$, $t_2(27) = 2.12$, $p < .05$, whereas error rates were unaffected by iconicity for fluent signers, ts < 1.

Translation Production Tasks

Forward translation (English to ASL)—For reaction time, the ANOVA results revealed a main effect of group, $F_1(1, 28) = 14.23$, MSE = 297,178.36, $p < .001$, $F_2(1, 26) = 286.05$, MSE = 13,708.26, $p < .001$ (see Table 3). Not surprisingly, fluent signers were faster (685 ms) than new learners (1216 ms). There was also a marginal main effect of iconicity in the analysis by participants $F_1(1, 28) = 3.19$, MSE = 7203, $p = .08$, $F_2(1, 26) < 1$. The interaction between participant group and iconicity was significant, although only in the analysis by participants $F_1(1, 28) = 5.20$, MSE = 7203, $p < .05$, $F_2(1, 26) < 1$. Given English words, new learners translated iconic signs significantly faster than non-iconic signs, $t_1(14) = 2.08$, $p < .05$, $t_2(14) < 1$. In contrast, translation times were not affected by iconicity for the fluent signers, ts < 1.

Error rates were overall low, and the ANOVA revealed only a main effect of group, $F_1(1, 28) = 5.96$, MSE = .002, $p < .05$, $F_2(1, 26) = 7.66$, MSE = .001, $p < .01$. Fluent signers produced fewer errors (0.9%) than new learners (3.6%).

Backward translation (ASL to English)—Results for reaction time showed a main effect of group, $F_1(1, 28) = 18.76$, MSE = 93,118.15, $p < .001$; $F_2(1, 24) = 83.37$, MSE = 18,844.41, $p < .001$, (see Table 3). Fluent signers were faster (1,096 ms) than new learners (1,476 ms). The main effect of effect of iconicity was significant, $F_1(1, 28) = 21.13$, MSE = 5,830.01, $p < .001$; $F_2(1, 24) = 4.51$, MSE = 26,743.81, $p < .05$. However, this effect

[2]Both hits (yes answers) and correct rejections were collapsed in the main analysis because analysis considering the type of answer (hits vs. correct rejections) revealed only a main effect of type of answer [$F(1, 28) = 83.390$, $p < .001$], showing that participants were faster in answering yes than no to the sign-word pairs. Importantly, neither the interaction with group nor the three-way interaction with group and iconicity were significant (all Fs < 1).

interacted with participant group, $F_1(1, 28) = 59.54$, MSE = 5830.01, $p < .001$; $F_2(1, 24) = 17.23$, MSE = 18,844.41, $p < .001$. As predicted, new learners translated iconic signs faster than non-iconic signs, $t_1(14) = 6.67$, $p < .001$, $t_2(24) = 3.21$, $p < .01$. In contrast, fluent signers translated iconic signs more slowly than non-iconic signs, $t_1(14) = 4.05$, $p < .001$, $t_2(24) = 2.23$, $p < .05$.

For error rates, the ANOVA again revealed a main effect of group, $F_1(1, 28) = 21.28$, MSE = .002, $p < .001$, $F_2(1, 24) = 10.10$, MSE = .002, $p < .01$. Fluent signers made fewer errors (0.3%) than new learners (5.3%). There was also a main effect of iconicity, $F_1(1, 28) = 21.28$, MSE = .002, $p < .001$, $F_2(1, 24) = 7.98$, MSE = .003, $p < .01$. However, the interaction between iconicity and group was significant, $F_1(1,28) = 15.98$, MSE = .002, $p < .001$, $F_2(1, 24) = 7.77$, MSE = .002, $p < .01$. New learners translated iconic signs more accurately than non-iconic signs, $t_1(14) = 3.21$, $p < .01$, $t_2(24) = 2.85$, $p < .01$; whereas the fluent signers showed no effect of iconicity on error rate, ts < 1.

