The Effect of Iconicity on Weak Hand Drop in American Sign Language

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1 Introduction

Iconicity — defined very generally as a resemblance between linguistic form and real-world entities — is a salient characteristic of signed languages. Even non-signers can recognize that certain signs "look like what they mean." Demonstrating that iconicity does not preclude linguistic structure was a major theme of early signed language research, which began with Stokoe 1960, 2005. This work showed that, despite iconicity's role in motivating sign forms, American Sign Language (ASL) contains a finite inventory of phonological units, and that these units combine in systematic ways to create form-meaning pairings that are conventionalized within a deaf community. Later work, like Brentari's (1998) Prosodic Model of phonology, aligned the study of signed language structure with spoken language linguistics even further by describing these phonological units, regardless of iconic motivation, as structured collections of features. The research community now accepts that signed and spoken languages contain both iconicity and arbitrariness. However, whether iconicity's relevance ends at new sign formation is still unknown. Its impact on statistical distributions of motivated forms throughout the lexicon is clear (e.g. Occhino, 2016). However, there has been little work to determine whether the iconic links between form and meaning are still active in some way that interacts with the synchronic grammar. The present study aims to address this gap in our knowledge by asking whether iconicity can affect the process of Weak Hand Drop (WHD) in ASL.

In the phonology of a signed language, signs may be specified as either one- or two-handed. WHD is a post-lexical phonological process in which only the dominant hand of an underlyingly two-handed sign surfaces. Whether or not iconicity affects WHD is unknown. There have been some preliminary suggestions that a pressure to preserve iconic associations between form and meaning may limit or block this process for some iconic signs. Brentari 1998 posits categories of signs that resist WHD in ASL and accounts for these by invoking Optimality Theoretic (Prince I& Smolensky, 2004) constraints formalized in terms of phonological features. Van der Kooij 2001 argues that some of these constraints only hold for Sign Language of the Netherlands when the feature is iconically motivated in a given sign. There has also been discussion of WHD as more acceptable if the weak hand iconically represents a surface (Battison, 1974). These claims have not been evaluated in a way that systematically controls for phonological similarity, however, which the present study does for ASL through experimentally collected acceptability judgments from native ASL signers. The findings show that iconic signs were more amenable to WHD than non-iconic signs: participants rated stimuli containing one-handed (1H) versions of two-handed (2H) iconic signs significantly higher than those containing 1H versions of phonologically similar non-iconic 2H signs.

The following sections will first provide background on two-handed signs in ASL, the process of WHD and proposed structural constraints, and the ideas on the role of iconicity mentioned above. The grammatical use of signing space, which was also tested as a variable in the acceptability judgment task, is also described. The design of the present study will then be presented, followed by the results and a discussion of these results with reference to the guiding research questions and hypotheses. The results support neither hypothesis fully and were gradient rather than categorical. There was a statistically significant difference between participants'

ratings of stimuli containing WHD versions of iconic and non-iconic two-handed signs: WHD was more acceptable for iconic than non-iconic signs, with no effect of grammatical use of signing space. The present study is part of a larger research project investigating whether the iconic associations that motivate a sign's form remain relevant to the grammar after a sign has become conventionalized. The discussion will argue that these associations must be accessible during the application of synchronic processes in order to account for these results, but the fact that these results cannot tell us a complete story about the interaction between iconicity and grammar is also addressed. This paper concludes by explaining how the other component of the larger study is hoped to shed more light on this broader question.

1.1   *Handedness*   A signed language phonology can recruit either one or both hands for underlying sign forms, referred to as the dominant hand (DH) and weak hand (WH). By default, a right-handed signer will likely realize DH specifications with their right hand. However, DH and WH are ultimately abstract, phonological categories rather than phonetic ones. Battison (1978) identified three types of two-handed (2H) signs. In type 1 or "symmetrical" signs, the two hands move symmetrically or in an alternating motion. The handshape is unrestricted but must be the same for both hands. In types 2 and 3, called "asymmetrical" 2H signs, only the DH moves and the WH acts as place of articulation for the DH. The handshapes are again unrestricted but the same for both hands in type 2. The two handshapes in type 3 signs differ and the WH is restricted to a set of seven handshapes[1], which Battison refers to as "unmarked" according to their distribution, cross-linguistic frequency, acquisition, perception, and articulatory complexity. There are exceptions to this pattern, such as the sign HELICOPTERthree[2], which has a WH handshape other than one of the seven unmarked handshapes identified by Battison. Many of these exceptions are highly iconic and appear to be still close to their depictive origins. Other variants of HELICOPTER do have an unmarked WH handshape, perhaps due to diachronic change in the direction of this handedness constraint. For an overview of how phonological representation of the WH has been handled in various theories, see Crasborn 2011.

