THE UNIVERSITY OF CHICAGO

BREAKING THE RULES BY BENDING THE FORM: ICONIC MODIFICATION IN AMERICAN SIGN LANGUAGE AND SILENT GESTURE

A DISSERTATION SUBMITTED TO

THE FACULTY OF THE DIVISION OF THE SOCIAL SCIENCES

IN CANDIDACY FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

BY

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CHICAGO, ILLINOIS

AUGUST 2024

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Acknowledgments

Thank you to my committee: Susan Goldin-Meadow, Diane Brentari, Howard Nusbaum, and Donna Jo Napoli. To Diane and Howard, your insights have helped to both broaden and hone this work in innumerable ways. To Donna Jo, once my teacher and now my collaborator and friend. As with so many things in academia, research, and life, you give me so much. I love thinking with you. To Susan, you've been such a wonderful mentor to me, and I would not be the researcher I am without you. Learning from you has enriched my approach to research and pedagogy so much, and I am incredibly grateful. The Goldin-Meadow lab past and present has been a supportive and inspiring group of people to work with and to learn from.

To the members of the Deaf communities in Chicago, Philadelphia, and California, who gave me their time and efforts, and without whom this dissertation would simply not be possible. It has been a privilege to learn from you.

To those of you that made UChicago feel like home to me as soon as I arrived -- To Jenny, without whom this project wouldn't exist and whose curiosity and enthusiasm have been inspiring throughout. To Jimmy, for late nights, laughter, and helping me feel like this was possible. To Yağmur, for guidance, brilliance, and humor every step of the way. To Claire, who manages to open my eyes to something new every time I see her. I was so lucky to have ended up in that office with you all.

To Jess, there isn't space to mention the million ways you've helped me. I'm so grateful to have met you. To Zena who has been there at every stage of this project, and whose knowledge and efforts have shaped this work in so many ways. To Ben, it's been so special to me to have had you on this ride with me from day one.

To my friends outside of Chicago – Sam, Eric, Ishita, Conor, Erin, Taylor, and many others. You've all done more for me than you realize.

To Marianne, you've been a sister to me since the second grade. Somehow, we've both managed to trick them into making us doctors.

To Mackenzie, who has spent more hours listening, brainstorming, and talking me through this process than probably anyone else. I'll undoubtedly be calling you as soon as I submit this.

To my brother Sam, who I've always counted on. You're the funniest person I know, and I'm sure getting my doctorate still won't be enough for me to beat you in a debate. I love joking and thinking with you. To my parents, Erin and Paul. You are the parents that everyone wants to have. You've made me who I am and encouraged me to be curious my whole life.

To my office on the 5th floor of Green where I sit as I write this, to my lab mates currently giggling across the hall, to the happy little dog I'll go home to tonight, and to the Chicago summer I'm about to take a walk in – I feel very lucky.

Abstract

Language is traditionally characterized as an arbitrary, symbolic system, made up of discrete, categorical forms. But iconicity and gradience are pervasive in communication. For example, in spoken languages, word forms can be "played with" in iconic gradient ways by varying vowel length, pitch, or speed (e.g., "It's been a looooooong day"). These instances of depiction have been called "vocal gesture". However, little is known about this process in sign languages, wherein both linguistic and gestural representations exist within the same modality . In this work we explore the gradient use of motion in American Sign Language (ASL) and silent gesture. In Study 1 we asked deaf signers of ASL (n = 11) to describe an event manipulated along speed, direction, or path, and observed their use of gradient modification in arbitrary and iconic signs. We found that signers alter the forms of both lexical and depicting signs to enhance meaning. However, the three motion dimensions were not modified equally in lexical signs, suggesting constraints on gradient modification. These constraints may be linguistic in nature, followed only by signers who know ASL or another sign language, or they may be a feature of manual or gestural communication more broadly. To test, in Study 2 we compared the ASL signers to English-speakers (n=11) asked to communicate silently using gesture. As in Study 1, the silent gesturers are given an ASL verb and asked to use it to describe a target event and three variants. We observe whether the target verb is modified to depict the variants. We find both similarities and differences between the groups. The groups are both influenced by the iconicity of these signs, suggesting that intuitions about modification may incorporate some gestural knowledge, since silent gesturers, unfamiliar with ASL, can generate them. However, the groups differed in their overall tendency to modify, as well as their treatment of the different dimensions of movement, indicating that there is more to these modifications than iconicity, and illustrating how iconicity and arbitrariness work together in linguistic system. In Study 3, we test deaf children using ASL (n=38) as well as hearing English-speaking children using silent gesture (n=15) on an adapted version of this paradigm. We find that these intuitions regarding how modification fits within the phonological constraints of ASL emerge early in development for children acquiring a sign language, but these patterns are not shared by children for whom manual communication is not linguistic (silent gesturers).

1. INTRODUCTION

1.1 Using Gradience to Play with Language

After a day of endless meetings, you might mention to your coworker that the day feels slow. In fact, you might think to yourself, *slow* doesn’t fully capture it. Perhaps you want to highlight just how endless this day has felt. Rather than opting for a different word, you may instead choose to “modify” the word *slow* to convey your intended meaning more forcefully. One way you might go about this is by using an external modifier such as an adjective or an adverb. These words modify what we might think of as the dictionary definition of *slow*, as shown in the examples below.

1. Today feels *extremely* slow.
2. Thursdays are always *incredibly* slow.

Another way to achieve the same effect is to “play with” the structure or sounds of the word itself.

3. Today feels *slooooooowwwwww*.

In this example, the speaker is dragging out the sounds in the word—specifically the vowel length. In so doing, the word ‘slow’ is, in fact, produced more slowly than is typical. This vowel lengthening is not a phonemic feature of the word ‘slow’, nor would the lengthening be considered a morphological process. However, the transformation is clearly meaningful. Dragging out the sound is not just drawing attention to the word—it’s adding the meaning "really slow". This instance of language play allows the speaker to express the modified meaning without using external modifiers.

We see similar modifications in sign language. Signers can play with their signs by modifying elements of manual form; for example, by repeating a phonological parameter or altering its length to capture changes in degree, intensity, plurality, size, etc. (Fuks, 2014, 2016). Figure *1* (taken from Fuks, 2014) presents examples of a signer of Israeli Sign Language, gradiently modifying the handshape in her sign for WALKING IN HEELED SHOES.

Figure 1: The sign for WALKING IN HEELED SHOES in Israeli Sign Language produced in two ways. In the left panel, the signer produces the sign with a conventional handshape indicating that she is walking in stiletto heels, and in the right panel she produces the sign with a modified handshape (not part of the inventory of ISL) which indicates that she is walking in shorter heels.

The image on the left is a part of a larger utterance wherein the signer expresses "Last week I **wore high heel shoes** to the party and stumbled all the time." Here, the signer uses a conventional handshape, with thumb and pinky extended, to indicate that she walked in stiletto heels. In particular, the extension of the thumb and pinky fingers in the handshape delineates an (imagined) line between the two outstretched fingers, thus, "enabling this unit to stand in for concrete objects characterized by straight long line contours such as heels-shoes, a kettle or a telephone” (p. 214). The image on the right is taken from an utterance where the signer expresses “To other party I **walked on lower-heeled shoes**”. Here, she uses a handshape where the pinky and thumb are extended but no longer spread apart from the remaining bent fingers and palm. This lack of spreading reduces the length of the virtual line, which serves as an analogous representation of the shorter heel being described. Importantly, the handshape used here to indicate that she walked in shorter heels (with the thumb and pinky pushed next to the bent fingers rather than spread apart) is not part of the ISL inventory.

These examples from both spoken and signed languages demonstrate the meaningful use of gradience in language. The modifications are gradient in form and they capture gradient differences in meaning. This phenomenon challenges traditional notions of language as a system in which meaning is conveyed not only through discrete symbols perceived categorically, but also through arbitrary symbols (Hockett, 1960). For gradient modifications to be used meaningfully, there must be an iconic, non-arbitrary relation between the form of the modification and its intended meaning. If we return to our earlier example, ‘Today feels *sloooooooowwwwww’,* the dragged out wordform captures “slow” in a motivated way—the word itself is slower. This modification to the speech rate and vowel length could not be used to indicate that the day feels hot or that it feels like a Friday. Indeed, there are likely no gradient modifications in speech that could convey these meanings in an iconic way, as the acoustic features of the speech signal do not imagistically map to notions of temperature (or days of the week) in the same way that they can map to notions of speed and timing.

But there is a second requirement for gradient modification—it must work within the phonological/morphological system of the language. In Okrent’s (2002) discussion of gradient modifications, which she calls “vocal gesture,” she notes that there will inevitably be restrictions on how this gradience combines with the categorical forms in a linguistic system. For example, although the modification shown in 4 still involves the gradient manipulation of speed/ lengthening in an iconic way, it would be unlikely that an English speaker would produce it.

4. *Today feels *ssssssssssslow*.

Certain sounds or parts of a word (in this case, the vowel) are better suited for the stretching out and slowing down transformation than others. As another example of a restriction on when a gradient form can be used in speech, manipulating pitch in sentences like *The bird flew up [high pitch] and down [low pitch*] works easily in English but is less effective in a tonal language like Mandarin, where tone is lexically specified and has phonemic value (Okrent, 2002). Gradience in speech is constrained by the linguistic system into which it fits.

Little work has explicitly explored restrictions on gradience in sign language, but there is reason to expect restrictions. Supalla (2003) argues that, even in atypical creative and playful language, such as jokes, play-on-words, or artistic renditions, the modifications signers make to handshape must conform to the constraints on phonological formation used in grammatical ASL (see also Fuks 2014, 2016). As an example, Duncan (2005) asked signers of Taiwanese Sign Language to describe a cartoon that has been used to study hand gestures in speakers of many different spoken languages (McNeill, 1992). She found that the signers, like speakers, used their hands to capture visual aspects of the cartoon characters' movements (e.g., a cat climbing up a drainpipe). But the signers accommodated their gestures to the handshape required for small animals in TSL—all of the signers overlaid their gestures onto this same handshape; the hearing speakers used a variety of handshapes. Our goal here is to explore signers' use of gradience to modulate motion meanings, and to ask whether there are restrictions on how that gradience is used.

1.2 Gradient Modification in Speech

The modifications we have been discussing are *depictive* rather than *descriptive* and, in this sense, are different from typical morpho-syntactic transformations. Depiction and description are two types of modes of representation in meaningful communication. Their semiotic distinction, as first laid out by Peirce (1955) and later expanded upon by Clark and Gerrig (1990), lies in the forms each uses, the way meaning is mapped onto those forms, and how that meaning is understood. Depiction involves an iconic mapping of meaning onto gradient forms. In contrast, description involves discrete symbols that have arbitrary aspects to their mapping.

Clark and Gerrig (1990) argue that description, depiction, and indicating (pointing) constitute the whole of meaningful communication (see also Peirce, 1955's distinctions symbol/icon/index). However, studies of language typically consider only descriptive communication. As noted by Dingemanse and Akita (2016), "a common shorthand for the distinction [between description and depiction] is 'word' versus 'image', reflecting a traditional view of language as a system of arbitrary words fully in the descriptive mode, with the depictive method of communication at best playing a secondary role in the gestures and bodily aspects of 'paralanguage'." Indeed, in many arenas, *language* has come to be synonymous with *descriptive* (de Saussure, 1915; Hockett, 1960; Newmeyer, 1992; Peirce, 1955; Whitney, 1874).

Depiction has been excluded from traditional accounts of language because of its gradient and iconic nature. Iconicity, which is a motivated relationship between the features of real-world referents and their linguistic forms (Frishberg, 1975), has also historically been ignored in the study of spoken language. This exclusion is due, in part, to the widely adopted notion that an arbitrary relation between a form (signifier) and its referent (signified) is an essential feature of language (de Saussure, 1915). Others have dismissed the importance of iconicity in spoken language on the grounds that its role is limited to small portions of the lexicon, namely, onomatopoeia (Newmeyer, 1992; Whitney, 1874) (for review see Perniss et al., 2010; Schmidtke et al., 2014). However, cross-linguistic investigations of iconicity suggest that it is more pervasive than once thought. Rich inventories of iconic sound-symbolism in the form of ideophones (marked words depictive of sensory imagery; Dingemanse, 2012) have been found in a wide array of spoken languages spanning sub-Saharan Africa (Msimang & Poulos, 2001; Schaefer, 2001), Australia (Alpher, 2001; McGregor, 2001), South-eastern Asia (Watson, 2001), and South America (Nuckolls, 2001). Moreover, many languages do not restrict their iconic forms to representations of sound (i.e., onomatopoeia), but also include depictions of other sensory perceptions, and even notions as abstract as emotions or mental states (Akita, 2009; Dingemanse, 2012).

Akita (2020) describes the ways in which "expressive features" (voicing, lengthening, pitch modulation, reduplication, etc.) can flexibly extend the forms of ideophones to elaborate their meanings (Akita, 2017; Childs, 1995; Dingemanse, 2017; Dingemanse & Akita, 2016; Nasu, 2002; Rhodes, 1995). The following examples, reproduced in **Error! Reference source not found.**.1, are based on the Japanese motion ideophone guruQ [gɯɾɯʔ] 'turning around,' and are taken from Akita (2020, p.7).

Table 1.1 Expressive features in the Japanese ideophone guruQ [gɯɾɯʔ] 'turning around'

Expressive feature	Ideophone	Meaning	Quality
Partial multiplication:	[gɯɾɯgɯɾɯgɯɾɯʔ]	'turning around and around'	Prefixal
	[gɯɾɯɾɯʔ]	'turning around quickly'	Prefixal
Vowel lengthening:	[gɯɾɯ::::ʔ]	'making a long turn'	
Mora augmentation:	[gɯɾːɯ::ʔ]	'turning around energetically'	Gemination
	[gɯnɾɯ::ʔ]	'turning around energetically'	Nasal insert

Table 1.1 continued

Prosodic foregrounding:	[ɡɯ̋ ɾɯ̋ ʔ]	‘turning around quickly’	Extra high
	[ɡɯ̆ ɾɯ̆ ʔ]	‘turning around quickly’	Extra short
	[ɡ̥ɯ̥ ̥ɾɯ̥ ʔ]	‘turning around quietly’	Voiceless

The vowels and consonants in 5.b and 5.c are modified gradually, which leads to a mimetic depiction of duration or intensity (see also Kawahara & Braver, 2013, 2014). In 5.d, pitch is gradually altered to represent the quickness of the turn referred to by the ideophone (see also Hinton et al., 1994).

Gradient depiction can also be overlaid onto non-iconic words, as exemplified in our initial ‘slow’ example. We see a similar expressive, playful manipulation of speed and lengthening in examples 6 and 7 below (taken from Perlman, 2010 and Shintel et al., 2006).

6. *Baseball should be morelikethis* [spoken rapidly and run together] *and less...like...this* [drawn out with deliberate pauses]

7. *The door did that thing where it openns reeeally sloowly and then slamsshut.*

In examples 6 and 7, the speakers use the speed of their speech to iconically depict the temporal quality of the events they are describing. In example 6, the interpretation of the speaker’s intended message (what baseball should be like) relies entirely on the gradient use of speech rate rather than the linguistic units in the utterance; in 7, the information regarding the speed of the event is marked in both the acoustic properties of the utterance and word choice.

Speakers also use lengthening (as in example 3) to depict magnitude and extent, shown in example 8 (from Okrent, 2002).

8. It was a looooong time

Here, the lengthening of the vowel expresses time-related imagery via the literal temporal extension of the word.

Repetition can likewise be manipulated to express amount and ordering of events as in example 9 (from Okrent, 2002).

9. Work, work, work, rest

The speaker creates an utterance in the moment such that the number of words reflects the amount of work vs. rest, and their ordering reflects the order of events.

Speakers also modify pitch to express height, as in example 10 (mentioned earlier, from Okrent, 2002) and example 11 (from Perlman, 2010).

10. The bird flew up [high pitch] *and down* [low pitch]

11. I've got friends in low [low pitch] *places*

In example 10, pitch is used to express information about height via a metaphor associating high and low pitch with high and low locations. In example 11, the metaphor is extended with the word "low," associated with social standing and iconically represented via low pitch.

Note that speakers can gradiently modify word forms or prosodic aspects of speech in ways that do *not* correspond to changes in meaning. For example, speakers may vary their speaking rate because they are nervous or in a hurry. These variations are not meant to convey gradations in meaning and are *not* the focus of this paper.

1.3 Gradient Modification in Sign

We turn now to gradient modification in sign, but before doing so, we note that signers too can gradiently modify sign forms in ways that are *not* meant to capture meaning. Signers can increase their signing space when communicating at a distance or modify their signs to increase their size when communicating with non-fluent signers or children. These modifications are meant to heighten the salience of the sign, not to modify its meaning. For example, Perniss et al., (2018) found that signers enlarge, lengthen, and repeat their signs when imagining communicating with a child. When these modifications are applied to iconic signs[1] (e.g., the sign DRIVE in British Sign Language, which resembles hands holding and turning a steering wheel), they often increase the salience of features in the iconic mapping (for DRIVE, they enlarge the shape and movement of the steering wheel). These modifications are not intended to modify the *meaning* of DRIVE, but rather to highlight features of the sign to increase their salience (presumably to make them easier for a child to process). Our focus here is not on these types of gradient modifications, but rather on gradient modification designed to capture subtle aspects of meaning.

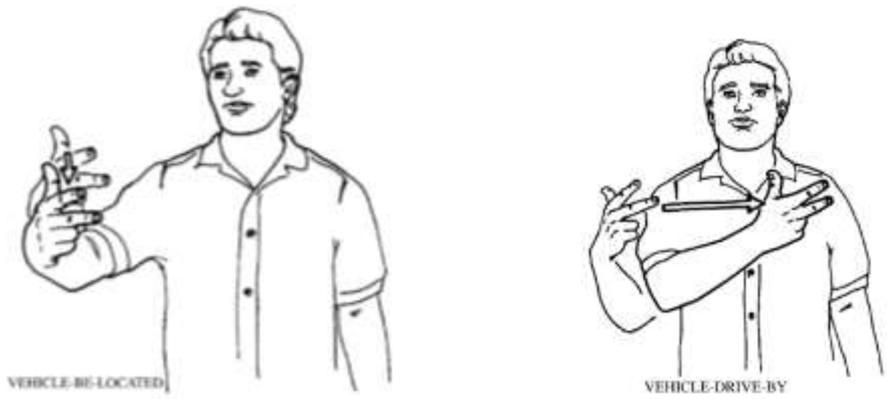
In this study, we focus on modification of *movement* in signs for two reasons. First, movement, as it is referred to in sign phonology, is made up of several different dimensions, each of which may be more or less restricted in how it can be used for gradient depiction. Second, actions can be conveyed by two different kinds of signs in ASL: *lexical* signs have a specified, prescribed movement; *classifier* or *depicting* signs flexibly depict movement in an

[1] Perniss et al. (2018) report that these modifications are more frequently applied to iconic than to non-iconic signs.

analog way. This aspect of ASL allows us to explore how overlaying gradience onto a categorical form to depict meaning compares to overlaying it onto an already-gradient form.

Lexical or “frozen” signs have fully lexically specified forms found in a sign language dictionary and are described in terms of four manual parameters (where some lexical signs also carry a nonmanual parameter): Handshape, Movement, Location, and Orientation (Stokoe, 1980). In lexical signs, these parameters are generally considered meaningless subparts of a sign, which become meaningful in a specific way only when combined. For example, on their own, a ‘tapping’ movement, ‘on the chin’ location, and an F handshape are meaningless sub-units. It is only when combined that these linguistic units become meaningful as the ASL sign translated as SOON, much like the sounds /s/ /u/ and /n/, which are not individually meaningful, become meaningful when combined into the English word “soon”. In lexical signs, the categories in each of these four parameters are phonological; each category is an unanalyzed, meaningless whole.

In contrast to lexical signs, in depicting signs, the four parameters are considered morphological or perhaps gestural, and thus meaningful (Johnston & Ferrara, 2012; Stokoe, 1980; Supalla, 1986; Zwitserlood, 2012). For example, in ASL, a one-handshape (the index finger extended with the remaining fingers closed in a fist) represents a person; a three-handshape (the thumb, index, and middle fingers extended, with the ring finger and pinky closed) represents a vehicle. To describe a moving object with a depicting sign, a signer selects a handshape from a limited set of specified handshapes that best represents the moving object; the signer combines that handshape with a motion that represents the moving act. A signer might produce the construction below in Figure *2* to express (a) where a vehicle was located, or (b) that a vehicle drove a certain way or in a specific direction.



A B

Figure 2: Examples of a vehicle classifier handshape (a) establishing location or (b) depicting movement. Images taken from Valli & Lucas, *(2000)*.

Although handshapes in depicting signs are drawn from a limited set of categories, motion in depicting signs is believed by some to be created in the moment by the signer (Cormier et al., 2013; Emmorey & Herzig, 2003; Liddell, 2003; Lu & Goldin-Meadow, 2018). The movement through space in a depicting sign is determined by properties of the actual event, mapping directly onto the referent's location and movement in an analog way (see Supalla, 1982 for a different view).

Figure *3* presents an example of a lexical sign and a depicting sign conveying the same meaning. To describe a person running quickly in a circle using lexical signs, a signer might produce the signs PERSON, RUN, FAST, CIRCLE (shown in the top row). However, to describe a person running quickly in circles using a depicting sign, a signer might produce the lexical sign for PERSON, and then move the 1-handshape (denoting a person) in a fast, circular motion to iconically depict the running event (shown in the bottom row).

Figure 3: The proposition ‘a person runs quickly in circles’, expressed via lexical signs (A), and via a depicting construction (B). The depicting construction simultaneously expresses the ‘run’, ‘quick’, and ‘speed’ information, while the lexical signs represent these concepts using discrete units (Figure adapted with images from *www.lifeprint.com*).

A signer’s willingness to gradiently modify a sign to convey subtleties in meaning could also be influenced by the iconicity of the sign itself. Some researchers of spoken language have claimed that gradient modifications are more commonly found in iconic words such as ideophones (Akita, 2020; Dingemanse & Akita, 2016; Zwicky & Pullum, 1987; see example 5 of the Japanese motion ideophone *guruQ*). However, much of the research finding that iconic words are prone to acoustic and prosodic manipulations, particularly in child-directed language, focuses on the unique and marked ways that the forms of these words can be modified, not on whether these modifications correspond to changes in meaning (e.g., Laing et al., 2017; Sundberg & Klintfors, 2009). We expect depicting signs, which are iconic, to naturally support this type of modification. But many lexical signs also display some degree of visual iconicity (Caselli et al., 2017). To the degree that the presence of an iconic mapping between a sign's form and its meaning supports gradient manipulation of that form to capture subtleties in meaning, we might expect gradience more often in lexical signs that have iconic components than lexical signs that do not. Our focus here is on gradient modifications of form in sign language that capture gradient aspects of meaning. We explore this in three studies.

Study 1: Exploring iconic modification in signers: In Study 1, we create a set of video stimuli depicting various actions and events, including multiple variations for each action along different dimensions (e.g., throwing forward, throwing to the side, throwing underhand, throwing slowly) We ask ASL signers to watch and describe these events, and observe under what conditions signers modify the ASL sign labels to depict the different variants.

- Do signers iconically modify "frozen" lexical signs? How does this compare to the use of iconicity in depicting constructions?
- Are certain aspects of a sign more easily modified than others? Does the phonology of ASL constrain this behavior?
- Does iconicity beget iconicity? Research from spoken language suggests iconic modifications are more common on iconic forms (Dingemanse, 2012; Zwicky & Pullum, 1987). Is this the case for sign language as well?

Study 2: Comparing sign to silent gesture: In Study 2 we have a group of non-signing hearing participants complete the same task. Participants are told to use silent gesture (gesture without accompanying speech) to represent or describe these scenes. Participants are shown the target ASL sign for each event and are told to incorporate it into their gestured response. We compare the non-signers' modifications to these signs with the pattern observed in the signing participants.

- To what extent is the pattern observed in signers unique versus shared across groups?
- Do the constraints observed in Study 1 depend on signing experience? Or do we find similar influences on gesture?

Study 3: Iconic modification in children: In Study 3 we adapt the paradigm from Studies 1 and 2 to be used with children. We will be testing deaf children between the ages of 4 and 8 acquiring ASL, as well as age-matched hearing controls.

- Is children's initial approach to language based on iconicity (i.e., modifying all dimensions of a sign)? Do children initially struggle with iconicity (i.e., never modifying)? Or is the way that iconicity is used and constrained in ASL appreciated by young signers even early in development (i.e., modifying selectively, like adults)?

2. SIGNERS' USE OF MODIFICATION

2.1 The Design of our Study and Predictions

In our study, we present signers with two scenes at a time. The first scene is designed to elicit the citation (neutral) form of a sign (e.g., a man running in a straight line); the second scene has a change in one of three dimensions of movement—speed, direction, or path (e.g., the same man running quickly). We ask signers to describe both scenes and note, first, whether they mention the change in the event (speed, in this case) and, if so, what devices they use to convey the change—by gradiently modifying the citation form of the sign to capture the change in speed (direction, or path), or by adding lexical items that capture the change.

Some research suggests that movement in classifier verbs of motion in sign may be gestural in nature. Singleton et al. (1993) analyzed signers' and non-signers' performance on the Verbs of Motion Production (VMP) task (Supalla et al., 1995). Participants view a motion event and then describe that event using signed language (for signers) or gesture without speech (for hearing non-signers). They found that when non-signers were asked to describe the events using silent gesture, their use of movement and location was strikingly similar to ASL signers' (88% match); their handshapes were far less similar (21.5% match). Schembri et al. (2005) compared deaf native signers of either Australian Sign Language or Taiwanese Sign Language to Australian hearing non-signers. Again, they found that non-signers did not resemble signers in their handshapes but were surprisingly similar to both sets of signers in their movements. The large overlap between signers and silent gesturers in direction and manner of movement suggests that these two dimensions may have a gestural component, which has the potential to support gradient modification. Although the third dimension, speed, has not been varied in studies of sign, it has been varied in studies of speech. English-speakers were asked to describe an animated dot moving at different speeds from left to right or from right to left, using the phrase *It is going left* or *It is going right*. The speakers spoke faster when the dot moved more quickly even though the propositional content of the utterance did not refer to speed (Shintel et al., 2006). Follow-up studies by Perlman (2010) and Perlman et al. (2015) found evidence for speed-related modulations of speech rate in unconstrained naturalistic speaking tasks. All three dimensions (path, direction, and speed) thus have the potential to be gradiently modified.

At the same time each of the three dimensions can, at times, be used categorically in ASL to distinguish between lexical signs. Figure *4* (top) displays two signs, CHRISTIAN and COMMITTEE, which are identical except for direction; note that the difference in direction between the two signs does not capture iconic aspects of the referents. Figure *4* (bottom) displays two signs, SCHOOL and PAPER, which are identical except for path; the difference in path between the two signs does not capture iconic aspects of the referents. Figure *5* displays two signs, SLOW and VERY-SLOW, which are identical except for speed; the speed of the movement in VERY-SLOW is faster than SLOW, illustrating again the lack of iconic mapping between sign and referent.[2]

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[2] Wilcox (2004) argues that the intensifier morpheme in the SLOW example is itself iconically motivated. However, our focus is on the mapping between the altered sign and its meaning, which (as Klima & Bellugi, 1979 argue) is made less rather than more iconic when this morphological process is applied.

Figure 4: Two examples of minimal pairs. The signs CHRISTIAN and COMMITTEE both involve a straight path of movement, directed either diagonally down from shoulder to hip (a) or horizontally from one shoulder to the other (b). The signs SCHOOL and PAPER are both articulated in neutral space with the palms contacting each other, either with a straight path (c) or a curved path (d). Handshape, palm orientation, and initial location are the same for each pair (Figure adapted using images from *www.lifeprint.com*).

Figure 5: The ASL sign SLOW produced in its citation form (a) and with a morphological speed change (b). The meaning 'very slow' is conveyed by producing the sign more quickly. (Figure taken from Klima and Bellugi, 1979).

The fact that each of the three dimensions can be used in ASL to capture categorical distinctions may limit signers' ability to use these dimensions gradiently. For example, prosodic features spell out the underlying types of movement of a sign in Brentari's (1998) phonological model of sign. Path features are dominated by the path node in the prosodic branch of this model and indicate the shape or direction of a movement. Signs may or may not be specified for direction, but speed is not specified in the model.[3] If signers are sensitive to these phonological differences, they might treat the three dimensions differently with respect to gradient modification. In other words, they may modify signs along some dimensions but not others—in the same way that speakers can manipulate their rate of speech to describe a fast-paced event but may not be able to manipulate voicing because it will produce a new word (e.g., *buzz* -> *bus*) or render the word meaningless (e.g., *buzz* -> *puzz*).

Among the parameters in sign phonology (handshape, orientation, location, and movement), the one most likely to be fecund in this exploration is movement, because (among other things) movement is what allows signers to draw shapes in the air -- so it has a wide range of depictive possibilities (C. Ferrara & Napoli, 2019). The path dimension of movement in particular is central to such depictions. Direction is essential to the depiction of spatial (and temporal) relations between two or more points, and again, movement is the only parameter that can show this. Speed, while not typically contrastive in sign (although there are exceptions to this, see Figure 5), is variable for movement, and allows us to test whether less-specified dimensions are relevant to this phenomenon. Speed can be a factor in morphology of sign languages, as shown in Figure 5, which is pertinent given our interest in how meaning is built into features of movement.

[3] In Sandler's (*1989*) Hand Tier model, fast movement may be the phonetic realization of a manner feature such as [+restrained]

To summarize, our goal is to explore when signers creatively play with their sign forms to capture variations in meaning. As Fuks (2016) notes, "Very few studies have reviewed the interactions between entries which are part of the established SL core-lexicon and gradient manual features in signing." Our goal is to explore signers' willingness to apply modifications to the movement of lexical signs, which are part of the core-lexicon of ASL and commonly considered in the literature to be relatively immune to such modifications (Cormier et al., 2013, p. 372; Emmorey, 1999, p. 145).

We present signers with videos of pairs of motion events that vary in path, direction, or speed, and we give them either a lexical sign or a depicting sign to use in describing the event pairs. Our question is whether signers iconically alter the form of their lexical and depicting signs to capture variations in motion. Based on previous literature, we expect that signers will iconically modify lexical signs to capture relevant distinctions in our stimuli. However, we expect lexical signs to be modified less often than depicting signs not only because lexical signs are likely to be less iconic, but also because the components of a lexical sign are phonemes rather than morphemes (Supalla, 1982, 1986) or gestures (Schembri et al., 2005). We then explore whether modification is equally likely for each of the three dimensions of motion. If not, we will have identified restrictions on modifiability that may have a linguistic basis. Finally, we ask whether modification is influenced by the iconicity of the base sign; in particular, whether items judged to be more iconic are more gradiently modifiable than items judged to be less iconic.