Discussion

The results support the hypothesis that for new learners of a sign language, connections between the lexicon and conceptual memory are stronger for iconic than non-iconic signs. Participants who had learned ASL signs in the laboratory were significantly more accurate and faster to recognize iconic sign translations of English words and to translate iconic signs into or from English. These results are consistent with those of Lieberth and Gamble (1991) and Campbell et al. (1992). Lieberth and Gamble (1991) found that new (sign-naïve) learners recalled English translations for iconic ASL signs more accurately than non-iconic signs after both a short delay (10 min) and a long delay (2 weeks). Campbell et al. (1992) reported that novice sign language learners remembered iconic signs more accurately than non-iconic signs in a forced choice recognition memory task. Thus, at the earliest stage of adult second language acquisition, iconicity appears to strengthen the link between a sign's form and its representation in conceptual memory, which leads to faster and more accurate translation performance. Moreover, the facilitatory effect of iconicity observed for forward and backward translations support the notion that both translation directions are conceptually mediated from the very early stages of second language learning (Finkbeiner & Nicol, 2003).

However, highly proficient signers either exhibited poorer performance for iconic signs or they exhibited no significant effect of iconicity. For the recognition translation task and the backward translation task (from ASL to English), response times were significantly slower for iconic signs than for non-iconic signs. For the forward translation task (from English to ASL) proficient signers were unaffected by sign iconicity, but results followed the same inhibitory tendency. Overall, results from the high-proficient hearing signers are not consistent with the assumptions made by the Revised Hierarchical Model (Kroll & Stewart, 1994). If, as proposed in that model, connections from L2 to the semantic memory system become stronger as L2 proficiency increases and hence more symmetrical involvement of the conceptual system between languages is observed, then a facilitatory effect of iconicity would be expected for both groups. For example, just as imageability facilitates translation performance no matter the degree of L2 proficiency (de Groot & Poot, 1997), the iconic link between form and meaning should increase involvement of conceptual memory (as does imageability) and thus speed translation for both new learners and skilled signers.

The results also do not support the hypothesis that iconicity becomes irrelevant to the translation task once a high level of language proficiency is obtained; rather, iconicity appeared to delay or interfere with ASL-English translation. Thompson et al. (2010) also found a negative effect of iconicity when signers made a phonological decision about

handshape, and they suggested that interference from iconicity could stem from more automatic access to meaning for iconic than for non-iconic signs. However, more automatic access to meaning should speed translation for iconic signs. How then do we explain that when the links between form and meaning are stronger, translation times are slower?

One possible explanation is that the ASL-English bilinguals relied on direct lexical mappings between ASL and English to achieve rapid translation and that iconic signs "forced" conceptually mediated translation, which slowed performance. The majority of the bilinguals in our study were professional simultaneous interpreters (11 out of 15) and may have used a lexical translation strategy, which taps a more direct route between lexical representations in ASL and English. It is possible that the imagistic or sensory-motor properties of the iconic signs induced these signs to be translated via conceptual mediation, which slowed translation times. However, most studies indicate that skilled interpreters are more likely to perform lexical translation tasks using conceptual mediation rather than direct lexical translation (e.g., Chen & Leung, 1989; Kroll & Curley, 1988; Macizo & Bajo, 2005). Furthermore, a correlation analysis revealed no relationship between years of sign language interpreting experience and the size of the iconicity effect for the forward translation task ($p = .28$).

Another possibility is that the ASL-English bilinguals, unlike the new learners, were sensitive to the lexical properties of the signs to be translated, such as the number of translation equivalents for the ASL signs and English words. Tokowicz and Kroll (2007) reported that in bilingual translation production tasks, words with multiple translations (in either direction) are translated more slowly than words with only a single translation equivalent. Therefore, we asked four hearing fluent signers to translate the English words into ASL and the ASL signs into English and to provide as many translation equivalents for each item as possible. The results showed that 83% of the first responses given by this new group of hearing signers were the same as the verb translations given in the experiment (equally distributed between the iconic and non-iconic conditions; $t < 1$). However, words/signs belonging to the iconic condition had significantly more translations (mean = 1.92) than words/signs in the non-iconic condition (mean =1.32), $t(27) = 2.83$, $p < 0.01$. Thus, for fluent signers, response times may have been influenced by the number of available translations, rather than by iconicity. However, this explanation must remain speculative because a regression analysis failed to show a significant relationship between number of translations and response time ($p = .55$).

