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“More is up” for domain restriction in ASL*

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Abstract This paper investigates a form-meaning mapping in American Sign Language (ASL) whereby pronouns, verbs, and quantifiers can be produced progressively higher in signing space to signal a widening of their contextually supplied domains. We show that this is not a gesture-like expression of surprise, uncertainty, or quantity, and is also not equivalent to well-studied domain-widened quantifiers in spoken language, but rather involves reference via plural pronouns in ASL. When appearing with verbs these pronouns are incorporated as arguments and when appearing with quantifiers as a partitive-like domain restriction. In addition, we show that the use of continuous space along the height dimension in ASL allows for gradient interpretations of domain widening and narrowing. We contrast the grammatical functions of this use of height in sign languages with superficially similar gesture and prosody accompanying spoken language.

Keywords: domain restriction, domain widening, quantification, sign languages, loci

1 Introduction

All languages provide an array of semantic information that allows conversational participants to keep track of discourse referents, although which are used in a particular language may vary. For example, some languages use gender features to keep track of possible antecedents for pronouns or omitted arguments of feature-marked verbs, while others use noun classes related to properties like animacy, size, proximity, etc. Yet other languages mark discourse-related properties like definiteness or specificity on noun phrases. In addition to these, sign languages are also known to make use of a modality-specific means of tracking discourse referents

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using three dimensional space in which, broadly speaking, noun phrases signed in the same location in space (sharing a referential "locus") co-refer (1).

- (1) FS(Alex)-a LIKE FS(Beth)-b. IX-a SMART.¹²
‘Alex likes Beth. She (Alex/*Beth) is smart.’

Sign language loci have featured prominently in discussions in sign language semantics, resulting in an overall picture that sign language loci allow for distinctions unique to the language mode, yet can be modeled using the same principles of linguistic structure found in spoken languages (Lillo-Martin & Meier 2011).

We focus here on another distinction that sign languages appear to make that spoken languages do not make in the same way, related to domain restriction. To illustrate the distinction, consider the following context: A group of several friends watch a movie together about one of their favorite kinds of fantastical characters: vampires. The next morning, one of these friends is recounting the evening to a third party and reports in English, "Last night I watched a movie with my friends about vampires. Afterwards I went to bed and I dreamt that everyone became vampires." In the English version, the speaker could mean (among other possible interpretations) that they dreamt that everyone who was watching the movie became vampires (2a), or also she could just as easily mean that she dreamt that everyone in the entire world became vampires (a reasonable possibility in a horror movie scenario) (2b).

- (2) Last night I watched a movie with my friends about vampires. Afterwards I went to bed and I dreamt that **everyone** became vampires.
- Everyone in that story (your friends) became vampires.
 - Everyone in the entire world became vampires.

In an example like (2), the listener is tasked with figuring out who exactly the speaker meant to include by "everyone." Note that both (2a)-(2b) involve universal quantification, so we can't attribute any difference in interpretation to the logical force of the quantifier. Rather, the difference seems to lie in the restriction of the domain for universal quantification: is *everyone* restricted to individuals in the story already mentioned or to everyone in the world? Usually this resolution happens

1 In (1) and throughout this paper, when a discourse uses contrasting arbitrary loci, typically on contra- and ipsi-lateral sides of signing space, we will note them as $-a$ and $-b$ following convention; these constrain coreference. When glosses do not include any horizontal locus, it indicates no contrastive use of horizontal signing space in that discourse fragment (i.e. "neutral" horizontal space).

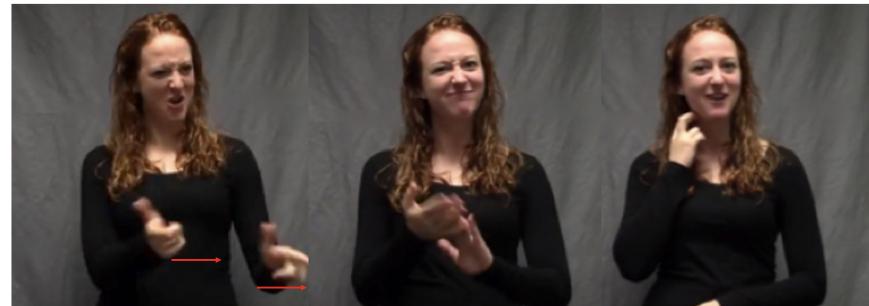
2 Throughout this paper, we have aimed to follow sign language glossing conventions (Hochgesang 2020), and employ searchable ID glosses for ASL (i.e., the ASL Signbank, Hochgesang et al. 2020). Core new data will include photos, as well as select videos on our OSF site: <https://osf.io/2h6ge/>

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seamlessly: sometimes later information cues in the listener in how many people should be considered, sometimes it doesn't matter, and sometimes it's clear in context who speakers intend. In an example like (2), though, the resolution is left to conversationalists' (substantial) pragmatic capacities.

By contrast, in American Sign Language (ASL) a distinction between the intended interpretations (2a) and (2b) of the sentence in (2) is naturally made in the linguistic form of the quantifier itself. Consider (3) below in ASL, signed in the same context as (2). The signer can sign FS(ALL) lower or higher in space (as shown in the accompanying photo), and this reflects a difference in meaning such that when signed lower (at an unmarked neutral height) it only quantifies over the smaller domain of friends who watched the movie (3a) and when signed higher it quantifies over a much wider domain, most naturally in this case everyone in the world (3b).³

- (3) Context: Signer has just said, "Last night I watched a movie with my friends about vampires. Afterwards I went to bed and I dreamt that..."



a. FS(ALL)-neutral BECOME VAMPIRE

'All of my friends became vampires'
'All of the people in the world became vampires'



b. FS(ALL)-high BECOME VAMPIRE

'All of the people in the world became vampires'
'All of my friends became vampires'

³ Here we follow the convention that a translation preceded by the symbol # indicates an unavailable interpretation for the form given the context.

Sign languages have been argued to make overt certain aspects of linguistic structure that are covert in spoken languages, across several unrelated areas within semantics (Lillo-Martin & Klima 1990, Wilbur 2003, Zucchi 2004, Quer 2005, Wilbur 2008, Schlenker 2011, Caponigro & Davidson 2011, Quer 2012, Kuhn & Aristodemo 2017, among many others). This distinction in expression of quantificational domains in (3) above, then, raises questions about both the structure of the quantified noun phrase in ASL and also how it might shed light on the nature of domain restriction in language generally, a topic long of interest to those working at the syntactic/semantic/pragmatic interface.

Our goal will be to provide a compositional analysis of the sensitivity of height to quantifier domain size exemplified in (3). Given only (3), several potential analyses could apply. First, one might want to analyze this sensitivity to height as (a) a variable, overt in sign languages but covert in spoken languages, for domain widening, following the idea that sign languages may visibly manifest structure that is covert in spoken languages. Such a variable might be attached at various structural positions within the quantified noun phrase, possibilities that we review below. We also might consider higher vertical expression to be (b) similar to well-known epistemic indefinites like German *irgendein* and its kin, acting as a dedicated domain widened version of quantifiers. The use of height could also be simply (c) emphatic, like increased pitch or volume in spoken English, or perhaps it (d) functions in the same way as a co-speech gesture for height might if added to English speech.

We argue that none of (a)-(d) are entirely correct, but rather that (e) this use of height occurs only in structures that contain (sometimes morphologically incorporated) pronominal elements. The initial observation that it appears co-produced with a quantifier might make one suspect it is a morphological addition to the quantifier itself (the syntactic determiner) or to a noun phrase within a quantified DP (the syntactic NP) in the various ways we suggested in (a)-(d) above, but we provide evidence that instead it is contributed by a pronoun that forms a partitive to create the restrictor NP. Given that height contributes this meaning via pronominals, the question becomes: is this a kind of morphosemantic feature that we are already familiar with? In spoken languages, we typically think about gender and number as features on pronouns that contribute a specific semantic content, but this semantic content for pronouns is not typically something like contextual availability. We connect our answer here to work on the use of both horizontal and vertical spatial loci in pronouns in sign languages. Finally, we address the observation that this use of height in ASL is something that even non-signers seem to find familiar, and suggest that in ASL it falls more clearly on the language side of the gesture/language spectrum than superficially similar uses of height in speech and co-speech gesture. In the remainder of this introduction, we will review the nature of quantifier domain

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restriction in spoken languages to position our contribution from ASL (1.1), and then describe our methodology for data collection (1.2).

1.1 Quantified noun phrases and domain restriction

We have seen the use of height exemplified in (3) to convey information about the domain of the quantifier ALL. In this section we review existing proposals for how quantifier domain restriction works in spoken languages.

One type of solution to the problem of contextual domain restriction is for the **pragmatics** to take the full burden (Bach 1997). Under a pragmatic solution to, e.g. the English example we saw in (2), the semantics is as it appears on the surface, a statement of universal quantification over all individuals in the universe. Domain restriction comes about via pragmatic reasoning based on the low probability that a speaker would want to quantify over, or even know anything about, everyone in the world. Because the literal interpretation is often unlikely to be intended by the speaker, the listener must adjust their interpretation of the quantifier's domain to a more restricted group in what is essentially a kind of quantity based conversational implicature. In other words, English speakers are constantly juggling both a basic semantic and enriched pragmatic meaning to these sentences, perhaps in a way that ASL signers need not. We purposely picked an "ambiguous" example for (2) that could be just as reasonable in a widened or restricted context, but many real life examples such as "Everyone came to the party" are clearly unlikely statements to hold of everyone in the entire universe, so it seems reasonable at first blush that a pragmatic story could restrict the contextual domain in such situations.

As has been widely discussed, a purely pragmatic story runs into difficulty with more complex examples of contextual domain restriction (Breheny 2003, Stanley & Szabó 2000, Stanley 2002). Consider (4): "everyone" who transforms into vampires must still be contextually restricted, since it could just be the relevant "everyone"/your friends, or everyone in the whole world. However, the relevant group can also vary with the quantifier "usually", so that perhaps a different group of friends (who watched the movie) is turning into vampires each time.

- (4) Last night I watched a movie with my friends about vampires. Usually when I do this, I dream that everyone becomes vampires.

Such examples show that there must be a place in the linguistic representation of the sentence with the universal quantifier that contains information about the contextually supplied domain, which itself can be bound by the higher quantifier "usually". This is indirect evidence in English for structural representation of the domain. Our ASL example in (3) actually provides more direct evidence, given that

a difference in form corresponds to a difference in meaning regarding domain size. Therefore, we move on from purely pragmatic explanations to a search for a place for domain size information within the linguistic structure of QNPs.

One possible structural solution for domain restriction is **syntactic ellipsis** (Sel-lars 1954, Collins 2018), positing an explicit domain in the structure, unpronounced in most cases in English (5) but potentially overt in ASL.

- (5) a. Everyone [I watched a movie with] becomes vampires.
b. Everyone [in the world] becomes vampires.

The problem with a straightforward ellipsis analysis of domain restriction in the English example is that what is elided is radically underdetermined. For example, one could arrive at the right interpretation for (5) with many other options for the elided clause: "everyone who was there during the movie", "everyone who enjoyed the movie with me", "everyone I sent an invitation to that day", etc.