2.2 Methods

2.2.1 Participants

11 Deaf participants (7 female) who use ASL as their primary language were recruited from the Chicago area. The mean age of participants was 49.3 years (*SD* = 17.5; range: 20.2 – 71.7). Eight of the participants were exposed to ASL from birth and come from deaf families. The remaining three report no deaf family members (at the time of their birth). One of the three began receiving regular ASL exposure starting at 8 months and enrollment in a deaf signing school at 5 years old. The remaining two report learning ASL at approximately 10 years. All listed ASL as their preferred form of communication. Signers were paid $75 for their participation and travel. Sessions were typically[4] conducted by a deaf signer fluent in ASL, and all instructions were given in ASL.

2.2.2 Task and Stimuli

The stimulus set contained videos representing different actions (here referred to as “events”). Each event could be described in ASL by a lexical sign and also by a depicting sign. The lexical and depicting signs presented to the participants are shown in Figure *6*.

[4] On two occasions, scheduling constraints required that two experimental sessions be run simultaneously, so two participants were tested by a hearing experimenter. Experimental sessions were always conducted in ASL.

Figure 6: All target lexical and depicting signs shown to participants as prompts.

We incorporated movement into the depicting signs we presented even though, by definition, depicting signs are not lexically specified for movement or path. We did so in order to make the depicting sign condition as comparable as possible to the lexical sign condition as possible. The movements used in the depicting sign prompts were designed to "match" the movement in the initial neutral video. In the majority of cases, multiple phonological parameters (including handshape and motion) distinguished the lexical sign for an event from the depicting sign for the same event; however, handshape was the only distinguishing feature for CLEAN, COMB, OPEN, PAINT, and THROW. Video examples of the signs that were presented to the participants by the experimenter are publicly available on the online repository [*https://osf.io/ksd37/?view_only=b95ca51fe0f345ec8b4da1debe9c230f*]

Three types of elicitations were presented to all participants in a within-subject design. In the first elicitation, signers were asked to watch the video pairs and then describe what happened in each pair, without any guidance about which signs to use in their descriptions. In the second and third elicitations (which were counter-balanced), participants watched the same video pairs and once again were asked to describe what happened in each, but this time they were given a particular sign to incorporate into their descriptions, either a frozen lexical sign or a productive depicting sign. The data from the first elicitation were not analyzed for modification but were instead used to ensure that all participants correctly interpreted the events shown in the videos, and as a sample of each participant's signing style that could be used as a reference point during coding in the case of ambiguities. The data presented in our analyses come only from the second and third elicitations.

Each participant saw videos of 14 different actions in each of the three elicitations. Each of the actions in an elicitation was presented in three event manipulations: once with an event that varied in speed, once in an event that varied in direction, and once in an event that varied in path. Each participant thus saw 126 stimuli (14 actions x 3 elicitation conditions x 3 event manipulations).

Participants were shown pairs of videos displaying two contrasting versions of the same action. One of the videos in each pair showed the action performed in such a way that it mirrored the citation form of the lexical sign for that action. For example, a common lexical sign for RUN in ASL uses both hands in L handshapes (with the thumb and index finger extended in the shape of an L), with the index finger of the non-dominant hand resting against the thumb of the dominant hand. The hands move forward together in a straight line while the index fingers flex into open-X shapes (where the index finger is curved with the thumb still extended), again with the non-dominant index finger hooking around the dominant thumb (see Figure *7*a). The event video designed to match this citation form in speed, direction, and path contained a woman running forward in a straight line across a field (Figure *7*b). The second video in the pair displayed an action that deviated from the first action; if a signer were to fully preserve the iconic mapping of the sign to that action, they would need to modify some aspect of that sign. Each altered event was designed to potentially elicit one of three types of modifications in the target sign:

Path—Altered events intended to elicit path modifications were designed so that the shape of the movement path would have to be modified for the sign to iconically depict the altered event. For example, in the citation form of the sign RUN, the path of the hands is a straight line and, in the unaltered event video, the person runs in a straight line (Figure *7*a,b). The event video altered for path shows a person running in a zigzag (Figure *7*e). To iconically depict this altered event, the signer would need to modify the movement path to a zigzag trajectory.

Direction—Altered events intended to elicit direction modifications were designed so that the direction of the movement would have to be modified for the sign to iconically depict the altered event. For example, the event video of RUN altered for direction shows a person running from left to right, rather than right to left (Figure *7*d). To iconically depict this altered event, the signer would need to modify the direction of the movement or the orientation of the hands and arms in the signing space (Figure *7*g).

Speed—Altered events intended to elicit speed modifications were designed so that the speed of the movement would have to be modified for the sign to iconically depict the altered event. For example, the event video of RUN altered for speed shows a person running faster than the unaltered event (Figure *7*c). To iconically depict this altered event, the signer would need to produce the movement more quickly than they did for the unaltered event.

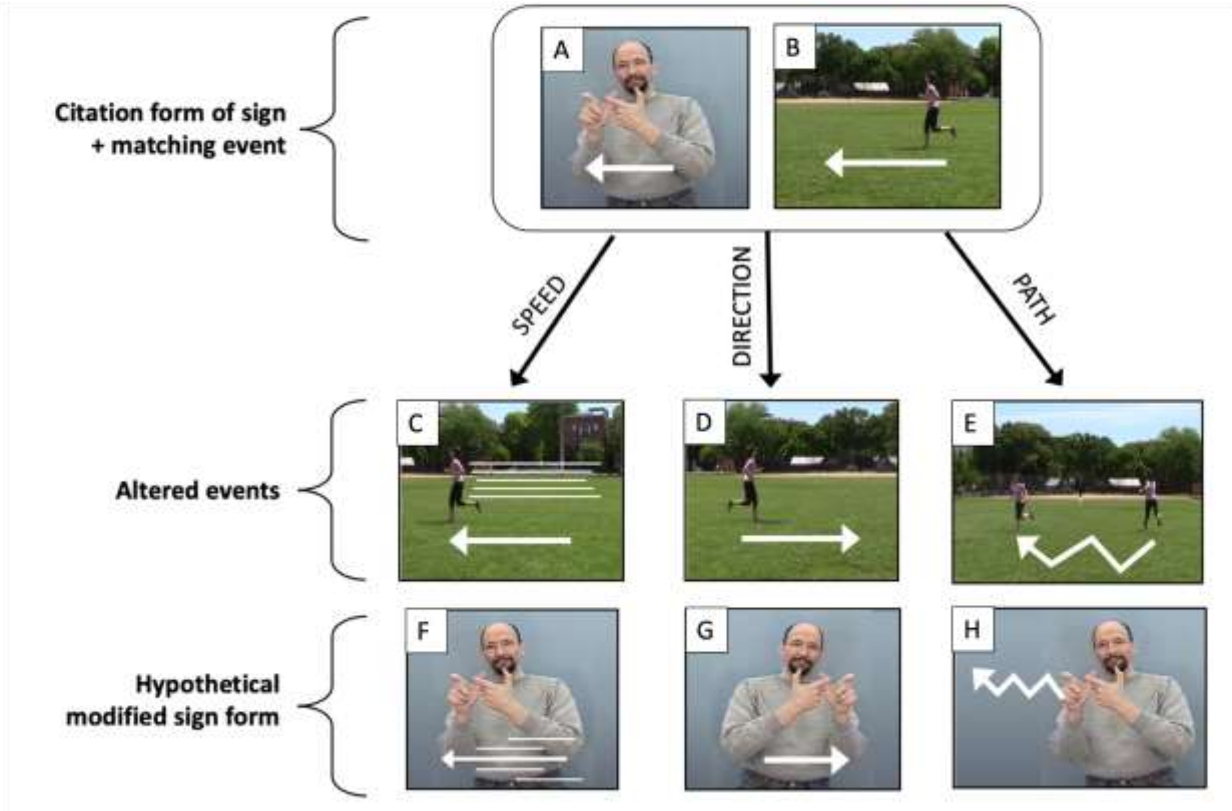

Figure 7: An example of video pairs presented to participants. The two images on the top display the lexical sign RUN (which the participant did not see), and the running event that mirrors this form (the participant did see the event). The three images underneath display the running event sped up (left), moving in the opposite direction (middle), and moving in a different path (right). The three images below the altered events display sign forms that capture the alterations in their form, speed on the left, direction in the middle, and path on the right. Participants saw the altered events, but not the modified signs. Images in A, F, G, and H adapted from *www.lifeprint.com.*

Each stimulus event was acted out and video recorded (rather than being digitally altered). Pairs of videos were presented side by side, with the action that mirrored the citation form of the lexical sign on the left, and the action that varied in either speed, direction, or path on the right. Thus, each action appeared as a video-pair three times: once for each type of alteration. Participants were instructed in ASL to watch the video on the left (the action that mirrored the lexical sign) and then the video on the right (the action that varied in either speed, direction, or path). They were then asked to describe to the experimenter what happened in the two videos.

Henceforth, we will use “trial” to refer to these presentations of video pairs. Participants were given three practice trials to ensure they understood that they were expected to provide descriptions of both the first and the second video, rather than a general description such as “two videos of someone running.”

In the second and third elicitation conditions, participants were encouraged to use the target lexical sign or depicting sign they were given in their descriptions. However, they were also told that, if the sign was not one they normally would use or did not seem like an appropriate label for the event, they were free to describe the event as they normally would. Participants chose not to use the target sign for a small proportion of the trials (74/462, 16% for the lexical condition, 30/462, 6.5% for the depicting condition across participants). These trials were not eliminated from the data but were not counted as either modification or non-modifications. Figure *8* presents a visualization of the task structure.

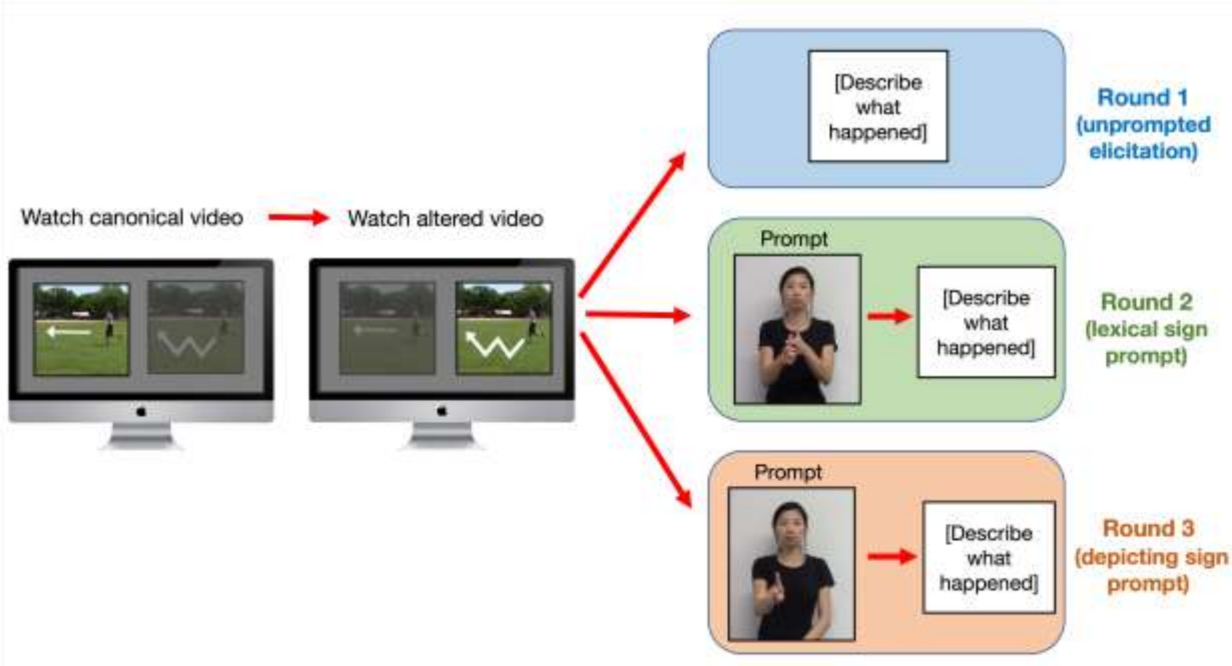

Figure 8: Experimental task structure. Participants watch each video pair three times: first in the 'UNPROMPTED elicitation round', where participants describe the pairs with no experimenter input; a second and third time in the 'lexical prompt' and the 'depicting prompt' rounds (also referred to as the lexical condition and the depicting condition).

All sessions were video recorded for later coding using a digital camera on a tripod, positioned so that the participants were fully in frame while signing (from the top of their head to their lap while seated, with space on either side). Participants directed their responses directly to the camera or to the experimenter (seated across from them, next to or in front of the camera). There were no instances where participants' signs were out of view of the camera. There were seven trials in the depicting condition where data was lost due to technical issues with the video recordings freezing. In our analyses, the values for these trials were replaced with the mean modification proportion for that trial among the remaining participants so as not to skew the distribution of the data.

Participants were told that another deaf signing participant would later watch the video of their responses and be asked to identify which videos the response referred to. These instructions were used to give participants a sense of how much detail to include in their descriptions, as well as to encourage them not to focus on whether the experimenter approved of their choice of signs. Once the task was completed, the experimenter debriefed the participants on the goal of the study.

Categorizing Verbs

One potential limitation of our study is the lack of agreed-upon criteria for categorizing signs as lexical or depicting (Johnston & Schembri, 1999; Schembri, 2003; Supalla, 1982, 1986; Zwitserlood, 2008, 2012). With this difficulty in mind, we developed our list of stimuli by first identifying actions that could be described by two distinct signs in ASL (not different versions of the same sign) which would both be glossed as the same verb in English. Of those verbs, we selected lexical signs that had a clear and identifiable citation form and could be found in an ASL dictionary (all are listed in both ASL-lex, Caselli et al., 2017, and ASL SignBank, Hochgesang et al., 2017). The parallel depicting sign varied from the lexical sign in at least one dimension (handshape, motion, location), participated in productive constructions, and could not be found in our dictionaries. Decisions regarding the lexical or depicting status of a sign were also informed by the deaf co-author of this project and a sign language linguist, both fluent in ASL. The difference in modification patterns between the lexical signs and depicting signs used in our study provides post-hoc evidence for our division of signs into lexical and depicting signs.

Typicality Ratings of the Events Shown in the Stimulus Videos

To ensure that our stimulus videos were good exemplars of the events used in the task, we recruited a sample of hearing, English-speaking participants via Amazon Mechanical Turk to rate the videos. Between 28 and 30 hearing participants rated each video. Participants were shown an action video alongside the English verb that best labeled it. They were asked whether the action shown in the video exemplified that verb (yes or no) and, if yes, to rate the action for how well it exemplified the verb on a seven-point Likert scale. These data were used to ensure: (1) that all of the actions shown in our video stimuli were good instances of the target verbs; and (2) that the variations of the three dimensions that were manipulated were equally identifiable.

Iconicity Ratings of the Lexical and Depicting Signs Used in the Study

To assess the iconicity of the lexical signs and depicting signs used in this task, we collected ratings for each target lexical sign and depicting sign (14 lexical signs + 14 depicting signs = 28 items in total). Ratings were collected in person from an additional group of 11 hearing non-signers[5]. Participants used a 1-7 Likert scale to judge how much the sign looked like what it meant. This iconicity task has been used by other research groups and elicits reliable ratings from both signing and non-signing individuals (Caselli et al., 2017; Sevcikova Sehyr & Emmorey, 2019; Vinson et al., 2008). In general, signers' iconicity ratings are highly correlated with non-signers' ratings; consequently, ratings from hearing non-signers are often used as a measure of sign iconicity (Bosworth & Emmorey, 2010; Caselli et al., 2017; Sevcikova Sehyr & Emmorey, 2019). We therefore combined the ratings from our deaf and hearing participants. Figure *9* presents a sample trial from the iconicity survey.

[5] We also attempted to collect iconicity ratings from our deaf signing participants. However, because the experimental task was long, some of our signing participants were unable to provide iconicity ratings at the end of the session, or only completed a portion of the survey. We were able to collect iconicity ratings from 5 of our signing participants for our lexical signs, and from 7 participants for our depicting signs.

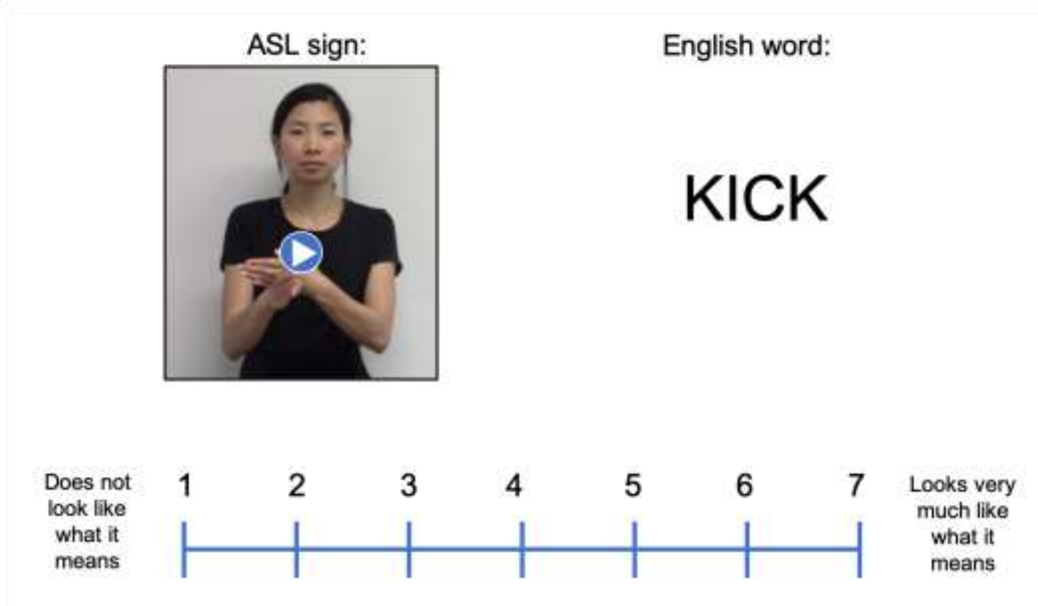

Figure 9: Example item from the iconicity survey.

Iconicity scores collected from in-person participants were normalized within-subject in order to correct for possible individual biases in Likert responses (e.g., a central tendency bias), and allow the participants' scores to be compared on the same scale. For each data point (verb iconicity rating), we took the raw score, subtracted that individual's mean overall score, and then divided the difference by that individual's standard deviation. This within-subject z-scoring procedure was used in the iconicity studies on which our measure is based (Baus et al., 2013; Bosworth & Emmorey, 2010; Caselli et al., 2017; Sevcikova Sehyr & Emmorey, 2019). These z-scores will be used throughout the iconicity analyses. The online sign database ASL-lex 2.0 reports iconicity scores for the lexical signs used in this task (collected from 28 hearing non-signers), but not for the depicting signs. We therefore report the in-person ratings collected from our participants to ensure that the ratings came from the same source for lexical and depicting signs. For our lexical signs, the in-person iconicity ratings were highly correlated with those reported on ASL-lex 2.0

(r = .85, $p < .0001$). We repeated our iconicity analyses (section 3.3) using the ASL-lex 2.0 ratings and found no difference in the reported patterns.

2.2.3 Coding

Video data from both the lexical and the depicting conditions were coded by the first author and an RA, both of whom are hearing and have used ASL for >10 years. The RA coder was blind to the hypotheses at the time of coding. All coding decisions were reviewed by both parties, and any disagreements were discussed with a deaf signing collaborator and a sign language linguist. Post-hoc reliability was calculated on 10% of the data (92 trials) sampled across participants, conditions, verbs, and dimensions. Inter-rater and intra-rater reliability were high; the Cronbach's Alpha score when comparing Coder 1, Coder 2, and the final coding was .94 (Coder1–Coder2 α = .88; Coder1–final coding α = .96; Coder2–final coding α = .88). Responses were annotated on a sign-by-sign basis using the ELAN software program (from the Max Planck Institute for Psycholinguistics), which enables annotations to be time-aligned to the relevant video frames (Wittenburg et al., 2006).

All participants structured their responses by first describing the video on the left (which matched the sign that described it, the unaltered event) and then describing the video on the right (which varied from the first event in speed, direction, or path, the altered event). The transition from describing the first to the second video was typically marked with a body shift and/or use of labels such as "first" and "second" or "left video" and "right video". Dividing trials into descriptions of the unaltered vs. altered events did not pose a problem for the coders, who agreed on all trial boundaries. Further details about the coding system can be found in the coding manual available on the online repository [*https://osf.io/ksd37/?view_only=b95ca51fe0f345ec8b4da1debe9c230f*].

We identified the portion of each response that described the altered event (second video in the pair). In each participant's description, we calculated the number of times that the target sign (the sign presented to the signer at the start of the trial) was modified so that the speed, direction, or path of the sign was changed to gradiently depict the altered event. To calculate the proportion of modifications for a trial, we divided this number by the total number of times the target sign was produced by the signer (modified or unmodified) in their descriptions of the altered event. Instances of the target verb in the description of the unaltered event (the first video in the pair) were not included in this calculation. For example, for a trial where the THROW verb is manipulated for path (throwing underhand) in the lexical condition, one signer produced the following description (approximately translated):

The first video shows a woman throwing a ball normally. The second video shows the same woman <u>throwing[unmodified]</u> a ball <u>but throwing[modified]</u> it underhand.

To calculate the score for this response, we focus on the description of the altered event (the second sentence in this example) and divide the number of times the target sign is modified (once) by the total number of times it appears (twice), yielding a score of 0.5 for this trial.

We opted for this proportion of total uses measure over a binary coding of modification as either present or absent in order to capture the fact that signers may feel a modification is "licensed" or allowed only if an unmodified version of the sign is also produced; the need to produce an unmodified form along with a modified form may signal a reduced willingness to modify. In other words, we wanted a measure that allowed for the possibility that some modifications could "stand on their own" while others might not. This possibility may be particularly relevant for modifications that are very low-frequency or that impact comprehensibility. In addition, the proportion measure allows us to advantage of all of the data we collected. As a result, the data presented here are based on the proportion measure. However, using the binary coding measure produces a nearly identical pattern of results (an R markdown file, which includes the results calculated in terms of the binary measure, is available on the OSF repo).

To determine whether a lexical sign was modified, coders first assessed whether the dimension of interest (speed, direction, path) was captured in the sign. If so, the coders then asked whether the sign was identical to the citation form in all respects except the modified dimension. For example, the stimulus for the altered path for the lexical sign CLEAN contained a circular movement (as opposed to the back and forth movement in the unaltered event). Lexical signs were coded as modifications only if the signer introduced a circular movement into the citation form for CLEAN and maintained all of the other aspects of the sign form (i.e., an open-B handshape and a palm-up non-dominant hand). If the signer used a handling handshape, or only one hand without a base hand (which in this case would make the sign more like the actual event), the response would be coded as a depicting construction rather than a modified lexical sign.

For depicting signs, recall that we incorporated movement into each sign presented to the participants even though depicting verbs are not specified for movement or path. The movement used in the depicting signs presented as stimuli mirrored the movements in the unaltered target events (see Figure *6* for reference, and the videos available in the online repository, for information on the movements used in the depicting prompts). A depicting sign was considered not modified if the signer copied the form of the sign presented for the unaltered event. For example, if the signer produced the depicting sign for RUN with a straight movement (the movement in the sign presented to them for the unaltered event) to describe running in a zigzag, the sign would be considered unmodified. If the signer produced it with a zig-zag movement comparable to the movement in the altered video, the depicting sign would be considered modified.

We did not time the signs produced in the speed trials; we judged the signs describing the altered event as either faster or slower than the signs describing the unaltered event. Since changes in speed can be difficult to measure, we performed a post-hoc check of our speed coding. For each speed trial, we calculated the difference in duration between the sign describing the unaltered event and the absolute value of the sign describing that event altered for speed. This difference was significantly larger for signs that we coded as modified for speed (M = 532.46 ms) than for signs that we coded as unmodified for speed (M = 276.6 ms, $t(89) = 4.10$, $p < .0001$)[6]. Our speed coding thus has face validity.

2.2.4 Analysis

We first compared the proportion of modification in lexical signs to the proportion of modification in depicting signs, and explored whether the three manipulated dimensions (speed, direction, path) were modified to the same degree. We conducted a two-way repeated-measures ANOVA, testing for a main effect of condition (lexical signs versus depicting signs), dimension (speed, direction, path), as well as an interaction between the two (section 3.1). We used two-tailed t-tests to determine whether and how the three dimensions differ in their modifiability within each condition (section 3.2). We then asked whether the iconicity of the base sign is correlated with gradient modification. We tested for correlations between the iconicity ratings for

[6] We did the post-hoc speed check only for the lexical signs since there were only two instances where a depicting sign was *not* modified for speed.

a given sign's citation form and the proportion of modification for that sign across participants (section 3.3). We conducted this analysis across all three dimensions, and within each individual dimension. Lastly, we analyzed the linguistic context in which modifications occur to investigate how signers package and distribute information across an utterance (section 3.4).

2.3 Results

2.3.1 Evaluating the overall success of the task

In order to compare if and how signing participants captured the three dimensions manipulated in this task, we need to know that participants reliably noticed the difference between the unaltered and altered videos in each trial and saw this contrast as relevant to include in their description. Participants included information on the manipulated dimension in almost all of their responses (98.5%, 910/924). Thus, the stimuli used in the task captured the manipulated dimensions well, and participants understood this information to be relevant to include in their descriptions.

A second important check on whether our data accurately reflect signers' intuitions regarding the modifiability of our target signs is assessing the extent to which our target signs were reasonable labels for these events and would be spontaneously used by our signers without prompting. Frequency of use data from ASL-lex 2.0[7] indicates that our target lexical signs had a mean frequency rating of 4.75 on a 7-point Likert scale (range = 3 – 6.1) indicating that our target signs were not particularly low frequency. Moreover, an analysis of the responses elicited in our UNPROMPTED condition (where signers had not yet been shown any of our target signs and

[7] Based on ratings from 25 – 30 deaf signers.

were simply asked to freely describe our stimuli pairs) indicates that signers frequently use both our lexical and depicting target signs as their unprompted labels for the events. When looking by participant, the median number of target signs (out of 14) produced by a participant unprompted was 11 for lexical targets and 12 for depicting targets. When looking by verb, the median number of participants (out of 11) to spontaneously produce a given target sign unprompted at least once was 9 for both lexical and depicting targets. Each of our target signs was produced spontaneously by multiple signers, and each of our signers spontaneously produced many of our target signs. Moreover, in the prompted conditions, participants failed to use the verb they were given by the experimenter in only 16% (74/462) trials for the lexical condition, and in 6.5% (30/462) trials for the depicting condition. Ten out of our 11 participants used the prompted option at least once, suggesting that our prompted forms were not unnatural for the signers. Taken together, these results indicate that despite the inherent unnaturalness of an experimental context, signers were using familiar signs in contexts that felt appropriate to them.

2.3.2 How does modification in lexical signs compare to modification in depicting signs?

The mean proportion of signs that were modified was 0.40, (*SD* = 0.45) in the lexical condition, and 0.90 (*SD* = 0.19) in the depicting condition. We used a two-way repeated-measures ANOVA to test for main effects of condition (lexical sign/depicting sign), dimension (speed, direction, path), as well as an interaction between the two. There was a significant main effect of condition $F(1) = 44.21$, $p = < .001$. Signers modified signs significantly more often in the depicting condition than in the lexical condition.

There was also a second significant main effect of dimension $F(2) = 12.72$, $p = < .001$, and a significant interaction between condition and dimension $F(2) = 4.13$, $p = .032$. We examine the effect of dimension and the interaction between condition and dimension in the following sections.

2.3.3 Are the three motion dimensions modified to different degrees?

Participants modified all three dimensions frequently in the depicting condition; the difference between the most modified dimension (speed) and the least (path) was only 0.08. In contrast, participants modified the three dimensions at very different proportions in the lexical condition; the difference between the most modified dimension (speed) and the least (path) was 0.30. Table 2.1 presents the means and standard deviations for proportion of modification, broken down by condition and dimension.

Table 2.1: How often signs were iconically modified along each dimension

Dimension	Lexical Signs	Depicting Signs
Altered Speed	*M* = 0.55, *SD* = 0.47	*M* = 0.93, *SD* = 0.19
Altered Direction	*M* = 0.39, *SD* = 0.45	*M* = 0.92, *SD* = 0.21
Altered Path	*M* = 0.25, *SD* = 0.39	*M* = 0.85, *SD* = 0.25

We used post-hoc two-tailed t-tests to assess whether the proportion of modification differed significantly between pairs of dimensions. In the lexical condition, the proportion of modification for path and for speed was significantly different [$t(10) = -4.28$, $p = .002$; Wilcoxon $V = 3$, $p = 0.005$] after a Bonferroni correction for multiple comparisons at alpha of 0.05. Differences between path-direction and direction-speed did not survive correction, nor did differences between any two dimensions in the depicting condition (although it is possible that the high proportion of modification for depicting signs may have produced a ceiling effect, obscuring any differences between dimensions in this condition). Note that while speed was the most frequently modified dimension within lexical signs, these were still less frequent than any modifications to depicting signs, $t(103) = 7.44$, $p < 0.00001$; Wilcoxon: $V = 1796.5$, $p < 0.00001$. The boxplot in Figure *10* displays the main effect of condition on proportion of modification, as well as the dimension effect in the lexical condition.