Handedness can vary synchronically in several ways. In Dominance Reversal (Frishberg, 1985), for example, a signer may use their non-dominant hand to realize DH features, and vice versa. Signing with the left or the right hand is not lexically contrastive in ASL, so this type of variation is possible without resulting in homophony. A third type of handedness variation is called weak drop (Padden I& Perlmutter, 1987) or weak hand drop (WHD), in which 2H signs surface as 1H. There are at least a few minimal pairs distinguished by production with one versus two hands, such as PURPLE and PARTYp in ASL, so WHD could lead to neutralization in these instances (Battison, 1974). It is this third process that is of interest in the present study, so more detail on this process in the following section.

1.2   *Weak Hand Drop*   WHD can occur as both a synchronic, post-lexical alternation and as a diachronic process. It is typically characterized as phonological reduction/deletion. As a synchronic process, it may also be seen as assimilation if it occurs in the environment of surrounding 1H signs. Various properties of signs can lead them to block or resist WHD, but the field lacks consensus on or comprehensive study of precisely what these constraints are. In the following paragraphs, I will present some claims about constraints on WHD from previous work and then discuss why further investigation, such as the present study, is needed.

Brentari 1998 presents an extensive analysis of prohibitions against WHD based on features proposed in the Prosodic Model of SiL phonology. Examples of ASL signs Brentari cites as resistant to WHD, according to their relevant characteristics, are given in Table 1 below.

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[1]   Refer to Battison 1978 for illustrations of these unmarked handshapes.

[2]   All sign glosses follow the annotation ID gloss conventions of ASL Signbank (Hochgesang et al., 2017-2021). Images and videos for all signs referenced in this paper can be viewed by entering the gloss in the "Search gloss" field at https://aslsignbank.haskings.yale.edu.

- alternating movement in signs with the same handshape on both hands (e.g. BICYCLE)

- continuous contact between the two hands throughout the sign (e.g. WITH)

- in type 2 signs, when "analogous parts of the hand are oriented toward each other" (p. 126) and contact one another (e.g. SCHOOL)

- in type 2 signs, when the DH is oriented toward the midsaggital plane (e.g. WHEN) or the frontal plane (e.g. JAIL), i.e. any plane other than the horizontal plane (e.g. REMEMBERsym)

- in type 3 signs, when the place of articulation for the DH is any part of the WH other than the palm (e.g. AREA)

Table 1: ASL signs that disallow WHD according to Brentari 1998

It is clear that phonological form plays a role in determining which signs can and cannot undergo WHD. However, accounts like Brentari's rely on categorical distinctions between acceptance or rejection of this process, and there is also evidence that the reality may be more of a gradient from more to less likely to undergo the process. Brentari does not provide information on her methodology for obtaining native signer judgments on which WHD forms are acceptable. Thus it is not clear whether the prohibitions she cites should be considered categorical, context or signer dependent, or otherwise mitigated. Furthermore, several other studies suggest that, in addition to the phonological features involved in a sign's form, we may need to consider iconicity and the grammatical use of signing space for a fuller explanation of constraints against and facilitation of WHD. The following paragraphs discuss this idea, which ultimately motivates the present study.

In a study of WHD in the Sign Language of the Netherlands, van der Kooij (2001) found exceptions to some of the prohibitions against WHD Brentari 1998 proposes for ASL, and she argues that the "semantic or iconic motivation of the presence of both hands" (p. 28) can account for these exceptions. She tested 36 signs with alternating movement, and her informants rejected WHD for only 16 of these. The relevant variable seemed not to be the formal specification of alternating movement but whether or not that movement was iconically motivated. Similarly, for 137 2H signs with complete symmetry for the two hands, 122 did allow WHD, as asserted for ASL in Battison 1974. The remaining signs did not, however, and in each of these, the two-handedness showed iconic motivation. It is possible that van der Kooij's findings simply reveal that the constraints proposed for ASL are language-specific. Another possibility is that some instances of WHD blocking that have been attributed to phonological characteristics are in fact due to iconic form-meaning mapping.