Under yet another approach, quantifier domain restriction occurs as an open **contextual variable**. In their instantiation of such a system, Stanley & Szabó (2000) propose that an open context variable C consisting of all of the individuals in the relevant context exists as part of the NP restriction of a quantifier. As illustrated in (6) with a separate complement, under their analysis the variable combines with the restrictor of the quantifier (e.g. women in (6)) first. This intersects the restrictor nominal with the context set, providing the interpretation that all friends (or all people, for *every one*) in the relevant context turned into vampires. The set C may be the local context of the speaker's friends, or the wider context of the whole world, or something else: its content is provided via pragmatics.

- (6) Every [[C] friend/one] transformed into vampires.
'Every contextually relevant friend/individual transformed into a vampire'

An open context variable may be more complex than a set of individuals that intersect with the set denoted by the nominal restrictor. Von Fintel (1994) puts the domain restriction ("resource domain") in the determiner quantifier itself: (7) illustrates the proposed hierarchical structure, while a third logically possible analysis is that a contextual restriction occurs on the entire quantified noun phrase, as in (8).

- (7) [Every $_C$ [friend/one]] transformed into vampires.
'Every contextually relevant friend/individual transformed into a vampire'

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- (8) [Every [friend/one]]_C transformed into vampires.
 ‘Every contextually relevant friend/individual transformed into a vampire’

In what follows, we bring ASL data to bear on this question of the structural possibilities for quantifier domain restriction by showing how it enters via height in ASL exemplified in (3) in a way that is different from any of these possibilities, though it most closely resembles Stanley & Szabó (2000) in being located in the nominal restrictor. Although it would be tempting to say that sign languages make “visible” the domain variable that is merely covert in spoken languages, we argue here that this would be incorrect: sign languages do not make a covert quantificational domain argument overt any more than spoken languages do. Instead, we show that domain restriction via height in ASL occurs through the way that vertical height restricts the interpretation of a *pronominal* element inside the QNP, roughly *All [of [them/those [-high]]]*. What on its face looks like a visible instantiation of domain restriction from a separate variable is simply part of the semantic contribution by plural pronouns in ASL, and in the end the structure of the QNPs in ASL marked for height proceeds with exactly the same pieces as we see in the English partitive constructions *All of them* or *Everyone of them*, with the height in the equivalent of the pronominal *them*. We intend for the evidence and argumentation we use to analyze the structure of ASL here to provide insights on diagnosing sources of domain restriction across language more broadly.

Evidence for our analysis comes from, first, the use of height in the pronominal system we focus on in Section 2. Given that pronouns and pronoun-like elements appear in other places in language, we then test and confirm our analysis in adjacent areas of the grammar. Section 3 will illustrate the same use of height in verbs in ASL, and lay out arguments in favor of our analysis of this use of height in verbs as coming through incorporated pronouns. Section 4 will then return to quantifiers, extending the argument from verbs to argue that the domain restriction is also achieved through a pronominal argument akin to a partitive construction. Section 5 will formalize these observations. Section 6 will discuss this use of height for representing domain sizes found in other languages beyond ASL, and Section 7 concludes.

1.2 A brief note on methodology

The focus of this paper is on domain restriction in American Sign Language (ASL), the language of the Deaf and Hard-of-Hearing communities of the United States and parts of Canada. Our data and images are based primarily on in-depth consultations with two Deaf, native signers (one male, one female, both exposed to ASL from birth from Deaf signing parents). Additional supporting data and images are from three other Deaf adults (one male, two female), one a native signer and two who were each

exposed to ASL before age 2. We did not make an effort to balance participation in terms of geography, race, age, educational experience, or other important factors that may influence dialectal variation of ASL, so our conclusions should be understood to be limited to the variety of ASL signed by these participants. As such, we consider this study to be the first step in investigating these phenomena in ASL and encourage future studies to expand on our findings with a larger, more diverse set of data.

Our methodology consisted of three parts: first, participants chatted informally with the authors (one of whom, DG, is a hearing native signer) while being video-recorded about topics designed by the authors to elicit the use of height that we discuss below. Second, we made notes of the examples that were elicited, and asked participants to produce sentences with and without changes to them in front of the camera, or in other words to "play around" with how small changes in the targeted forms affected grammaticality. Third, example sentences deemed most natural by participants were recorded in "clean" versions in isolation to the camera, which are the ones that appear in figures here. We made a conscious choice to err on the side of reporting more natural examples accepted by all consultants, sacrificing in some cases perfectly controlled minimal pairs that had murkier judgments for reasons that are still unclear to us. Videos for illustrative examples 3, 25, 26, and 37 can be found on our OSF project site: <https://osf.io/2h6ge/>.

2 Height for signaling domain in pronouns in ASL

We begin with a brief discussion of loci in pronouns in ASL, including basic means for tracking discourse referents and other meaningful uses of spatial modification, in order to discuss a use that has not been previously described. We propose that this use relates to the relative size of sets that form the basis for plural pronouns, which we suggest is the same use seen in the domain restriction of quantifiers in ASL.

2.1 Background: Noun phrases and loci in ASL

In ASL, as in many other sign languages, a point of the index finger (IX) functions as a pronoun, unmarked for gender. With appropriate contextual support, nominal reference can be made via such a pronoun (9a), argument omission (9b), bare noun phrases (9c), or a combination of IX and noun phrase (9d). It has been argued that IX can sometimes be used as a definite article when it is prenominal as in (9d) like "the" in English (MacLaughlin 1997) or the 'strong definite' in German (Irani 2016). Others have argued that ASL is an 'NP language' in the typology argued for by Bošković (2005), concluding that all noun phrases in ASL are bare noun phrases, and such uses of IX are modifiers of some sort (Koulidobrova 2012) or demonstratives (Koulidobrova & Lillo-Martin 2016). Barberà (2015, 2012) has suggested that the

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prenominal IX in examples like (9d) marks specificity, not definiteness, at least in the equivalent in Catalan Sign Language but also possibly extending to ASL.

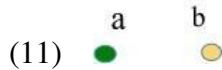
- (9) a. NS(Mia) LOVEs IX-a.
"Mia loves her/him/it/them(singular)."
- b. NS(Mia) LOVEs.
"Mia loves her/him/it/them"
- c. NS(Mia) LOVEs WOMAN5.
"Mia loves a/the woman/women"
- d. NS(Mia) LOVEs IX-a WOMAN5
"Mia loves the/that/SPEC woman"

For our purposes it will not be directly relevant how we analyze prenominal IX, since we will primarily focus on uses of index-finger pointing sign IX where it appears on its own as a pro-form as in the **singular** form in (9a) and the **plural** form IX-arc in (10). Example (10) illustrates a common sentence structure in ASL: base word order is subject-verb-object, and we see the subject FRIENDS in sentence-initial topic position (marked overtly with raised eyebrows on FRIEND), and the pronominal IX-arc_a appears in its argument position. The plural form IX-arc_a traces out an arc or circle to outline a 2-dimensional area in front of the signer. The area traced out by IX-arc in (10) is noted here as *a*, since the space chosen (the plural "locus") is for our purposes arbitrary.



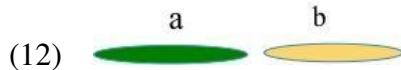
As we noted at the outset, one way of keeping track of discourse referents in ASL is through a system of spatial “locus” co-occurrence. As an example, consider (11). The signer spells the name FS(Jordan) in one location (the locus “*a*”) in signing space. Unless otherwise specified, this location is at a “neutral” vertical signing height (approximately mid-torso) and either to the signer’s right or left. They can then express another name FS(Alex) at a different location at neutral signing height, usually the opposite side (left if right) from the first name (here, locus “*b*”). The

establishment of these names in space then allows a pronoun in the next sentence IX to unambiguously refer to one of these referents depending on which location it points to (if *a*, then Jordan is the referent; if *b*, it is Alex). We include (11b) to show that association of discourse referents with locations in space is optional, although it is frequently used if the continuing discourse will be making reference to their contents and especially in cases requiring contrast (Ahn et al. 2019).



- a. FS(Jordan)-a LIKE FS(Alex)-b. IX-a SMART. *singular with locus*
'Jordan likes Alex. He (Jordan) is smart.'
- b. FS(Jordan) LIKE FS(Jordan). *singular, no locus*
'Jordan likes Alex.'

We focus in this paper on plural discourse referents, which display these same properties. Like the singular the use of loci, associating plural noun phrases with loci is optional but frequently used when the contents will be referred to again in subsequent discourse and involve contrast (12).

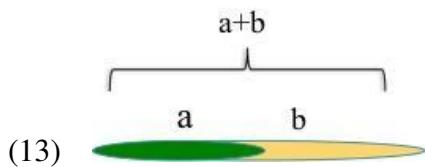


- a. MANY STUDENT IX-arc-a LIKE TEACHER IX-arc-b.
IX-arc-a SMART. *plural with locus*
'Many students like the/their teachers. They (the students) are smart.'
- b. MANY STUDENT LIKE TEACHER. *plural, no locus*
'Many student(s) like the/their teacher(s).'

Schlenker et al. (2013) highlight a further property of plural loci (emphasized by Liddell et al. 2003), which is that they follow what they call an "iconic geometry." By this, they mean that the spatial relationship (specifically: the set/subset relationship) of the arc/circles in 2-dimensional space in the default/neutral locus plane should correspond to the same relationship of their referents. So, if a signer establishes a plural locus for a plural referent (for example, a group of students), and then later wants to establish a plural locus for a subset of this group, that second locus should spatially take up a subset of the space of the first locus. Similarly, if one establishes a locus for a group and later wants to establish a locus for a superset of this group, the new locus should be a superset of the space of the first locus (13a). Furthermore,

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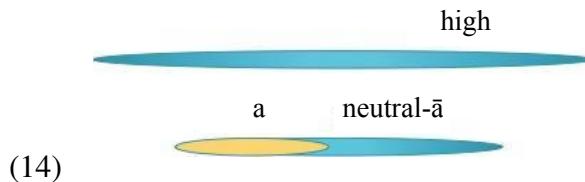
they note that the way that the locus system makes use of geometry provides access to discourse referents that are otherwise more difficult in non-spatial languages, as in complement set anaphora: in (13) the signer can assign the large group of students to a large locus ($a+b$) and assign a subset of that set to a subset locus (a), and then by the enforced mapping can simply point to the remainder of the large locus (b) to refer to the complement (boys) of the smaller set within the large set. Schlenker et al. note that a rough translation with the same meaning is ungrammatical in English, since the only available discourse referents for the plural third person pronoun are the large set and the smaller set (13b).



- a. STUDENT IX-arc-a+b SMART.
GIRL IX-arc-a HAPPY.
IX-arc-b NOT HAPPY.
'The students are all smart. The girls (a subset of the students) are happy, but the others are not happy.'
- b. The students are smart.
The girls are happy.
#They (intended: the ones who are not girls) are not happy.