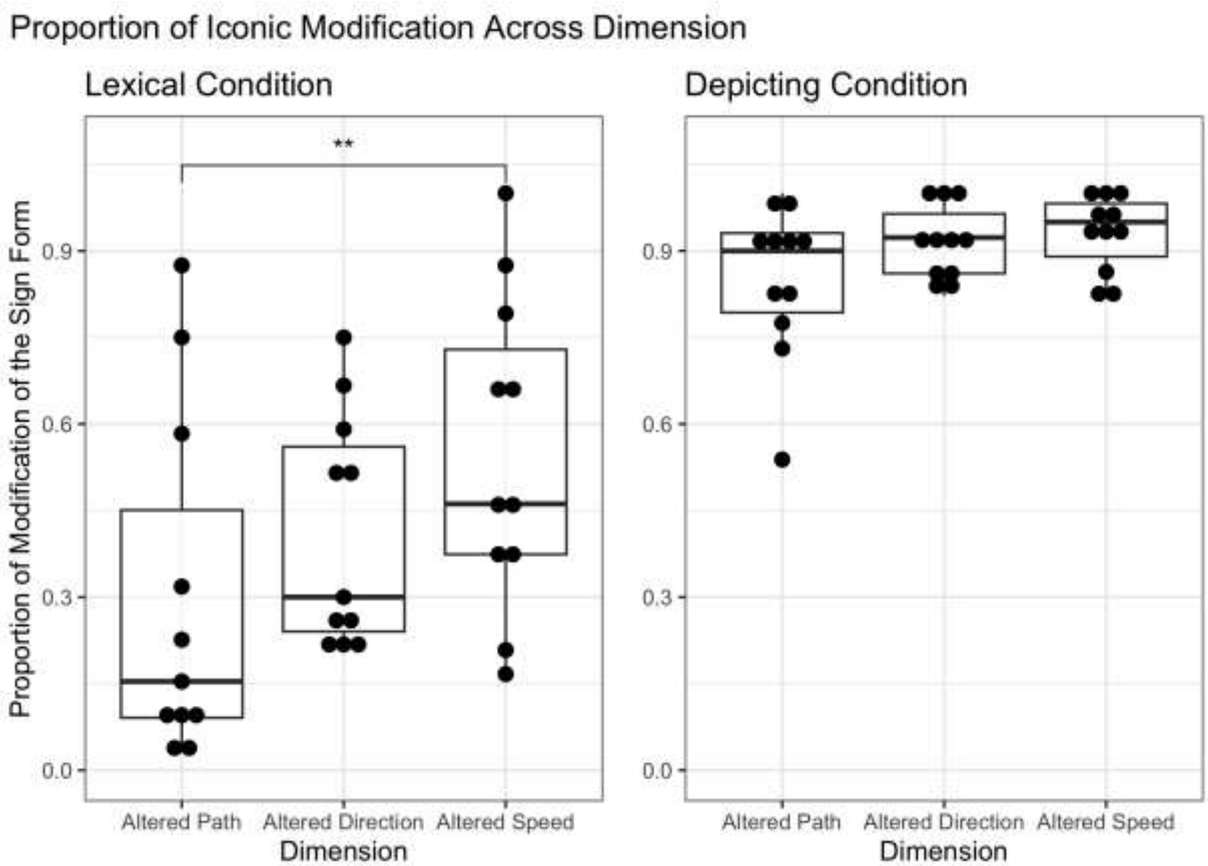

Figure 10: Proportion of modification in the lexical and depicting conditions, broken down by dimension

Within Participant

We also examined proportion of modification within individual signers to determine whether individuals differed in how likely they were to gradiently modify their signs. At the participant-level, we found a large range of modification rates for lexical signs (range = 0.19 to 0.88 in overall proportion of modification). However, all signers produced modifications for all three dimensions at least once. Modification was more likely for speed than for path at the individual level, with all but one participant modifying speed more often than path ($Z = 10$, $p = .01$, sign test). The relationship between direction and the other two parameters was less consistent. The majority of signers modified speed more than direction (7 out of 11), and direction more than path (8 out of 11), but neither result was significant ($Z = 8$, $p = .23$; $Z = 7$, $p = .55$).

Within Verb

We also examined verb differences in rate of modification in lexical verbs (range = 0.82 to 0.98 in overall mean modification). Modification was found in all lexical verbs, and all verbs but one (MEASURE) were modified along each of the three dimensions. As in our subject-level effects, there is evidence for our dimension pattern at the verb-level: Speed was modified more often than path in 12 of the 14 verbs ($Z = 12$, $p = .01$, sign test). Modification of direction fell in between path and speed for 10 of the 14 verbs, but this pattern was not significant ($Z = 10$, $p = .18$; $Z = 10$, $p = .18$).

Sign Type

The target signs we used were of multiple types (see table in the supplementary materials available on the OSF repository): *one-handed signs,* which are formed using a single hand (e.g., THROW); *symmetric two-handed signs*, in which both hands move in the same way (e.g., OPEN); *asymmetric two-handed signs,* in which the dominant hand is active while the non-dominant hand is held static (e.g., KICK). These signs may also be *body-anchored* produced on the signer's body (e.g., HUG), or in *neutral space* produced at chest level in front of the signer (e.g., CLEAN). Lastly, signs may be *directional*, in which they move in the direction of one or more of its arguments, (e.g. CHASE), or *non-directional* which do not (e.g., MEASURE). Each of these types has linguistic constraints that could affect how often and how they are modified (Brentari, 1998; Mandel, 1981; Napoli & Wu, 2003; van der Hulst, 1993). For example, two-handed symmetric signs are subject to the Symmetry Constraint, which specifies that both hands in a symmetric two-handed sign must have the same or a mirrored configuration, orientation, and movement (Battison, 1974, 1978), with those that reflect across the midsagittal plane being the simplest to perform from a motor-coordination point of view (C. Ferrara & Napoli, 2019; Napoli & Wu, 2003). Modifiability across the types of signs ranged from .48 to .86, M = 0.62, SD = 0.16. However, the important result for our question is that, for every sign type, signers were more willing to modify for speed than for path: body-anchored signs (.85 speed, .62 path), neutral space signs (.73 speed, .57 path), one-handed signs (.88 speed, path .77), two-handed signs (.71 speed, .52 path), symmetric signs (.70 speed, .50 path), asymmetric signs (.72 speed, .54 path), directional signs (.63 speed, .34 path), and non-directional signs (.51 speed, .21 path). Sign type therefore does not interact with our basic phenomenon regarding dimension.

2.3.4 Does iconicity influence modifiability?

We now ask whether signers are more willing to iconically modify signs rated as iconic than signs rated as non-iconic. Figure *11* is a scatterplot comparing iconicity and modification rate for the 28 signs in this study (each of 14 verbs represented both as lexical signs and depicting signs), overlaid with each condition's best fit line. Note that each verb label appears twice–-once for the lexical condition (triangles) and once for the depicting condition (circles).

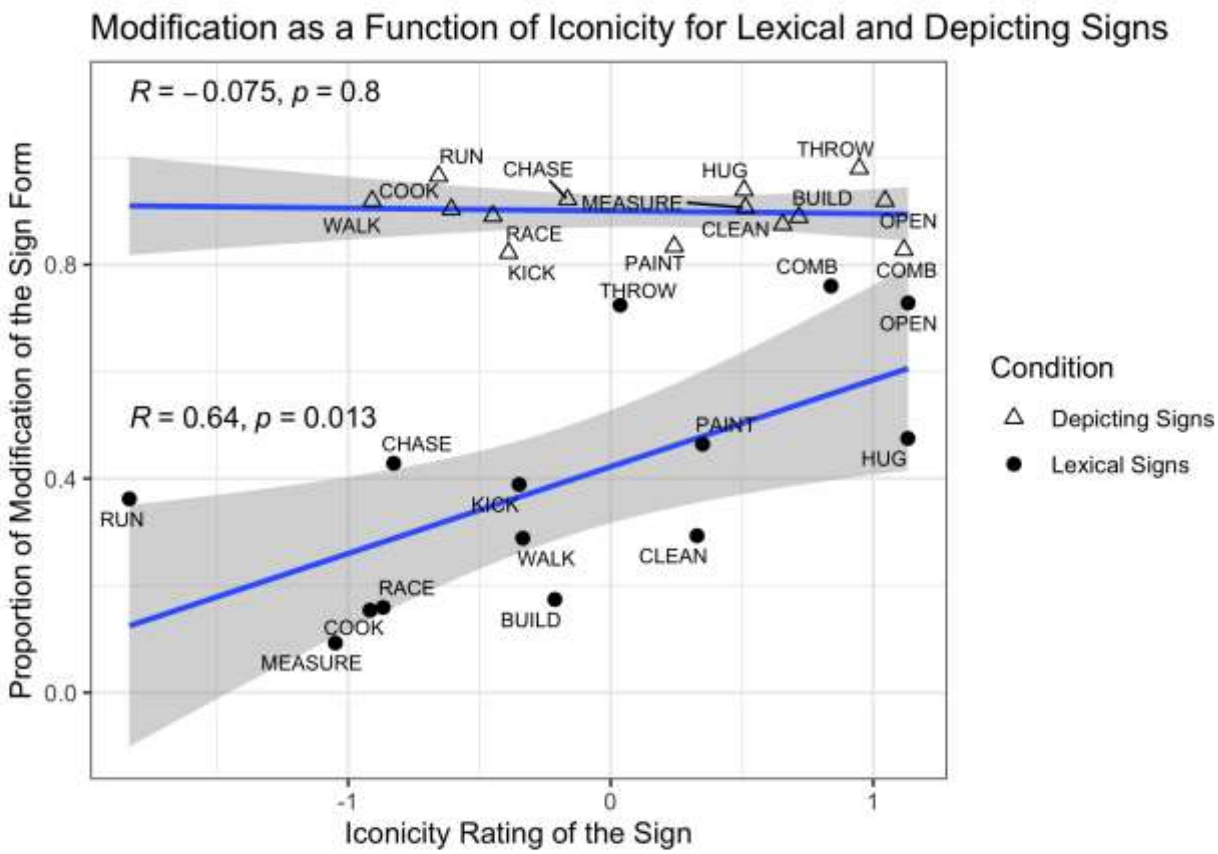

Figure 11: Correlation between iconicity and proportion of modification for verbs in the lexical and depicting conditions. The open triangles represent the depicting condition; the filled circles represent the lexical condition.

There was a significant correlation between iconicity and modification proportion for the lexical signs ($r = .64$, $p = .01$) but not for the depicting signs ($r = -.08$, $p = .8$). The correlation in the lexical signs remains significant after removing the high leverage point RUN. The iconicity scores shown here represent the ratings collected from our participants, as described in section 2.2.3. However, when we repeat this analysis using the ASL-Lex 2.0 iconicity ratings for the lexical signs (our depicting signs are not available on ASL-Lex 2.0), the correlation remains significant (*r* = .76, *p* = .002).

It is difficult to look for correlation effects when we break the data down into different sign types. Because the different sign types are unequally represented in our data, with some have very few observations, it is difficult to interpret the presence or absence of our iconicity main effect within these types. With that said, when we look the relationship between iconicity and modification within the different sign types we find that correlation between iconicity and modification holds for those produced in neutral space ($r = .47$, $p = .02$), two-handed signs ($r = .51$, $p = .01$), and non-directional signs ($r = .89$, $p < .001$), and is marginally significant for symmetrical signs ($r = .57$, $p = .05$). The correlation is in the correct direction but is not significant for asymmetrical signs ($r = .40$, $p = .25$) and directional signs ($r = .71$, $p = .29$), and the correlation reverses direction (and is also insignificant) for body-anchored signs ($r = -.70$, $p = .30$), and one-handed signs ($r = -.29$, $p = .57$). However, this pattern is difficult to interpret as there are only 4 body-anchored signs and 6 one-handed signs. Each dot in Figure *11* represents a sign's modification rate averaged across its three dimension manipulations. We next asked whether the correlation with iconicity is present in all three dimensions in the lexical condition. Figure *12* presents the data.

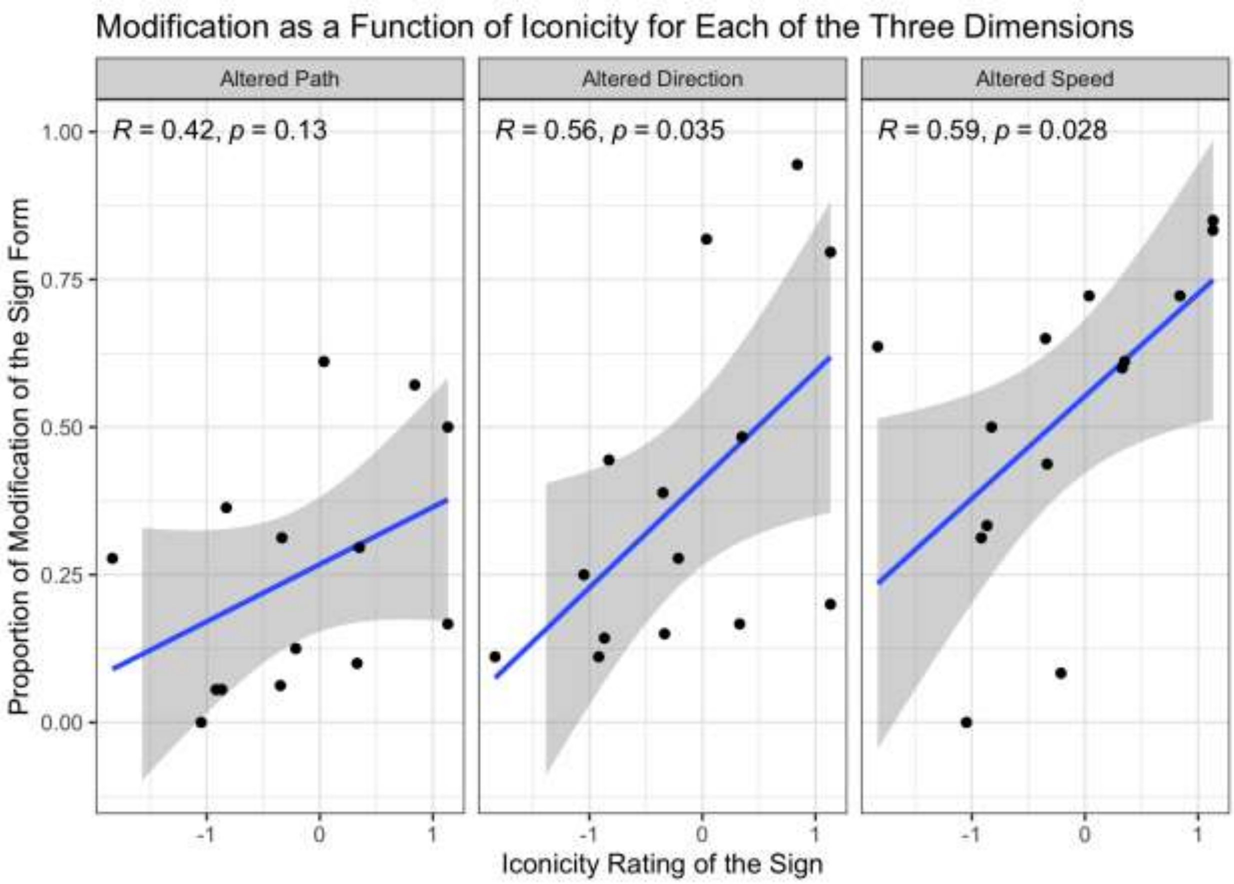

Figure 12: Correlation between iconicity and modification rate in the lexical condition, broken down by dimension.

Although iconicity is related to modification in all three dimensions, the strength of the relation differs across the dimensions. There is a significant relation of moderate strength between iconicity and direction (r = .56, p = .035) and between iconicity and speed (r = .59, p = .03). However, the relationship to iconicity is weaker for path, and is not significant (r = .42, p = .13).

2.3.5 What additional productions accompany modified and unmodified forms?

The final analyses examine in more detail how signers package the relevant information in their utterances. Modification of a sign may occur on its own or alongside other types of structures. To explore this question, we characterized responses as belonging to one of several categories. To exemplify the categories, let's consider a trial from the lexical condition for the verb CLEAN intended to elicit a path modification. In this trial, the unaltered video shows a person cleaning a surface side-to-side in a horizontal motion, which matches the movement in the lexical sign CLEAN (see Figure *13*, right image). The altered video manipulates the path by showing a person cleaning using a circular motion. Figure *13* (left image) displays a sign that has been modified to capture this circular cleaning motion.

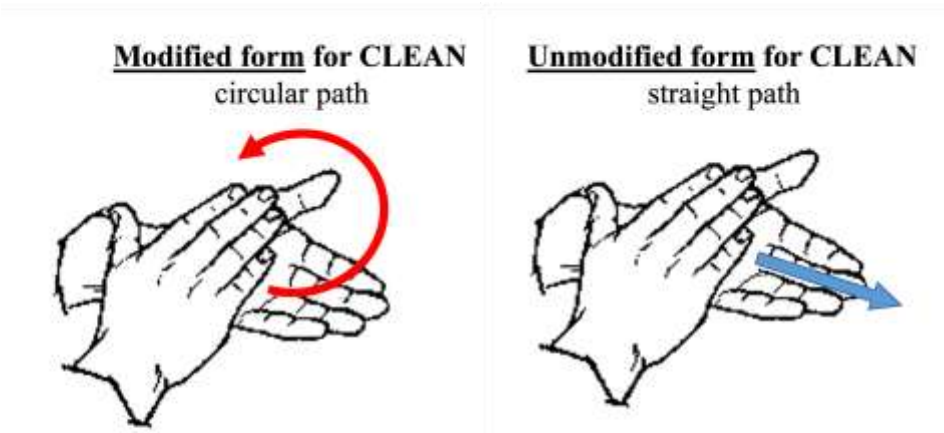

Figure 13: Visualizations of the modified (left) and unmodified (right) forms for the verb CLEAN. The unmodified form is the citation form for CLEAN found in ASL dictionaries.

Figure 14 presents the unmodified form with and without additional description (right column) and the modified form with and without additional description (left column). Note that the top left cell, in which the unmodified sign is produced on its own, is underinformative as it fails to mention the manipulated dimension. As mentioned at the beginning of the results section, underinformative responses were rare (~ 1.5% of the data). Responses falling into the bottom left cell provide information about the manipulated dimension in both the target verb and the additional descriptions; the dimension of change is thus marked redundantly.

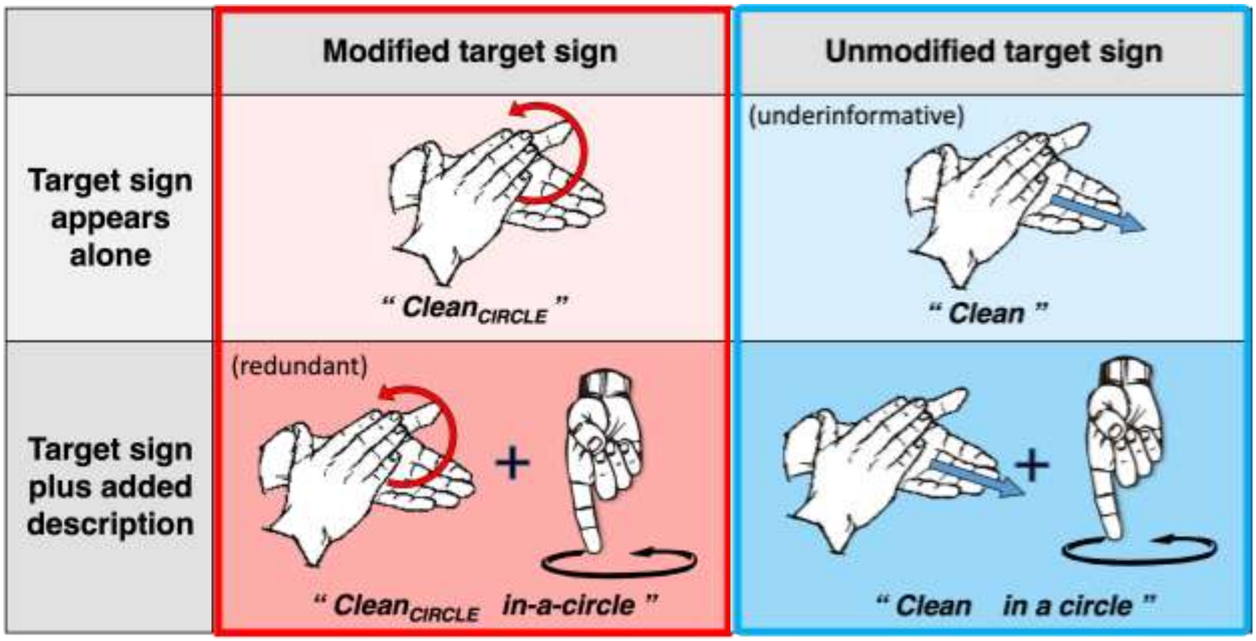

Figure 14: Example responses to the CLEAN videos. The column on the left displays the modified target sign, and the column on the right displays the unmodified target sign. Note that responses in the bottom left cell are redundant in that they include the relevant contrast information more than once; responses in the top right cell are under-informative in that they do not comment on the relevant contrast.

When the target sign was not modified, participants expressed the relevant difference between the unaltered and altered stimuli using a variety of structures, including adjectives or adverbial modifiers, such as FAST, SLOW, LEFT, RIGHT, etc.; fingerspelled words, such as Z-I-G-Z-A-G); and classifier constructions. Below we illustrate examples of the different strategies used by signers to describe these videos. Examples of each strategy are transcribed in examples 12 -17, and illustrated in images in

Figure 15 –Figure *20*. For the following examples, the participant's first utterance (describing the initial un-altered video), and their second (describing the altered video) are listed on separate lines.

Unmodified target (lexical verb) + adjective/descriptor

A response falling into the bottom right cell of

Figure 14 is transcribed in example 12 and shown in

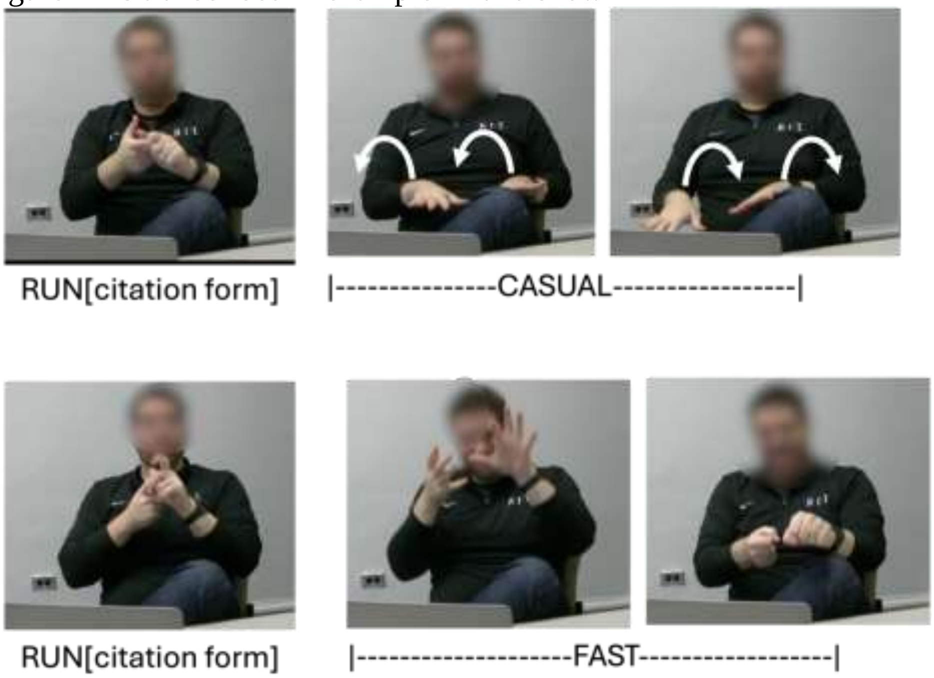

Figure *15*, where a signer produces an unmodified lexical sign accompanied by additional descriptions).

12. RUN[lexical sign citation form] CASUAL
RUN[lexical sign citation form] FAST

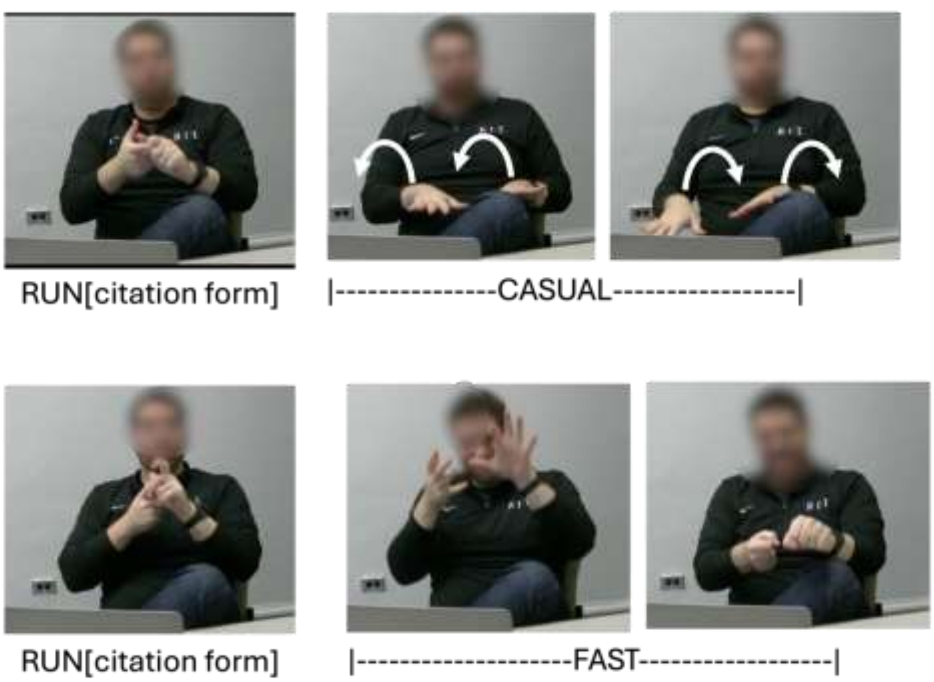

Figure 15: A signer expressing a speed difference via an external modifier, without modifying the target sign (RUN).

Responses of this type may also include tracings, classifiers, or other depictions that represent the contrast as shown in example 13 and visualized in Figure *16*.

13. CLEAN[lexical sign citation form] [handling depiction]
CLEAN[lexical sign citation form] [tracing depiction of circular path]

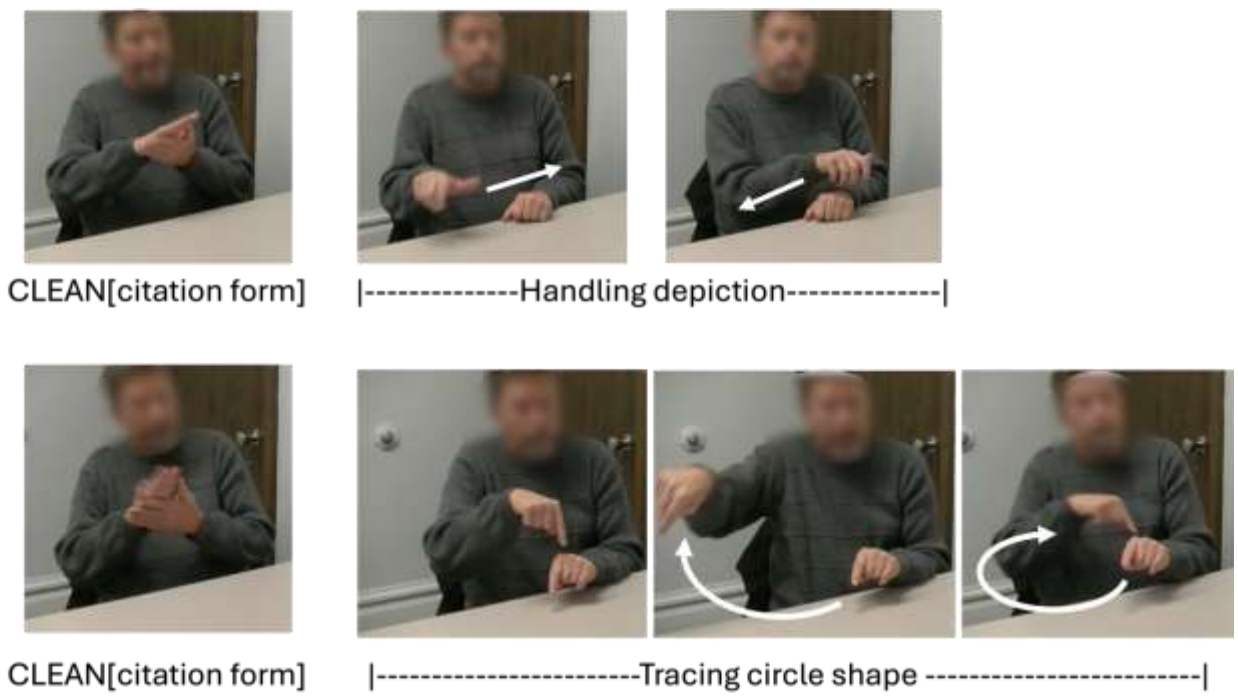

Figure 16: A signer expressing a path change via an external modifier (tracing/depiction), without modifying the target sign (CLEAN).

Modified target (lexical verb; Ø descriptor)

Example 14 and Figure 17 *presents a response with a modified lexical sign with no additional descriptions (the top cell on the left in*

Figure *14*).

14. PERSON BALL THROW[lexical sign citation form]
PERSON BALL THROW[lexical sign modified for path].

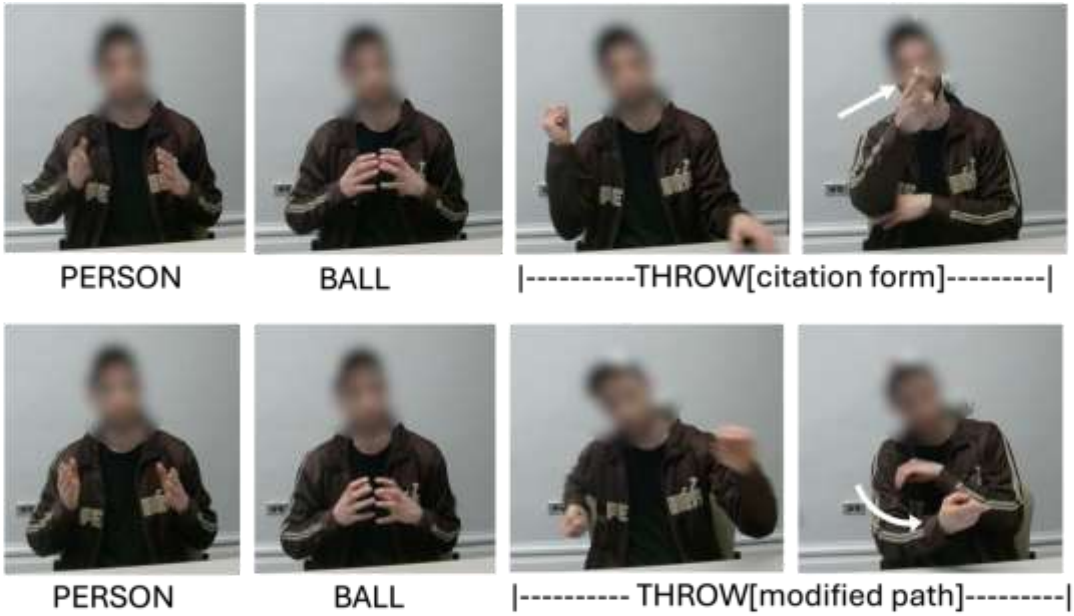

Figure 17: A signer expressing a path change via an iconic modification of the path of the target verb (THROW).