Another pattern that suggests the need to consider iconicity in WHD is the tendency of type 3 signs with the relatively unmarked B handshape (all four fingers and thumb fully extended and fully or partially touching along the edges) on the WH to accept WHD, noted in Battison 1974. Brentari 1998 proposes an Optimality Theoretic constraint that prohibits WHD in type 3 signs with any WH handshape other than the B handshape. At least two researchers suggest an account of this pattern that are not purely formal in nature, however. Van der Kooij (2001) found that these signs made up a large portion of the type 3 signs for which her consultants accepted WHD. She ultimately accounts for this formally by analyzing the B handshape as unspecified and therefore susceptible to deletion. But she also appeals to the iconic or semantic motivation of this handshape in many of these signs, where the hand represents a surface or plane. She writes that as a WH in 2H signs, the "B handshapes seem superfluous...because B handshapes often refer to some surface or plane" and that "virtual surfaces or planes are established conceptually [in the signing space] in the sense of grounded mental spaces" (p. 38). What this notion, and the one presented in the previous paragraph, suggest is that iconicity affects the acceptability of WHD but that in some signs iconicity may inhibit WHD drop while promoting it in others. This discussion also suggests that the grammatical use of signing space may be relevant to WHD. Battison's (1974) participants judged WHD in type 2 signs as ungrammatical when asked about these signs in isolation but occasionally produced them as one-handed in spontaneous signing. Battison describes that the DH in these cases was articulated against a "ghost" WH (p. 10) in the form of another part of the body, a nearby surface, or signing space. In a signed language, the space around the signer may be employed in a meaningful way during discourse: a signer may establish s given area of signing space as representing a particular entity or concept. They may then direct signs toward this space throughout the discourse, and

these signs will be understood in reference to this entity or concept, without needing to rename the entity or concept. It may be that signing space may act as an articulator to replace a WH in a 2H sign. Or it may be that employing signing space in a meaningful way highlights the visual accessibility of the articulators in a way that foregrounds iconic form-meaning mapping. Furthermore, whether this phenomenon is restricted to the B handshape or if it can apply to other WH handshapes is unknown.

When considering iconic motivation of the WH in 2H signs, we must consider whether the WH can in fact be considered morphemic, which has been cited as a reason that some signs resist WHD. These explanations are not satisfactory, however. One example is found in Brentari 1998, which cites examples like a reciprocal form of LOOK[3], in which the index and middle finger of each the two hands point toward each other. This sign is clearly closely related to a depictive or classifier form of an utterance meaning 'look at each other,' in which case omission of one of the hands is not an example of WHD. As a lexicalized form, however, it is not clear why the two hands should be considered morphemes in this sign but not in other forms derived from classifier constructions in which each hand iconically represents a separate entity. A purely formal account of the resistance to WHD in the case of this particular sign may also be possible without appealing to morphemic status of the WH, since deletion of the WH would result in neutralization of a contrast between the sign LOOK that is non-reciprocal. Van der Kooij 2002 also appeals to this notion, but this analysis runs into problems when explaining the difference between signs with a WH B handshape and other WH handshapes. Van der Kooij views the B handshape as morphemic but also says that it is not only phonologically underspecified but also "lack(s) semantic content," stating that "the more semantic content the morphemic weak hand configuration (or hand arrangement) has, the less likely it will be dropped" (p. 276). Thus, to explain why some morphemic WH handshapes are *more* likely to delete and some less, the WH B handshape is analyzed as morphemic but also meaningless. What seems necessary here is a more thorough investigation of the role of iconicity and its interaction with the grammatical use of signing space rather than an attempt to categorically distinguish between phonemic and morphemic WHs.

2   Present Study

From an examination of previous work on WHD, we can see that a systematic comparison of the effects of iconicity and phonology is warranted. Furthermore, the difficulty (noted in the introduction) of teasing apart diachronic from synchronic effects of iconicity, which has prevented us from doing so thus far, calls for investigating iconicity's role in a synchronic alternation. Because signs that are related in iconic motivation are likely to also be phonologically related, this requires testing of carefully controlled stimuli. For the present study, pairs of two-handed ASL signs (all type 2 or 3) were chosen, in which one was iconic and the other non-iconic, but both were phonologically very similar. An acceptability judgment experiment was created in PsychoPy (Peirce et al., 2019) and run on Pavlovia.org (an online platform designed to run PsychoPy experiments) in order to compare participant ratings of WHD forms of these signs. The following sections describe the participants, stimuli, and method for collecting these judgments, followed by the results and a discussion of their interpretation.

In pursuit of a deeper understanding of the role of iconicity in WHD, this study poses two specific research question and hypotheses:

Research Question

Is WHD less acceptable for asymmetrical 2H ASL signs whose form displays iconic form-meaning mapping?