To this discussion we add a further observation, briefly made in previous work (Davidson & Gagne 2014), that these plural loci need not always be established overtly to make use of the same system including its depictive geometric properties. One naturally expands the plural arc to the remainder of the geometric plane, which leads to an interpretation of a superset of any of these previously mentioned groups (essentially, the whole contextually available domain). In the picture in (14), we contrast this *contextually* available default plane with the *overtly* marked arcs by using blue colors in the figure accompanying (14). For example, in a single discourse a signer can establish a locus "a" for a group of students at a neutral height. This can be followed with an arc that traces out the remainder of the neutral signing space ("neutral- \bar{a} "), as if the whole low plane were the relevant superset, and is interpreted as everyone else in the current context besides the students (14a). Davidson & Gagne (2014) observe that if instead that same "whole plane" arc was made at a higher height (the plane noted as unspecific for indefinites by Barberà (2015)), the

interpretation is that the referent is of a much larger group, a superset of both the small original locus and the neutral superset (14b).



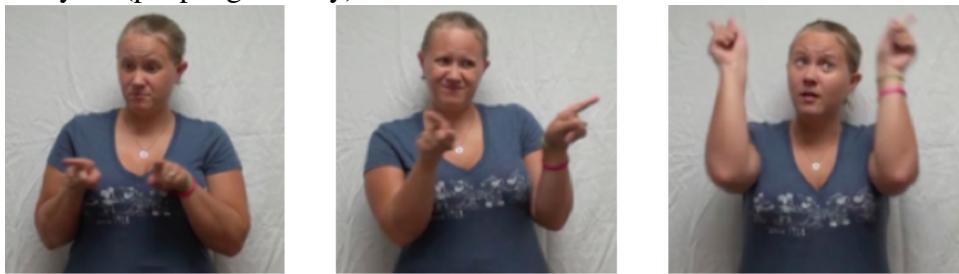
- a. STUDENT IX-arc-a SMART. IX-arc-neutral-ā NOT. *implicit loci*
'The students, they are smart. The rest are not.'
- b. STUDENT IX-arc-a SMART. IX-arc-high NOT.
'The students, they are smart. Generally, everyone else is not.'

In sum: the iconic geometry extends not just to overtly used loci, but to the relationship of these loci to other available planes. Moreover, the neutral signing space can be used with a plural pronoun to refer to the entirety/whole universe for the contextually relevant/restricted default context, while a higher space seems to allow reference to a superset of this set, when the signer wants to signal a larger domain than was already being considered.

One important fact about this use of height is that it is not binary, despite implications that might be drawn from our "high" vs "neutral" notation. For example, consider (15): in this (admittedly highly contrived!) context the signer discusses a story in which a character unexpectedly finds themself and their family at a nudist colony. In such a context, the signer can use the lower neutral height to set up a locus for the family as in any discourse, and then a plural pronoun to the mid-level height to refer to a superset of the family which is all of the people at the nudist colony, and finally a plural pronoun to a further higher level to pick out all of the people in the world (a superset of the nudist colony). Note that we used the unusual predicate of wearing clothes/not wearing clothes for a motivated reason: it's a description that overwhelmingly holds of people in the world, but (unlike, say, breathing or other biological imperatives) also allows for exceptions, and among certain groups of people (e.g. the nudist colony) the expectation is reversed. This allows for felicitous use of the plural pronoun at each of these levels (including the highest one), given that exceptions are allowed for third person plurals without overt universal quantifiers, e.g. "They wear/don't wear clothes (here)" (see Križ 2016 for insights on homogeneity requirements in spoken language).

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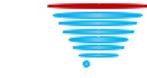
- (15) Context: Discussing an accidental family visit to a nudist colony. (The family is a subset of people at the nudist colony, who are in turn a subset of people in the world.)
- POSS-1 FAMILY IX-arc-neutral WEAR CLOTHES.
‘My family, they all wear clothes.’
 - IX-arc-mid NOT WEAR CLOTHES.
‘They all (at the nudist colony) don’t wear clothes.’
 - IX-arc-high WEAR CLOTHES.
‘They all (people generally) wear clothes.’



a. IX-arc-neutral

b. IX-arc-mid

c. IX-arc-high



If the signer only wanted to contrast two groups, she could use two levels, with the lower of these spaces for the local nudist colony instead of her family as in (16). The contrast between (15) and (16) also illustrates that these heights are only conveying relative, not absolute, contextual restriction: if one is signed higher than another then it is less restrictive, but it is not the case that a particular height corresponds to some constant degree of restriction.

- (16) Context: Discussing an accidental family visit to a nudist colony. (The family is a subset of people at the nudist colony, who are in turn a subset of people in the world.)
- IX-arc-neutral NOT WEAR CLOTHES.
‘They all (at the nudist colony) don’t wear clothes.’
 - IX-arc-high WEAR CLOTHES.
‘They all (people generally) wear clothes.’

We see, then, that the pronominal expression IX-arc has a use of height that involves information about set size, and we will argue that this is in fact the same use of height that we see in the quantifier domain restriction example that we started with in (3). We have not actually distinguished whether IX is a personal or demonstrative

pronoun, but see [Koulidobrova & Lillo-Martin \(2016\)](#) for arguments in favor of a demonstrative pronoun analysis. At the least, we will commit to a semantic behavior in which IX-arc makes reference to plural individuals and returns the maximal entity in the domain, which can be modified by height to be larger or smaller. The semantic result is at least determinate in the sense of [Coppock & Beaver \(2015\)](#), and in its syntactic behavior IX-arc substitutes for nominal expressions. The question becomes, then, where else does this use of height appear outside of the pronoun IX-arc, and in those contexts can it also be analyzed as this same pronoun? We argue that the answer is yes, as we see in Section 3 for verbs and in Section 4 for quantifiers.

3 Verbs and height in ASL

In the previous section, we discussed a use of height in plural pronouns in sign languages that reflects a set/superset relationship. In this section, we extend this observation to loci in certain classes of verbs in sign languages.

3.1 Background on directional verbs in sign languages

Like other sign languages, ASL is well known to have different morphological verb classes, of which some change their form depending on their arguments (call these ‘directional’ verbs), while others do not (called ‘plain’ verbs) ([Padden 1988](#)). For example, plain verbs (e.g. LIKE) do not change their form for subject and object ([17](#)), which contrasts with directional verbs (e.g. INFORM) ([18](#)).

- (17) a. (IX-1) LIKE (IX-arc) ‘I like them’
 - b. *(IX-1) LIKE-arc-a ‘I like them’
- (18) a. 1-INFORM-arc-a ‘I inform them(plural)’
 - b. 1-INFORM-a ‘I inform him/her/it/them(singular)’
 - c. a-INFORM-1 ‘He/she/it/they(singular) informs me’

The forms that these directional verbs take are closely related to the locus system. In fact, the sharing of features between pronouns and loci have lead many researchers to talk about verb directionality as verb ‘agreement’, and to call these ‘agreeing verbs’ in an analogy to spoken language ϕ feature agreement on verbs ([Neidle 2000, Sandler & Lillo-Martin 2006, Lillo-Martin & Meier 2011](#), among many others). However, there are also differences between directionality and verb agreement as seen in spoken languages, some of which point toward even closer ties between locus use in directional verbs in sign languages and pronouns (see [Nevins 2011](#) for more). For example, discourse-dependent notions like saliency and ambiguity determine

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pronoun use as well as locus use, while typically agreement is obligatory (Ahn et al. 2019, Kocab et al. 2019). Schlenker et al. (2013) also note that their observations about “iconic variables” apply not only to loci as used in pronouns, but also to the use of loci in directional verbs as well, as in a verb moving toward/from especially high or low locations in space for referents that are in physically unusually high or low locations. Finally, just as pronouns IX and IX-arc can point to not only arbitrary loci (e.g. *a*, *b*, etc.) in anaphoric uses but also pick out referents from the real world in deictic uses (e.g. pointing directly to an intended referent that is present in the discourse)(19), so can directional verbs (20).

- (19) IX-1 LIKE IX-(Mia)(→ pointing to Mia) ‘I like Mia’
- (20) a. 1-INFORM-(Mia)(→ directed from speaker toward Mia) ‘I inform Mia’
b. (Mia)(→ directed from Mia toward speaker)-INFORM-1 ‘Mia informs me’

Given the deictic and iconic properties of directionality in sign language verbs, an analysis as traditionally grammatical agreement seems at the very least unusual (Lillo-Martin & Meier 2011). As outlined most clearly by Nevins (2011), there are in fact many reasons to analyze this directionality as incorporated/cliticized pronouns instead of agreement. Among several properties that he notes strongly favor a pronominal clitic analysis of loci and directional verbs, we note a few that we find most compelling. First, while subject agreement tends to be an all/none phenomenon across verbs within a language, subject clitics can be optional. This is also the case in sign languages, with both directional and plain verb classes. Sign language directionality is also more likely to mark indirect objects over direct objects (Janis 1995), which happens in clitics in spoken language, while the opposite happens in spoken language agreement. Third, directionality is found in what seem to be infinitival/non-finite clauses in sign languages (Padden 1988), unexpected for agreement. Fourth, the deictic uses we mentioned above are found in clitics but not agreement. Finally, number is dissociable from person marking (Mathur 2000), as in clitics but not typically agreement. We saw in Section 2 the use of height on plural pronouns to mark domain size information. Given syntactic evidence for directionality as a feature encoded on cliticized pronouns, we might expect to see the same use of height extending to verbs. In the next section, we see that it does.

3.2 Verbs and the use of height for signaling domain

The use of height that we reported in pronouns in the previous section is indeed found in directional verbs. “Plain” verbs do not use height in this way but instead use pronouns to express widened domain via height (21), while “directional” verbs can change height of the verb itself (22).

- (21) a. *(IX-1) LIKE-arc-neutral ‘I like them’
b. (IX-1) LIKE IX-arc-neutral ‘I like them’
c. *(IX-1) LIKE-arc-high ‘I like everyone’
d. (IX-1) LIKE IX-arc-high ‘I like everyone’
- (22) a. 1-INFORM-arc-neutral ‘I inform them’
b. 1-INFORM-arc-high ‘I inform everyone’

On the one hand, this is somewhat surprising given that we’re not aware of any previous descriptions of this use of height to indicate set size used in directional verbs in sign languages. On the other hand, given discussion in the past subsection about the evidence in favor of a pronominal incorporation analysis of directionality, and if plural pronouns make use of height to indicate set size, then it is perhaps unsurprising that directional verbs would look like they are using height to indicate context set size.

This use of height in verbs even shows the same semantic range as the use of height in pronouns and that we will see in quantifiers, including an indiscriminate interpretation (23).

- (23) a. 1-PICK-FROM(alternating repetition)-arc-neutral
‘I pick from among this specified set’
b. 1-PICK-FROM(alternating repetition)-arc-high
‘I pick indiscriminately (I could end up with anyone)’

Also, just as with pronouns, although we generally simplify and use two levels for illustration, it is also possible to have more than two levels. Consider (24).

- (24) Scenario: someone is talking about a bunch of fliers they’ve printed to advertise for an upcoming event:
GIVE-OUT-neutral CLASS, HAVE LEFT.
GIVE-OUT-mid CAMPUS, STILL HAVE LEFT.
GIVE-OUT-high OTHER PEOPLE MY TOWN.
“I passed out (the flyers) to my classmates, but I had some left, so I passed some out (to people) on campus, but I still had some left, so I gave them out (to whoever I found) in town.”