Modified target (lexical verb + adjective/descriptor

Example 15 and Figure 18 *present a response containing both a modified lexical sign and additional descriptions (the bottom cell on the left in*

Figure *14*). The signer produced an unmodified lexical sign RUN in the first utterance, followed by an utterance containing RUN modified for speed along with the adverb FASTER; in other words, a redundant response containing an internally modified lexical verb along with an external adverb conveying the same information.

15. P-A-R-K [finger-spelled] WOMAN RUN[lexical sign citation form]
SECOND VIDEO SHOWS WOMAN RUN[lexical sign modified for speed] FASTER

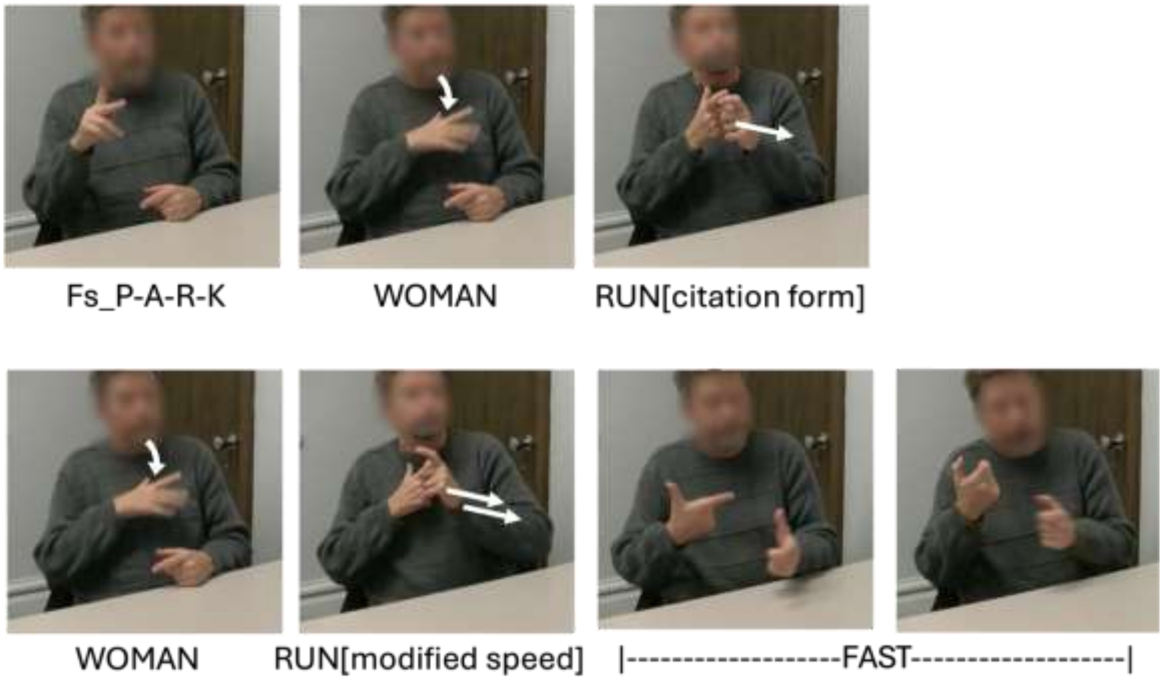

Figure 18: A signer expressing a speed change via iconic modification of the speed of the target verb (RUN) as well as through an external modifier (FAST).

Modified target (depicting verb); ∅ adjective/descriptor

Depicting signs were rarely unmodified but they were produced with and without additional descriptions. Example 16 and Figure *19* presents a modified depicting sign without additional descriptions. The signer produced an unmodified depicting sign for chase in the first utterance, followed by a second utterance in which the depicting sign was modified for direction with no additional descriptions.

16. CHASE[depicting sign unmodified]
OTHER(as in the other video), CHASE[depicting sign modified for direction]

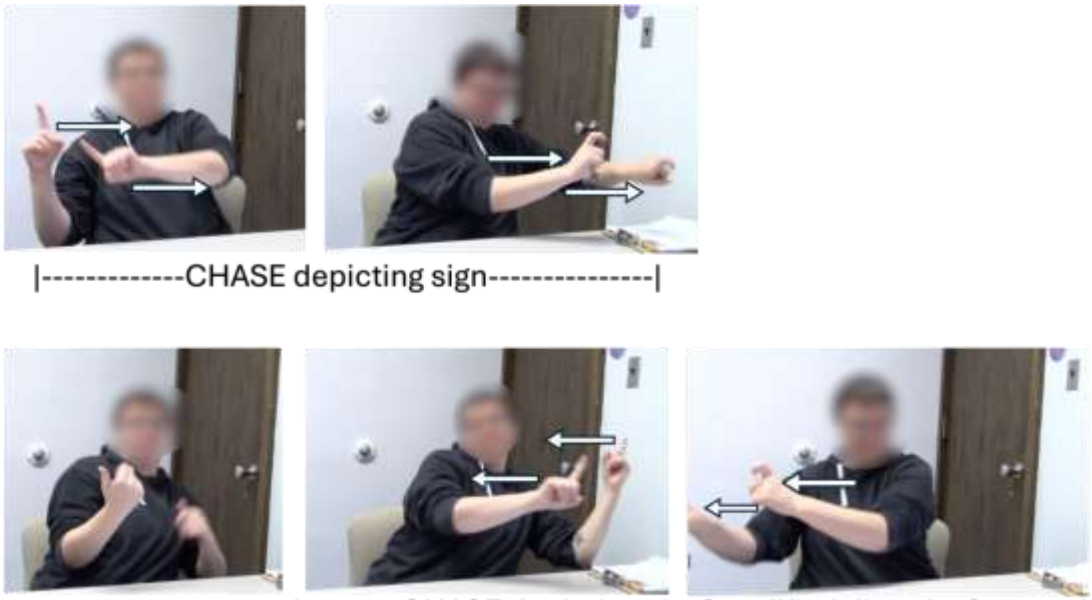

Figure 19: A signer expressing a change in direction via a depicting sign (CHASE).

Modified target (depicting verb) + adjective/descriptor

Example 17 and Figure *20* show a redundant response for a depicting sign—a modified depicting sign accompanied by additional descriptions. In the first utterance, the signer uses a depicting sign with a handling handshape to represent the action, and in the second utterance, the signer produces the depicting sign markedly slower to depict the change in speed, as well as marking the speed change via the use of adjectives such as SLOW and EXAGGERATED.

17. CHASE[depicting sign unmodified]
CHASE[depicting sign modified for speed] SLOW.

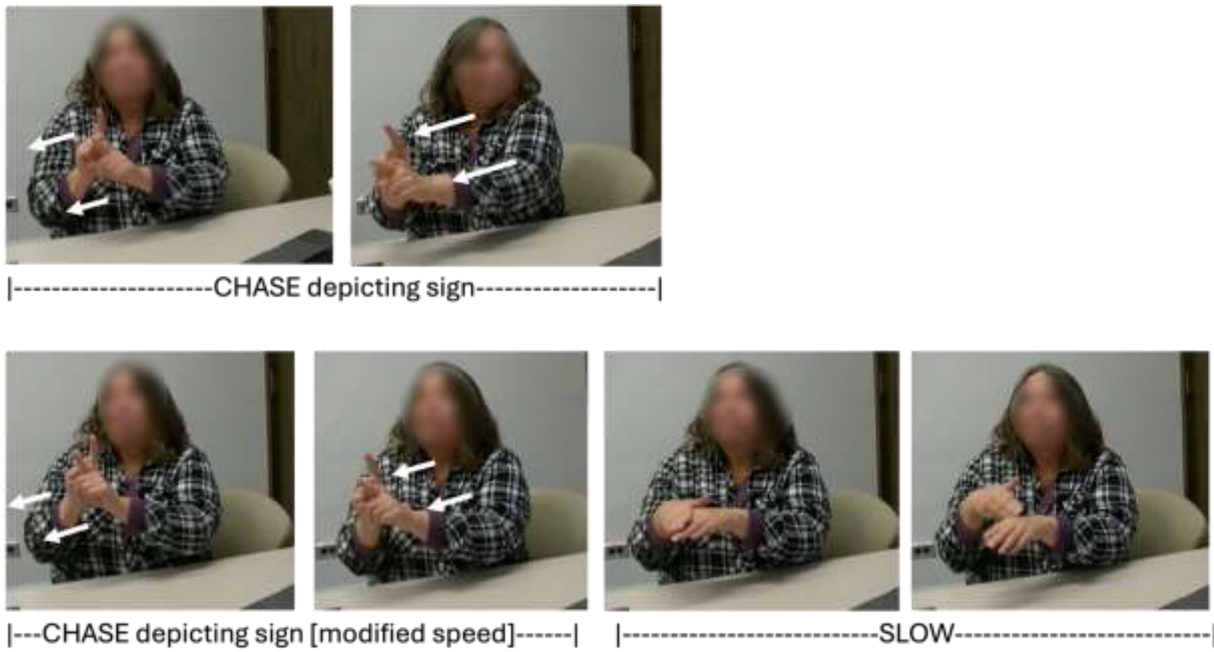

Figure 20: A signer expressing a change in speed via a depicting sign as well as through an external modifier (SLOW).

The data that fall into these four categories are plotted in Figure *21* for lexical signs (top graphs, a and b) and depicting signs (bottom graphs, c and d). Modified signs are in the left graphs (a and c), unmodified signs are in the right graphs (b and d); target signs without description are in black and target signs with description are in gray. The data are divided into the three manipulated dimensions: path, direction, speed. The proportions do not sum to 1.00 because responses that contained both a modified and unmodified form, or failed to include the target sign at all, are not displayed in the graph.

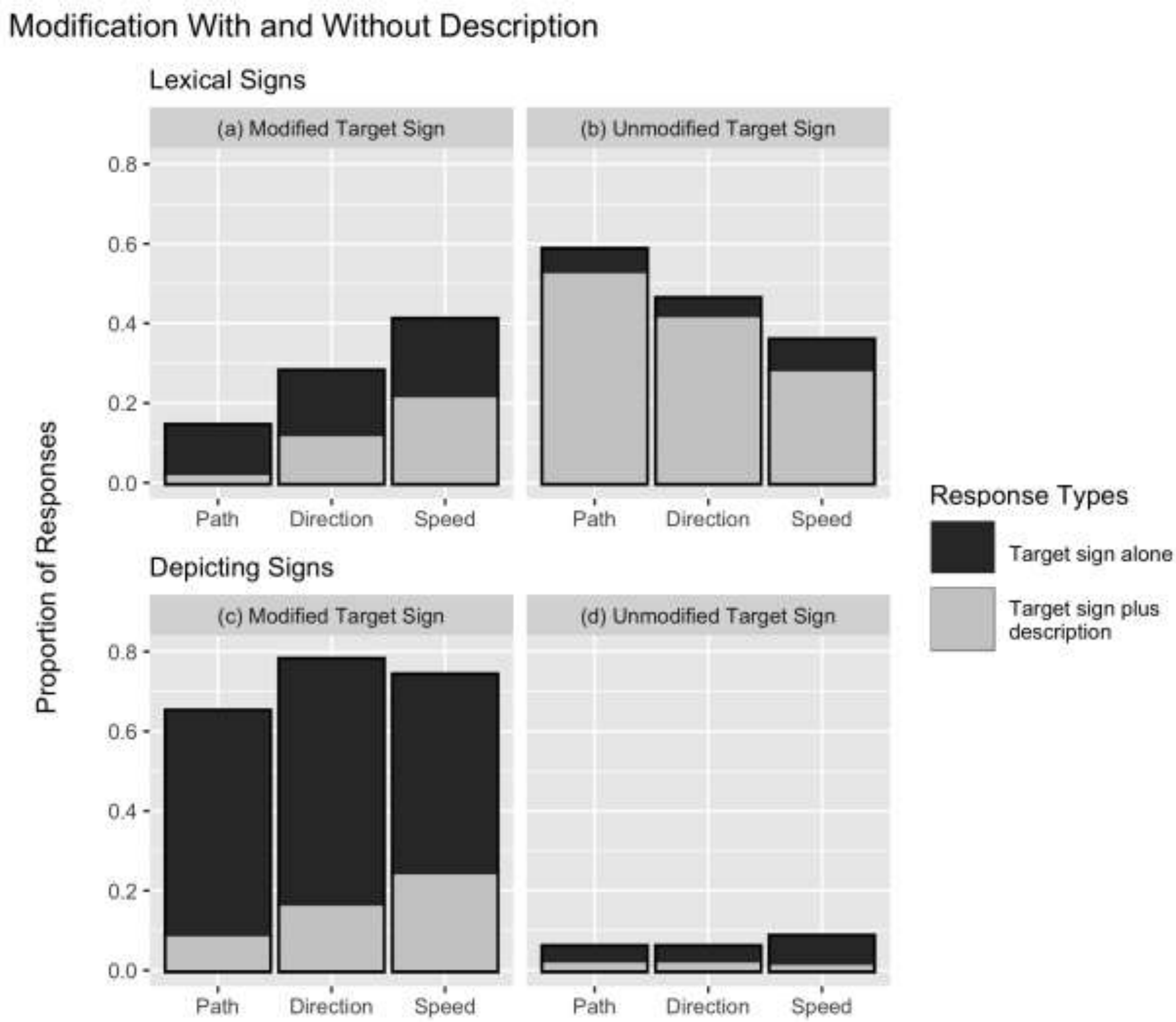

Figure 21: Distribution of response categories in the lexical condition (top) and in the depicting condition (bottom), classified according to the dimension modified and whether the target sign was alone or accompanied by additional descriptions.

The basic phenomenon for lexical signs can be seen in the top two graphs (a and b) in Figure *21*-- modification (with or without additional descriptions) is most likely on trials in which the event's speed was manipulated, and least likely on trials in which the event's path was manipulated (the bars increase in height in the left graph and decrease in height in the right graph). Looking first at the *unmodified* forms in the lexical condition (Figure *21*b), we find that the majority of these unmodified signs were produced with descriptions (gray portions) for all three manipulated dimensions. This result makes it clear that signers were noticing the differences between the pairs of videos, and used additional signs to describe those differences if they did not encode it in the target sign. Looking at the *modified* forms in the lexical condition (Figure *21*a), we find that additional descriptions (indicated in gray in each bar) were proportionally least likely for the path manipulation, increasing for direction manipulations, and most likely for speed manipulations. Redundancy was thus least likely for path manipulations, most likely for speed.

The bottom graphs of Figure *21* (c and d) display comparable data for the depicting sign condition. Target depicting signs were modified (that is, mapped to their referent in an analog way) very frequently. There was also little variation among the three manipulated dimensions, with the exception that the light sections (target sign plus description) increased from path to direction to speed, as in lexical signs. In other words, redundancy was again least likely for path manipulations, most likely for speed.

Although the differences are not significant in either lexical or depicting signs, redundancy (i.e., within-sign modification accompanied by additional modifiers) was more frequent for speed manipulations than for direction modifications, and more frequent for direction manipulations than path manipulations. Signers might produce external modifiers alongside a sign that already has internal modification because they are not confident that their addressee will detect their within-sign modifications—the additional markers increase the chances that the addressee will grasp the intended message. Internal speed modifications may be harder for addressees to see than internal direction modifications which, in turn, are harder for addressees to see than internal path modifications. The fact that external modifications are added to already-modified signs for speed and direction more often than for path in both depicting and lexical signs lends weight to this pragmatic explanation.

2.3.6 Testing for Order Effects

We additionally tested for an effect of condition order on modification, to evaluate whether participants were influenced by whether they completed the depicting or the lexical condition first. It is possible, for example, that a signer who begins our task[8] by being prompted to use depicting forms may carry over some of those depiction strategies when they are later prompted to use lexical signs in the subsequent condition. 6 of our participants completed the lexical condition after having already completed the depicting condition ("lex-second"), while the remaining 5 had not yet seen the depicting condition before beginning the lexical condition ("lex-first").

When we compare the overall rate of modification to target lexical signs (collapsing across all three dimension manipulations) between participants who had already completed the depicting condition (M = 0.45, SD = 0.47) versus those who had not (M = 0.35, SD = 0.44), we find that they did significantly differ [$t(343) = -2.23$, $p = .026$; *Wilcoxo*n $W = 14618$, $p = .029$]. However, the main effect of dimension (path versus speed) reported in section 2.3.3 and seen in Figure *10* within lexical signs likewise remains significant when we restrict the data to only those participants who completed the lexical condition first [$t(50) = 3.74$, $p = .0005$; *Wilcoxon V* = 301.5, $p = .001$], or to those who completed the lexical condition after the depicting condition

[8] As mentioned in section 2.2 (Methods), all participants began our task with an initial unprompted round, where they received no target sign prompts from the experimenter. All discussion of whether the lexical or depicting condition was "first" or "second" for a participant in this section refers to whether that was the first or second *prompted* condition.

[$t(46) = 5.356$, $p < .0001$; *Wilcoxon* $V = 337.5$, $p < .0001$]. When we compare “lex-first” and “lex-second” participants’ modifications to a specific dimension we find no effects of condition order within Speed modifications [lex-first $M = 0.476$, $SD = 0.457$; lex-second $M = 0.627$, $SD = 0.470$; $t(118.27) = -1.80$, $p = .075$; *Wilcoxon* $W = 1508$, $p = .067$], Direction modifications [lex-first: $M = 0.352$, $SD = 0.443$; lex-second: $M = 0.444$, $SD = 0.462$; $t(111.67) = -1.126$, $p = .263$; *Wilcoxon* $W = 1713$, $p = .260$], or Path modifications [lex-first: $M = 0.226$, $SD = 0.385$; lex-second: $M = 0.274$, $SD = 0.399$; $t(109.78) = -0.564$, $p = .515$; *Wilcoxon* $W = 1656.5$, $p = .445$]. In summary, we found some evidence to suggest that completing the depicting condition first makes signers more willing to modify lexical signs in the subsequent lexical condition. However, any influence of condition order was not evident when looking within any given parameter, and the main effect of dimension is present regardless of the order in which a participant completed the conditions.

2.4 Discussion

Okrent (2002) identified restrictions on how gradience combines with categorical forms when both are expressed in the oral modality (i.e., in speech and vocal gesture). We build on this work by investigating whether there are restrictions on how gradience combines with categorical forms when both are produced in the *manual* modality. We explored how gradience is used to iconically modify meaning in ASL, which contains two types of signs that vary in iconicity: *Lexical* signs are composed of phonemic movements that are not meaningful when isolated from the sign; *Depicting* signs are composed of movements that iconically map onto the event it describes (these movements are considered morphemes by some, Supalla, 1986, gestures by others, Schembri et al., 2005). This feature of ASL thus allows us to examine how overlaying gradience onto a categorical form to depict meaning compares to overlaying it onto an already-gradient form. We found that signers gradiently modify the forms of both types of signs to enhance iconicity but do so more frequently for depicting signs than for lexical signs.

Okrent (2002) also observed that a parameter in a spoken language will not be freely used to gradiently modify a meaning if that parameter has phonemic value, that is, if it is contrastive in the language (e.g., the use of pitch in a tonal language). To explore this issue in ASL, we examined signers' willingness to gradiently alter the form of lexical and depicting signs to capture three dimensions of a motion event—speed, direction, path. Each of these dimensions has the potential to be contrastive in ASL, but they differ in the extent to which they are phonologically specified. The dimensions thus allow us to explore language-specific restrictions on gradient modification in ASL. We found that the signers captured variations in the speed, direction, and path of an event equally often in their depicting signs but were more likely to gradiently modify their lexical signs to capture variations in speed than variations in path.

Although research suggests that *iconic* signs and words are more prone to gradient modification than non-iconic forms, this work, for the most part, has not distinguished between modifications that iconically capture changes in meaning and modifications that serve other functions (e.g., increasing salience). Here we examined whether the iconicity of the sign itself affects how willing signers are to gradiently modify that sign to alter its meaning. We found an effect of sign iconicity on likelihood of gradient modification for lexical signs—the more iconic a lexical sign, the more likely it is to be gradiently modified to capture changes in meaning. Modification in depicting signs was not influenced by iconicity, although this null effect may be because the proportion of gradient modification in depicting signs was close to ceiling. In addition, iconicity had an impact on how often a lexical sign was modified to capture *speed* and *direction* but was not significantly related to how often the sign was modified to capture *path*. The limitations on how likely a lexical sign is to be gradiently modified for path cannot be fully explained by the sign's iconicity. We first discuss the impact of iconicity on gradient modification in the manual modality, and then turn to the limitations on gradient modification in lexical signs.

2.4.1 Iconicity affects gradient modification

The difference in how often lexical signs versus depicting signs are gradiently modified could reflect the fact that depicting signs are, in general, highly iconic, whereas lexical signs vary in their degree of iconicity, with many lexical signs being completely arbitrary. However, our data suggest a more nuanced account. The depicting signs and lexical signs we used in our task occupy the same range on an iconicity scale (see the x-axis of Figure *11*). Nevertheless, depicting signs were consistently modified, independent of their iconicity rating. In contrast, lexical signs were more likely to be modified the higher their iconic rating. In addition, within lexical signs, iconicity interacted with the physical dimension that the modification captures. Gradient modification was positively and significantly correlated with iconicity for speed and for direction, but not for path (see Figure *12*). Again, the influence of iconicity appears to be subject to limitations, in this case, limitations based on the dimension of change. Taken together, these patterns suggest that the role iconicity plays in a sign language is at least partially constrained by features of that language.

The relationship between iconicity and gradient modification that we report here builds on previous research on both spoken and signed languages showing that iconic words/signs are particularly prone to gradient modification. For example, speakers often modify the forms of ideophones (which are, by definition, iconic) using gradient processes such as stem repetition, partial multiplication, emphatic mora augmentation, vowel lengthening, and gemination; these processes are applied less frequently to non-iconic or "plain" words than to iconic words (Akita, 2009; Dingemanse & Akita, 2016; Hamano, 1988; Nasu, 2002). As another example, adults gradiently modify words (e.g., changing pitch, duration, repetition, vocal quality, etc.) and signs (e.g., changing size, length, repetition, etc.) used with children more often when the forms are iconic than non-iconic (Laing et al., 2017; Perniss et al., 2018; Sundberg & Klintfors, 2009). However, the modifications described in this body of work are not always themselves iconic. For example, much of the work on ideophones focuses on the emphatic function of these expressive features, which serve to enhance the intensity or emotional power of ideophones, rather than to iconically depict changes to meaning (Bolinger, 1986; Dingemanse, 2017; Dingemanse & Akita, 2016; see Akita, 2020 for discussion), Similarly, findings from child-directed language illustrate how gradient modification when applied to onomatopoeia and iconic signs makes these words/signs more salient to children; but the changes do not necessarily alter the meaning of the sign.

Our study focused on gradient modification that is designed to change the meaning of a sign. Recall that changes to the sign form that did not iconically depict the altered meaning (e.g., changing the speed, duration, size, direction, etc. of a target sign in a trial where path was the relevant contrast) were not counted as gradient modifications in our data. We found that the more iconic a sign is, the more likely signers were to apply gradient modification to that sign. Our findings thus show that, as in spoken language (cf. Akita, 2020), gradient modification designed to elaborate the meaning of a sign is also preferentially applied to iconic forms in sign language.

Much of the work on gradient modification in spoken language draws a categorical distinction between iconic and non-iconic words (i.e., onomatopoetic/ideophonic versus non-onomatopoetic/non-ideophonic words). Our work here suggests that a scalar view of iconicity may allow for a more nuanced analysis of how gradient modification works in language—an approach that has been adopted by many sign language researchers (e.g., Caselli et al., 2017; Thompson et al., 2012; D. Vinson et al., 2015; D. P. Vinson et al., 2008), as well as some researchers in spoken language (e.g., Dingemanse & Thompson, 2020; Perlman et al., 2018; Perry et al., 2015; Winter et al., 2017)[9].

2.4.2 Lexical signs are gradiently modifiable, but the modifications have limits

Gradient depiction can represent meanings that are difficult to encode in a categorical form (Bolinger, 1986; Kendon, 1980; McNeill, 1992) and can, as a result, enhance and enrich messages transmitted through categorical units in language (Fuks, 2014). The task design we used in our study emphasized a single difference in movement between otherwise identical scenes and prompted signers with a specific sign to use in their descriptions. Our goal was to create contexts where gradiently modifying a sign to depict a subtle variation in meaning would be an efficient and effective way to convey the variation. The fact that the signers in our study routinely gradiently modified movement in *depicting* signs (even in UNPROMPTED trials where they used whatever verb they wanted) indicates that our design was successful—the signers found gradient depiction to be an appropriate and useful way of capturing the events in our stimuli. However, they took advantage of this strategy much less frequently in their *lexical* signs, often opting to capture the distinctions by adding other signs and phrases. In addition to

[9] See Dingemanse et al., (2020) for a discussion different construals of iconicity.

using gradient modification more often in depicting signs than in lexical signs, signers also used the device selectively for different dimensions of motion in lexical signs: They were more willing to gradiently modify their lexical signs to capture changes in the speed of an event than to capture changes in the path of the same event (changes in direction fell in between path and speed).

Our data are thus consistent with previous findings showing that gradient modification can occur not only in depicting signs, but also in lexical signs. Our findings take the literature one step farther by showing that gradient modification in lexical signs has systematic limitations. What our findings do not (and cannot) address is whether the limitations we have found on gradient modification in lexical signs are linguistic in nature.

On one hand, signers may treat the dimensions of path and speed in a lexical sign as differentially modifiable because of the rules and patterns of ASL. The fact that signers are less likely to gradiently alter the path of a sign than its speed to capture details of a described event provides support for Okrent (2002)—features that are contrastive in a language (like path in ASL) will have more restrictions on how often they are gradiently modified than features that are not contrastive in the language (like speed in ASL). Although each of our dimensions of interest *can* be used contrastively in ASL, path maps most closely to what linguists refer to as the "movement" parameter—it is phonologically specified and is frequently distinguished between minimal pairs of signs. The speed of movement, on the other hand, although potentially contrastive in ASL (see the example in Figure 5), is not considered phonologically specified. Thus, the degree to which ASL signers modify path and speed may mirror the extent to which that dimension is phonologically specified (cf., Brentari, 1998). If so, whether an aspect of a sign can, or cannot, be gradiently modified may be linguistic knowledge acquired through learning the language.

On the other hand, the patterns we have found may reflect non-linguistic pressures that would be there even if the signer did not know ASL. For example, signs that reflect across the midsagittal plane are the simplest to perform from a motor-coordination point of view (Napoli & Wu, 2003; Ferrara & Napoli, 2019), a finding that is supported by work on general hand movement (Kelso, Southard, & Goodman, 1979). Path modifications might therefore be more phonotactically complex than speed modifications because of biomechanical influences on the realization of these modifications. If so, one would *not* need to know ASL to modify speed more often than path.

The best way to determine whether the limitations we have identified are linguistic is to ask individuals who do not know ASL to describe the videos in our study using signs that we give them. There is a high degree of similarity between signers' and non-signers' judgments of the perceived iconicity of a sign, suggesting that the form-to-meaning relationship in iconic signs is at least partially accessible to those who do not know the sign language. Non-signers may display the same patterns we have found in our signers but even here, knowledge of the language may intrude—subtle differences in the perception of iconicity may be mediated through linguistic knowledge. For example, when shown examples of signs from their own sign language and a foreign sign language, signers consistently rate signs from their own sign language as more iconic, suggesting that perception of iconicity is mediated by a signer's known mappings of form and meaning (Occhino et al., 2017). In addition, although signers' and non-signers' iconicity ratings are highly correlated, the groups differ in their ratings of certain sub-classes of signs. Signers tend to rate verbs and nouns as equally iconic, but non-signers rate verbs as more iconic than nouns. Similarly, only signers are sensitive to one- versus two-handed signs and rate the former as less iconic than the latter; non-signers rate these one- and two-handed signs as equally iconic (Sevcikova Sehyr & Emmorey, 2019).

The next step in this line of research will be to explore whether the limitations on gradient modification in lexical signs are linguistic in nature. By collecting data from hearing non-signers on the task we gave to signers and providing them with the same lexical and depicting signs, we will be able to test whether the patterns found in our data are language-specific effects. It is likely that hearing non-signers will be influenced by the iconicity of the signs and modify iconic signs more frequently than non-iconic signs. However, if the dimension effect we observed is the result of linguistic knowledge—specifically, knowing that path is gradiently modified less often than direction or speed—then non-signers should not display this pattern. Similarly, if knowing the linguistic status of a sign as either lexical or depicting is what determines the overall difference in gradient modification between the two, non-signers should not show this condition effect. If, on the other hand, what distinguishes these two groups is a feature of the forms themselves—either iconicity or a feature such as bio-mechanical complexity—non-signers should treat these two types of signs differently in terms of how often they are modified, just as signers do.

In sum, our findings show that gradiently modifying a lexical sign for speed is far more likely in ASL than gradiently modifying a sign for path. In other words, gradient patterns are not always freely applied but rather are systematically restricted as a function of the movement dimension involved. It is this systematic restriction that suggests we cannot ignore the distinction between categorical linguistic units and gradient gestures. Studying hearing non-signers will allow us to investigate the source of the knowledge underlying gradient modification, providing insights into the linguistic nature of this phenomenon.

Our findings on gradient modification in sign language open the door to further investigations of gradient modification in spoken language. We know that gradient modification in a spoken language is subject to the phonotactic regularities in that language (e.g., Okrent, 2002). Having found that gradient modification of movement dimensions is more restricted in lexical signs than in depicting signs, we can now ask whether the same holds true of spoken language. For example, Akita (2020) lists a number of expressive features (e.g., partial multiplication, vowel lengthening, mora augmentation, prosodic foregrounding) in Japanese that can be applied to the ideophone *guruQ* to modify its meaning, resulting in *turning around and around*, *turning around quickly*, *turning around energetically*, *turning around quietly*, *making a long turn*, etc. (see example 5). Are these gradient modifications possible in plain words in Japanese? If so, are speakers equally willing to apply the modifications to plain words (akin to lexical signs in our study) and ideophones (akin to depicting signs in our study)? Our findings set the stage for exploring the role that gradient modification plays in language, signed or spoken. We can no longer relegate gradient modification to the sidelines. It is time to figure out how gradient depiction and categorical description work together to create human language.