In sum, our results are consistent with the hypothesis that iconicity aids memorization of signs during the first stages of sign learning and that adult learners can exploit the iconic properties of signs when they become aware of the link between form and meaning. However, the results also indicate that the role of iconicity in translation changes with increased fluency. For fluent signers, iconicity may interfere with a strategy of direct lexical translation by forcing conceptual mediation, which slows processing (Kroll & Stewart, 1984), or the facilitatory effects of iconicity may be overridden by other factors, such as the number of available translations. The effects of iconicity on sign language processing appear to be fairly task dependent, with null effects observed for lexical decision, facilitatory effects observed for sign-picture matching tasks, and inhibitory effects observed for phonological and lexical translation tasks. Given the pervasiveness of iconicity in the lexica of sign languages and the modular division between phonological and semantic representations assumed by most models of language processing, more research is needed to identify the mechanisms that give rise to iconicity effects during processing and to determine whether and when these effects are strategic versus automatic.

Acknowledgments

This research was supported by NIH Grants R01 HD047736 and R01 DC010997 (to KE), a postdoctoral fellowship JCI-2010-06504 from the Spanish Government (to CB), and Grants PSI 2009-08889 and CONSOLIDER INGENIO 2010 CSD2008-00048 (to MC). We thank Rachael Colvin, Franco Korpics, Heather Larrabee, and Brenda Nicodemus for assistance with the study, and we thank all of the participants.

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APPENDIX

List of ASL verbs.

Iconic	Non-iconic
STIR	SING
DRINK	DANCE
BRUSH	BET
SNOW	SEARCH
SAW	SKI
POUR	PREACH

Iconic	Non-iconic
GRAB	GESTURE
THROW	TRAVEL
EAT	REBEL
CRUSH	KISS
SPRAY	DRY
SEW	PASS
SMOKE	BORN
BAT (use a baseball bat)	BURN