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Finally, just as loci with neutral height are known to make available their locus for later anaphora, the same is true for "high" locations/high space, even ones that are only marked through this height modification on a verb. For example, the verb PICK was used by one signer in a story about an apocalyptic event, and this signer later went back to the same area of space used for the domain in that verb to refer to the people who were chosen, either from a specified group (25) or generally from the population (26). Videos can be seen on our OSF project site <https://osf.io/2h6ge/>.

- (25) INFORM-2 WORLD WILL MESS.
 IX-arc-neutral(thumb) GOVERNMENT HAVE SPECIAL^f BOAT READY.
UNDERSTAND IX-arc-neutral PICK-neutral(alternating-repetition)
 LIMIT PEOPLE WHO_{bent} FILE-ON ON BOAT IX-left.
UNDERSTAND IX-arc-right-neutral RESPONSIBILITY WHAT_{pu-rq}.
 POSS-neutral-right DRESS BAG EAT INVOLVE BRING FILE-ON--left.
UNDERSTAND GOVERNMENT PROVIDE BOAT FINISH.
 “I’ll tell you, the world is getting destroyed but the government has a special boat- they’re ready for it- and they choose people (from a previously determined set) who can go on it. The people who are chosen are responsible for bringing their own supplies. The government is just providing the boat.”
- (26) WORLD HAPPEN MESS PU. INFORM GOVERNMENT HAVE SPECIAL BOAT READY FOR.
UNDERSTAND IX-right-high PICK-high(alternating repetition) PEOPLE WHO_{bent} CAN FILE-ON-left.
UNDERSTAND IX-arc-right-high RESPONSIBILITY WHAT_{pu-rq}.
 POSS-right-mid BAG DRESS EAT INCLUDE.
 GOVERNMENT PROVIDE WHAT_{pu-rq} BOAT FINISH.
 “The world is getting destroyed! (But) FYI, the government has a special boat- they’re ready for it- and they are choosing people (randomly, from everyone) who can go on it. The people who are chosen (a subset of everyone) are responsible for bringing their own supplies. The government just provides the boat.”



This example also addresses the anaphoric availability of the pronoun for domain size. [Stanley \(2002\)](#) uses the inability of English covert domain restriction to support anaphora to conclude that domain restriction is not contributed by a pronoun with its own syntactic node. In contrast, we see here in ASL that the higher locus can be used as an antecedent for the subsequent IX-arc. We can take the difference in anaphoric licensing to be due to the covert/overt status or to its syntactic status, or both, but in any case it licenses an analysis of ASL that may differ from the English case, and is consistent with our proposal that the domain size is contributed as part of a pronoun, here one that is incorporated into a directional verb.

In this section we have seen that directional verbs can also make use of vertical height to signal domain size of their argument. Although not the primary contribution of our paper, we take this as evidence to add to others in favor of a cliticized pronoun analysis of agreement in general, since we can provide a straightforward semantic analysis by simply using the same analysis given to pronouns. In fact, we are going to use the fact that pronouns and verbs that incorporate pronouns show this modification for height to argue that the height use on quantifiers is also coming from a pronoun in its restrictor, as a partitive-like construction. Before we do so, though, we will take the next section to note what kind of structures do not modify for height, even if we could have give them a plausible meaning: these are noun phrases which lack an unsaturated argument position and thus have no independent reason to incorporate a pronominal argument.

3.3 Only structures that include pronominal arguments modify for height

So far, it would be possible to argue that there is nothing special about pronouns for providing domain information in ASL: it seems that everything can change its height to signal consideration of larger or smaller sets. Perhaps, as one reader phrased an alternative hypothesis, "height signals set size more generally in ASL." This has been consistent so far with the data we have seen for quantifiers, IX itself, and directional verbs, at first a heterogeneous set which we argue is unified in allowing pronouns within their structure. However, we next discuss a case that does *not* allow a change in height to be interpreted as widened or restricted domains: noun phrases.

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As shown in (27), vertical height cannot combine with bare nouns and be interpreted as conveying domain size information (27a).

- (27) Context: Talking about adopting a pet.
 IX-1 WANT DOG-high.
- a. # ‘I want any/all dog(s).’
 - b. ? ‘I want the/a dog that is high (e.g. up on that roof).’
 (marginal, if possible only available with eye gaze to DOG)

We know this is not a phonological restriction on the noun sign itself: the word DOG can be pronounced with one hand in neutral space, and can be moved to high space to iconically illustrate, for example, the physically high location of a dog (on a roof, for example)(27b). This latter, more iconic use of high space not only has a different interpretation, but involves different eye gaze behavior: it must be directed toward the sign DOG for the “physically high” interpretation. The iconic use contrasts with the high use of space for domain restriction, where gaze is toward the interlocutor (not the locus), as noted by Barberà 2012 for high existential quantifiers. All signers that we consulted indicated the complete unavailability of a widening domain interpretation for nouns like DOG with height. We find this especially interesting because there is a very plausible interpretation, namely the indiscriminate interpretation expressed in (28), although the closest to expressing this with height must involve an existential quantifier, e.g. SOMEONE/SOMETHING-high ‘some/any’ as in (28).

- (28) IX-1 WANT DOG, SOMETHING-high.
 ‘I want a dog, (any kind of dog).’

Under an analysis in which height is providing domain information via a pronoun, it should not be surprising that nouns cannot move higher for a widening interpretation, since a NP like DOG has no unsaturated argument position for such a pronoun. We are then in the position of explaining what is happening in the quantified NPs, since we began our observation with the quantifier ALL. Our proposal for quantifiers will be completely parallel to the one for verbs, not only in showing what role the pronoun plays (a verbal argument for verbs, in the partitive-like restrictor for quantifiers), but also in lexical variability. Just as one class of verbs (directional verbs) can incorporate pronouns into their structure while another class requires a phonologically separate IX marked for height, so too we find one set of quantifiers that incorporate the pronoun into a single pronunciation, and another set that requires a separate IX, for phonological/formed based reasons. Together, this suggests a compelling picture for treating the domain-widening height feature as a contribution of an (incorporated or separately pronounced) pronominal IX.

4 Quantifiers and sign height in ASL

Quantifiers were the source of the original observation above that ASL disambiguates the size of the restrictor of a quantifier in a way that English does not. To understand more about the role that height plays, note first that quantificational noun phrases are like referential noun phrases in ASL in showing optionality of locus use: they may be signed without using a locus (29) or they can be associated with a locus at neutral height that functions as the domain of the quantifier (30) (Petronio 1995, Boster 1996, Barberà 2015a, 2012b). As with non-quantified noun phrases, the second option (let's call it a "Spatial QNP") is common in signed discourse when expressing contrast and allows for unambiguous anaphora resolution, as in (30).

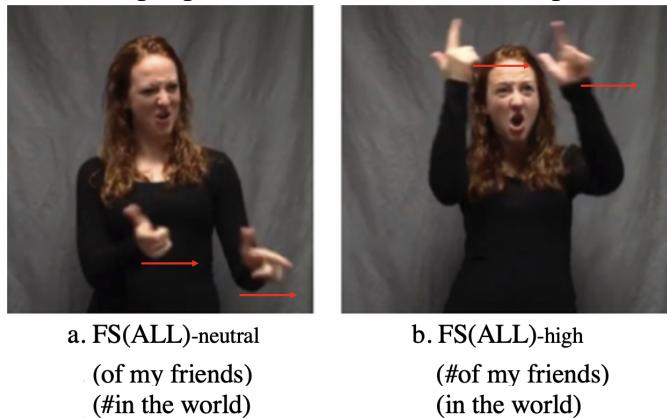
- (29) FS(ALL)/NONE/SOMEONE LIKE TEST
'Everyone/No-one/someone likes tests/that test' *QNP without locus*
- (30) Context: A group of my friends recently took the bar exam.
FS(ALL)-a/NONE-a/ONE-a FAIL. *Spatial QNP*
'All/none/one of them (of the friends) failed.'
IX-arc-a MAD.
'They (my friends) were mad'

When it comes to the use of higher loci for domain restriction, recall that in Section 1 we discussed the puzzle with our example about friends watching a vampire movie ((2), repeated below as (31)). In English, the sentence "Everyone transformed into vampires" lacks a distinction that ASL makes regarding the size of the domain of the universal quantifier: did just all of the friends turned into vampires, or everyone in the world? Is the domain for that universal quantifier more or less restricted? In ASL the same sentence FS(ALL) BECOME VAMPIRE can be signed in different ways to signal these smaller or larger domains. The only difference is in the spatial QNPs ((3), repeated below as (32)).

- (31) Last night I watched a movie with my friends about vampires. Afterwards I went to bed and I dreamt that everyone became vampires.
- a. Everyone in that story (your friends/the people in the context) became vampires
 - b. Everyone in the entire world became vampires

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- (32) Context: Signer has just said, "Last night I watched a movie with my friends about vampires. Afterwards I went to bed and I dreamt that..."
- FS(ALL)-neutral BECOME VAMPIRE
‘All of my friends became vampires’
 - FS(ALL)-high BECOME VAMPIRE
‘All of the people in the world became vampires’



In (32), when FS(ALL) is signed at a neutral height it is interpreted as having a different domain than when signed at a high height: in particular, the neutral FS(ALL) has a domain that is restricted to a set based on the context, namely whoever is in the group we have been talking about, even if that default restricted set has not yet been explicitly assigned a locus. It is as if the neutral height is always able to refer to the sum of the default pragmatically restricted set. (Recall that we saw the same use of the default height in (14) above with a pronoun.) When FS(ALL) is signed higher (at the level of the signer’s head), it is interpreted as having a wider than default domain, or even the widest possible. Note, importantly, that the signer’s hands are not actually more spread apart or wider for the high case, so this is not merely a case of the use of space in horizontal planes for set-superset relationships, as in the “iconic geometry” discussed by Schlenker et al. (2013). The nonmanual/facial expressions are also equally emphatic in both cases. Instead, the difference comes from the signer’s eyegaze, which is directed down (for neutral space) or up (for high space), and from IX-arc (directed down or up for neutral and high space respectively), and this is sufficient to convey a different interpretation for the same string of words.

From the semantic perspective, one surprising pattern is that this use of height holds not just for FS(ALL), but also for a variety of different quantifiers. A second example illustrating this point is the negative quantifier NONEsym, ‘no one’ (33).

- (33) Context: Discussion of whether anyone in signer's family is Deaf...

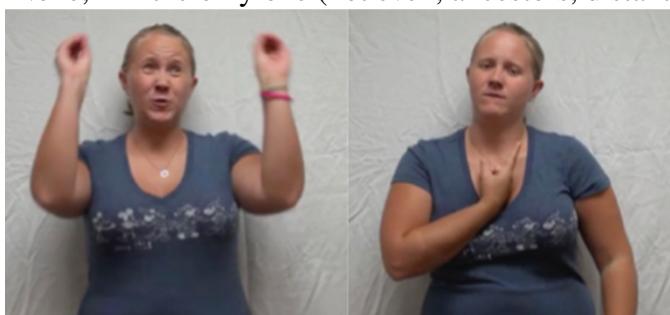
- a. NONEsym⁴-neutral ALONE

'None (of my immediate family), I'm the only one'



- b. NONEsym-high ALONE

'None, I'm the only one (not even, ancestors, distant relations, etc.)'