Hypothesis 1

In isolation form and when not directed toward an area of signing space (in a non-spatial context), iconicity will not affect acceptability of WHD for asymmetrical two-handed signs.

Hypothesis 2

When a sign is directed toward an area of signing space (that is, in a spatial context), iconicity will make WHD acceptable when it is otherwise prohibited.

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[3] The examples listed were not accompanied by images or phonological descriptions, so it is not entirely clear what forms are being referred to. Of the four examples listed, the reciprocal form of LOOK is the one for which I am most sure of the phonological form being referenced

2.1 *Participants*   Participants were recruited using the Gallaudet University Daily Digest email listserv, online social media platforms including Facebook and Twitter, and by spreading word among the Deaf community. All self-identified as Deaf. All reported exposure to ASL between birth and age four (except one who reported exposure by age "4 or 5") and were living in the United States. Participants' language models included parents, siblings, other family members, educators, and classmates. One was natively bilingual in ASL and Puerto Rican Sign Language, and two reported conversational skills in other signed languages. The rest reported either no skills in other signed languages or only knowledge of alphabets and basic signs outside of ASL. In the open-ended gender identity field, 27 identified as female, ten as male, two as non-binary, and one as both male and non-binary. In the open-ended racial/ethnic identity field, 31 identified as white, two as Hispanic or Hispanic/Latino, two as Asian, one as Indigenous (Black Seminole/Miccosukee), one as Indian and white, one as Black/Hispanic, one as Mexican and white, and one did not provide a response. All identified as sighted.

2.2 *Stimuli*   Stimuli were developed in collaboration with two Deaf native ASL signers with expertise in ASL teaching and linguistics. One of these signers also produced stimuli on video for the experiment. Six pairs of asymmetrical 2H ASL signs (henceforth referred to as target signs) were chosen. Each pair contained one highly iconic sign and one sign that was less iconic but phonologically similar to the target sign. Much of the initial search for sign pairs was done using the phonological neighborhoods map provided on ASL-LEX (Caselli et al., 2017). Finding ASL signs with no discernible iconic motivation is extremely difficult. For the purposes of this study, signs were considered iconic if formal elements of both hands can be mapped to a representation of a physical entity encountered in the real world, such as a tool, body, hand, or surface. Although many of the phonologically similar signs that were paired with these iconic signs could also be considered to have iconic motivation, in each case, its iconic motivation is now backgrounded and/or exists through metaphorical extension. These phonologically similar signs matched with the iconic signs will be referred to throughout this dissertation as "non-iconic." For example, in the pair GET-OFF and RESIGN, both hands of the target sign GET-OFF can be mapped to physical entities associated with its meaning, namely the weak hand to a vehicle and the dominant hand to the body of a person. In RESIGN, the same mapping can be identified but only through metaphorical extension, since its meaning refers not to the literal movement of a person out of a physical space but rather to figurative movement, as of from a job. This distinction between iconic and non-iconic signs was initially identified by the author and consultants but were then confirmed by a difference in iconicity Z-scores provided in the ASL-LEX database[4]. For each sign pair, the iconic sign received a positive iconicity Z-score and for all but two pairs, the non-iconic sign received a negative iconicity Z-score. Only the non-iconic signs THINK-PENETRATE and STOP also received positive iconicity Z-scores.

All but one sign (THINK-PENETRATE) was non-body anchored, and all signs were asymmetrical (one moving and one stationary hand). For each iconic sign, a non-iconic counterpart was chosen that was phonologically similar. For all but two pairs, both the DH and WH handshapes of the iconic and non-iconic pair member were the same. In the remaining two pairs, the WH handshapes were identical, and the DH handshapes shared selected fingers but differed in joint configuration. Members of each pair differed from one another in movement of the DH (again, WHs were all stationary), and some also differed in palm orientation of the DH. Members of each pair were matched for morphosyntactic category: four pairs were nouns and eight were verbs. The full list of sign pairs, identified by their ASL SignBank Annotation ID glosses, is given in Table **??** below. In each pair, the iconic sign is listed first, followed by the non-iconic sign.

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[4] At the time of stimuli development, iconicity ratings available on ASL-LEX were only those collected from hearing non-signers. Iconicity ratings from Deaf signers was not available

- FORKpa and POTATO

- SCAN and CHARGE

- PET and SUMMON

- SLIP and CLEAN

- GET-OFF and RESIGN

- WRITEbo and SCORE

- KNIFEix and MONTH

- CRACK and BUDGET

- INTO and ACCESS

- DRILL and THINK-PENETRATE

- CHOP and STOP

- PANCAKE[5] and SCHOOL

Table 2: Stimuli pairs (iconic followed by non-iconic)

In addition to iconic/non-iconic target sign pairs, 24 one-handed distractor signs were also chosen. Ten distractor signs were nouns and fourteen were verbs. For each target sign, a one-handed distractor of the same morphosyntactic category and similar frequency and iconicity rating in the ASL-LEX 2.0 database was chosen.