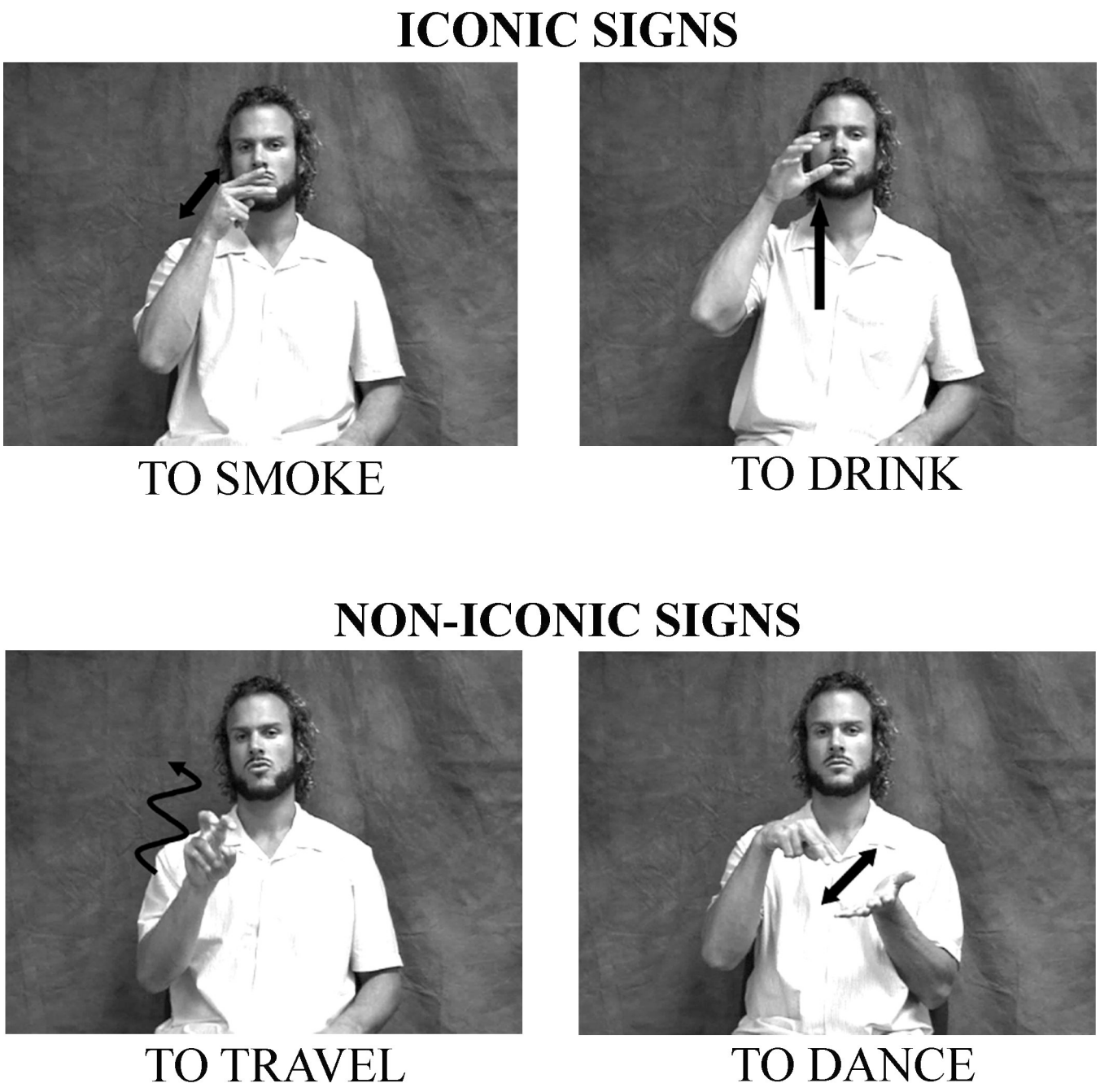

Figure 1.
Illustration of iconic and non-iconic signs in ASL.

Table 1

Lexical properties of the English words used in the recognition and translation tasks. Standard deviations are in parenthesis.

	English translation verbs		
	Iconic	**Non-iconic**	
Log frequency	1.51 (0.4)	1.47 (0.5)	t (26) < 1
Imageability	529.8 (56)	488.1 (71)	t (26) = 1.66; p = .10
Number of letters	4.1 (0.8)	4.6 (1)	t (26) < 1
Number of phonemes	3.4 (0.9)	3.6 (1)	t (26) p = .03

Table 2

Reaction times (ms) and error rate (%) for both groups in the recognition translation task. Standard deviations are in parenthesis.

	Iconic		Non-iconic	
Group	**RTs**	**Error rate**	**RTs**	**Error rate**
Fluent Signers	1,213 (170)	3.8 (4.3)	1,189 (159)	2.8 (3.6)
New Learners	1,319 (109)	8.1 (7.9)	1,351 (114)	16 (13)

Table 3

Reaction times (ms) and error rate (%) for forward and backward translation directions. Standard deviations are given in parentheses.

FORWARD TRANSLATION: English (L1) to ASL (L2)				
	Iconic		**Non-iconic**	
Group	**RT**	**ERROR**	**RT**	**ERROR**
Fluent Signers	690 (149)	0.9 (3.6)	679 (150)	0.9 (2.4)
New learners	1,171 (515)	1.8 (4.1)	1,261 (545)	5.1 (5.5)
BACKWARD TRANSLATION: ASL (L2) to English (L1)				
	Iconic		**Non-iconic**	
Group	RT	ERROR	RT	ERROR
Fluent Signers	1,129 (76)	0.0 (0)	1,068 (97)	0.6 (2.5)
New learners	1,319 (284)	0.6 (2.5)	1,561 (318)	10 (7.5)