Note in (33) that even the "large" domain for high NONEsym is still pragmatically restricted in some sense, since here the high set "no one" can't apply to everyone in the entire world, since the signer is not the only Deaf person in the entire world. Rather, this would mean that she is the only Deaf person in her entire family, in an unexpectedly broad sense, with more people to be included than in the default interpretation of family. Thus, it is not the case that the highest space necessarily means everyone possible, only that it is a contrastively larger domain than when signed lower. In other words, here we see explicitly that context still plays some role in pragmatic restriction even of the largest set, but the use of space allows for a set/superset distinction of default and expanded domains that isn't available in English.

4 'Sym' refers to the symmetrical nature of this sign, used in the ID Gloss to distinguish it from other forms to express negative quantification.

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We can see the relative restricting/widening also by looking at height across three levels for quantifiers, just as we saw for pronouns and in verbs in (34). In the actual production for (34) there is minimal difference between *mid* and *high* productions, but all signers consulted for this project had the intuition that they were targeting three different heights, and reported this, even when phonetic realization was close: they had the sense that the heights differ when the domains differ.

- (34) Scenario: lack of bananas first at store, then in town, then in whole country.
- (a) *NONEsym-neutral* BANANAS.
 - (b) *NONEsym-mid* BANANAS.
 - (c) *NONEsym-high* BANANAS.

"Today I went to the grocery store. There were no bananas in the store! I asked where the bananas were, and they said there were no bananas in the whole town! Then I went home and watched TV and saw that in the whole country there are no bananas!"



a. *NONEsym-neutral*
b. *NONEsym-mid*
c. *NONEsym-high*

Recall that domain restriction in spoken languages participates in quantificational binding relationships, as in (4) above ("Usually when I do this, I dream that everyone becomes vampires."), posing problems for a purely pragmatic analysis of domain restriction in English. Example (35) shows a similar pattern in ASL with *NONE-sym*, which can be signed either neutral or high. Despite this variation in size of contextual restriction, nevertheless the adverb *TYPICALLY/TEND* quantifies over these contexts such that the people in the restricted group (when *NONE-sym* is signed at a neutral height) may be different in each case, but still, none of them fail. We can see, then, that the linguistic structure needs to include an expression of these domains that both vary (with height) and can also be bound by quantificational adverbs.

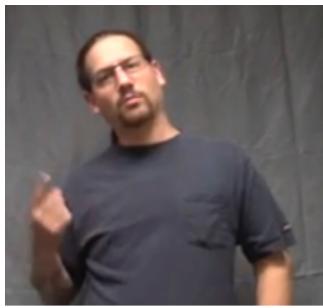
- (35) Context: Signer is discussing the numerous tests that he gives out.
 TYPICALLY *NONE-sym-neutral/high FAIL*.
 'Typically/most times none (in the group/at all) fail.'

At this point, we've seen a similar use of height in a pronoun, in directional verbs, and in two different quantifiers, ALL and NONE. A third quantifier to show a

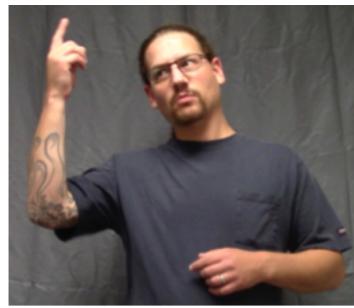
similar use of height is the existential quantifier SOMEONE ‘someone’/‘something’ (36). Similar to ALL and NONE, SOMEONE is interpreted as ranging over a restricted domain when signed neutrally, but a much wider domain when signed high.

(36) Context: Deciding condiments to put out at a party. Host says:

- a. TYPICALLY SOMEONE-neutral LIKE MUSTARD.
‘Usually there is someone who likes mustard.’ (may be a different person for different parties)
- b. TYPICALLY SOMEONE-high LIKE MUSTARD.
‘Usually there is someone (in the world) who likes mustard.’ (easily made true, person doesn’t have to be at a party)



a. SOMEONE-neutral



b. SOMEONE-high

Example (36) also involves the quantificational adverb TYPICALLY scoping over the situations described with the result that the domain varies with the adverb. Here, the individual who satisfies (36a) (the “someone” who likes mustard) can vary from party to party - it doesn’t have to be the same person at every party. In addition, there is another specific reading of (36a) in which SOMEONE-neutral is interpreted with widest scope, such that the same person at each party likes mustard. In fact, Barberà (2012) shows that when the existential quantifier SOMEONE in Catalan Sign Language (LSC) is signed especially low, it receives a specific reading, concluding that specificity is the key notion separating the lower from higher planes. While it is true that specificity seems to correlate with height also in ASL, we argue at least for ASL that by viewing this as contextual restriction, we better capture the similarity between existentials and the use of height in other quantifiers like ALL and NONE. In fact, if we follow the view of specificity as extreme domain restriction as suggested by Schwarzschild (2002), we predict that a neutral/low SOMEONE should be able to be interpreted as specific, which is exactly what Barberà (2012) reports for LSC.

Crucially, the interpretation of height for existential quantification as also involving a wider domain helps clarify that it is not merely a strengthening of truth conditions. Since both negative and universal quantification are downward-monotonic

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in their first argument, in those cases if height is primarily used to strengthen an utterance, then we would expect the restrictor to be interpreted as a larger set for purposes of imposing stronger truth conditions. This is, in fact, what has been argued by Bergen (2016) for heightened prosody on quantifiers like *some* and *all* in English. However, under an analysis of height as a type of intensifier, we would expect different behavior with existential quantification, where a smaller restrictor set leads to stronger truth conditions. Instead, we see that height is still used to signal a larger set size, with weaker truth conditions. We can conclude that height is contributing something about the set size itself, and not just changing the strength of the utterance.

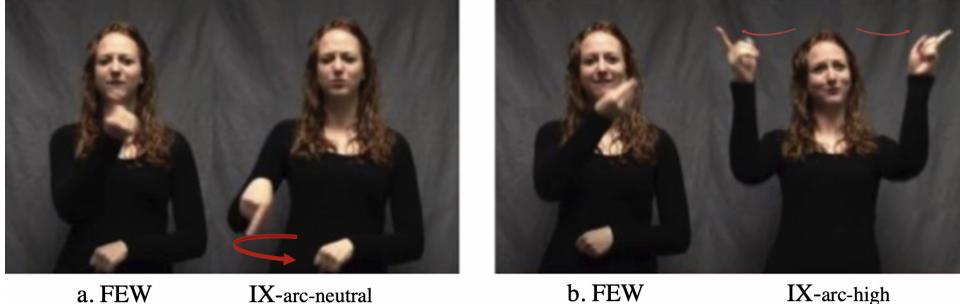
4.1 Quantifiers that can't move for phonological reasons

So far, we have seen pronouns make use of height for set restriction, as well as verbs that incorporate pronouns, and in the last section quantifiers, too. We have suggested that the height is also incorporated via a pronoun in the case of quantifiers, looking at three different quantifiers: FS(ALL), NONE, and SOMEONE. In this section, we discuss other quantifiers which cannot be marked for height in this way, for phonological reasons: EACH, MOST, FEW, ALL-B all have phonological specifications which make moving the quantifier higher in space phonologically difficult and/or ill-formed (these are: a specific location in their phonological form, an internal movement to the sign, or a dominant hand acting on a non-dominant hand). Intriguingly, and in an exact parallel to directional vs. plain verbs, this set of quantifiers expresses the same meaning sequentially with the quantifier followed by a pronoun IX that uses height.

Example (37) illustrates this with the quantifier FEW. The signer begins with the same context ‘My family goes to the beach every year,’ without establishing any locus for either the family or the beach (both signed in neutral space). She can continue with (37a), signing FEW followed by IX-arc (one-handed in the figure) located at a neutral height, with the interpretation that a few of the people already available in the context in a restricted sense (‘my family’) got sick. Alternatively, she could continue the context with (37b), signing FEW followed by IX-arc in higher space, with the interpretation that a few people from among a wider group than one might have originally expected based on salience in prior discourse (not just her family, but all of the people at the beach) got sick.

(37) Context: My family goes to the beach every year.

- a. FEW IX-arc-neutral FEEL HIT SICK
‘A few of them (my family) got sick.’
- b. FEW IX-arc-high FEEL HIT SICK
‘A few of (all) the people (at the beach) got sick.’



This use of IX in the same way following the quantifier provides further evidence, then, that spatially modifiable QNPs may involve a simultaneous pronunciation of quantifier and the following IX-arc pronominal. They also illustrate that the height is connected to the pronoun first and only the quantifier second by way of incorporating a pronoun, since in cases above when the two are separate, the pronoun is marked for height. Additionally, in sentences with quantifiers that do allow spatial modification for height (in other words, that already incorporate a pronoun), signers rejected a spatially modified quantifier followed by a pronoun.

(38) Context: My family goes to the beach every year.

- a. *FS(ALL)-high/NONE-high/SOMEONE-high IX-arc-neutral SICK.
‘All/none/one (of all of the people) were sick.’

We also note at this point that despite the difference in height modifications for two classes of quantifiers in terms of pronunciation (some simultaneous with the pronoun, some sequential), there is surprising semantic homogeneity among the quantifiers in their ability to combine with pronouns (either simultaneously or sequentially) that widen and restrict domains with height. The breadth of quantifiers that combine with height in ASL is somewhat surprising given different behavior of classes of quantifiers reported in other languages. One such contrast that we might have expected to matter for domain restriction is that between "weak" quantifiers (e.g., *some*, *two*, *many*) which have been argued to not be determiners, but rather noun phrase modifiers that do not combine with a domain variable, in contrast to strong quantifiers (*none*, *every*) that undergo contextual domain restriction (Etxeberria & Giannakidou 2014). Our data from ASL suggest that all spatial QNPs can be modified for domains (39).

(39) Context: Discussing an exam

- a. NONE-high/[EACH IX-arc-high] FAIL.
‘None/each (of everyone) failed.’

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- b. ONE-high/TWO-high /[MANY IX-arc-high] FAIL.
 ‘Someone(or other)/two/many (we’re not sure who) failed’

A wide domain in weak quantifiers often leads naturally to indiscriminate readings (“some or other, doesn’t matter who”, Horn 2000), but this is a side effect of a widened domain and not the primary contribution of height (see below for comparison with epistemic indefinites like German *irgendein*). Free choice and/or indiscriminate readings are not traditionally considered domain “restriction” (in fact, they seem to be quite unrestricted, hence the highest height), but in the phenomenon we are discussing here they arise as opposite ends of the same spectrum: higher in space indicates a larger than expected domain, and lower in space is a more narrowly defined domain. Both occur through precisely the same structural configuration: the use of vertical height that provides domain information. That is, while English uses a morphological alternation *some/any* for domain widening and a covert variable for domain restriction, spatial QNPs in ASL use the same process for both by making reference to the domain via a pronoun, whether simultaneous or sequential.