Carrier sentences were developed for each iconic, non-iconic, and one-handed distractor sign. Carrier sentences for noun targets were in rhetorical question form (a more common sentence structure in ASL than in English). The subject of each of these sentences was the first person pronoun IX_1 (*I*), with the target sign in sentence-final position as the direct object of the verb following the sign THAT. For example, the carrier sentence for CRACK was:

(1)   IX_1 CAUSE WHAT-PU THAT CRACK

Carrier sentences for verb targets were in topic-comment form. Each sentence began with a topicalized object and ended with the target sign as the predicate. For example, the carrier sentence for CHOP was:

(2)   THAT VEGETABLE IX_1 CHOP

Occurrence in a spatial grammar context was also included as an independent variable in this experiment. Two versions of each carrier sentence were created: one "plain" version in which signing space was not used grammatically and one "spatial" version in which signing space was used grammatically. In spatial sentences, the signer produced the target sign to her right, as if the object of the target verb or the entity referred to by the target noun were physically present off screen. The demonstrative THAT was also directed toward the same area of signing space. Following the intuitions of the consultant producing the stimuli, some verbs preceding the predicate containing a target noun were also directed toward this signing space.

The consultant was instructed to produce natural, syntactically appropriate non-manual gestures along with the manual signs for each carrier sentence. These non-manual gestures included raised eyebrows during production of the sign WHAT-PU in noun target carrier sentences and during the sentence-initial topic of the verb target carrier sentences. In addition, the signer directed her eye gaze toward the designated area of signing space in portions of the spatial carrier sentences when it felt natural to her.

In addition to being filmed as a spatial and non-spatial sentence, each carrier sentence for the two-handed target signs was also produced with the sign in both a 2H (citation) form and a 1H (WHD) form. Thus, for each target sign, four carrier sentences were filmed: 2H plain, 2H spatial, 1H plain, and 1H spatial. For each distractor sign, two carrier sentence types were filmed: spatial and non-spatial.

2.3 *Method*   After providing informed consent and demographic information, participants watched a video of instructions produced by a Deaf, native ASL signer. This video instructed participants to rate each sentence or isolated sign they saw as a whole-number from 1 ("very strange ASL") to 5 ("perfectly natural ASL") by clicking on a scale that appeared on the computer screen after each video clip. After viewing the instructions, participants completed a short practice round before providing judgments for the experimental stimuli.

Participant ratings reflect judgments of each carrier sentence as a whole; participants were not told to focus on any particular part of the sentence. However, every effort was made to control any factors outside of iconicity and grammatical use of space. As described above, paired iconic and non-iconic signs were phonologically similar. Carrier sentences for each pair were also designed to be as similar as possible. To avoid priming effects that would impact a second viewing of a target sign, stimuli were divided into four blocks, with a between-subjects design in which each block contained only one instance of each target sign. For each iconic target sign, its non-iconic paired target occurred in the same form and carrier type in the same block. For example, in the block containing CHOP in its one-handed version in a spatial carrier, its non-iconic paired sign STOP also occurred in its one-handed version in a spatial carrier. The block containing CHOP in its two-handed version in a plain carrier contained STOP in its two-handed version in a plain carrier, and so on. Half of the distractor items in each block occurred in plain carriers and half in spatial carriers. Each block was shown to ten participants. Table 3 provides a summary of the contents of each block. The items were randomized within each block.

- 3 iconic signs in two-handed form in plain carriers

- 3 non-iconic signs in two-handed form in plain carriers

- 3 iconic signs in one-handed form in plain carriers

- 3 non-iconic signs in one-handed form in plain carriers

- 3 iconic signs in two-handed form in spatial carriers

- 3 non-iconic signs in two-handed form in spatial carriers

- 3 iconic signs in one-handed form in spatial carriers

- 3 non-iconic signs in one-handed form in spatial carriers

- 12 distractor signs in plain carriers

- 12 distractor signs in spatial carriers

Table 3: Stimuli contained in each block

Following each block, participants were instructed to provide judgments for each iconic and non-iconic two-handed target sign in isolation, first in a one-handed form and then in its two-handed citation form.