2.5 Conclusions

Our study is the first systematic exploration of the degree to which lexical and depicting signs can be gradiently modified to enhance iconicity. Our data provide evidence that signers do indeed play with the forms of their lexical signs, but (unlike how they play with depicting signs) they do so selectively. Depicting signs are highly modifiable without any evidence of constraint in our data (although some restrictions on the production of depicting signs have been identified, (Emmorey & Herzig, 2003; Liddell & Johnson, 1987). In contrast, gradient modification of lexical signs is influenced by both the iconicity of the sign (the more iconic a lexical sign, the more likely it is to be gradiently modified) and the movement dimension that is modified (path is gradiently modified infrequently, direction more often, and speed most often).

We have created a paradigm to study gradient modification in sign language and found that some signs are more flexible than others, and that different aspects of a sign can be modified more or less often. Previous work has explored gradient depiction in sign languages (Cormier et al., 2013; Duncan, 2005; Emmorey & Herzig, 2003; Fuks, 2014, 2016; Liddell, 2003; Lu & Goldin-Meadow, 2018), but little research has focused on how gradient modification is realized in lexical signs (an exception is Fuks, 2014, 2016) and whether its application is restricted. Our data suggest an account of gradient modification than integrates both linguistic and non-linguistic knowledge—which dimension is likely to be modified may depend on knowledge of the language, but the ability to use iconic resources to gradiently modify signs may arise from world experience with action and an ability to access structural analogy beyond language. Our ongoing work using non-signers in a silent gesture paradigm identical to the paradigm we use here will shed light on this question. Our findings thus broaden our understanding of the interaction between categories and gradience in sign language and set the stage for asking the same questions in spoken language.

3. GESTURERS' USE OF MODIFICATION

3.1 Background

A growing body of evidence suggests that non-arbitrariness is pervasive in human communication. Although ideophones (words that depict sensory imagery, including onomatopoeia; Dingemanse, 2012) make up a small proportion of English, research on non-Indo-European languages finds large inventories of iconic sound symbolism (Kunene, 2001; Voeltz & Kilian-Hatz, 2001). Depictive correspondences between meaning and linguistic form are found at morphological, syntactic, and discourse levels (Goldin-Meadow et al., 2008; Haiman, 2008; Levinson & Holler, 2014) not only in spoken languages, but also in signed languages and co-speech gesture (Gasser et al., 2010; Gershkoff-Stowe & Goldin-Meadow, 2002; Goldin-Meadow & Alibali, 2013; Lu & Goldin-Meadow, 2018; Özyürek, 2014; Perniss et al., 2010; Perniss & Vigliocco, 2014).

Depictions communicate via structural resemblances between meaning (referent) and form (word, gesture, etc.). To decode the intended meaning of a message, recipients imagine the experience of viewing (or hearing, touching, etc.) the thing depicted, as opposed to using stored knowledge of the language. Recipients are "shown" rather than "told" the message (Clark & Gerrig, 1990; Dingemanse et al., 2015; L. Ferrara & Hodge, 2018; Peirce, 1955).

Iconic lexical items are one way in which speakers and signers use language to depict rather than describe. However, depiction can be accomplished in other ways; for example, by modifying speech rate (Perlman, 2010; Shintel & Nusbaum, 2007, 2008) repeating a word root (choo-choo) or lengthening a vowel (it's been a *looooooong* day). These types of modulations are commonly applied to iconic, rather than non-iconic, words (Dingemanse, 2012). Moreover, they are not applied indiscriminately, at least in spoken languages. For example, it is acceptable to lengthen the word long by extending the *o* sound into *looooooong*; however, it is odd to lengthen the word by extending the *l* sound, as in *llllllllong.*

In study 1 we explored whether depiction in sign language was similarly constrained and found that signers gradiently modified the speed of movement in lexical ASL signs to depict changes in speed, but rarely modified movement path to depict changes in path (with modifications depicting changes in direction somewhere in between).

Where does this pattern come from? ASL signers may differentially modify path, direction, and speed because of the rules of ASL, rules that they acquired through learning the language. However, the pattern could also reflect non-linguistic pressures (e.g., the difficulty of producing or imagining forms to depict changes in path) and be found even in individuals who don't know the language. To distinguish between these hypotheses, we presented hearing speakers with the videos from Study 1, showed them the citation forms of the ASL signs for the target events, and asked them to describe events that varied from the target in speed, direction, and path using their hands and no words. Our question was whether silent gesturers modify their forms like signers do.

There may be non-linguistic pressures that prevent signers from modifying their signs to depict changes in path. If so, signers and silent gesturers should display the same modification patterns, suggesting that these modifications are gestural, even for signers. However, encoding the dimensions of path or speed may be more, or less, categorical in sign, and silent gesturers will not know the categorical distinctions. For example, path is captured by the phonological parameter movement, a categorical rather than gradient feature of ASL (Fenlon et al., 2017; Stokoe, 1980). Differences in the movement parameter can distinguish between minimal pairs of signs (e.g., PLAY/PARTY are two signs that differ only in movement). Speakers who do not know ASL would not be aware of the categorical constraints on movement and therefore would see nothing wrong with modifying a sign to capture changes in its path—modifications that the signers in Study 1 rarely made. If so, the constraint on path modification is likely to be linguistic in signers, and an example of how arbitrariness and iconicity work together in natural language.

3.2 Methods

3.2.1 Participants

Eleven hearing English speakers (7 female; mean age = 19.2 years) participated in the study. All reported that they had no exposure to ASL or any other sign language. In exchange for their participation, hearing participants received course credit. The 11 deaf signers who participated in Study 1 (7 female; mean age = 48.7 years) served as a comparison group for the hearing participants. Sessions with hearing participants were conducted in English. Once the task was completed, the experimenter debriefed participants on the goal of the study.

3.2.2 Task

Participants were shown the same videos used in Study 1 showing various events in pairs: a “neutral” version on the left, and one of the three altered versions on the right. Participants were instructed to watch the video on the left (the target event) and then the video on the right (the altered event). They were then asked to describe to the experimenter what happened in the two videos using silent gesture. As in Study 1, responses were elicited in three rounds. In the first round, participants were asked to watch the video pairs and then silently gesture or sign about what happened in each pair without any further prompting from the experimenter. The data from this first round were not analyzed for modification but were used to ensure that all participants correctly interpreted the events shown in the videos, and as a sample of each participant's gesture style that could be used as a reference point during coding in case of ambiguities. In the second round, participants were again shown the videos, but before beginning their descriptions, they were given the citation form of the sign for that event by the experimenter. They were asked to incorporate the form into their response. In the third round, participants were prompted with depicting signs. These two conditions are the data that we use in our analyses here. These data contain the gesture responses to the 42 lexical prompt trials during round two across the 11 participants, totaling 462 data points (in addition to the 462 data points from Study 1).

Hearing participants were shown the ASL sign for the target event and told to use it in their responses to each of the three pairs. They were also encouraged to include as many of their own gestures as they felt necessary to fully communicate the contents of the videos. Participants opted not to use the target sign for a small proportion of trials (26 out of 462 trials); these trials were included when evaluating whether participants overall noticed the relevant contrasts in the stimuli, but were not counted as either a modification nor non-modification. All sessions were video-recorded for later coding.

3.3 Results

3.3.1 Manipulation Check

We first need to ensure that the participants noticed the differences between the target video and its altered videos and understood this change to be relevant to their descriptions. Participants included information about the alteration in almost all of their responses (97%, 450/462 for hearing participants). We therefore can be confident that our stimuli effectively portrayed the intended contrasts and that participants identified these contrasts as important enough to convey.

3.2.3 Strategies

When describing the events, participants could express the relevant contrast information for that trial in a variety of ways, illustrated in Figure *22* -Figure *24* below. In almost all cases (91.9%, 849/924 total trials), the silent gesturers modified the speed, direction, or path of movement of the target sign form somewhere in their response. Typically, these modified target signs were the sole way in which information regarding the verb or the relevant contrast appeared in a given response. That is, they occurred without the presence of additional gestures representing the verb or the change in dimension or an unmodified version of the target sign. This was the case for 81.7% (755/924) of trials. Figure *22* below shows an example of this, in a participant's response for a path variant trial for the verb CLEAN (lexical condition).

Figure 22: Example response from a trial showing someone running in a zig-zag. Subject depicts the path information (zig-zag movement) by modifying the movement path of the sign.

Silent gesturers rarely opted for other strategies, but when they did the next most common was to modify the target sign as well as incorporate other external modifiers to express the change in dimension. This strategy was used 6.9% of the time across the two conditions. An example of a silent gesturer using this strategy is shown below in Figure *23*. First, she produces a handling depiction representing a person pulling a measuring tape across a surface, which depicts both the action and the direction of movement. She then produces a version of the target lexical sign MEASURE, modified for direction.

Figure 23: A silent gesturer representing measuring, altered for direction. She first uses a handling depiction (not shown to her by the experimenter), followed by a modified version of the target lexical sign.

A third possible strategy was to produce the target sign unmodified, along with additional signs or gestures that conveyed the variation. This strategy was rarely used by the silent gesturers, 10.2% of the time across both conditions. An example of a silent gesturer using this strategy is shown below in Figure *24* showing a gesturer's response for an altered-direction trial for WALK (lexical condition).

Figure 24: Example response from a trial showing someone walking from left to right. Subject produces the sign WALK unmodified, and instead depicts the direction information by using a depicting gesture (not shown to her before), and then tracing the direction again.

The remaining responses that did not fall into the above three categories were instances where the gesturer produced both a modified and unmodified version of the target sign in their response (3.2% of trials), failed to notice or comment on the relevant dimension contrast (2.5% of trials, or did not produce the target sign in their response (2.8% of trials).

In the following section, we report the overall rate of modification by silent gestures, comparing between condition (lexical versus depicting) and dimension (speed, direction, and path). We then report the results of a mixed effects regression model of both the signer and silent gesturer data. We then explore the relationship between iconicity of the target sign and modification, again comparing both signers (Study 1) and silent gesturers (Study 2).

3.3.2 Condition and Dimension

Looking first at the overall rate of internal modification in each group, we find that hearing gesturers not only modify their forms (M=0.9, SD=0.29), but do so more often, and more consistently, than deaf signers (M=0.37, SD=0.45).

Recall that in Study 1 we found that deaf signers made internal modifications to the signs they produced to depict changes in path less often than the signs they produced to depict changes in direction or speed. Signers internally modified their forms for path least often (path *M*=0.23, *SD*=0.38; direction *M*=0.37, *SD*=0.45; speed *M*=0.51, *SD*=0.47). Did non-signers show this same pattern? If so, the pattern is not likely to reflect the linguistic constraints of ASL. Gesturers modified all three types of forms at a high rate, with little evidence of sensitivity to the modified dimension (path: *M*=0.87, *SD*=0.32; direction: *M*=0.93, *SD*=0.24; speed: *M*=0.9, *SD*=0.29). These results are displayed in Figure 24.

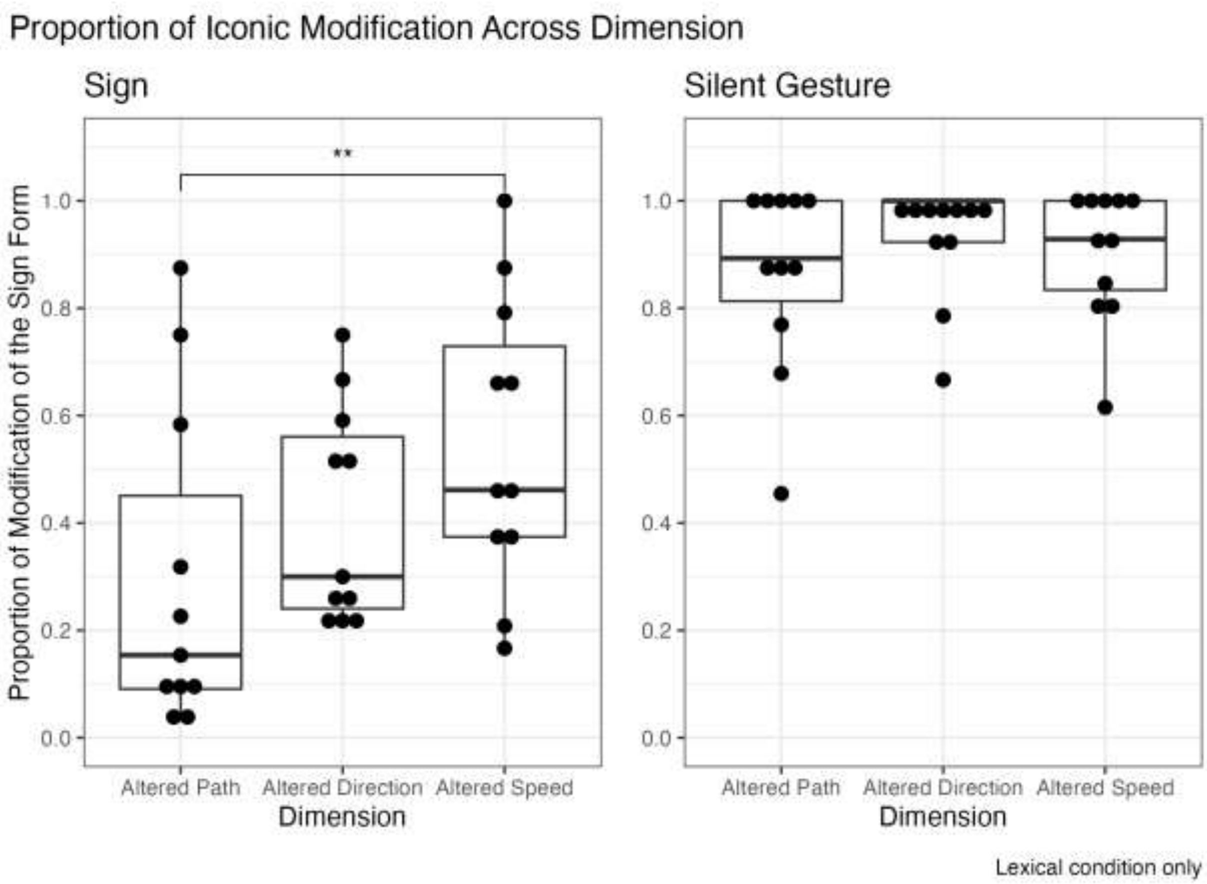

Figure 25: Rate of internal modification as a function of the altered dimension (path, direction, speed) for deaf signers (left) and hearing gesturers (right).

Recall that within signers, the mean proportion modification for path was significantly less than for speed dimensions was significant. In contrast, after correcting for multiple comparisons, there were no significant differences between dimensions among hearing silent gesturers. However, given the high rate of modification among hearing gesturers, a ceiling effect might have obscured any sensitivity the gesturers had to the different dimensions of change.

3.3.4 Modeling

To compare patterns in signers vs. gesturers, we ran a mixed effects linear model using the lme4 package in R (Bates et al., 2015). We included fixed effects of Subject Group (deaf, hearing), Dimension (speed, direction, path), an interaction term, and a random effect of Subject.

Modification ~ SubjectGroup + Dimension + SubjectGroup:Dimension + (1|Subject)

Hearing participants were significantly more likely to internally modify the target form than deaf participants (β = 0.62, t = 7.66, p < 0.001, 95% *CI* [0.46, 0.78]). Overall, participants were significantly more likely to modify speed than path (β = 0.28, t = 6.63, p < 0.001, 95% *CI* [0.19, 0.36]) and direction than path (β = 0.14, t = 3.42, p < 0.001, 95% *CI* [0.06, 0.22]). But the difference between modification for speed and path for hearing participants was significantly smaller than for deaf participants (β = -0.24, t = -4.21, p < 0.001, 95% *CI* [-0.35, -0.13]). The difference between direction and path was not significantly different for the two groups (β = -0.07, t = -1.298, p = 0.195, 95% *CI* [-0.19, 0.04]). The marginal R squared is 0.346 and the conditional R squared is 0.475. To test for multicollinearity, we calculated the generalized variance inflation factor for our two fixed effects and our interaction term. To make GVIFs comparable across dimensions, Fox & Monette (1992) suggest using $GVIF(1/(2*Df))$, where

Df is the number of coefficients in the subset. All GVIF values are < 5, and all $GVIF(1/(2 * Df))$ are < 2 indicating multicollinearity is not a concern for this model.

When asked to judge how iconic a particular sign is, hearing non-signers provide comparable ratings to signers (Sevcikova Sehyr & Emmorey, 2019). Does iconicity play a role in determining what signs are modified and, if so, does it play the same role for silent gesturers and signers? We used iconicity ratings collected in Study 1 for each of the signs in our study and asked whether the iconicity of a sign predicted its rate of modification in each group. Figure *26* presents the data; the rate of internal modification for a target sign is displayed as a function of that sign's iconicity rating (z-scores of ratings by deaf and hearing participants) for events in which the path of the event was altered (left graphs), the direction of the event was altered (middle graphs), and the speed of the event was altered (right graphs).

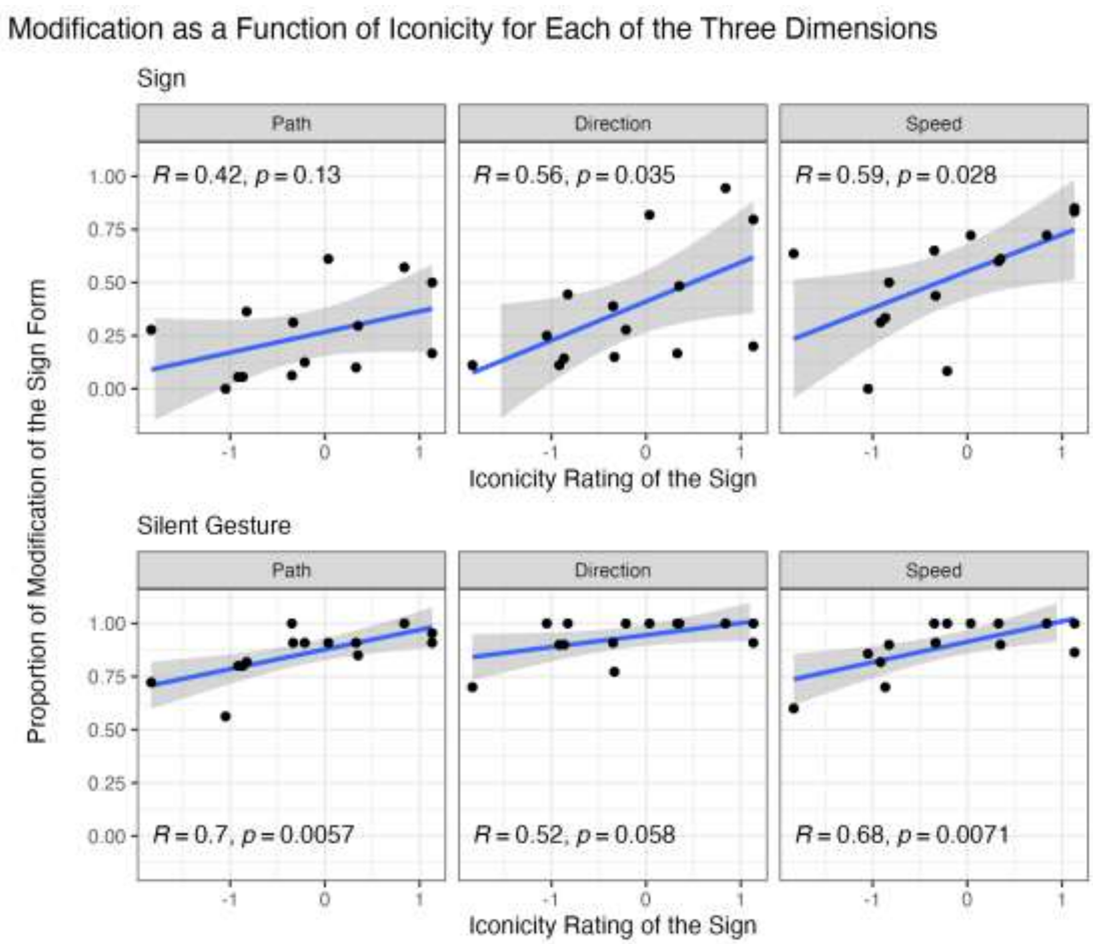

Figure 26: Correlation between iconicity rankings (x-axis) and internal modification rate (y-axis) broken down by dimension: path, direction, and speed.

Recall that for signers, the strength of the relationship between a sign's iconicity and its modifiability differed between certain dimensions. Iconicity correlated with internal modification for signs that depicted alterations in direction (R = .54, p = .047) and speed (R = .56, p = .037), but not for signs that depicted alterations in path (R = .32, p = .27). This pattern makes sense if internal modification in path is determined by rule, rather than lexical iconicity. In contrast, for silent gesturers, there is a significant correlation between iconicity and modifiability for all three dimensions (path R = .70, p = .006, direction R = .52, p = .058, speed R = .68, p = .007).

3.4 Discussion

In Study 2 we explored the use of iconic modification in ASL signers and silent gesturers (speakers asked to describe events in gesture without speech). We found similarities and differences between the two groups, which shed light on the way iconicity is incorporated into language. Both signers and silent gesturers altered the forms they used to depict changes in an event. In other words, both were able to gradiently modify their forms, and both did so more often for forms that were themselves iconic.

However, there were also differences between the groups. Silent gesturers altered the forms they used to depict changes in speed, direction, and path. In contrast, although signers also altered their forms to depict changes in speed, they rarely used the device to depict changes in path. The fact that signers are less willing to extend their gradient modifications to path points to limits on when gesture can, and cannot, be used in ASL. In general, our findings suggest that some iconic modifications made to ASL verbs may be gestural. However, our findings also indicate that these potentially-gestural modifications are linguistically constrained. We focus on these points in the next sections.

Not surprisingly, all of the modifications made in our study were iconic. Moreover, for both groups, the more iconic a sign, the more that sign was modified to enhance its iconicity and depict changes in its referent. Non-signers' judgments of iconicity in signs are highly correlated with signers' judgments (Sevcikova Sehyr & Emmorey, 2019), and these iconicity judgments correlated with how likely a form was to be modified in both the signers and silent gesturers in our study.

Although signers and silent gesturers both iconically modified the ASL verb forms they were given, the silent gesturers used this strategy more often than the signers. When signers chose not to modify a form, they conveyed the change in the event by adding other signs that conveyed the same information, often iconically. For example, a signer produced the sign for CLEAN, which contains a back-and-forth movement, and added to it a CIRCLE sign (an index finger tracing a circle) to capture the alteration in path.

Why didn't silent gesturers use this multi-gesture strategy? Previous work (Özçalışkan et al., 2016, 2018) has found that silent gesturers prefer to combine two pieces of information within a single gesture (e.g., wiggling the fingers as the hand moves forward to show walking forward) rather than producing the same information in two sequential gestures (wiggling the fingers to show walking, followed by the hand moving forward without finger-wiggling to show forwardness). This preference for conflated forms in silent gesture may explain why the gesturers used this strategy so frequently to depict changes in the events.

We are suggesting that the iconic modifications made to verbs in ASL to depict changes in speed and perhaps direction are gestural. Duncan (2005) has described gestures in Taiwanese Sign Language that are comparable to the modifications we find here. Duncan asked Taiwanese signers to describe a Tweety Bird cartoon, often used in gesture studies with speakers (McNeill, 1992). She found that the Taiwanese signers used a thumb-and-pinky handshape (denoting an animal) to represent the cat in the story, and gradiently modified the handshape to represent the cat's ever-changing body form as it moved up the drainpipe. The signers' modifications captured the same kind of information that hearing speakers convey in their co-speech gestures when describing the same scenes. Moreover, the signers' modifications were idiosyncratic and differed from signer to signer, as do hearing speakers' gestures.

The signers in Duncan's (2005) study are gesturing by making spontaneous and idiosyncratic adjustments to their lexical handshapes, overlaying gradient patterning onto their categorical signs. This is precisely the strategy that each of the signers (and the silent gesturers) in our study followed when modifying the lexical forms we gave them. It is also the strategy that speakers use when modifying their speech to depict an image, e.g., "*loooooong*." Okrent (2002) calls these modifications, which are imagistic, unconventional, and gradient, *spoken gesture*. And as noted by Okrent (2002), we find language-particular restrictions on the way that iconic gradient elements combine with a given language, specifically in cases where the phonetic form used to convey the imagery has phonemic value. This lexical specification restricted the iconic modification of movement path in signers, but not silent gesturers (who don't know the rules of ASL).

4. CHILDREN’S USE OF MODIFICATION (ASL & SILENT GESTURE)

4.1 Background

The results of Studies 1 and 2 raise important questions about the role of depiction and gradience in children’s acquisition of sign language. For deaf children acquiring a sign language, learning to productively employ adult-like gradient depiction strategies requires several skills: that they perceive iconicity in a given sign form and map those iconic features to a referent, that they understand how to productively overlay gradience onto a given sign form to produce modified (and in some cases novel) signs (i.e., going beyond their own input), and that they be sensitive to the phonological constraints on modification, which restrict how this gradience can be applied. In the following sections we review the existing literature on deaf and hearing children’s early exposure and sensitivity to iconicity and gradience and describe research on its possible role in early acquisition.

4.1.1 Depiction in the input

To what extent are children exposed to depictive modes of representation (gradience, iconicity) in their input? While children may have an early-emerging capacity to recognize certain types of iconicity, for it to scaffold language development, there must be iconicity present in their input to take advantage of. There is, in fact, evidence that the gradient and iconic features of depiction are present in the lexical items in speech directed to children. Caregivers use more iconic forms in child-directed language than in the language they direct to adults (Fernald & Morikawa, 1993; Perry et al., 2018; Toda et al., 1990; Yoshida, 2012).

Beyond the lexical items themselves, parents also use more gradient, depictive strategies in spoken language directed to children than in adult-directed language. The iconic forms that feature more frequently in child-directed speech are frequently accompanied by gradient vocal modulations, for example, variations in intonation, vocal quality, speed, and reduplication. Caregivers use these gradient features of their vocalization to highlight features of the objects to which they refer (e.g., using speech volume to indicate referent size) (Herold et al., 2012; Nygaard et al., 2009), and these features are particularly salient in iconic words (Laing et al., 2017; Sundberg & Klintfors, 2009).

Iconic and gradient features of language are also found in sign languages of the deaf. Between one-third and one-half of signs in a given sign language are estimated to be at least partially iconic (Boyes Braem, 1986; Ortega, 2017; Zeshan, 2000), with iconicity especially frequent in signs likely to occur in child-directed language (i.e., referring to objects and actions) (Perniss et al., 2018). Caregivers use gradient transformations such as enlargement, lengthening, and repetition, to augment the iconic forms they direct to children (Holzrichter & Meier, 2000; Pizer & Meier, 2008). These modulations to the sign form are more commonly applied to already-iconic signs, where they serve to emphasize the iconic features of that sign (Perniss et al., 2018).

4.1.2 Hearing children's sensitivity to iconicity

There is evidence that, early in development, hearing children are sensitive to the iconicity in the spoken language directed to them by their hearing parents. For example, infants are sensitive to several of the pervasive sound-meaning patterns thought to be iconically motivated. In a preferential looking paradigm, Spanish-learning three-month-olds preferentially attended to object-sound pairings that matched certain sound-meaning patterns common in many languages (e.g., small shapes with a "di" label or large objects with a "do" label) over mismatches (Peña et al., 2011). These visual-auditory mappings may be an unlearned aspect of perceptual cognition, as suggested by the sensitivity that 3- to 4-month old infants show to the mappings. Neural signatures of this sensitivity appear early in development as well. Japanese-learning 11-month-old infants showed an N400-like effect when presented with mismatching word-shape pairs (e.g., bouba-like words paired with a spiky shape), indicating that they appreciated the incongruence between the word form and object shape (Asano et al., 2015). Older children (two- to three-year olds) demonstrate the classic finding that specific sounds are preferentially paired with certain shapes (e.g., a round shape corresponds to 'bouba' while a spiky shape corresponds to 'kiki' (Kohler 1929; see also Ramachandran and Hubbard 2001). Children in this age range show a preference for pairing words with rounded vowels to rounded shapes and for pairing words with unrounded vowels to pointed shapes (Maurer et al., 2006). Therefore, the potential role of iconicity is supported (even for spoken languages) .

There is thus evidence that children have early expectations about iconic sound-meaning mappings, and that this iconicity is present in the early input. Imai and Kita (2014) additionally point to findings suggesting that children actively recruit iconicity in both speech and gesture in novel word learning tasks. When presented with novel verb labels for different actions, 3-year-olds often fail to map the label to a new scene or new actor (Forbes & Farrar, 1995; Imai et al., 2005; Imai, Li, et al., 2008; Kersten & Smith, 2002). However, when the novel verb is iconic of the action being performed, 3-year-olds can successfully generalize the verb label to a new event (Imai, Kita, et al., 2008; Kantartzis et al., 2011; Yoshida, 2012). Children as young as two years old have similarly been found to recruit information conveyed iconically through gesture when inferring the meaning of novel words (Goodrich & Hudson Kam, 2009; Mumford & Kita, 2014).

In their "sound symbolism bootstrapping hypothesis", Imai and Kita (2014) propose that sound symbolism (or a non-arbitrary relationship between word sounds and meaning) scaffolds children's lexical development. They claim that, even before speaking, children are sensitive to these non-arbitrary relationships, and point to research suggesting an innate ability to integrate multi-modal input. They propose that this sound symbolism allows infants to develop referential insight (the understanding that speech sounds refer to entities), and to identify referents within a larger complex context (i.e., Quine's problem), which facilitates children's formation of lexical representations.

4.1.3 Deaf children's sensitivity to iconicity

Early investigations of deaf children found little evidence that iconicity facilitated their acquisition of sign. In a longitudinal study of 13 deaf children (median age at outset of 10 months), Orlansky and Bonvillian (1984) found that only around a third of children's early signs were transparently iconic, which corresponds to the prevalence of iconic signs in the adult ASL lexicon. Children's early phonological errors tend to diminish rather than enhance iconic features of signs (Meier et al., 2008), and the early trajectories and sequences of sign acquisition were found to be highly similar between deaf and hearing children (Anderson & Reilly, 2002) which was taken at the time to mean that deaf children were not influenced by the more pervasive presence of iconicity in their language relative to spoken languages (although see discussion in the previous section regarding the presence of iconicity in early spoken vocabularies).