5 Height as domain size

So far, we have seen the use of height for conveying set/superset distinctions in pronouns, directional verbs, and quantifiers. We argued that this use of height enters in a restricted grammatical context, namely, via pronouns (sometimes incorporated pronominals), which in the case of verbs function as basic arguments, and in the case of quantifiers function as partitive-like restrictor phrases (“all of them”). How, then, can we describe the relationship between the pronoun and the use of height? We suggest a parallelism to semantic features on (personal and demonstrative) pronouns in spoken languages, such as gender on personal pronouns (*he* vs. *she*) and the proximal/distal distinction on demonstrative pronouns (*these* vs. *those*). Our semantics reflects this parallelism, similar to the treatment of female gender in the English personal pronoun *she* as a presupposition (Heim & Kratzer 1998). In the rest of this section we will specify both the meaning height contributes and account for its more gradient uses.

In taking height as we have described it to be a feature we are conservative with respect to prior literature on vertical height, agreeing with Barberà (2014), who proposes that this use of the upper frontal plane in Catalan Sign Language is a semantic feature that can be interpreted in one of four ways (40):

- (40) [upper]: hierarchical position, locative information, nonspecificity, absence in the physical context

Ultimately these four meanings as proposed by Barberà may not all be disentangled quite so neatly from either each other, or from the meaning we described in this paper. For example, at least *nonspecificity* and *absence in the physical context* seem to overlap in what cases they would cover, and both relate to our case of plural discourse referents since larger domains involve less specificity and (more indirectly) may also allow less connection to the physical context. One option then is that we can simply add yet another (fifth) meaning of the use of the upper plane, which may extend and ultimately subsume one or more of the existing proposed features. However, that's only the first part of the story: as it is, the type of meanings encoded by this feature as-is create a strict binary based on the contrast between the upper vs lower part of the plane (e.g., physically absent or not), while we have already seen several examples already in ASL where height is used for domain restriction with at least a 3-way distinction. What we propose, then, is that this use of height we have seen for domain restriction encodes the discourse availability of the plural referent in the case of the neutral plane use, with gradient height deviations from this availability corresponding to increasingly larger or smaller contextual domains.

To motivate our analysis, consider a parallel phenomenon with distance and demonstratives. In English, physical distance can be encoded morphemically through the proximal/distal distinction in demonstratives (*these*, *those*); there is no third morphemically encoded level of distance. However, a three-way (or more) distinction can nevertheless be made using non-lexical elements like pointing gestures or vocal modulations so that the conversational participants can infer a three-way (or more) ordering along the dimension encoded in the mere binary linguistic feature, in this case physical distance (41).

(41) *Context: On a hike in a forest*

These trees look like they're just about to turn red, while **those** ones {that are just ahead/[with accompanying deictic gesture]} already turned, and **those** ones {way far ahead/[with accompanying deictic gesture]} are already falling off!

The idea is that the English speaker has ordered the groups of trees by physical distance $x_1 < x_2 < x_3$ (where x_1 is about to turn, x_2 just turned, and x_3 already started to fall), even though the English demonstrative only encode a single proximal/distal distinction, which she enhances with an increasingly emphatic use of the distal demonstrative and an optional pointing gesture. One distinction is part of the user's linguistic knowledge (proximal/distal), and upon that we impose extra-linguistic distinctions in the case of medium and farther distinct distal demonstratives.

In general, the use of continuous space in sign languages allows for communication about specific points along a dimension in a more detailed way than is typically available in the discrete lexicons of, say, written English, such as in the

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visible degrees of gradable adjectives (Aristodemo & Geraci 2018). Gradability is also present in the other meanings for the upper plane mentioned by Barberà (2014). Schlenker et al. (2013) discuss two cases in which IX to a higher locus can be used with two of these meanings mentioned by Barberà (2014), namely physically high referents, such as a person on top of a house or tall basketball players (see (42) taken as example (26) from Schlenker et al. 2013), and honorificity, in which honorable entities (e.g., gods, bosses) are placed high in space (43). When height is used with these more directly iconic meanings, it need not be in a binary way, and this motivates the presuppositional analysis of height on loci by Schlenker et al. (2013) as an iconic function in which participants map the signing height onto a dimension of actual height or (metaphorical) honorific height.

(42) Physical height:

POSS-1 YOUNG BROTHER WANT IX-1 REST. IX-1 UNDERSTAND IX-a-high.

'My younger brother wants me to rest. I understand him.'

Interlocutor infers: the speaker's younger brother is tall.

(43) Honorific height:

POSS-1 BROTHER WANT IX-1 REST. IX-1 UNDERSTAND IX-a-high.

'My brother wants me to rest. I understand him.'

Interlocutor infers: the speaker's brother is older and/or more venerable.

Although it shares gradability, the use of height we have been discussing in the rest of this paper is not an immediate extension or special case of these more "iconic" uses of height. First, the use of high space for wide contexts picks out plural referents which need not be in any way made of tall referents or individuals in a high location. We have, in fact, given many examples in which the neutral height versions are proper subsets of the high versions, so it is clear that there is no difference in physical/spatial height or in honorability of the members that make up the reference set. The meaning for height for larger sets that we discuss is also strongly discourse dependent, encoding enlargement of the contextually supplied domain (a generalization of Barberà's specificity meaning), as illustrated in the contrast between two and three levels in (15)-(16). Thus, we need to add a new sense of meaning to this use of the upper plane and ensure that the continuous space allows interpretations of this sort of meaning along the vertical dimension in a more-than-binary distinction.

We implement a semantics for height for domain size, then, in a two-step process. The first is the interpretation of a high height as a non-default domain (at varying heights k). For plural referents, the non-default domain (at height k) will add a presupposition that the plural referent properly contain the contextually supplied domain (44).

- (44) $\llbracket \text{high} \rrbracket^C = \llbracket \text{domain-}k \rrbracket^C = \lambda x : C_e \subset \{y : y \leq x\}.x$
 (where \leq is mereological parthood)

We may ask: where does *domain* sit in the structure of a pronoun that is pronounced with a high vertical height, with respect to other changes to pronominal form with semantic consequences, like the *arc* used for plural referents? There are multiple suggestions on the table in general for morphosyntactic configurations within IX relating to the arrangement of loci, indices, and relevant ϕ features, including recent proposals by Esipova (2019) and Ahn (2020), and as far as we can see, our data do not arbitrate between them. We will, therefore, make a proposal using fairly simple cumulative presuppositions, the order of which may be implemented differently than we do here depending on one's preferred system.

In our analysis take the *index* (e.g. i) to be covertly contributed by a pronoun (which itself could be null or overt, as in IX), exactly as in spoken languages, and will include it in notation when concerned with interpretations of pronouns. A *locus* refers to an area of signing space associated to a pronoun. In most sign linguistics work the locus is meant to only describe placement within the horizontal signing space (e.g. $-a$, or $-R$, etc.), but since we are also focused on the vertical dimension, we use *locus* to mean an area of signing space taking into account both of these dimensions. In terms of notation, we will on occasion omit the "default" vertical and horizontal uses of space, as in the expression of a horizontally neutral but vertically marked locus (*high*), or a vertically neutral but horizontally marked locus (*a*). We can of course have a vertically marked locus that is also non-neutral horizontally (as in *high-a*, or *mid-b*). In the case of a pronoun, we will gloss as $\text{IX}_i\text{-}\text{arc}\text{-}\text{high}\text{-}a$ an indexical point in the form of a plural arc to a high locus associated with horizontal area a , interpreted via the assignment function g over index i .

5.1 Contribution of horizontal locus

It should be clear by our glossing and our discussion that we are thus not equating horizontal loci with indices, in contrast to Lillo-Martin & Klima (1990) and Schlenker (2011), but instead follow closer to the proposal in Steinbach & Onea (2016) of a dynamic view of pronouns in which space constrains coreference but is not itself a visible instantiation of the variable. Our reasons for separating loci from indices are, first empirical: Among them, there is a noticed incompatibility has been noticed between negative quantifiers and overt loci (Graf & Abner 2012, Kuhn 2020) and overt loci can be considered unacceptable if they are not pragmatically motivated (Kocab et al. 2019, Ahn et al. 2019), both unexpected if loci are indices (among previous objects given in, e.g. Kuhn 2015). Another objection is conceptual: what researchers in dynamic semantics mean by indices is usually a highly abstract aspect

of a linguistic system for tracking discourse referents and computing operations over them, while signers' use of space can frequently align with this system of tracking without necessarily being a visible manifestation of it. That said, we see no reason why the main idea behind our proposal for the meaning contribution of *vertical* height on plural pronouns as domain ordering cannot be implemented in a loci-as-indices account; a straightforward way would be via a presupposition with the domain-providing semantics we propose but implemented along the lines of the iconic presuppositions for less abstract uses of height in Schlenker et al. (2013).

If non-default uses of horizontal space are not equated with dynamic indices, what does horizontal space contribute? We take a non-neutral horizontal placement of a locus to contribute contrast (requiring that there exist members of the focus alternative set ALT that are not equal to the referent), motivated by data from Ahn et al. 2019 showing that the use of horizontal locus is conditioned by pragmatic contrast. This doesn't ensure different interpretations for $-a$ and $-b$, though: what prevents two referents from being associated to the same locus? On the one hand, we don't want to entirely rule out multiple discourse referents associated to the same locus: if two referents are conceptually related they are often associated to the same locus (Kuhn 2015), such as two family members playing the same conceptual role in a dialogue, even when introduced in separate noun phrases. On the other hand, we saw above that when separate loci are associated to separate discourse referents, loci restrict coreference (1). One could then say that this is purely conventional, as a kind of grammatical feature like gender but in this case spatial (Schlenker 2016, Steinbach & Onea 2016, Kuhn 2015, Neidle 2000, and others all provide proposals along these lines, in different ways). One might also be inclined to take this as less conventional and more depictive, along the lines suggested by Liddell et al. (2003), in which general properties of spatial reasoning play this role, similar to how when an image/video unfolds over time we ascribe identity to something in the same location and disjoint reference to two objects in different locations unless we have reason to do otherwise. This fits the frequently depictive use of loci in narratives and other contexts. Both may play a role in interpretation of horizontal loci: consider that gender features in some languages and contexts are purely conventionalized (arbitrary noun classes) and are simply used for disambiguation but in other languages add information related to semantic classifications of the referents. However, the important aspects for our purposes are that the use of a non-neutral horizontal locus conventionally contributes contrast, indices occur covertly as in spoken language, and separate loci are interpreted as separate referents based on principles of spatial cognition, featural convention, or some combination.