2.4 *Results*   For each target sign, 120 observations were collected: 80 times in isolation (40 times each in 1H and 2H form by each participant) and ten times each in 2H plain, 2H spatial, 1H plain, and 1H spatial (that is, one time by ten participants each). To account for how different participants utilized the rating scale, ratings were first normalized by converting to Z-score, calculated over each participant. The means were then calculated as mean Z-transformed ratings for each sign. As noted, participants gave ratings for carrier sentences as a whole rather than of a target or control sign explicitly, except when signs were presented in isolation. However, because carrier sentences were designed to control for extraneous variables and target pairs were chosen to be as phonologically similar as possible, the presence or absence of iconicity in the target sign is assumed to be the only relevant difference between carrier sentences containing paired iconic/non-iconic target signs. Accordingly, in the following discussion, differences in acceptability ratings are attributed to this difference in iconicity and ratings are discussed as ratings of iconic vs. non-iconic stimuli, although this serves as a short-hand given that ratings for plain and spatial contexts reflect judgments of entire carrier sentences.

Before presenting results from the statistical tests, a visualization of means for all Z-transformed judgments according to handedness, iconicity, and context is shown in Figure 1 below.
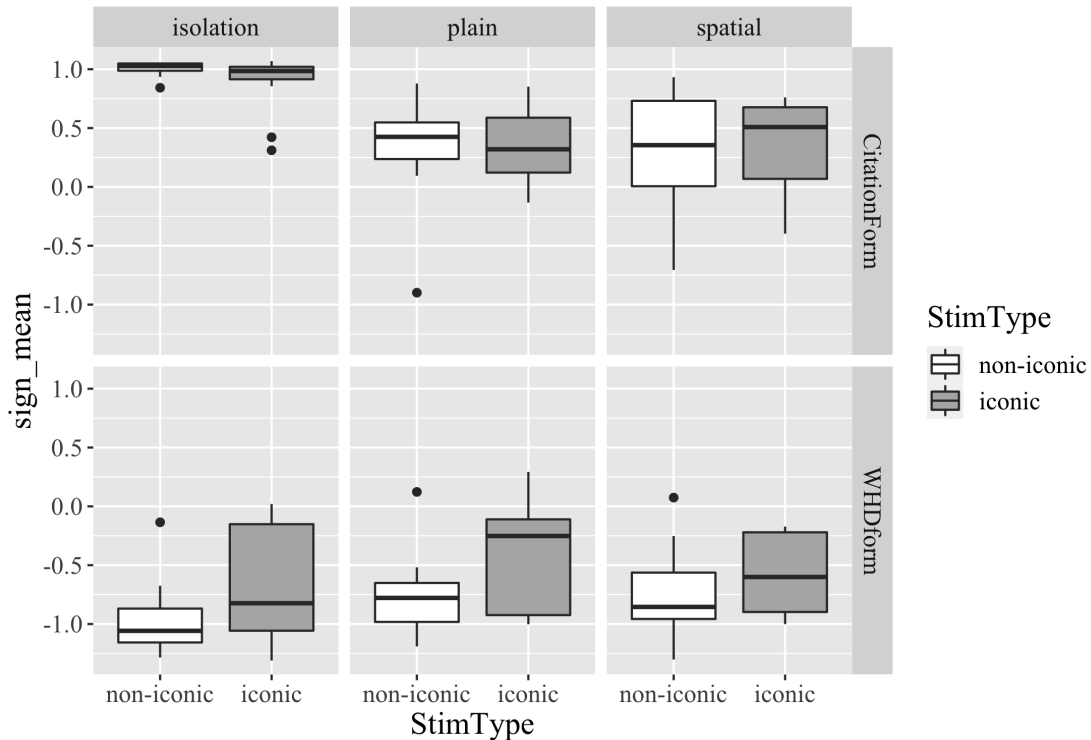

Figure 1: Plot of Z-transformed acceptability judgments for iconic and non-iconic signs in citation form and WHD form, and in isolation, plain, and spatial contexts.

White boxes on the left of each panel represent Z-transformed judgments of non-iconic stimuli, and gray boxes on the right represent Z-transformed judgments of iconic stimuli. The panels, from left to right, present judgments for isolation, plain, and spatial stimuli. The top row shows judgments for citation forms, and the bottom row shows WHD form judgments. The bottom row suggests a pattern in which judgments of WHD forms was higher for iconic signs than non-iconic signs. The similarity of means for iconic and non-iconic stimuli in each panel of the top row suggests that this preference for iconic signs in WHD form does not reflect a preference for the iconic signs overall. Statistical analysis is required to confirm significance of these patters, and this analysis is presented next.