Despite the null effects reported in these early investigations (Anderson & Reilly, 2002; Meier, 2002; Meier et al., 2008; Orlansky & Bonvillian, 1984), more recent work does in fact find an effect of iconicity on sign language L1 acquisition. Thompson et al. (2012) revisit the question of children's early sensitivity to iconicity, acknowledging that children's early production errors -- which did not increase sign iconicity and typically involved phonological reduction and the substitution of less-marked features -- may be best explained by a motoric-based account as proposed by Meier and colleagues (2008). However, iconicity's role beyond phonological complexity may be more appropriately studied in comprehension, which is less influenced by these constraints. Using parental reports of comprehension and production (MacArthur Bates CDI for BSL) for 31 Deaf children between 8 and 36 months old from Deaf BSL-signing families, and a list of 89 BSL signs that each had iconicity ratings (based on BSL signers' judgements on a 7 point scale from *not at all iconic* to *highly iconic*), they find a positive correlation between degree of a sign's iconicity and the age at which it is acquired. After accounting for phonological complexity, early signs tended to be iconic, even for children younger than 3 years old for whom some types of iconicity would not yet be accessible.

Caselli and Pyers (2017) also revisit this question in ASL acquisition, using the ASL-CDI data reported by Anderson and Reilly (2002) and a set of signs with ASL iconicity ratings. As in Thompson et al. (2012), iconicity facilitated vocabulary acquisition. There were also independent faciliatory effects of neighborhood density and lexical frequency on acquisition, independent of iconicity. These studies suggest that, although it is not the sole driver of acquisition, iconicity does indeed assist learning in deaf children acquiring sign.

While less research has looked at the extent to which deaf children are sensitive to the gradient aspects of depiction in their input, a study comparing child-directed signing in ostensive vs. non-ostensive contexts suggests that gradient modifications used by parents are intended to facilitate comprehension and word-learning in their children (Perniss et al., 2018).

However, learning to employ depiction and gradience as adult signers do in Study 1 requires the child to do more than recognize iconicity in a sign form and interpret gradient modulations of that form as meaningful. It also requires that the child understand how to *employ* these gradient depictive strategies as well as the way in which they interact with and are constrained by the linguistic system. In Study 3a, we explores this specifically in an adapted version of the adult production task.

4.1.4 Hypotheses

In the following studies, we adapt our paradigm to address these questions about the early stages of sign language development. Specifically, we show young ASL learners the target events and the path and speed changes in those events and ask them to describe the events using the same ASL forms that we gave the adults in our study. There are three possible outcomes. (1) If children's initial approach to language is based on iconicity, they should modify the sign forms to depict changes in both speed and path. (2) If iconicity is difficult for young children (as some researchers have suggested, e.g., Namy et al., 2004), they should not iconically modify sign forms to depict either speed or path. (3) Finally, if, early in development, ASL learners appreciate the way that gesture is used and constrained in their language, they should modify sign forms to depict changes in speed, but not path. Together, these studies promise to reveal how children develop the ability to modify signs in an adult-like fashion, and more generally appreciate how gesture functions in sign language.

4.2 Deaf children, ASL (Study 3a)

4.2.1 Methods

Participants

Deaf children acquiring ASL and hearing non-signing children between the ages of 4 – 8 years old were recruited for this task. Prior pilot testing of a related task with deaf children found that children as young as four were able to successfully complete the task with some difficulty and assistance from the experimenter. Studies of hearing children using silent gesture also suggest a similar age range (Bohn et al., 2019). Deaf participants were recruited through California School for the Deaf in Riverside (CSDR) and tested on the CSDR campus. Teachers at CSDR who allowed students from their classes to participate each received a $50 gift-card, and each child who chose to participate received $5 and a toy prize. Consent forms sent to parents at CSDR were provided in written English as well as in video form using ASL.

A total of 44 deaf children signed up to participate. Five participants were unable to complete any meaningful portion of the task and their data has been excluded from analysis. One additional participant's data was unusable due to a recording error. Of the remaining participants, seven only completed the UNPROMPTED and GIVEN-LEXICAL conditions and did not complete the GIVEN-DEPICTING condition, either due to timing constraints or because the participant asked to end the session early. These participants' data are used only in analyses within the lexical condition but are by default excluded from any paired analyses comparing lexical and depicting conditions. The age range of our final sample (years;months) was between 4;1 – 8;10 (mean age = 7;3).

California School for the Deaf at Riverside educates deaf and hard of hearing children from across southern California and is largely attended by children from families with one or more deaf family members. Our sample of participants reflects this- according to a demographics survey filled out parents, 30 of the 38 participants analyzed here had at least one deaf parent and were exposed to ASL from birth. Of the remaining eight participants, three were reported to have been exposed to ASL early (age three or younger) through deaf siblings and other deaf family members, but do not have deaf parents. We will refer to these three participants as the "medium-exposed learners". Three participants were reported to have been exposed to ASL later in development, at ages 5, (n=2) and 6 (n=1). No age of exposure information was provided for the remaining two participants, but they report no close deaf family members, so it is likely these children were exposed to ASL later in development as well. We will refer to these five participants as the "late-exposed learners".

Task

Adapting the paradigm

To make the adult task appropriate for children, we first shortened it significantly (the adult task lasted up to 90 minutes). To do so, we narrowed the trials down to only path and speed manipulations. Our motivation for selecting these trials came from our adult data, where adult signers modified speed and path at significantly different rates. Next, we cut the verb list to only those verbs that showed the clearest pattern in our adult signers (i.e., a clear difference in modification between speed and path and relatively low variation across participants; see *Lexical Stimuli* below)[10]. This cut our number of trials down to 12 (6 verbs x 2 variants) per condition,

[10] Those verbs were CLEAN, COMB, HUG, KICK, OPEN, AND RUN.

with a total of 36 trials across all three conditions (UNPROMPTED, GIVEN-LEXICAL, and GIVEN-DEPICTING). Several different versions of the task were piloted with hearing children verify that the task was of an appropriate length for our target age group, as well as to identify the ideal presentation and pacing to maximize engagement in child participants. For pilot hearing participants, the total session time was typically 30 – 40 minutes including instructions, practice, and critical trials. For deaf participants, the session time was typically much shorter (approximately 15 minutes)—the difference in times is largely because the deaf participants did not need extra time to become familiar with the concept of silent manual communication as the hearing children did.

Lexical Stimuli

The verbs selected for this modified version of our task were CLEAN, COMB, HUG, KICK, OPEN, AND RUN. Age of acquisition estimates indicate that the target signs shown to participants were likely already acquired by the school-age participants in our task. These estimates, reported in Caselli et al. (2020) are based on data from an ASL adaptation of the MacArthur Bates Communicative Development Inventory. The mean age (in months) at which our target lexical signs are expected to be acquired, as predicted using a Bayesian Generalized Linear Model was 30 months (range = 26 – 32).

4.2.2 Results

In the following sections, we begin by qualitatively describing the different approaches deaf children used in describing the stimuli in this task, from most frequent to least frequent, and provide visual examples of each. We then describe the two main "profiles" of modification behavior that characterize the majority of participants in Study 3. We then report the results of our statistical analyses.

Description Strategies

In order to compare if and how participants captured the two dimensions manipulated in this task, we need to know that, like the adults in Studies 1 and 2, our child participants reliably noticed the difference between the unaltered and altered videos in each trial and saw this contrast as relevant to include in their description. Participants included information on the manipulated dimension in their response for the large majority of trials– 91.8% of trials (755/822). Thus, the stimuli used in the task captured the manipulated dimensions well, and participants understood this information to be relevant to include in their descriptions.

The deaf children in this study used a wide variety of strategies when describing the stimulus videos. Below, we describe and illustrate each strategy, as they varied across the following dimensions: (a) inclusion of the target sign, (b) modification of the target sign, (c) inclusion of an adjective or other descriptor, and (d) presence and relative timing of embodied action.

Non-target V (excluding the target sign)[11]

Deaf children participating in our task opted not to use the lexical signs they were prompted with more frequently than deaf adults, replacing the target sign with another sign or construction

[11] Note that trials where children did not use the prompted lexical sign in their description are considered when estimating the rate at which participants noticed and commented on our target manipulations but are excluded from our modification calculations.

24.4% of the time (110/450)[12]. This happened less frequently in the depicting condition, approximately 15.9% of the time (59/372). These trials are considered when estimating the rate at which participants noticed and commented on our target manipulations but are excluded from our modification calculations. This is to ensure that instances of modification between children are compared within the same sign form. Future analyses will explore patterns of modification within these non-target verbs. We briefly illustrate strategies in this category, before going into detail on description strategies employing the target verb supplied to participants.

In these cases participants still expressed the relevant verb and dimension information, but via alternate construction(s). Figure 27 shows an example of a participant response where the verb ‘running’ and the altered path of movement are both expressed via depicting constructions (neither of which she had been prompted with in either condition). First, using a V-handshape, she shows the legs running, and moves her hand along a zig-zag path to capture the target manipulation. She then produces a tracing depiction again representing the movement path (but no longer explicitly representing running, as in Figure 31).

Figure 27: Participant (age 5;7) describing someone running (path manipulation, lexical condition). The participant fails to produce the target lexical sign for RUN after prompting, instead, producing two (non-target) depicting construction to represent the verb and the path.

[12] Because these are early-acquired and high-frequency signs, this is possibly due more to preference than lack of familiarity with the target sign. For example, some signers would provide meta-commentary on the sign prompts, saying things like “I typically use this sign over that one.”

When children did include the target sign (as was the case for the majority of trials), they could produce the sign in its unmodified form or in a modified form, with or without additional descriptions of the manipulated dimension (e.g., with an adjective/adverb or with a non-target depicting construction capturing the relevant contrast). Below we report rates and illustrative examples of these different response strategies in our child sample, from the most frequent to the least frequent.

Modified target V; Ø descriptor

Deaf participants frequently expressed what they saw in the stimuli videos by directly modifying the sign they were prompted with, without any additional description or depicting signs--approximately 37.9% of the time for lexical signs, and 54% of the time for depicting signs. This was the most frequent strategy observed in the children's responses. In these cases, the information regarding what the verb was as well as the information about the relevant dimension contrast are expressed simultaneously. Figure *28* below shows an example.

Figure 28: Participant (age 7;10) describing someone cleaning (path manipulation, lexical condition). The participant produces the target sign CLEAN with a modified movement path.

Modified target V + adj/descriptor

The next most frequent strategy used by the deaf children was to modify the target sign internally and also include additional external description or depictions conveying the same contrast. In other words, the information about the changed dimension change (path or speed) was marked redundantly, both within the modified sign itself and in an external modifier. This strategy was used for 15.4% of trials in the lexical condition and 12.9% of trials in the depicting condition. Examples of this strategy are shown in Figure *29* and Figure *30*, below. Note that the dimension information (in this case, speed) is expressed explicitly through the lexical adjectives FAST and SLOW but is captured in facial expression. In the first example (Figure *29*), the signer opens his mouth and squints his eyes to show intensity while signing RUN and grits his teeth while signing FAST. In the second example (Figure *30*) the signer scrunches her lips into a small "o" shape while signing SLOW.

Figure 29: Participant (age 8;9) describing someone running (speed manipulation, lexical condition). The participant produces the target sign RUN with a modified speed, as well as the lexical adjective FAST. The intensity of the movement is also marked by the participants facial expression (not shown here), body posture, and the speed at which he produces the sign FAST.

Figure 30: Participant (age 8;8) describing someone kicking (speed manipulation, depicting condition). The participant produces the lexical adjective SLOW followed by the target depicting sign KICK with a modified speed. The information regarding speed is also captured in her mouthing (lips pursed, not shown here) and the speed at which she produces the sign SLOW.

Unmodified target V + adj/descriptor

Deaf participants produced the target sign unmodified and instead expressed the relevant contrast information via the addition of an adjective or adverb phrase, or the addition of some (non-target) depicting construction 9.2% of the time in the lexical condition and 1.9% of the time in the depicting condition. Figure *31* and Figure *32* show two examples of such constructions. In the first example (Figure *31*), the signer produces the citation form for the target sign, and then adds a conventionalized adjective expressing BACK or BACKWARDS. In the second example (Figure *32*), after producing the citation form of the target sign, the signer depicts the path of motion, tracing a zig-zag trajectory. However, note that the handshape used in this tracing is not indicative of a person running (which would typically be formed using a 1-handshape, with the index finger extended to represent a person), but instead is used only to outline the path of movement– separating out the verb information from the path information.

Figure 31: Participant (age 7;10) describing someone kicking (path manipulation, lexical condition). The participant produces the target lexical sign KICK unmodified, followed by a sign indicating BACK/BACKWARDS. Information regarding what the verb is (kicking) and how it is performed (backwards) are expressed independently and neither is marked redundantly.

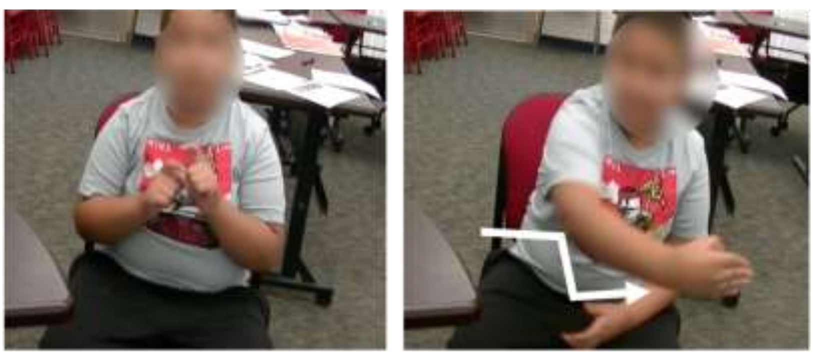

Figure 32: Participant (age 7;10) describing someone running (path manipulation, lexical condition). The participant produces the target lexical sign RUN unmodified, and then traces the path of movement.

Unmodified target V + modified target V

Participants also would at times produce the target sign multiple times in a single response, both modified and unmodified. Figure *33* below is an example of a signer producing this type of response, where he first produces the lexical sign KICK unmodified, and then produces a modified version to show the change in dimension. Responses like this were relatively uncommon, making up 5.9% of trials in the lexical condition and 9.9% of trials in the depicting condition.

Figure 33: Participant (age 8;9) describing someone kicking (path manipulation, lexical condition). The participant produces the target lexical sign KICK unmodified, followed by a version of the sign modified for path.

Target V + embodied action (simultaneous)

One type of response produced by the deaf children but not seen among the deaf adults was the use of “embodied” action. Participants would at times actually perform the actions shown in the stimuli during their descriptions. Embodiment is commonly used in narratives (Johnson, 2017), and the young signers may be adopting a storytelling technique in these contexts (Bulgarelli & Celo, 2022). In Figure *34* and Figure *35* below, the signers enact the action while simultaneously producing the target signs. In Figure *34*, the signer stands up and runs in place while producing the sign for RUN with a path modification. In Figure *35* the signer kicks her leg while producing the target depicting sign for KICK. Note that the second example shows that signer’s description of the initial neutral video for KICK and is not intended to capture any change in dimension.

Figure 34: Participant (age 7;0) describing someone running (path manipulation, lexical condition). The participant produces the target lexical sign RUN modified for path while simultaneously running in place.

Figure 35: Participant (age 8;8) describing someone kicking (neutral video, depicting condition). The participant produces the target depicting sign KICK while simultaneously kicking her leg.

Target V + embodied action (sequential)

These embodied enactments also occurred without a simultaneous sign, appearing on their own in the sequence of signs in the response. In Figure *36* below, the participant produces the citation form lexical sign for RUN, and then proceeds to stand up and run off camera. In Figure *37*, the signer describes the unaltered video of kicking by first producing an embodied enactment, then the target depicting sign for KICK. Note that both of these examples are taken from signers' descriptions of the initial neutral video in the pair and are not intended to express any change in dimension.

Figure 36: Participant (age 5;7) describing someone running (neutral video, lexical condition). The participant produces the target lexical sign RUN, and then proceeds to stand up and run off camera.

Figure 37: Participant (age 8;8) describing someone kicking (neutral video, depicting condition). The participant kicks her leg, and then produces the target depicting sign KICK.

In the following sections we will describe group level analysis of modification comparing lexical and depicting signs , as well as the different dimensions of interest. We then describe the different "profiles" of modification that individual subjects demonstrated. Then, we perform a correlation analysis to explore the effect of iconicity on modification. We then discuss possible effects of age on modification. Lastly, we report the results of a mixed effects regression model.

Modification Profiles

When looking at participants individually, they appear to align with one of several profiles of modification behavior. These are characterized below.

Depicting signs

In the depicting condition, the vast majority of participants fell into a single pattern—modifying the target signs frequently and treating path and speed as similarly modifiable. This is the case for 25 of the 31 participants for whom we have data in the depicting condition (recall that seven of our participants completed the lexical condition but not the depicting condition). They are plotted in Figure *38* below. Note that in the following plots, the medium-exposed learners are marked with an asterisk (*), and the late-exposed learners marked with two asterisks (**) following the facet label.

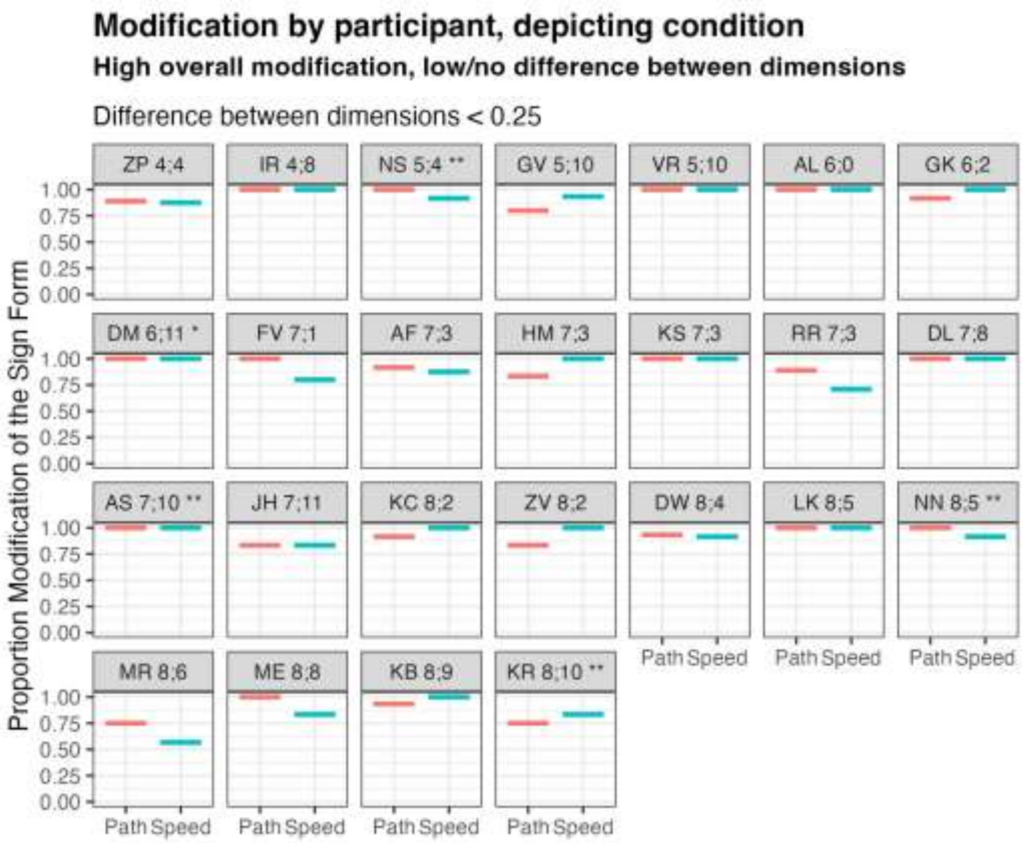

Figure 38: Modification patterns for participants that fell into the "high overall modification, little/no distinction between dimensions" profile for lexical signs. This was case for the vast majority of participants.

Of the remaining six participants, two modified path more than speed and four modified speed more than path. No consistent pattern regarding dimension emerges in the depicting condition, suggesting that the tendency to treat speed as more modifiable than path in the lexical condition is tied to those signs being lexical signs, rather than a general tendency to express speed simultaneously with the verb and express path externally.

Lexical signs

Deaf participants overwhelmingly fell into one of two categories in their treatment of lexical signs: either they modified the signs frequently, with little to no difference between speed and path modifications, or they showed a differentiation between dimensions, modifying path less frequently than speed. Because of the relatively few observations per subject per verb we have in these data, in the following plots, a participant's choice of whether or not to modify on any given trial has the potential to shift these means significantly. Therefore, in the following plots and descriptions, we do not interpret differences of less than |0.25| in mean modification between path and speed as meaningful. However, adjusting this threshold to be more or less conservative does not greatly change the overall tendencies we report here. Note that in the following plots, the medium-exposed learners are marked with an asterisk (*), and the late-exposed learners marked with two asterisks (**) following the facet label.

A large number of subjects (19 out of 38) fell into "high modification, little/no differentiation" profile, treating lexical signs as highly flexible for both the path of movement and speed of movement. Participants falling into this profile are plotted below in Figure *39*. Two of the medium-exposed learners (DM, EG) and three of the late-exposed learners (KR, NN, NS) fell into this pattern.

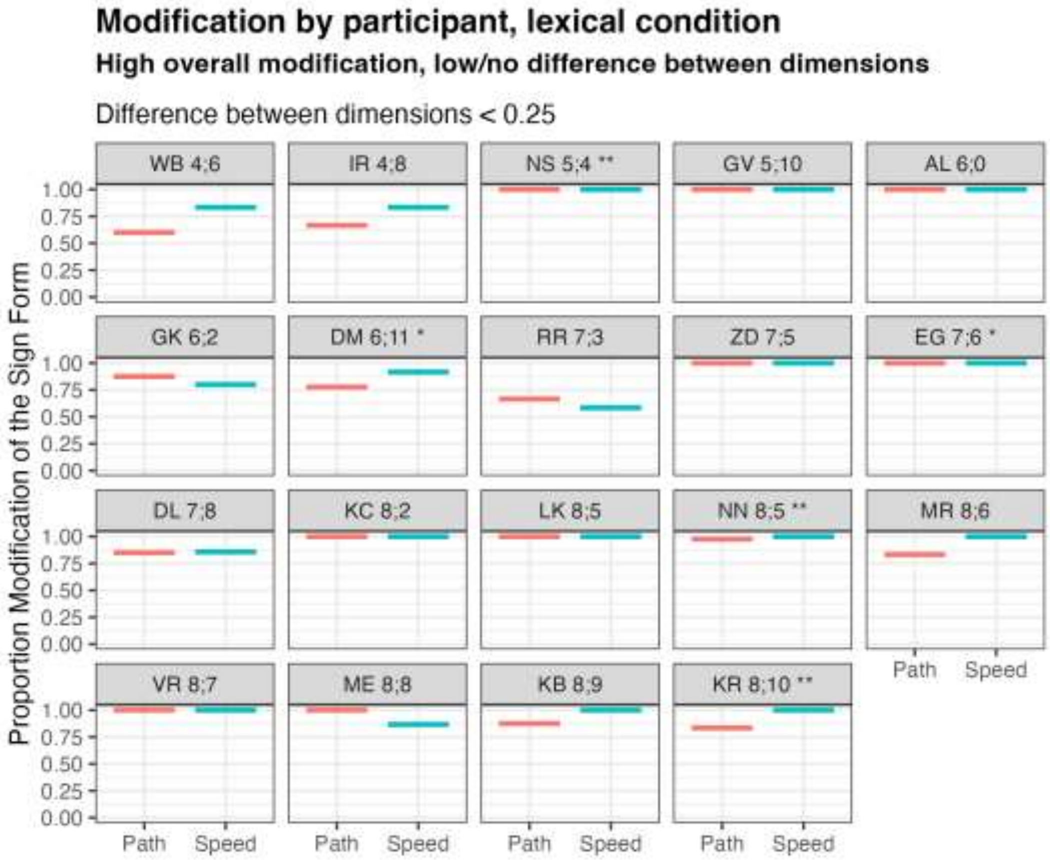

Figure 39: Modification patterns for participants that fell into the "high overall modification, little/no distinction between dimensions" profile for lexical signs.

The other most frequent pattern in the lexical condition was for signers to modify speed more readily than path. 17 signing participants fell into this profile. Two of the late-exposed learners (AS and CP) and one of the medium-exposed learners (TG) fell into this pattern.

Their data are plotted below in Figure *40*.

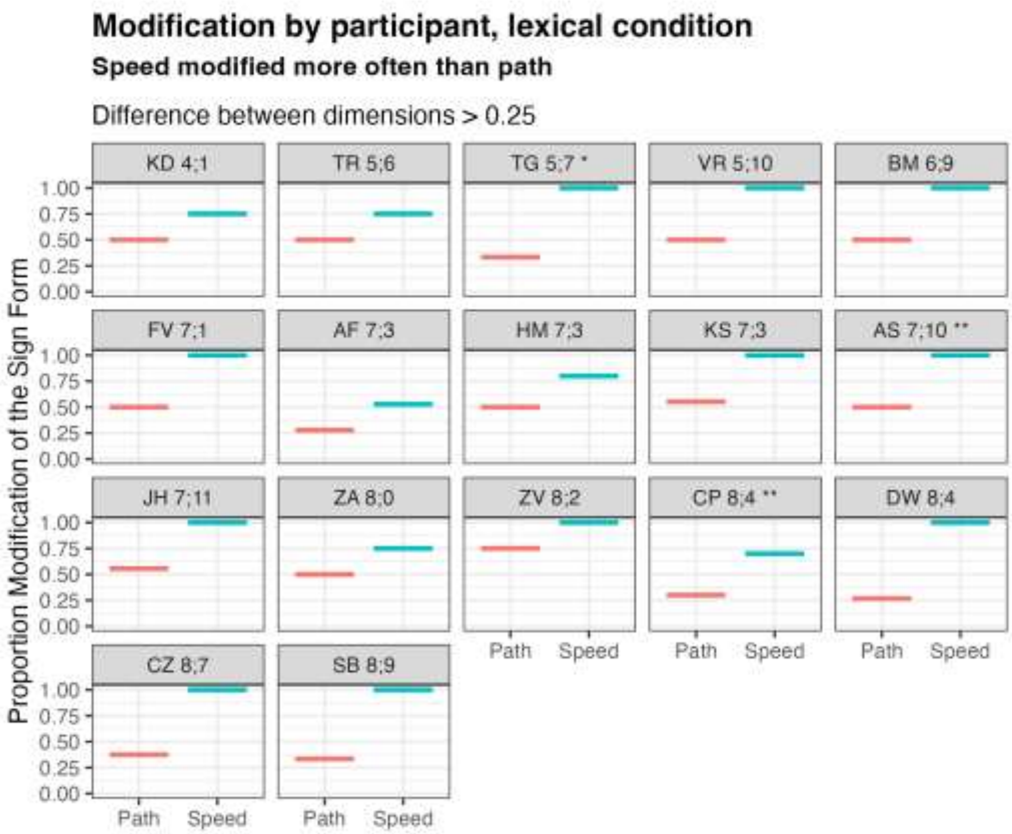

Figure 40: Modification patterns for participants that fell into the "Distinguishing between dimensions, path < speed" profile.

These two profiles account for 36 of the 38 participants in the lexical condition. Of the remaining two participants, one showed a low rate of overall modification (M = 0.38) and did not distinguish between path and speed for modifiability, and the other distinguished between dimension in the reverse direction, modifying path more so than speed (path M = 1.0, speed M = 0.75).

Condition and Dimension Analysis

Participants modified both lexical and depicting signs very frequently. As described in chapter 2, the mean proportion of modification by deaf adults was 0.40, (*SD* = 0.45) in the lexical condition, and 0.90 (*SD* = 0.19) in the depicting condition. In contrast, deaf children's mean proportion modification of was 0.79 (*SD* = 0.38) for the target lexical signs and 0.9 (SD = 0.24) for target depicting signs. However, like the adult signers, the child signers did distinguish between lexical and depicting signs, modifying the depicting signs significantly more often than lexical signs, $t(30) = -2.96$, $p = .006$; Wilcoxon: $V = 339.5$, $p = .009$.

Also like the adult signers, the child signers distinguished between speed and path modifications for lexical signs, but not depicting signs. Mean proportion modification for each dimension and condition are shown below in Table 4.1.

Table 4.1 How often signs were iconically modified along each dimension by child signers

Dimension	Lexical Signs	Depicting Signs
Altered Speed	$M = 0.89$, $SD = 0.29$	$M = 0.9$, $SD = 0.24$
Altered Path	$M = 0.69$, $SD = 0.43$	$M = 0.9$, $SD = 0.23$

In the lexical condition, the proportion of modification for path and for speed were significantly different, $t(37) = -5.13$, $p = < 0.001$; Wilcoxon: $V = 34.5$, $p = 0.00005$. No significant difference was found in the depicting condition $t(30) = -0.51$, $p = 0.62$; Wilcoxon $V = 116.5$; $p = 0.76$. Modifications for speed did not differ between the lexical and depicting conditions, $t(102) = -0.32$, $p = 0.75$, Wilcoxon: $V = 167$, $p = 0.836$. However, modifications for path were significantly more likely in the depicting condition than the lexical condition, $t(114) = 3.846$, $p = 0.0002$, Wilcoxon: $V = 906$, $p = 0.0003$. These results are summarized in Figure *41*.