5.2 Contribution of vertical locus

Turning to the second dimension of interest, when a plural locus is placed at a non-default height k in the vertical plane, it can be interpreted as in (44) to mark a non-default domain. A neutral use of the vertical locus simply preserves the domain under consideration, requiring that it not expand the given domain. Thus, just as a marked horizontal locus had a semantic effect and then beyond an additional set of heuristics (perhaps some conventional, other depictive) determined choices of locations within those marked versions, we find the same in vertical loci: a marked vertical locus has a semantic effect (a non-default domain), but then further principles come into play in determining which heights are used. Given the gradient use of three or more levels of height that we have seen, we want the following generalization to hold: that for any two heights of a plural referent introduced by IX-arc in ASL, if one is higher than another, then their referents are in a mereological containment relationship, with the minimal unit in this containment ordering having all of its subparts members of the contextually available discourse, i.e. elements of C_e (45).

(45) Interpretation of continuous vertical height

a. *Vertical ordering*

Let $<_v$ be a "vertical" ordering relation among loci (areas in signing space) along the frontal plane. That is, for any k and k' , if k' is physically higher in signing space in the vertical plane (toward the signer's head) than k , then $k <_v k'$.

b. *Vertical ordering corresponds to mereological part-hood*

For any two pronouns expressing a contrasting domain as defined in (44), if $k <_v k'$, then the referents of these pronouns form a mereological proper part-hood relation: $\llbracket \text{IX}_i\text{-arc-domain-}k \rrbracket^{g,C} < \llbracket \text{IX}_{i'}\text{-arc-domain-}k' \rrbracket^{g,C}$

For more intuitive readability in this paper, we have been using *mid* and *high* for glossing when two loci are both marked with *domain* and one is vertically ordered higher than another. In other words, consider *mid*=*domain-k* and *high*=*domain-k'* for some $k <_v k'$.

As two illustrative examples, we contrast below a high pronoun with an unmarked/neutral horizontal locus (46) with a pronoun at neutral height signed in horizontal locus a (47); these are common combinations, but both neutral and high IX can appear with and without an overt horizontal locus. The indexical pointing sign IX is a definite expression restricted via an assignment function g over indices i . We assume that presuppositional features combine via conjoined definedness conditions.

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- (46) a. $\llbracket \text{arc} \rrbracket^{g,C} = \lambda x: \neg \text{atomic}(x).x$
 b. $\llbracket \text{high} \rrbracket^{g,C} = \llbracket \text{domain-k} \rrbracket^{g,C} = \lambda x: C_e \subset \{y: y \leq x\}.x$
 c. $\llbracket \text{IX}_i \rrbracket^{g,C} = \iota z.(z = g(i))$
 d. $\llbracket [\text{IX}_i]\text{-arc} \rrbracket^{g,C} = \iota z: \neg \text{atomic}(z).(z = g(i))$
 e. $\llbracket [\text{IX}_i]\text{-arc-high} \rrbracket^{g,C} = \iota z: \neg \text{atomic}(z) \wedge (C_e \subset \{y: y \leq z\}).(z = g(i))$
- (47) a. $\llbracket \text{arc} \rrbracket^{g,C} = \lambda x: \neg \text{atomic}(x).x$
 b. $\llbracket \text{-a} \rrbracket^{g,C} = \lambda x: \exists y(y \in \text{ALT}(x) \wedge x \neq y).x$
 c. $\llbracket \text{neutral} \rrbracket^{g,C} = \lambda x: \forall y(y \leq x \rightarrow y \in C_e).x$
 d. $\llbracket \text{IX}_i \rrbracket^{g,C} = \iota z.(z = g(i))$
 e. $\llbracket [\text{IX}_i]\text{-arc-neutral} \rrbracket^{g,C} = \iota z: \neg \text{atomic}(z) \wedge \forall y(y \leq z \rightarrow y \in C_e).(z = g(i))$
 f. $\llbracket [\text{IX}_i]\text{-arc-neutral}\text{-a} \rrbracket^{g,C} = \iota z: \neg \text{atomic}(z) \wedge \forall y(y \leq z \rightarrow y \in C_e) \wedge \exists y(y \in \text{ALT}(z) \wedge z \neq y).(z = g(i))$

Comparing (46)-(47e), we have the desired result that in the absence of differentiating horizontal loci, then IX-arc-high refers to a plural individual that contains as a proper subpart the plural individual referred to by IX-arc-neutral. If the locus is further marked in the horizontal plane, as in (47f), there is an additional requirement for another element in the set of focus alternatives (ALT)(47b).

In the case of multiple high loci, if two plural pronouns are the same except one is signed higher than the other, then they have the same compositional components, differing only in one way: the convention that height corresponds to a mereological part-hood relation (48).

- (48) $\llbracket [\text{IX}_i]\text{-arc-domain-k} \rrbracket^{g,C} = \iota z: \neg \text{atomic}(z) \wedge (C_e \subset \{y: y \leq z\}).(z = g(i))$
 If $k <_v k'$, then the referents of these pronouns form a mereological proper part-hood relation: $\llbracket \text{IX}_i\text{-arc-domain-k} \rrbracket^{g,C} < \llbracket \text{IX}_{i'}\text{-arc-domain-k}' \rrbracket^{g,C}$

In its reliance on broadly familiar extra-grammatical conventions (see discussion in Section 6 below), this generalization on the choice of particular loci is similar to the case of two different horizontal loci (-a and -b) which will have the same compositional semantics overlaid with a convention for disjoint reference when associated to two locations in space. The linguistic knowledge available to sign language users is the use of marked loci for domain information or contrastive focus, while other factors including motivated depictions, etc. influence the particular choice of loci given those marking.

As we saw earlier in our example about Deaf family (33), high space can be used easily even if not everyone in the universe is included in the domain, only that the

domain widens compared to the default. Conversely, even if something would be considered relatively numerous in the given context but does not contain as a subpart the contextually supplied group of salient individuals, then it isn't expressed using high space. For example, ten spouses might be considered an unusually high number of spouses for an individual to have, but nevertheless all of our consultants judge it to be impossible for high space to be used to discuss this relatively small group. Despite being an "unexpectedly large" group, it does not contain the contextually available domain as a subpart.

One might be inclined to eliminate the idea of a marking of *domain* entirely from the analysis, and have the interpretation of height fall out entirely from the mereological containment relationship proposed in (45) (and indeed, a reviewer suggested exactly this). This would simplify the current proposal, and it would also align this analysis more closely with those of more iconic uses (physical/locative height and honorifics), as in Schlenker et al. (2013). However, we keep the semantic feature for reasons that we find even more compelling. First, while honorific and locative uses of height seem to be equally ordered in both directions (higher and lower than neutral), it's not clear that this is symmetric for non-default domains. The contextually supplied domain crucially also has to be available at the neutral height, which is captured via a binary distinction of neutral from non-neutral (higher) plural loci. It is precisely this use of height for conveying a surprising domain size that seems to be part of what it is to know ASL, and moreover, outside of sign languages, non-iconic categorical expressions for domain widening exist in spoken language (Kadmon & Landman 1993), so we consider the complexity added by the feature in our analysis to be minimal from the perspective of ingredients known to be available for encoding in human language; however, implementing it through the pronominal system allows for especially wide ranging uses in sign languages.

Regarding whether the mapping extends in both directions, we do have anecdotal evidence that an especially *low* height can be used with an existential quantifier *SOME-low* to have a specific indefinite meaning, as 'someone [I -and maybe you-know who]'. This is consistent with reports from LSC from Barberà (2012) and suggests that in some cases the ordering in (48) can be extended for any domains; at the same time, as far as we can tell this use also seems restricted in possible quantifiers to existentials, unlike the use of the higher space explored throughout this paper which can appear anywhere we have a (overt or incorporated) pronoun. The use of the vertical dimension as generally conveying domain ordering seems clearly related, though, and is consistent with the view of specificity as extreme domain restriction (Schwarzschild 2002), so we are optimistic that future work will provide further analysis of these specific meanings expressed in a marked vertical low height in ASL.

5.3 Quantificational domain restriction, revised

We return now to our original example of height in quantification ((3), repeated as (49)), for a step-by-step computation (50)-(51). First, for the neutral height (50): IX-arc signed at a neutral height contributes a plural pronoun, which functions as the semantic restrictor of the universal quantifier via a "composed of" type function (Ladusaw 1982). This restrictor is then either incorporated when pronounced, or pronounced as a separate pronoun depending on form features of the quantifier. This quantificational DP is then followed by the (here, simplified) predicate *become a vampire*. Example (51) illustrates the same for the higher height, which carries with it the requirement that any other plural referent be a subpart (so, the maximal group in the context, unless another ends up being signed even higher).

- (49) Context: Signer has just said, "Last night I watched a movie with my friends about vampires. Afterwards I went to bed and I dreamt that... "
- a. FS(ALL)-neutral BECOME VAMPIRE
‘All of my friends became vampires’
 - b. FS(ALL)-high BECOME VAMPIRE
‘All of the people in the world became vampires’
- (50) a. $\llbracket \text{IX}_i\text{-arc-neutral} \rrbracket^{g,C} = \iota z : \neg \text{atomic}(z) \wedge \forall y(y \leq z \rightarrow y \in C). (z = g(i))$
(plural pronoun, the maximal discourse entity (here, the movie watching friends) unless further restricted by descriptive content, locus, etc.)
- b. $\llbracket (\text{of}) \rrbracket = \lambda x \lambda y. y \leq x$
 - c. $\llbracket (\text{of}) \text{ IX}_i\text{-arc-neutral} \rrbracket^{g,C} = \lambda y. y \leq \iota z : \neg \text{atomic}(z) \wedge \forall y(y \leq z \rightarrow y \in C). (z = g(i))$
 $= \lambda y. y \in C_e$
 - d. $\llbracket \text{FS-ALL} \rrbracket = \lambda P \lambda Q (\forall x(P(x) \rightarrow Q(x)))$
 - e. $\llbracket \text{FS-ALL-neutral} \rrbracket^{g,C} = \llbracket \text{FS-ALL[-of[IX}_i\text{-arc-neutral]]} \rrbracket^{g,C} = \lambda Q (\forall x(x \in C_e \rightarrow Q(x)))$
‘All of them’ (default domain C_e unless further restricted by descriptive content, locus, etc.)
- (51) a. $\llbracket \text{IX}_i\text{-arc-high} \rrbracket^{g,C} = \iota z : \neg \text{atomic}(z) \wedge (C \subset \{y : y \leq z\}). (z = g(i))$
- b. $\llbracket (\text{of}) \rrbracket = \lambda x \lambda y. y \leq x$
 - c. $\llbracket (\text{of}) \text{ IX}_i\text{-arc-high} \rrbracket^{g,C}$
 $= \lambda y. y \leq \iota z : \neg \text{atomic}(z) \wedge (C \subset \{y : y \leq z\}). (z = g(i))$
 $= \lambda y. y \in C'$

- d. $\llbracket \text{FS-ALL} \rrbracket = \lambda P \lambda Q (\forall x (P(x) \rightarrow Q(x)))$
- e. $\llbracket \text{FS-ALL-high} \rrbracket^{g,C} = \llbracket \text{FS-ALL[-of[IX}_i\text{-arc-high]]} \rrbracket^{g,C} = \lambda Q (\forall x (x \in C'_e \rightarrow Q(x)))$
 ‘All of them’ (expanded domain C' , where $C \subset C'$)

In other words, we compare the same sentence where the quantifier FS(ALL) is associated with two different heights. In one, the quantifier is at a neutral height, and in the other at a higher than neutral height. In the case of the first, there are no special restrictions from descriptive content, so pragmatic mechanisms associate the plural pronoun to the most accessible plural individual at that point in the available discourse, which here consists of the friends who watched the movie, the members in the starting context set C . In the case of the higher FS(ALL), the same applies, except that with the presupposition imposed by the high *domain* this must resolve to a superset of the default domain, and in this case the only contextually available superset is everyone in the world (which we notate as C'). We have modeled the composition through a partitive as a conservative analysis that preserves the generalized quantifier structure, but we note that there is no direct morphosyntactic evidence for the partitive, while in contrast we’ve argued that there is direct evidence for the pronoun, so direct composition of the quantifier and the type e pronominal argument could proceed along the lines suggested by Matthewson (2001).