Two comparisons within the results of the acceptability judgments were relevant to evaluating Hypotheses 1 and 2. One is a comparison between participant ratings of WHD forms of iconic and non-iconic signs. Because of the imbalance in number of observations between isolated signs and signs in carrier sentences, this comparison was done separately for these two categories of judgments. The other relevant comparison is between acceptability of WHD for iconic signs in plain carrier sentences versus iconic signs in spatial carriers. To analyze carrier sentence data, a linear mixed effects regression predicting Z-score judgments was run using the lmer function in the lme4 package in R (Bates et al., 2015). The model included a three way interaction between iconicity (StimType), grammatical use of space (SentenceType), and application of WHD (Handedness), with a random effect of sign. Figure 2 presents the results.

Predictors	ZJudgment		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.34	0.13 – 0.55	**0.002**
StimType [iconic]	-0.01	-0.31 – 0.29	0.930
SentenceType [spatial]	-0.01	-0.19 – 0.16	0.867
Handedness [WHDform]	-1.10	-1.27 – -0.93	**<0.001**
StimType [iconic] * SentenceType [spatial]	0.03	-0.21 – 0.27	0.808
StimType [iconic] * Handedness [WHDform]	0.35	0.11 – 0.59	**0.005**
SentenceType [spatial] * Handedness [WHDform]	0.05	-0.19 – 0.29	0.692
(StimType [iconic] * SentenceType [spatial]) * Handedness [WHDform]	-0.22	-0.56 – 0.12	0.213
Random Effects			
σ^2	0.45		
$\tau_{00 \text{ Sign}}$	0.09		
ICC	0.17		
N $_{\text{Sign}}$	24		
Observations	960		
Marginal R^2 / Conditional R^2	0.302 / 0.422		

Figure 2: Results of linear regression model comparing effects of iconicity and grammatical use of space on WHD acceptability. ZJudgment $\sim$ StimType*SentenceType*Handedness + $(1\|Sign)$

Sentences in which signing space was used grammatically were judged no differently than those in which it was not ($p = 0.835$), and the three-way interaction between iconicity, grammatical use of space, and handedness was not significant ($p = 0.538$). There was a simple effect of iconicity ($p = 0.049$), wherein sentences containing iconic signs were rated more highly than those containing non-iconic signs overall, and of handedness ($p < 0.001$), wherein sentences containing 2H forms of target signs were rated more highly than those containing 1H (WHD) forms. These simple effects, however, are carried by a two-way interaction between iconicity and handedness ($p = 0.022$): iconic stimuli to which WHD applied were rated as significantly better than non-iconic stimuli to which WHD had applied.

To compare judgments for signs in isolation, a separate linear mixed effects regression predicting Z-score judgments was run using the lmer function in the lme4 package in R (Bates et al., 2015). This model included a two-way interaction between iconicity (StimType) and application of WHD (Handedness), with a random effect of sign. The table in Figure 3 presents the results.

Predictors	ZJudgment		
	Estimates	*CI*	*p*
(Intercept)	1.01	0.87 – 1.14	**<0.001**
StimType [iconic]	-0.12	-0.31 – 0.08	0.229
Handedness [WHDform]	-1.97	-2.03 – -1.90	**<0.001**
StimType [iconic] * Handedness [WHDform]	0.44	0.35 – 0.53	**<0.001**
Random Effects			
σ^2	0.25		
$\tau_{00 \text{ Sign}}$	0.05		
ICC	0.17		
N_{Sign}	24		
Observations	1920		
Marginal R^2 / Conditional R^2	0.719 / 0.768		

Figure 3: Results of linear regression model comparing effect of iconicity and handedness on acceptability of isolated signs. ZJudgment $\sim$ StimType*Handedness + $(1\|Sign)$

The interaction between iconicity and handedness was significant ($p < 0.001$) for signs tested in isolation, confirming the same pattern that was found in the carrier sentence data: when WHD was applied, iconic target signs were rated more highly than non-iconic target signs. The next section discusses how these results are interpreted in relation to the proposed hypotheses.

2.5 *Discussion*   Recall that the research question and hypotheses motivating this experiment were as follows:

Research Question

Is WHD less acceptable for asymmetrical 2H ASL signs whose form displays iconic form-meaning mapping?

Hypothesis 1

In isolation form and when not directed toward an area of signing space (in a non-spatial context), iconicity will not affect acceptability of WHD for asymmetrical two-handed signs.