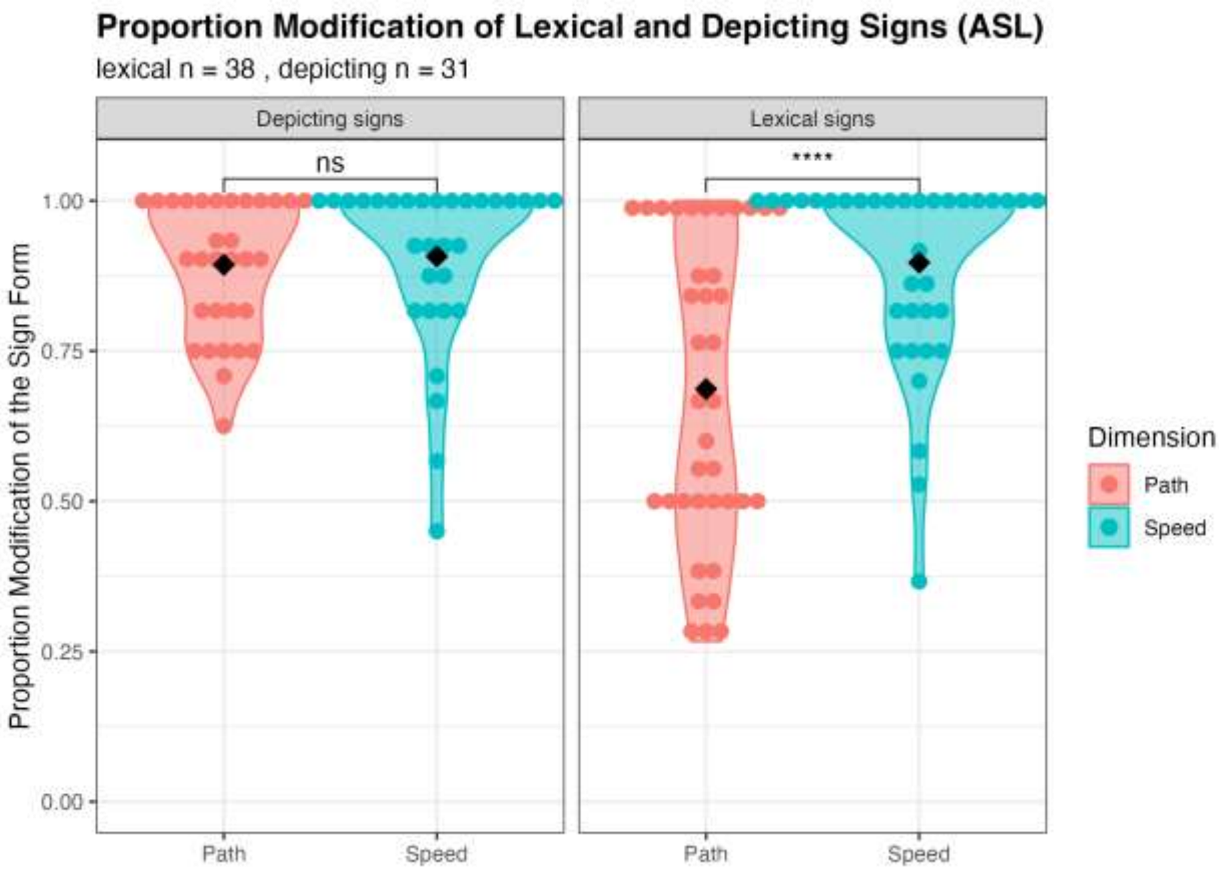

Figure 41: Proportion of modification of the target sign by signers (children), separated by dimension (path vs speed) and condition (lexical vs depicting). Group means are marked with a black diamond.

Iconicity

We next looked to see whether, like adults, deaf children were more likely to modify already-iconic signs. We find moderate evidence suggesting that deaf children's modifications are influenced by the iconicity of the target sign. Whether or not a child signer modified a target lexical sign in their response was weakly correlated with that sign's iconicity ($r_s = 0.18$, $p = 0.0016$). This is plotted in Figure *42* below.

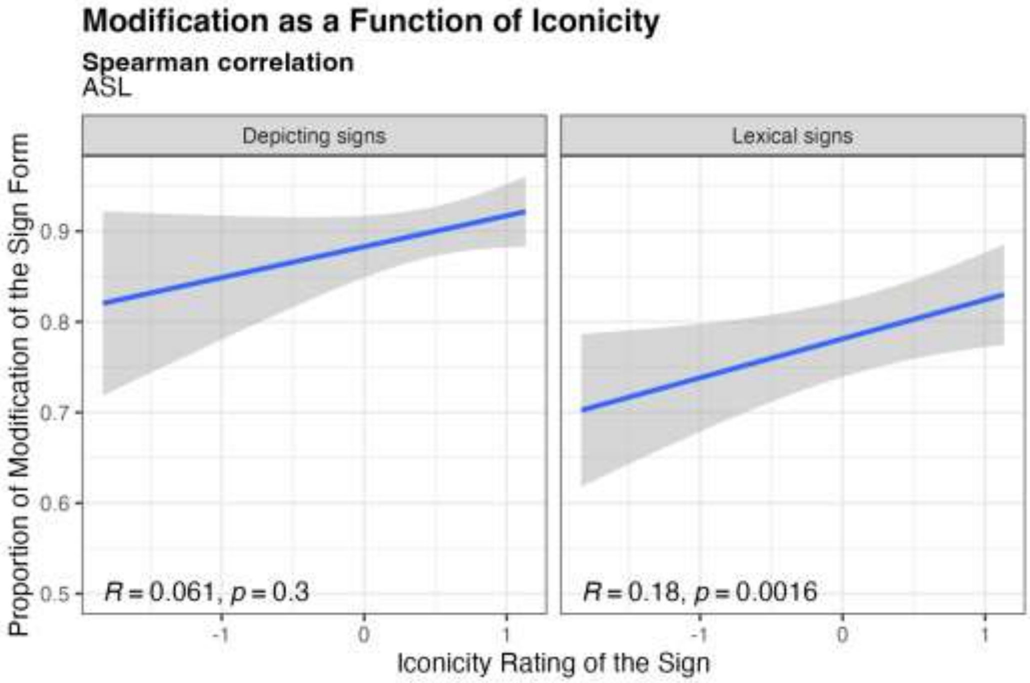

Figure 42: Correlation between iconicity and proportion of modification for verbs in the lexical and depicting conditions (child signers).

Age

When looking at participants' overall modification rate, collapsing across dimension, we find no evidence for a correlation with age among deaf participants (depicting signs $r_s = -.25$, $p = .17$; lexical signs $r_s = .18$, $p = .28$). The mean age of participants falling into either modification profile (high modification across both dimensions, or selective modification with path less modified than speed) was roughly equivalent (across-the-board modifiers M = 7;2, SD = 17.13; selective modifiers M = 7;2, SD = 15.5). When looking at the proportion of participants falling into each of these profiles across age groups, we visually find little evidence that age is driving young singers towards on pattern versus the other. These data are shown in Figure *43*.

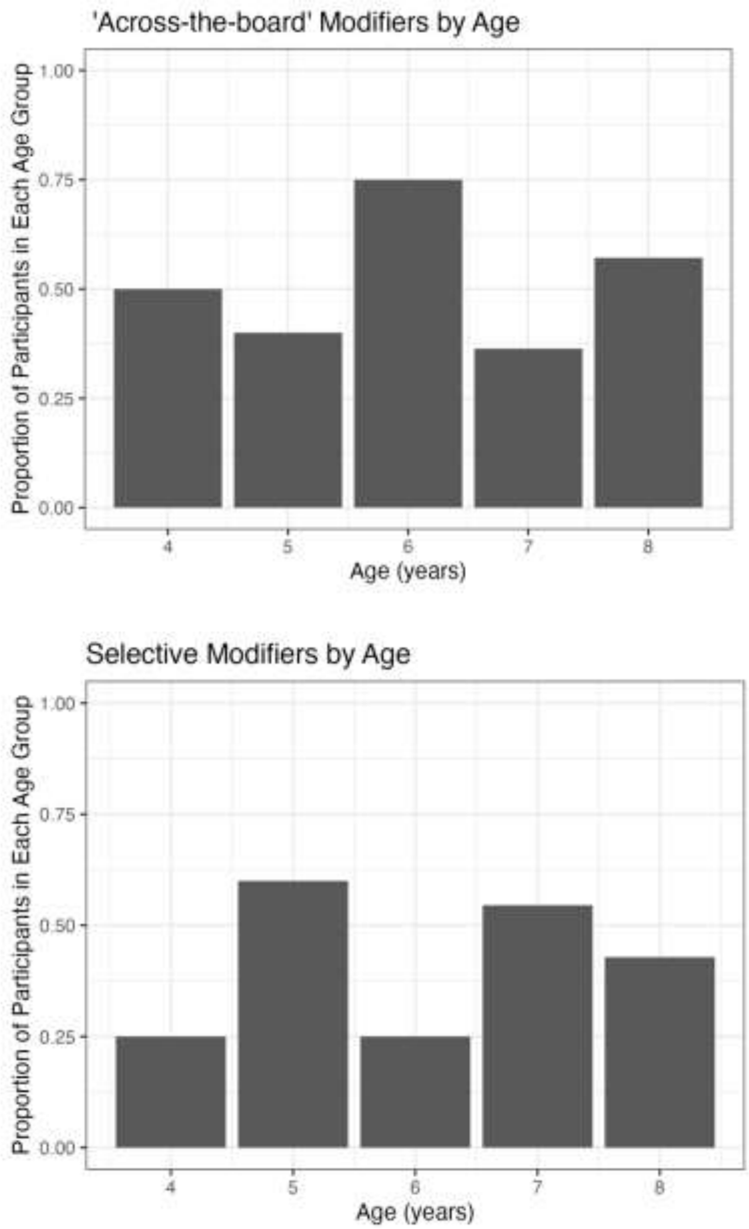

Figure 43: Proportion of signers that have an "across-the-board" approach to depiction (above) versus a selective approach to depiction (below).

However, a visualization of these data with both age and modification treated continuously (Figure *44*) we see that for deaf children, the extent to which they distinguish between path and speed within lexical signs may change over time, with the older children appearing to treat path as more constrained than speed (the adult pattern) more so than younger children.

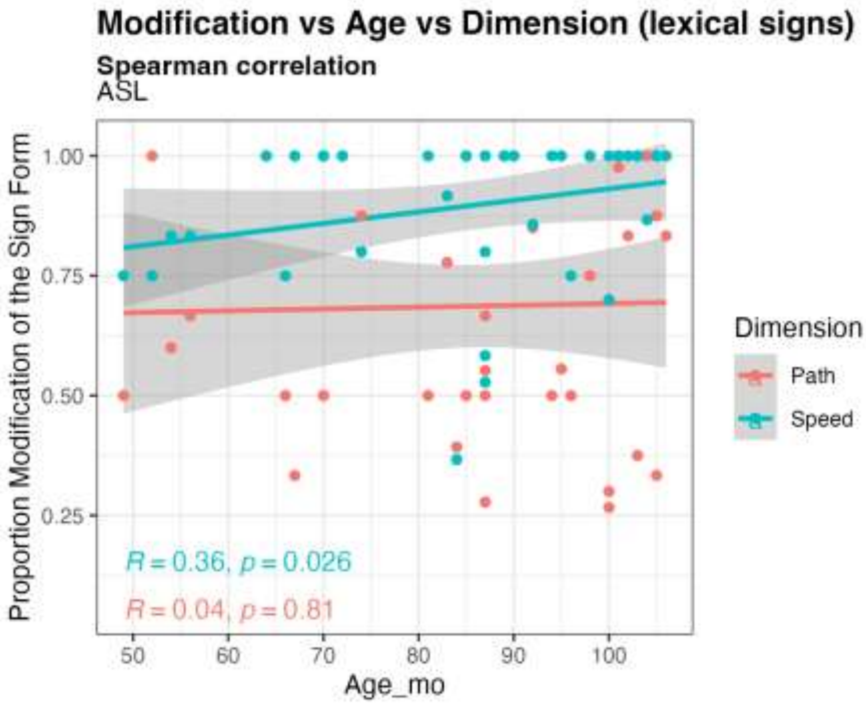

Figure 44: Plot of modification across age for lexical signs, separated by dimension.

When we look within age groups, the effect of dimension is weaker within the four and five year old participants [$t(53) = 1.92$, $p = .06$; Wilcoxon $W = 607$, $p = .092$] than the older participants [$t(213) = 4.35$, $p = 0.00002$; Wilcoxon $W = 9601$, $p = .00001$]. However, our participants are not evenly distributed across this age range, with more older children participating (six-year-olds n = 4, seven-year-olds n = 11, eight-year-olds n = 14) than younger children (four-year-olds n = 4, five-year-olds n = 5). The somewhat more pronounced effect of dimension observed in older children may be the result of insufficient data in the younger age groups, and these trends are interpreted with caution. (see Interim Discussion section).

Modeling

Below we report the results of a quasibinomial logistic regression model predicting modification of target signs. We include a fixed effect of Dimension (path, speed), Iconicity of the target sign, Age (in months), Condition (lexical, depicting), as well as an interaction term for Iconicity:Condition and Dimension:Condition. The output of this model is summarized in Table 4.2.

Table 4.2 Summary of model output for the following model:
Modification ~ Dimension + Iconicity + Age + Condition + Iconicity:Condition + Dimension:Condition

	Est.	S.E.	t val.	p
Intercept	2.43	0.62	3.94	0.00009***
DimensionSpeed	-0.02	0.34	-0.07	0.94
Iconicity	0.36	0.24	1.48	0.14
Age	0.0	0.01	-0.67	0.50
ConditionLex	-1.27	0.28	-4.49	0.000009***
DimensionSpeed:ConditionLex	1.26	0.42	2.97	0.003 **

$\chi^2(6) = 38.39$, p = 0.00
Pseudo-R^2 (Cragg-Uhler) = 0.07
Pseudo-R^2 (McFadden) = 0.05

In this model, Condition (lexical or depicting) emerges as a significant predictor, as well as the interaction between dimension and condition. Participants were significantly more likely to modify the form of lexical signs than depicting signs (β = -1.27, *t* = -4.49, *p* < .00001, 95% *CI* [-1.84, -0.73]. The difference between modification for speed and path among depicting signs was significantly smaller than among lexical signs (β = 1.26, *t* = 2.97, *p* = .003, 95% *CI* [0.43, 2.10]).

Order Effects

We additionally tested for an effect of condition order on modification, to evaluate whether young signing participants were influenced by whether they completed the depicting or the lexical condition first. It is possible, for example, that a signer who begins our task[13] by being prompted to use depicting forms may carry over some of those depiction strategies when they are later prompted to use lexical signs in the subsequent condition. Half of our participants (n = 19) completed the lexical condition after having already completed the depicting condition ("lex-second"), while the other half had not yet seen the depicting condition before beginning the lexical condition ("lex-first")[14].

We found that the overall rate of modification to target lexical signs (both for speed and path manipulations) between participants who had already completed the depicting condition (M = 0.75, SD = 0.41) versus those who had not (M = 0.81, SD = 0.35) did not significantly differ [$t(254) = -1.44$, $p = .15$; *Wilcoxon W* = 11034, $p = .19$]. The significant difference between path versus speed modifications within lexical signs likewise remains significant when we restrict the data to only those participants who completed the lexical condition first [$t(44) = 3.17$, $p = .003$], or to those who completed the lexical condition after the depicting condition [$t(73) = 2.29$, $p = .03$][15]. However, it is worth noting that when we compare modifications specifically to path within the lexical condition for participants who completed the lexical condition first (M = 0.60 , SD = 0.47) versus those who saw the depicting condition first (M = 0.75, SD = 0.39), path

[13] As mentioned in section 4.2.1 (Methods), all participants began our task with an initial unprompted round, where they received no target sign prompts from the experimenter. All discussion of whether the lexical or depicting condition was "first" or "second" for a participant in this section refers to whether that was the first or second *prompted* condition.
[14] This group includes those seven participants that did not ultimately end up completing the depicting condition at all.
[15] Note that the difference in degrees of freedom between these two t-tests is because the data from the lex-first group included a higher number of trials in which the proportion modification score could not be calculated for either the path or speed dimension manipulations. This occurs when the participant either does not produce the target sign they were prompted with or when they failed to comment on the relevant difference between the videos (either through modification or external description) and thus may not have noticed the difference.

modifications were less likely among those participants who had not yet completed the depicting condition [$t(125) = -2.14$, $p = .03$].

4.2.3 Interim Discussion

The results of study 3a provides insight into how deaf children acquiring a sign language employ depiction and gradience in their communication, both in terms of their general facility with depiction as well as their intuitions regarding how these features interact with and are constrained by their specifics of their linguistic system. We find no evidence that deaf children treat lexical signs as unanalyzed wholes. Instead, they employ gradient modification frequently (more frequently than do adults), using both speed of movement and path of movement to depict gradient change in meaning. However, despite this willingness to modify these signs, deaf children in this age range still show different patterns of modification in lexical signs versus depicting signs. Deaf children were significantly less willing to modify lexical signs than they were depicting signs (a pattern shared by the adult signers).

Lexical versus depicting signs

Deaf children in this task modified depicting signs almost 100% of the time, as did the deaf adults. In adults, this result is not particularly surprising, given that signs of this type are used, as the name suggests, to depict. When used to represent verbs of motion, the movement of these signs flexibly depicts the movement in the event or action in an analog way. Unlike signs in the "core lexicon", depicting signs are not bound by constraints on form such as Battison's (1978) symmetry and dominance conditions (Aronoff et al., 2003). However, some work indicates that the system of depicting signs is not fully mastered until late childhood (Kantor, 1980; Newport & Meier, 1985; Schick, 1990; Slobin et al., 2003; Supalla, 1982). Children as young as 3 begin to differentially use handshapes when designating the relevant noun class, but do not master other elements of these constructions (e.g., integrating of both hands, positioning them in relation to each other, moving through space, non-manual markers etc.) (Schick, 1990). Newport and Meier (1985, p. 911) note that "the relatively late acquisition of morphology in ASL may be due to its simultaneity", such as the simultaneous indication of path and manner in motion verbs. They report that the predominant error found in children's production of complex verbs of motion is what they refer to as the "partial omission of morphology", where they fail to include all aspects of a motion event. For example, when describing a hen jumping to the roof of a barn for which a child should have produced a sign combining an arc movement path with an upward direction, the child produces the arc movement, omitting the upward component. However, the youngest children in our sample do not differ from the rest of the group in their tendency to express even complex movement information via depicting signs, and they treat them as highly modifiable relative to lexical signs. This suggests that by age 4, deaf children acquiring ASL understand this class of signs to be distinct from lexical signs in its expressive capacity and phonological flexibility.

Dimension (lexical signs)

The deaf children in our study also distinguished between lexical and depicting signs in their willingness to modify different dimensions of movement within a sign. While they were equally willing to modify both the speed and path of movement of depicting signs, path was treated as less modifiable than speed within lexical signs. This mirrors the pattern found among deaf signing adults, who likewise are less willing to depict changes to the path of movement in an action via modifying the path of the lexical sign than they are to depict the speed of an action via modulating the speed movement of the sign. Young signers therefore show evidence of an emerging sensitivity to the ways in which gradience and depiction are constrained within their linguistic system.

However, deaf adults' treatment of lexical signs as less modifiable than depicting signs was evident across all dimensions studied, including speed. That is, despite speed being the most modifiable dimension in the lexical signs for both deaf adults and children, the deaf adults in Study 1 still modified speed significantly less often in lexical signs. In contrast, deaf children modified speed very frequently in both the lexical and depicting conditions, with no significant difference in willingness to modify between the two conditions.

Deaf children thus pattern similarly to their adult counterparts in at least two ways: (1) in treating lexical signs as more constrained than depicting signs in the extent to which they can be gradiently modified, and (2) in treating path as more highly constrained than speed for lexical signs, but not depicting signs, where they treat path and speed as equally modifiable. However, deaf children also differ from deaf adults in their use of modification. The most dramatic difference is in the frequency with which they employ gradient modification, with children modifying the target lexical signs more frequently than adults, both for speed and path. Possibly as a result of this, the distinction between lexical and depicting signs is more pronounced in the deaf adults than in deaf children. Adult signers modified lexical signs less frequently than depicting signs along each dimension, while deaf children distinguished lexical and depicting signs for path modifications, but not for speed.

There are several possible explanations for this difference between deaf children and adults. One possibility is that there is a ceiling effect due to children's high overall modification rate, which obscures any possible differences between speed modifications in lexical signs compared depicting signs. A second possibility is that deaf children still acquiring ASL had fewer alternate methods of expressing these contrasts in their vocabulary than adults with full command of the language. Adult signers in our study did employ a wide variety of descriptions when expressing the contrasts in our stimuli. For example, at times signing adults would describe the actors in our stimuli as "excited" or "in a hurry" when describing faster speed manipulations or describe them as "tired" or "dramatic" in slower speed manipulations. However, at least for speed manipulations, it is likely that even our youngest signers would have non-depictive methods of expressing speed in their communicative repertoire via signs for SLOW and FAST, which are both early-acquired and would likely be in the vocabularies of even our younger participants.

A third possibility for why adult signers were more likely to express speed contrasts through external modifiers than were children may be related to pragmatics. Adults may have a pragmatic intuition that speed changes are less at-issue (among lexical signs), making them more likely to mark speed explicitly via external constructions. This is supported by the adults' tendency to produce additional descriptions commenting on speed information, even in contexts where they have already modified the target sign to depict speed, as shown in Figure *21* from Study 1 – a pattern that is not shared by the adult silent gesturers. This reduced willingness among deaf adults to modify speed in lexical signs relative to depicting signs may not be the result of constraints in a phonological/morphological sense (as we suspect is the case for restrictions on path), but instead the result of adults' pragmatic intuitions regarding depictive modifications to lexical signs. Davidson (2015, p. 515) notes that “If a signer does exert extra effort in order to move their hands further apart or to do this particularly quickly, then interlocutors can assume this is an iconic modification. However, should the signer not wish to convey an iconic modification, then it is likely they will move their hands the minimal amount/easiest or smoothest way possible and in line with the speed that they generally sign. In that case, it would not be so clear that this additional indication of speed and amount is actually ‘internal”. She compares two signed utterances, describing two individuals walking towards each other- one in which the signer brings their hands (representing people) together in a straight path, and another using a zigzagging path. “In [the first example] the straight path is the easiest way to articulate bringing the two hands together and so may not be intending to demonstrate any manner of path at all. In contrast, the zigzagging path in [the second example] takes more effort to produce and so should be interpreted as part of the demonstration.” (p. 515).

Barnes and Ebert (2023) discuss this in the context of the at-issue status of iconic enrichments in sign languages, arguing that gradient depiction in sign languages is more at-issue than iconic co-speech gestures in spoken language. It may be possible to extend this reasoning a step further, to say that for modifications to movement in lexical signs, which require deviating from a prescribed, “neutral” movement, certain kinds of iconic modifications (e.g., to path) may be more readily interpreted as part of the demonstration, or contributing at-issue content, than are others (e.g., speed). However, for depicting signs, which lack a pre-determined movement, all dimensions of the depiction are interpreted as meaningful. If this were the case, it would explain why adults express speed information via depiction less often in lexical signs than depicting signs. These pragmatic intuitions may not yet be acquired by young deaf signers, who gradiently modify lexical signs far more frequently than their adult counterparts and who are equally (and highly) likely to express speed information through iconic modification of both lexical and depicting signs. Future work should explore signers' interpretation of these modifications to see whether and how pragmatic intuitions vary in this regard .

Iconicity

While we found evidence in Study 1 that modification in deaf adults was correlated with a given sign's iconicity, we are limited in the extent to which we can test for iconicity effects among the deaf children. This is both due to the more limited set of verbs included in the child-version of this task (six lexical and six depicting verbs, compared to 14 lexical and 14 depicting verbs in the adult task), as well as the fact that the verbs selected for inclusion in the children's task are not evenly distributed across a range of iconicity. That said, we do find a correlation between iconicity and modification, where lexical signs that have a more iconic citation form are more likely to be modified. Future work should explore this effect using additional verbs across a range of iconicity.

Age

We found limited evidence for an effect of age on modification in these data. Correlations between age and modification were not significant, nor did we find age to be a significant predictor of modification in our model. The youngest children in our sample fell into both profiles of modification ("high modification with little/no differentiation between dimensions", and "modifying speed more than path"). However, the plot in Figure *44* visually suggests a trend where older children distinguish between path and speed to a greater degree (the pink and blue lines separate over age). This may indicate that, although many children in our sample from across our age range treat path as less modifiable than speed (as do deaf adults), older children may conform to this adult-like pattern more consistently and in a more pronounced way. Because the cross-sectional nature of these data limits our ability to make longitudinal claims, future work should explore how these tendencies change within a given child across development.

Next Steps

We now ask whether the limitations on gradient modification in lexical signs are linguistic in nature for deaf children acquiring ASL. We approach this question in children as we did in adults: by testing the extent to which the observed patterns in deaf signers of ASL are also found in hearing non-signers on the same task. The results of Study 2 with hearing non-signing adults showed that the effect of condition and dimension (where lexical signs are modified less frequently than depicting signs, and among lexical signs, path is modified less often than speed) was unique to adult signers—silent gesturers treated both classes of signs and all dimensions as highly modifiable. This suggests that the observed patterns are not the result of certain signs or modifications being more difficult to articulate. And while both signers and non-signers were more likely to modify highly iconic signs than less iconic signs, only for signers did the use of iconicity need to fit within the structure and constraints of a linguistic system.

However, it is possible that the observed patterns in deaf children arise out of features of our now-reduced stimuli or task unrelated to a sign's status as lexical or depicting or to the phonological specification of different dimensions. By testing hearing non-signers on this task, we can identify the extent to which the effects of condition and dimension found in our deaf signers are tied to their knowledge of sign, rather than to non-linguistic influences on modification such as articulation, biomechanics, visual perception, iconicity etc. It likewise allows us to qualitatively explore children's intuitions about depiction.

4.3 Hearing Children, Silent Gesture (Study 3b)

4.3.1 Methods

Participants

Hearing participants were recruited from the UChicago Infant Database, which represents a socio-economically diverse sample of families from the Chicago area. These participants were tested at the University of Chicago. Hearing families were paid $25 for participation.

A total of 16 hearing children were recruited for this task. One participant was unable to struggled to understand the instructions and was unable to successfully complete any meaningful portion of the task, and her data is excluded here. And additional two participants were only able to complete the UNPROMPTED and GIVEN-LEXICAL conditions and did not complete the GIVEN-DEPICTING condition. These were our two youngest participants and they struggled to sustain their attention for the full length of the task, so the GIVEN-DEPICTING condition was dropped by the experimenter. Note that because of these instances of partial data, there are a larger number of observations in in the GIVEN-LEXICAL condition than the GIVEN-DEPICTING condition. The age range of our final sample (years;months) was between 4;1 – 8;6 (mean age = 6;7).

Task

Because of the relative complexity of the task for hearing children, who had little to no experience using silent gesture, they were introduced to the task in two practice phases. First, they were practiced identifying the differences between videos verbally using example trials of verbs/events not included in the actual experiment. The video pairs were shown side by side with either a speed or a path difference (as they were to be presented in the experiment) and practiced identifying what was happening in the videos and identifying the difference between the two videos out loud. Once the child successfully described the events and variations verbally, they were introduced to the concept of silently gesturing to show what was happening. They practiced using silent gesture to "show the experimenter what is happening without using words". This was done first using just individual videos, and then eventually with the video pairs, allowing the participant to first practice using their body to convey more general information (what is happening) and then more specific information (what is the difference between the two). Participants were instructed to gesture in a way that the experimenter could see (i.e., above the table) and to stay in one spot so the camera would be able to capture them.

After participants practiced communicating only through silent gesture and successfully understood the kinds of information they would be expected to represent, they then began the unprompted silent gesture round.

As expected, the child silent gesturers were generally unfamiliar with the concept of silent gesture, and at times required additional prompting from the experimenter during practice or during the UNPROMPTED condition. This is in keeping with previous work using silent gesture with children, which reported that in a silent communication task, "six-year-olds spontaneously invented novel referential signs. Four-year-olds quickly adopted a new mode of communication and used it productively to create novel gestures. Three-year-olds, however, imitated model solutions and had to be introduced to novel meanings in a piecemeal fashion." (Bohn et al., 2019).

4.3.2 Results

In the following sections, we begin by qualitatively describing the different approaches the hearing children used in describing the stimuli in this task, from most frequent to least frequent, and provide visual examples of each. We then describe the main "profile" of modification behavior that characterize the majority of participants in Study 3b. We then report the results of our statistical analyses.

Manipulation Check

In order to compare if and how participants captured the three dimensions manipulated in this task, we need to know that, like the adults in Studies 1 and 2, our child participants reliably noticed the difference between the unaltered and altered videos in each trial and saw this contrast as relevant to include in their description. The young silent gesturers rarely failed to include information on the manipulated dimension in their response –12.8% of trials (43/336). Thus, the stimuli used in the task captured the manipulated dimensions well, and participants understood this information to be relevant to include in their descriptions.

Description Strategies

Like the descriptions from deaf signing children, the hearing children's responses in this study varied across the following dimensions: (a) inclusion of the target sign, (b) modification of the target sign, (c) inclusion of an adjective or other descriptor, and (d) presence and relative timing of embodied action. Below, we describe and illustrate each strategy.

Excluding the Target Sign

Hearing children participating in our task opted to not use the target signs they were prompted with, replacing the target sign with their own gestures, on 9.4% of trials (17/180) in the lexical condition and 4.5% of trials (7/156) in the depicting condition. The most frequent signs that gesturers failed to produce in their responses were the lexical signs for HUG (5), COMB (4), and RUN (4). For HUG and COMB, this may have (counter-intuitively) been due to the high iconicity of those target signs, and their resemblance to iconic co-speech gestures. Research on novice and L2 learners of a sign language has found that while iconic signs are often learned more quickly and retained more easily than non-iconic signs (Baus et al., 2013; Campbell et al., 1992; Lieberth & Gamble, 1991), there may be a trade-off with accuracy in production, where iconic signs are produced less accurately than arbitrary signs (Ortega & Morgan, 2015). The similarity with iconic co-speech gestures may prevent learners from attending to the specifics of the sign's phonological structure. For RUN, we believe this was more likely due to the low-iconicity (and potentially the phonological complexity) of the sign, where participants were not sure how this form could represent running in a meaningful way and instead chose not to use it.

As with adults, children who used the target sign in their descriptions could produce the sign fall into the same broad categories as the adult responses: The target verb can appear in its unmodified form or in a modified form, with or without and may or may not appear alongside additional descriptions of the manipulated dimension (e.g., with an adjective/adverb or with a non-target depicting construction capturing the relevant contrast). Below we report rates and illustrative examples of these different response strategies in our child sample, from the most frequent to the least frequent.