5.4 Comparison to other domain widening quantification

So far, we have argued that domain size information conveyed via height enters quantificational noun phrases in ASL through a feature expressed on the pronominal IX. However, the kind of widened domain inferences that arise in our high version of IX here are similar to those seen in the family of well known indefinite quantifiers that also carry a universal free choice inference, like English *any*, Italian *qualsiasi*, or German *irgendein* (Kratzer & Shimoyama 2002, Chierchia 2013). Is the “domain widening” reported in domain widening quantifiers the same kind of domain widening we report here in ASL? We argue that it is not.

First, there are foundational structural differences. The domain widening seen in domain widening indefinite expressions applies to existential quantifiers and may also interact with universal quantifiers (Kratzer & Shimoyama 2002, Chierchia 2013), but we’ve already seen several examples in ASL with the domain widening on negative and proportional quantifiers, among other expressions like pronouns and directional height in verbs. In fact, we’ve argued that this height is a condition on localizing plural referents in ASL via pronouns, a very different pattern of use than the indefinite-combining expressions that have also been called “domain widening” within the semantics literature.

Second, even when both appear in the same context, there are interpretive differences: *irgend-* leads to a universal free choice inference across the set already provided by the context, while the upper plane explicitly widens the domain of individuals to a new domain. To be more specific, in German marrying *irgendein* doctor allows one to choose among any doctor, it doesn't matter who, while in ASL SOME-high doctor doesn't necessarily allow free choices among doctors, but it does allow more individuals to be considered in the pool of doctors (perhaps those who live in other countries, have PhDs or dental degrees, etc.), as in the classic domain widening attributed to *any* (Kadmon & Landman 1993). The epistemic effect of *irgendein* seems likely to be expressed in ASL both in nonmanual marking of quantifiers like SOME which can co-occur with *domain*, and in internal movements of these quantifiers and other expressions (e.g., alternating reduplication in directional verbs).

6 Height as widened domain beyond ASL

Many people who do not know a sign language claim that the use of height in ASL for domain widening discussed in this paper seems intuitive, and in this section we discuss whether we see something like it occurring in other linguistic systems.

6.1 Contrast with height as contextual restriction in spoken language

Within the framework of Embodied Cognition there have been suggestions that English speakers associate the concepts MORE and HIGH. For example, Langston (2002) reports that while reading English sentences, participants show increased processing difficulties when height and amount fail to correlate, as in (52a). Such mismatches were found to be more difficult to read than an example where they do correlate (52b).

- (52) a. Pepsi has more calories than Coke so we put it below Coke on the shelf.
(incongruent)
- b. Pepsi has more calories than Coke so we put it above Coke on the shelf.
(congruent)

In addition, Sell & Kaschak (2012) found that when English speaking participants read sentences that involved discussion of greater quantities (e.g. "The Yankees scored more runs") and had to press an "up" button to move to the next sentence they performed the task faster than when height and amount did not correlate. For example, they were slower if they had to press the "down" button in a "more" scenario to go on to the next sentence. These kinds of studies provide some evidence

that English-speaking nonsigners do have some association, at least in processing, between these concepts. In the related literature on metaphor, Lakoff & Johnson (1980) discuss how the metaphor MORE IS UP could be motivated by certain physical examples such as the pouring of liquid into a container, where more liquid reaches a higher level, followed by extrapolation to a wider variety of cases for which this physical relationship no longer exists. Of course, formal semanticists use this very metaphor every time they discuss *upward* and *downward entailment*, which refer to abstract superset/subset relationships, and not actual height. It is a natural question to ask, then, whether English speakers use height in precisely this way to represent information about contextual restriction like ASL does, perhaps concurrently with our speech either in our intonation or with co-speech gestures.

Turning first to prosody, there are indeed some similarities but ultimately also important differences between higher intonational pitches in English and higher sign space in ASL. First, intonation contours with extreme high points can be used to bring attention to things in English, and sometimes this means a larger context under consideration, but many times it does not. For example, consider (53), where both sentences in English have high pitch on the capitalized word. In (53a) our intuition is that high pitch does bias the interpretation toward an exceptionally large or unexpectedly wider context. Bergen (2016) discusses the use of stress to strengthen quantified statements using universal quantifiers. However, in English this requirement seems to be able to be overridden by surrounding context without a sense of contradiction (by following with an explanation that it was just one's friends), while this is impossible in ASL. Another contrast is that while at least there is the possibility of a strengthening analysis with universal and negative quantifiers in ASL, height has the opposite effect with existential quantifiers (domain widening leading to a weakened statement, contra Bergen 2016). Finally, unlike in ASL, the option of adding high pitch to a pronoun to bias it to be a wider domain is entirely out in English. For example, (53b) can never mean that everyone in the world transformed into vampires. In English, the pronoun THEY requires an antecedent, and here the only option is the friends, so the high intonation signals something like surprise or unexpectedness, not a wider domain, whereas the wide domain interpretation is precisely what is available in ASL.

- (53) a. Last night my friends and I watched a movie about vampires and later I dreamed that EVERYONE transformed into vampires!
- b. Last night my friends and I watched a movie about vampires and later I dreamt that THEY transformed into vampires!

There is also an intonational generalization across spoken languages in which higher pitch has been associated to smaller things, contrasting with lower pitch for large

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size, and which goes in precisely the opposite direction (Ohala 1984), so we hesitate in attributing any natural correspondance between the use of height in ASL and intonational height in English (or other spoken languages of which we are aware).

If not intonation, one might wonder whether a similar connection between height and domain widening may also occur in the gestures of some non-signing spoken language users. Elicited gesture production data from Durkin et al. (2016) show that there is some correlation between height and set size in domain restriction in gestures accompanying both universal and negative quantifiers in English, but that they are not able to be dissociated from wider gestures in horizontal space in the same way as the two dimensions can be dissociated in ASL. More work on both gestural and intonational components would help clarify the source in co-speech gesture, but these preliminary findings suggest that there may be more worth pursuing in the manual gestural domain than in the intonational domain in spoken language.

6.2 The source of height in other sign languages

Finally, we can also ask whether other sign languages show the same pattern as ASL. Preliminary data suggest that at least some other sign languages have similar uses. Example (54) is a spontaneously occurring example from Japanese Sign Language (JSL) in which a native signer used the following set of three contrastive sentences, starting low (reported as "@ chest") for his class, moving to a mid level (reported as "@cheek") for his school, and a high level (reported as "@forehead") for the entire prefecture.⁵ Example (55), from a consultation in Nicaragua between the second author DG and a signer of Nicaraguan Sign Language, shows the quantifier TODO ('all') in Nicaraguan sign language⁶ used with the same form but differing only in height, neutral/mid in one context where it was clear that the signer was referring to the pragmatically restricted context (all of his friends turning into zombies, analogous to our vampire example), and high in another context where the signer was referring to a widened context (everyone in the world turning into zombies).

(54) Glosses of Japanese Sign Language:

- a. CLASSMATE DEAF-FAMILY NONE(@chest) SELF FINISH
'There is/was nobody from a deaf family in my class. Just me.'
- b. SCHOOL DEAF-FAMILY NONE(@cheek) SELF FINISH
'There is/was nobody from a deaf family in my school. Just me.'

⁵ We thank Kazumi Matsuoka for sharing this observation.

⁶ Here we say Nicaraguan as the descriptor of the language's location; the deaf community in Nicaragua currently refer to their language as Lengua de Señas Nicaragüense (Ley 675 2009).

- c. WAKAYAMA DEAF-FAMILY NONE(@forehead) SELF FINISH
 'There is/was nobody from a deaf family in (the prefecture of) Wakayama.
 Just me.'
- (55) Glosses of Nicaraguan Sign Language (LSN):
- 
- a. TODO-mid
 All [of us here]
- b. TODO-high
 All [of Nicaragua]

We take these to suggest much more interesting work to be done with and within sign language communities to understand whether the use of height we report here for ASL is an area of cross-semantic variation, or is drawing on more universal cognitive tendencies. In our opinion, either would be an interesting finding, and will bear on the universality of a metaphor equivalent to MORE IS UP and its use in conveying domain size.

7 Conclusions

In this paper we started with the observation that in American Sign Language, the use of vertical height in signing space has the effect of providing domain restriction information for quantifiers, making a distinction that English appears to lack. We compared possible analyses of quantifier domain restriction and widening to consider whether ASL fits these patterns. We then argued that despite first impressions of height as an overt manifestation of a contextual domain variable for quantifiers, in ASL the use of height extends to all, and only, structures which include a pronoun. This includes overt pronouns themselves, quantifiers, and directional verbs. This led us to a compositional analysis of height via a domain feature attached to pronouns, both in stand-alone pronouns and those incorporated with quantifiers or verbs. In some sense this mirrors other presuppositional analyses of the use of non-default height with pronouns in ASL, in iconic or honorific uses. However, it expands this work by extending it to plurals, incorporation in other grammatical categories (verbs and quantifiers) and also to a much more abstract notion of set membership via height.

How exactly domain restriction occurs in natural language has long been an outstanding question at the syntax/semantics/pragmatic interface. We take our analysis to shed light on this question in language more broadly in two ways. First, we show that the mereological relationship of contextually supplied domains is conveyed via height in ASL, and that the language marks a non-default domain in a way observed in other (spoken) languages, but here by making direct reference to plural sets via the pronominal system. Second, Stanley (2002) has argued that a needed domain variable in English QNPs cannot be provided via a pronoun because it doesn't license anaphora; we showed that this is precisely what does happen in ASL, offering some indirect support for Stanley (2002)'s argument by illustrating what might have been possible were English structured differently. More intriguingly, it suggests that we should not rule out this possibility in understudied languages, where contextual domain restriction may license anaphora in a way that English cannot.

Several open questions remain. First, what is the nature of this use of height in other sign languages (cross-linguistically/typologically)? Second, is this related to the use of height in metaphor in the surrounding culture in a way that sheds light on the language/cognition interface? At the level of composition, our data support an analysis for directional verbs in which loci carry pronominal-like semantics, but how much of the syntactic structure of a pronoun must be present? We hope that this spurs new work not just on quantificational domains in understudied languages, but also the way that space is used at the semantics/pragmatics interface, an area that we were only able to touch upon briefly but we think is especially promising given in this paper the way it informed classically rich areas in formal semantic analysis like domain restriction and anaphora.

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