Hypothesis 2

When a sign is directed toward an area of signing space (that is, in a spatial context), iconicity will make WHD acceptable when it is otherwise prohibited.

The results of the acceptability judgment task support neither hypothesis fully. They do suggest that iconicity plays a role in the acceptability of WHD. The direction of the effect of iconic form-meaning mapping suggests that iconicity correlates with higher likelihood of accepting WHD, regardless of whether or not the sign is used in a spatial grammar context. Examining results for individual sign pairs, however, reveals that more work is needed to determine precisely when iconicity may have this facilitating effect on WHD, as not all sign pairs followed this pattern, and only a few seemed to display it strongly. Because the number of observations for each sign in a given form (1H or 2H) and context is small, no statistics were run on individual sign pairs. However, visual examination of the means for each sign pair suggest that it is only a few that are driving the aggregate results. Pairs that most strongly displayed this pattern were CRACK and BUDGET, PET and SUMMON, WRITEbo and SCORE, and DRILL and THINK-PENETRATE. For three pairs, participants seemed resistant to the WHD form for both signs, but with slightly less resistance for the iconic target signs: SLIP and CLEAN, FORKpa and POTATO, and SCAN and CHARGE. For the pair KNIFE and MONTH and the pair SCHOOL and PANCAKE, WHD appeared to be unacceptable for both members of each pair. In GET-OFF and RESIGN, the difference emerged only in isolation. For one pair — CHOP and STOP — the opposite pattern

emerged, in which ratings of the WHD form were lower for the iconic target sign than for the non-iconic target sign. (For the pair INTO and ACCESS, participants gave low ratings for the the non-iconic sign in both citation form and WHD form when viewing the carrier sentence, but not in isolation, indicating a potential problem with the carrier sentence rather than the target sign.)

The question that arises then is what can account for a facilitative effect of iconicity for WHD in some signs but not others, and potentially even the opposite effect for some signs, like CHOP. The study design makes it fairly likely that any differences we see within most pairs are the result of iconicity differences. The one exception is FORKpa and POTATO, where FORKpa may have resisted WHD because of contact between the DH and a part of the WH other than the palm, which is a case Brentari (1998) says prohibits WHD. For the pair PANCAKE and SCHOOL and the pair KNIFE and MONTH, resistance to WHD may be phonological, due to the palms' orientation towards one another, which Brentari 1998 cites as constraining WHD. But both members of each of these pairs resisted WHD, and no known phonological explanation exists for iconic members of the remaining pairs that did not display the pattern. The idea that the B WH handshape plays a role in the acceptability of WHD does not provide clarity here, as this handshape appears as the WH for some — but not all — signs that clearly follow the pattern, as well as some that do not. Nor does relative iconicity score, nor difference between the scores within pairs, differ according to the pattern each pair displayed. In fact, of the pair that showed the opposite pattern, the iconic sign (CHOP) had the second highest iconicity rating. The only iconicity ratings available for all the target signs in ASL-LEX were collected from hearing non-signers. Since all participants were Deaf and native ASL signers, it is possible that ratings collected from Deaf native signers would correlate with these findings in a clearer way. If and when these findings become available for all target signs, this possibility will be pursued further. A final observation is that all of the sign pairs for which the pattern was observed are verbs, although some verb pairs did not follow the pattern.

The bigger question underlying the present study, as well as the larger dissertation study of which this experiment is a part, is whether iconic associates between form and meaning are accessible to the synchronic grammar during application of a grammatical process. Despite the messiness of these data, they point toward the general conclusion that this is the case. Previous work on iconicity and phonology have not allowed us to determine whether analogies between form and meaning are actually preserved or whether the effects observed are simply the result of diachronically evolved categories. Because, in this study, iconic form-meaning mapping affected the acceptability of a synchronic, post-lexical process, these mappings must, on some level, be accessible to the synchronic grammar for some signs. The effect is not categorical, so something like a binary [ICONIC] feature for which a [+] value fully licenses WHD is not a viable explanation, nor is an analysis of the WH as morphemic in these cases. This result is not compatible with a view of iconicity as an external pressure akin to ease of production, or to attempts to encode the role of iconicity as faithfulness constraints, as in Eccarius 2008. In some sign pairs here, iconicity in fact allowed for more phonological reduction. It is possible that in another process iconicity may in fact limit reduction or variation. Further ongoing work studies sign lowering, contact loss, and WHD in narrative data in order to gain understanding of how iconicity affects phonetic and phonological variation in spontaneous signing and, in the case of sign lowering, in a case where variation is less inherently categorical than in WHD and contact loss.

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