Modified target V; ∅ descriptor

The young silent gesturers in this task opted to express the dimension contrasts via modification of the sign form, with no other additional gestures, the vast majority of the time (75.0% of the time for depicting signs and 67.8% of the time for lexical signs). This suggests that the participants understood these unfamiliar signs (presented to them as "gestures") could be mapped to the action being performed in the stimuli videos and that they correctly identified the relevant contrasts to be expressed in their responses. This mirrors the adult pattern as well, where the hearing adults using silent gesture produced a modified target sign without additional external descriptors the majority of the time. As discussed in Chapter 3, section 3 (Results), this may reflect a preference for combining two pieces of information into a single form observed in other studies of adults using silent gesture (Özçalışkan et al., 2016, 2018). However, there were several observed strategies employed by the hearing children in this class that go beyond producing a single modified sign form. Examples of these are described below:

Creating novel depictions

During the initial UNPROMPTED condition, where participants are not prompted with a sign and are only told to silently gesture about the stimuli videos, participants spontaneously created their own gestural representations of the events shown to them. However, even when they were provided a sign to use in the GIVEN-LEXICAL and GIVEN-DEPICTING conditions, hearing participants would at times include their own gestural representations in their response. In the two prompted conditions, participants included their own gestures (not shown to them by the experimenter) approximately a quarter of the time (82/336 trials). One context in which this occurred by default was when the participant rejected or failed to produce the target that sign they had been prompted with, instead opting to represent the information via their own gestures. This occurred 4.5% (7/156) of the time for depicting signs, 9.4% (17/180) of the time for lexical signs (24/336 7.1% total). The most frequent signs that gesturers failed to produce in their responses were the lexical signs for HUG (5), COMB (4), and RUN (4). For HUG and COMB, this may have (counter-intuitively) been due to the high iconicity of those target signs, and their resemblance to iconic co-speech gestures. Research on novice and L2 learners of a sign language has found that while iconic signs are often learned more quickly and retained more easily than non-iconic signs (Baus et al., 2013; Campbell et al., 1992; Lieberth & Gamble, 1991), there may be a trade-off with accuracy in production, where iconic signs are produced less accurately than arbitrary signs (Ortega & Morgan, 2015). The similarity with iconic co-speech gestures may prevent learners from attending to the specifics of the sign's phonological structure. For RUN, we believe this was more likely due to the low iconicity (and potentially the phonological complexity) of the sign, where participants were not sure how this form could represent running in any meaningful way and instead chose not to use it.

Target V + Gesture

Participants also included their own novel non-target gestures alongside the target sign prompt 17.3% (58/336) of the time. Figure *45* shows an example of a participant producing their own gesture to represent kicking as well as the relevant contrast (kicking slower) after producing the target sign for KICK. They form their non-dominant hand into a V-handshape, with the index and middle fingers extended, and place this on the table to represent a person's legs standing and form their dominant hand into an O-handshape (fingertips touching the thumb, creating a circle) to represent the ball that is kicked in the video. They then extend the index finger of their non-dominant hand (the leg) to make contact with their dominant hand (the ball), and then show the movement of the ball my moving their dominant hand away in an arcing path.

Figure 45: Participant (age 8;9) representing someone kicking (neutral video, lexical condition). The participant produces the target sign KICK in its citation form, and then produces their own depicting construction (that they had not seen before in any condition) to represent kicking. They use the two extended fingers of one hand to represent legs, and the other hand to represent the ball being kicked.

Co-gesture Vocalizations

Although the young silent gesturers were instructed to communicate only through gesture and without speech during this task, many of them, particularly the younger ones, found this difficult to inhibit. As described at the end of section 4.3.1 (“Task”) this task is relatively complex for the youngest hearing children—while watching the stimuli videos, they must (1) identify what action/verb is happening as well as identify the difference between the two videos in each pair, (2) copy the target sign they are shown by the experimenter, (3) figure out how to use that sign to represent the verb and the relevant contrast, and (4) inhibit speech. That the younger children had a difficult time inhibiting their speech may be a result of the high cognitive load this task presents. To help the young silent gesturers understand that their gesturers needed to convey the relevant information and not their speech, we had the child communicate via gesture with a confederate wearing headphones, telling the child that the confederate couldn’t hear them and could only see them. Despite this, some children continued to vocalize. While any vocal components of the children's responses are not considered in our analyses of modification, they provide potential avenues of future analysis on children's multimodal expressions.

In some cases, the (not so) silent gesturers produced sound effects during their gestures that were evocative of the action or some aspect of that action (often speed). Figure *46* is an example of a silent gesturer producing the target depicting sign for RUN, modified for speed (faster), while producing a simultaneous sound effect (a whooshing/blowing noise) evocative of that speed. Note that in examples involving both the vocal and gestural modalities, gesture responses are described on the top line, and vocalizations represented on the bottom line.

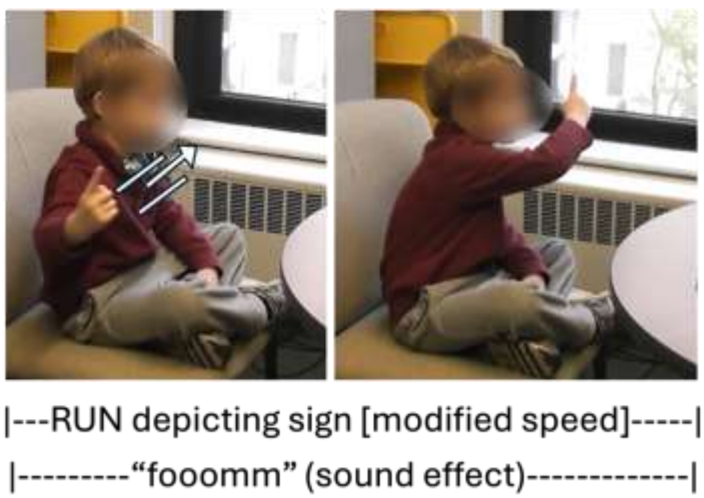

Figure 46: Participant (age 4;8) representing someone running (speed change, lexical condition). The participant produces the target depicting sign RUN modified to show the speed contrast, while also producing an iconic sound effect evocative of speed.

When the silent gesturers included speech in their response, it typically occurred either immediately after seeing the videos for that trial (at which point the experimenter would remind them to use silent gesture and not to speak), or after they had produced their gestured response in a way that reiterated what they had been trying to represent in their gestures. In the example shown in Figure *47* below, a participant produces the target depicting sign for RUN, modified to show speed (faster) while simultaneously producing a sound effect, and then after the gesture is complete, he adds the spoken description "It's spaceship fast".

Figure 47: Participant (age 5;6) representing someone running (speed change, lexical condition). The participant produces the target depicting sign RUN modified to show the speed contrast, while also producing an iconic sound effect evocative of speed. He then adds a spoken description, explicitly mentioning the speed of the action.

These spoken descriptions generally commented on new information being entered into the "discourse" – that is, information that the silent gesturer was themselves finding a way to depict, rather than commenting on or simply labeling the verb signs being given to them by the presenter. For example, silent gesturers were more likely to add spoken descriptions when representing the altered video (the second one in the pair) than when representing the initial neutral/unaltered videos in the trial pair (i.e., an instance where the participant would typically re-produce the sign they were prompted with without modification). These descriptions would often mention the relevant contrast that was being represented (e.g., "she did it fast", or "zig-zag") rather than simply reiterating the verb ("kicking"). Figure *48* and Figure *49* below show two examples of a young silent gesturer that expresses the relevant dimension changes for each trial in three ways: by modifying the target sign, by adding an additional gesture they had created, and through simultaneous speech.

Figure 48: Participant (age 5;6) representing someone combing their hair (path change, depicting condition). The participant produces the target depicting sign COMB modified to show the change in path contrast. They then produce their own additional gestures which trace the new path of the action using an extended index finger. While producing these tracing gestures, he says "down, and side", again commenting on the path change.

Figure 49: Participant (age 5;6) representing someone hugging another person (speed change, depicting condition). The participant first produces a non-target gesture that they spontaneously generated in which the hands are begin at either side of the chest with palms facing forward and then they both quickly extend forward in a pushing motion. While doing this gesture, the participant says "faster". They then proceed to produce the target depicting sign for HUG unmodified for speed, while saying "slow", followed by the same target depicting sign now modified for speed, while saying "then fast".

Embodied action

The hearing children often incorporated other parts of the body into their responses simultaneously, such as kicking their feet when gesturing about kicking, as in Figure *50* below.

Figure 50: Participant (age 7;9) describing a kick (speed manipulation, lexical condition). The participant simultaneously produces the target sign KICK while also kicking out his own leg, representing the speed change in both.

Many participants incorporate these embodied actions as well as other non-manuals into their gestures, and non-manuals from the torso up (visible to the experimenter and camera) were not explicitly discouraged. These included leaning the torso to the side, “wiggling” in their seat, shaking their head, and were used to enact the verbs in a more embodied way (e.g., actually kicking for KICK trials), to mark the speed or path variations (e.g., kicking their legs or wiggling in their seats to show some action was happening fast), or both. This was not unlike what was observed among the deaf signers, with many of them (particularly the younger signers) enacting the different actions (kicking, running, combing) either concurrently with their signs, or sequentially.

Novel Iconic Mappings

There were several notable features of the silent-gesturers productions that distinguished them from the deaf signers. One of these was related to their perception of the target sign form. Because the silent gesturers in this task had no exposure to any sign language, all of the target sign forms were unfamiliar to them, and unsurprisingly, they would at times struggle to reproduce the signs accurately. Although the experimenter would have them watch and copy the target sign form before each trial and would continue showing them how to produce the sign until they were reasonably successful before beginning the trial, there was still more variation in the formational realization of these signs among the silent gesturers than among the signers. In some cases, the silent gesturers would alter the form of the sign in a way that reflected a different interpretation of how the features of that sign might map to the referent. In the example shown in Figure *51*, the silent gesturer is producing the target lexical sign RUN while describing the neutral/unaltered video (meaning this response was not intended to reflect any contrast in dimension). Before the trial begins (not pictured), she correctly copies the citation form of the sign from the experimenter, which involves the two hands moving forward in a straight line together, connected via the index finger of one hooking around the thumb of the other. However, when she begins describing the first (unaltered) video showing a person running in a straight path, she represents this by initially starting with the hands together (in the correct handshape), but then separates them and moves the dominant hand forward to replace the nondominant hand. After re-connecting them in this position, she separates them again, this time moving the nondominant hand forward, and so on, incrementally moving each articulator forward incrementally. This may reflect her interpreting the hands as each representing a foot or a leg, and therefore to be moved independently to reflect strides. She may have been sensitive to the lack of transparent iconicity in this sign and opted to modify the form in a way she felt was more transparent.

Figure 51: Participant (age 7;8) produces a version of the lexical sign RUN in which she modifies the form to move the hands independently, possibly depicting strides/steps. Note that this is not intended to depict a path or speed manipulation from the stimuli, as this was produced while gesturing about the "neutral" unaltered event video.

This has been observed in studies of iconicity perception in non-signers, where those unfamiliar with a sign may "over-interpret" parts of the sign to be iconic that signers do not (Sevcikova Sehyr & Emmorey, 2019).

Modification Profiles

Recall that the vast majority of young deaf signers fell into one of two modification profiles for lexical signs: (1) high overall modification + little/no difference between path and speed, or (2) modifying speed more than path. In contrast, hearing children using silent gesture overwhelmingly fell into this first category, modifying path and speed very frequently with little to no distinction between them, both for lexical and depicting signs. Figure *52*andFigure *53* below show the modification patterns for the young silent gesturers for both lexical signs (Figure *52*) and depicting signs (Figure *53*).

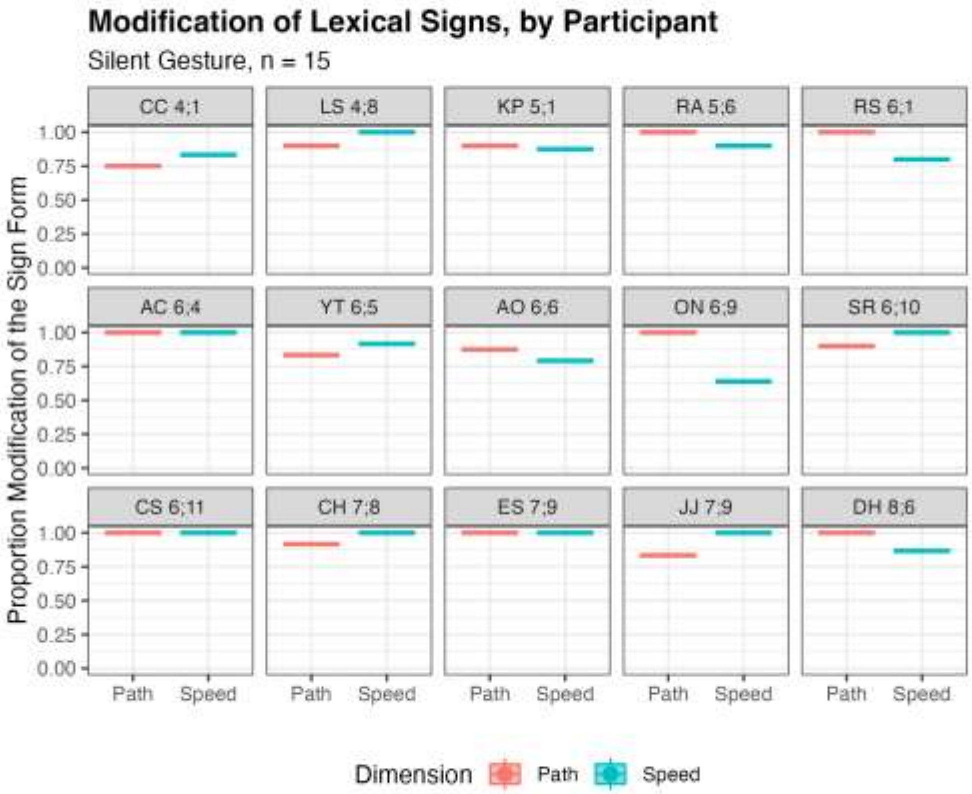

Figure 52: Modification patterns for hearing child participants, lexical signs

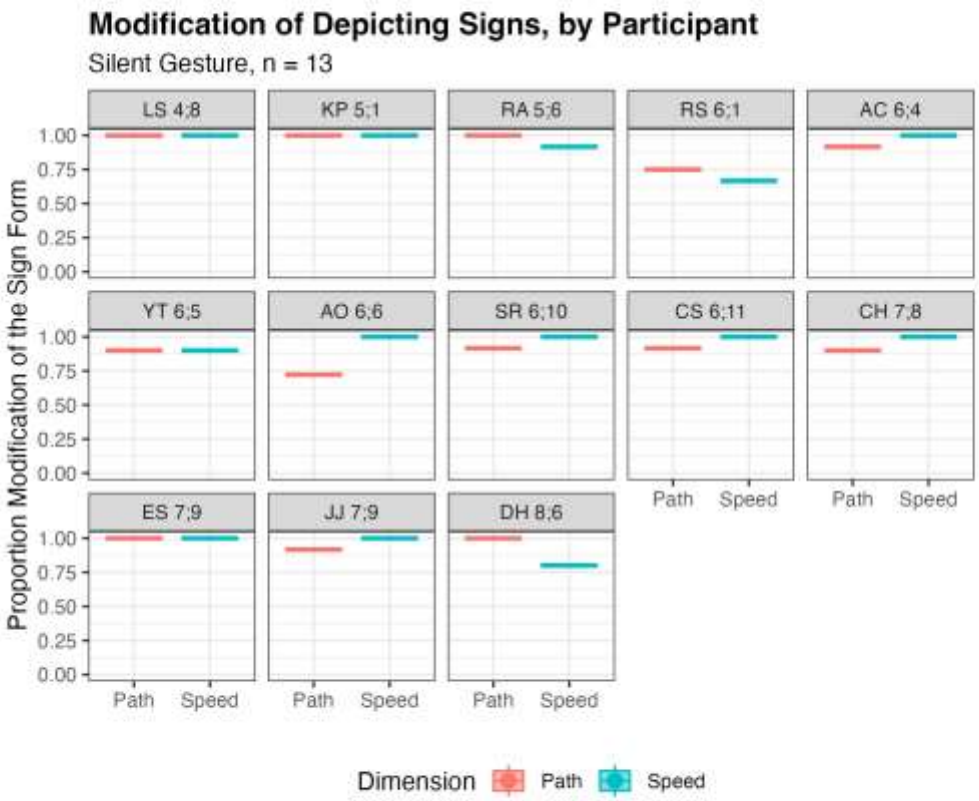

Figure 53: Modification patterns for hearing child participants, depicting signs

Applying the same threshold for what counts as differentiation between speed and path as we do for the signers (a difference of >= 0.25 , <= -0.25), only two of the individual plots shown above meet this criteria: AO modified speed more than path in depicting signs and ON modified path more than speed in lexical signs. All remaining participants show little to no difference in their treatment of the two dimensions for both lexical and depicting signs.

Condition and Dimension

The hearing children in the silent gesture task treat both the lexical and the depicting sign forms as highly modifiable across both conditions and dimensions. The mean proportion modification rates broken down by condition and dimension, are reported in Table 4.3Table *4.3*.

Table 4.3 How often signs were iconically modified along each dimension by child silent gesturers

Dimension	Lexical Signs	Depicting Signs
Altered Speed	*M* = 0.95, *SD* = 0.24	*M* = 0.94, *SD* = 0.19
Altered Path	*M* = 0.93, *SD* = 0.17	*M* = 0.92, *SD* = 0.21

Hearing children did not distinguish between lexical and depicting signs [$t(12) = 0.27$, $p = 0.79$; *Wilcoxon V* = 40, $p = 0.969$] and there was no significant difference between modifications for path and for speed in either the lexical or the depicting condition [lexical condition: $t(14)= 0.53$, $p = 0.6$, *Wilcoxon V* = 44, $p = 0.723$; depicting condition: $t(12)= -0.83$, $p = 0.42$; *Wilcoxon V* = 15, $p = 0.392$]. These data are visualized in Figure *54*.

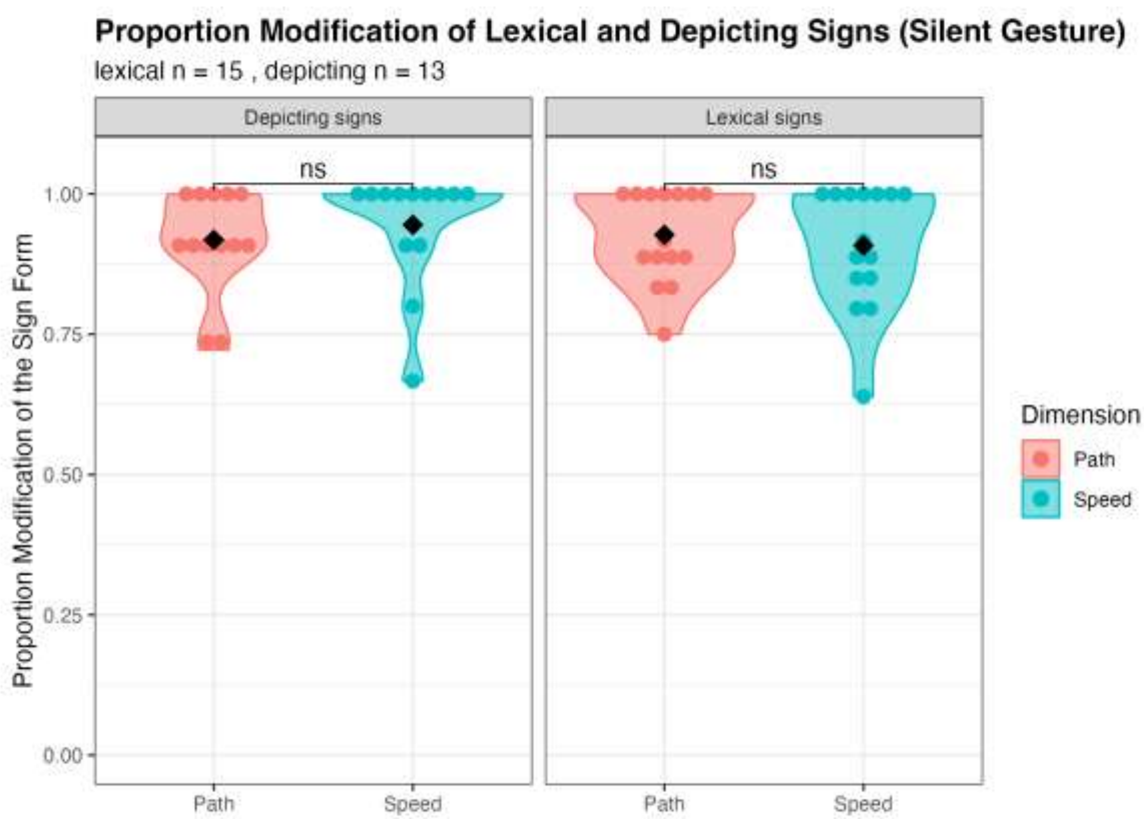

Figure 54: Rate of modification of the target sign by silent gesturers (children), separated by dimension (path vs speed) and condition (lexical vs depicting).

The high overall rate of modification indicates that the child participants identified the sign prompts as representative of the verb in each video, and successfully identified the different variations in the video pairs, suggesting the stimuli are sufficiently clear and comprehensible.

Iconicity & Age (Null effects)

Correlations between iconicity and modification do not reach significance for hearing participants in either condition (lexical signs: $r_s = 0.028$, $p = .74$; depicting signs: $r_s = .058$, $p = .51$). Because the young silent gesturers modified the target signs at such a high rate (more than either the deaf children or the hearing adults), there is likely insufficient variation in young silent gesturers' modification behavior to capture any possible effect of iconicity.

Modeling: Hearing and Deaf (Lexical condition only)

Below we report the results of a quasibinomial logistic regression model that now includes data from both deaf and hearing participants (lexical condition only). We include fixed effects for Dimension (speed vs path), Subject group (deaf vs hearing), Iconicity of the sign, and Age (in months). We also include interaction terms for Dimension:SubjectGroup. The output of this model is summarized in

Table 4.4.

Table 4.4 Summary of model output for the following model:

Modification ~ Dimension+ SubjGroup + Iconicity + Age + Dimension:SubjGroup

	Est.	S.E.	t val.	p
Intercept	0.31	0.64	0.49	0.62
DimensionSpeed	1.23	0.26	4.68	0.000004***
Iconicity	0.23	0.10	2.41	0.017*
Age	0.01	0.01	0.75	0.45
SubjGroupHearing	1.88	0.44	4.30	0.00002***
DimensionSpeed:SubjGroupHearing	-1.67	0.60	-2.80	0.005**

$\chi^2(5) = 36.86$, p = 0.00
Pseudo-R^2 (Cragg-Uhler) = 0.08
Pseudo-R^2 (McFadden) = 0.05

Of our fixed effects, Dimension, Iconicity, and Subject Group emerge as significant predictors. We also find a significant interaction between Dimension and Subject Group. Participants were significantly more likely to internally modify the target form for speed than for path (β = 1.23, *t* = 4.68, *p* < 0.0001, 95% *CI* [0.73, 1.76]). Iconicity of the target sign also emerged as a significant positive predictor of modification (β = 0.23, *t* = 2.41, *p* = .016, 95% *CI* [0.04, 0.42]). Hearing participants were significantly more likely to modify target signs than were deaf participants (β = 1.88, *t* = 4.30, *p* < .0001, 95% *CI* [1.09, 2.83]). Lastly, there was a significant interaction between Dimension and Subject Group, where the difference between path and speed modifications was significantly smaller for hearing participants than deaf participants (β = -1.67, *t* = -2.80, *p* = .005, 95% *CI* [-2.88, -0.51]). All VIF values fall between 1.01 – 2.61, indicating that multicollinearity is not an issue for this model.

4.3.3 Interim Discussion

The results of Study 3b offer valuable insights into the sign modification strategies employed by deaf signing children observed in Study 3a when depicting aspects of motion in lexical and depicting verbs. The results of this study shed light on how deaf signing children navigate the complex interplay between gradience, iconicity, and linguistic constraints. Deaf children exhibit different modification patterns depending on the type of sign and the specific dimension being depicted, suggesting a complex interplay between linguistic structure and iconic representation: certain signs, and certain features of that sign-form, are more available for depiction than others. Study 3b finds that these intuitions are not shared by non-signers. While both groups of children (signers and non-signers) modify the target signs in this task frequently, only the young signers appear sensitive to which dimensions of a sign are more or less amenable to modification. While the deaf children were less willing to modify path than speed for lexical signs (not depicting signs), the hearing children treated both of these dimensions, and both classes of signs, as highly flexible to modification. This suggests that deaf children acquiring ASL have a developing sense of the ways in which gestural depiction (gradience, iconicity) fits within the confines of a linguistic system.

GENERAL DISCUSSION & CONCLUSIONS

Summary of findings

Together, Studies 1-3 explore signers' and gesturers' use of iconic, gradient, depiction in manual communication. In Study 1 we investigate to what extent iconic modification of lexical signs occurs in American Sign Language (ASL) and what influences this phenomenon. In the case where both gestural and linguistic modes of representation exist within a single modality (as is the case for manual gesture in sign as well as vocal gesture in speech), there will likely exist restrictions on the way in which the two semiotic codes are combined, particularly for features that are elsewhere contrastive or more phonologically specified. We find that signers do indeed modify lexical signs as well as depicting signs, but that these modifications appear restricted—some dimensions of movement are more modifiable than others. Additionally, we found that signs that were more iconic themselves were more likely to be iconically modified.

We next explored the extent to which the observed patterns in signers were unique to signers, or if they arose out of broader influences on manual communication that affect gesturers as well. If the constraints on the use of depiction are the result of sign-specific restrictions on combination (of depiction and description), they should distinguish those that know the language (and are therefore familiar with how those restrictions manifest) from those that do not. We find signers are distinct from silent gesturers on this task, both among adults (Study 1) and children (Study 3a). While both signers and non-signers depict motion events via the gradient modification of these sign forms, only signers are restricted in how these modifications can be applied, suggesting that linguistic knowledge and signing experience underlie signers' intuitions about depiction. However, both groups were influenced by the iconicity of a given sign form, treating more iconic signs as better suited for depiction than less iconic signs.

In Study 3a we asked how deaf children acquiring ASL approached gradient depiction. We found that deaf children frequently modified both lexical and depicting signs to express different movement contrasts, more so than did the adult signers in Study 1. However, we found evidence that deaf children are sensitive to the ways in which movement is constrained in their language: path was treated as less modifiable than speed within lexical signs, but not within depicting signs, mirroring the adult pattern. Study 3b likewise demonstrates that this effect is not simply a feature of the manual modality, but rather depends on a child's experience with a sign language. For young deaf signers, these manual depictions must fit within a broader linguistic system, which brings with it certain restrictions on how gradience can be overlaid on categorical forms.

Limitations of the current work and possible future directions

The findings presented in Studies 1 – 3 lay the groundwork for several promising avenues of future research aimed at further elucidating the mechanisms and implications of iconic modification in sign. In the current research, our signer and non-signer populations are distinguished both by their knowledge of ASL as well as by experience with a sign language more broadly. That is, our results cannot directly speak to whether the observed differences between signers and non-signers is due to signers' knowledge as a signer of any sign language, or if this is ASL-specific knowledge that a signer of a different sign language would not have access to. Future work looking at signers of a non-ASL sign language on this same task will shed light on whether and how these patterns are tied to ASL versus sign languages more broadly.

Comparative studies across different sign languages could shed light on the universality versus language-specific nature of sign modification strategies. Exploring how signers of different languages utilize modification to convey similar concepts or nuances could uncover underlying principles of iconicity and linguistic structure.

Another avenue for future inquiry is in examining this phenomenon longitudinally across development. Conducting longitudinal studies tracking deaf children's development of sign modification skills over time would provide valuable insights into the trajectory of these abilities. By examining how modification patterns evolve throughout different stages of language acquisition, researchers can gain a deeper understanding of the developmental processes underlying children's understanding of depiction and its relationship with language.
Exploring how these skills may vary with children's early language background would likewise elucidate the extent to which early exposure shapes children and adults' understandings of the interplay between language and gesture in ASL. In Study 3, the majority of the signers acquired ASL starting from birth through their deaf parent(s). While the later-exposed participants in our sample did not demonstrate markedly different patterns of modification from the rest of the participants, more data is needed to speak to the possible role of language background on this phenomenon.

Implications for ongoing work

As discussed in section 2.4, this work represents an important contribution to multiple ongoing issues in research on iconicity and depiction. First, the approach used in studies 1-3 allows us to isolate the use of iconicity, gradience, and modification as used for meaningful depiction from other uses such as emphasis or salience. The modification of iconic word forms, such as onomatopoeia and ideophones in spoken languages , has been well documented. However, much of this evidence comes from research on child-directed language and highlights the use of modification to draw attention to these words, mark them as unique, or to bootstrap the learning of those lexical items by exaggerating features of the form that correspond to the abstracted meaning of the word (Fernald & Morikawa, 1993; Herold et al., 2012; Laing et al., 2017; Nygaard et al., 2009; Perniss et al., 2018; Perry et al., 2018; Sundberg & Klintfors, 2009; Toda et al., 1990; Yoshida, 2012). In the present work, gradient modifications are not used to increase salience or bootstrap word learning, but instead are used to depict specific meaningful changes in meaning to an interlocutor, and modifications of this nature are also related to the iconicity of the base sign form. One reason that the spoken language literature cited above often connects modification of word forms to heightened salience rather than depiction of meaning (with some exceptions, e.g., Herold et al., 2012, Nygaard et al., 2009) may be due to the affordances of the vocal modality for depiction of meaning. One reason spoken languages are often described as being "less" iconic than are sign languages comes from the constraints on what kinds of meaning can be iconically represented through sound. For example, information about loudness is easy to iconically capture vocally, while spatial relations or visual shape are not (Dingemanse, 2013; Dingemanse et al., 2015; Meir et al., 2013). This may likewise limit the extent to which modifications to spoken words are able to iconically capture gradient changes in meaning, and these modifications instead serve to draw attention to these words rather than change their meaning.

These results highlight the value of a scalar notion of iconicity, where words and signs may be more or less iconic, as opposed to a binary notion of iconicity as simply present or absent. For both signers and silent gesturers, the relationship between sign iconicity and gradient modification is revealed only through a scaled score of iconicity. This approach is relatively new, but is growing in popularity due to its benefits, which include more nuanced analyses of iconicity effects on language as well as the ability to make cross-linguistic and even cross-modal comparisons (Caselli et al., 2017; Dingemanse & Thompson, 2020; Perry et al., 2015, 2018; Thompson et al., 2012; Vinson et al., 2008, 2015; Winter et al., 2017).

This work additionally emphasizes iconicity's role as situated within a communicative context. The modification to "frozen" lexical forms we report here demonstrate a way in which depiction may feature prominently within language that is not captured when language is abstracted away from the context in which it occurs. While they represent the overwhelming focus of language research to date, the structured, categorical elements of language, isolated from other contextual components of communication represent an incomplete picture of language and how it manifests. Categorical elements of speech and sign do not exist alone in situated communication. Meaning is created through multiple channels and multiple semiotic codes simultaneously and is tied to the environmental and discourse context in which it occurs (Clark, 2016; Mondada, 2019; Holler & Levinson, 2019; Kendon, 2012, 2014; Perniss, 2018; Vigliocco et al., 2014). The gradient depictions signers produced in our task were created in the moment to disambiguate between two specific referents. While the experimental constraints of our studies provided necessary statistical power and allowed us to leverage the lexical versus depicting status of our target signs (among other factors), future work exploring this phenomenon in a more natural communication context will shed further light on how frequently these modifications feature in typical signed communication.

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