

Effects of iconicity and monotonicity on licensing complement anaphora¹

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Abstract. Complement anaphora is generally only licensed by downward monotone quantifiers, like ‘few’ (Nouwen 2003). Yet, sign language data suggest that the use of iconic “loci” can license complement anaphora with upward monotone quantifiers like ‘most’ (Schlenker 2012; Schlenker et al. 2013). This paper tests the hypothesis that the iconic nature of loci would extend to iconic uses of space in co-speech gestures in English. We hypothesised that, when accompanied by iconic co-speech gestures, complement anaphora will be licensed with upward monotone quantifiers, and will be degraded with downward monotone ones. We designed an experiment testing downward and upward monotone quantifiers with and without gesture, and found a significant effect of both gesture and quantifier type, as well as an interaction between the two. Our results show that iconicity affects complement anaphora licensing, and has the inverse effect of monotonicity. We suggest that the iconicity effects are not sign language specific, but are instead more broad, having to do with how humans interpret iconicity in language. We further argue that iconic co-speech gestures trigger an iconic inference of existence, along the lines of what has been suggested for iconic loci in ASL (Kuhn 2020).

Keywords: complement set, anaphora licensing, co-speech gestures, monotonicity, iconicity

1. Introduction

Pronouns, like ‘they’, ‘he’, ‘she’, have what we call *anaphoric* uses in the sense that they can co-refer with a previously established *antecedent* in the discourse, via which we resolve the pronoun’s interpretation. For example, in the following sentence the pronoun ‘she’ shares the same referent as ‘Mary’, indicated by the shared indices *i*:

(1) Mary_{*i*} wore a red dress. She_{*i*} was great!

Natural language also makes use of quantifiers, such as ‘most’ and ‘few’. Quantifiers relate two sets, e.g. $Q(R)(S)$, where R is their restrictor and S their scope. In the examples below, R is the set of students and S is the set of people who came to class, and the quantifier Q (most/some) relates these two sets.

(2) Most students came to class.

(3) Few students came to class.

How does pronominal anaphora interact with quantificational noun phrases? A pronoun following a quantified noun phrase can refer to the *reference set* $R \cap S$, i.e., the students that came to class, as below:

(4) Few students came to class. They were at least very active!

A pronoun can also refer to the *maximal set* R , i.e. the whole set of students/the restrictor.

(5) Few students came to class. But they all submitted a final paper.

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Are these the only available sets? Is the *complement* set, i.e. the set that includes elements in $R \cap \neg S$, an available referent?² In spoken languages, the claim is that the complement set can be referred to only with negative quantifiers, like ‘few’, but not with positive ones like ‘most’. So, it has been claimed that quantifier *monotonicity* plays a role in licensing anaphora for complement sets (henceforth CA) (Moxey and Sanford 1993; Sanford et al. 1994; Nouwen 2003). Interestingly, in sign languages, iconicity has also been argued to support licensing of CA (Schlenker 2012; Schlenker et al. 2013). This paper tests the hypothesis that iconicity as found in co-speech gestures can support CA in spoken language too.

2. Complement Anaphora

It has been claimed that, in contrast to reference or maximal set anaphora, complement Anaphora is in general less available and needs to be forced by the context (Nouwen 2003). In an out of the blue scenario, we would not interpret a pronoun as being anaphoric to the complement set, unless the only referent that can make the sentence true is the complement set one. Thus, we will focus on examples where a pronoun can only plausibly be anaphoric to the complement set, investigating what factors can influence licensing. In what follows, we examine the role of monotonicity and iconicity in licensing.

2.1. The role of monotonicity

Quantifiers have a restrictor R and a scope S : $Q(R)(S)$. They can be upward (e.g., *most*) or downward (e.g., *few*) monotonic on their scope S :

(6) $Q(R)(S)$ is upward monotonic on its scope S , if for all $S \subseteq S'$ $Q(R)(S')$ also holds.

For example, “most” is such a quantifier, since whenever we have “Most girls run fast” being true, it must also be the case that “Most girls run”; and $\{x : x \text{ is a girl who runs fast}\} \subset \{x : x \text{ is a girl who runs}\}$. We will call such quantifiers *positive* quantifiers for short, although it is known that it is their entailment patterns and not any negative valence which has this effect.

A quantifier can also be downward (e.g., *few*) monotonic on its scope S :

(7) $Q(R)(S)$ is downward monotonic on its scope S , if for all $S' \subseteq S$ $Q(R)(S')$ also holds.

For instance, “few” is such a quantifier, since whenever we have “Few girls run” being true, it must also be the case that “Few girls run fast”; and $\{x : x \text{ is a girl who runs fast}\} \subset \{x : x \text{ is a girl who runs}\}$. We will call such quantifiers *negative* quantifiers.

Whether a quantifier is positive or negative plays a role in licensing anaphora. More specifically, anaphora can be licensed to the maximal ($R \cap S$) and the restrictor set (R), but not the complement set ($R \cap \neg S$) with positive quantifiers (Moxey and Sanford 1993; Sanford et al. 1994; Nouwen 2003):

(8) Most students came to class. They were very engaged in the discussion. *maximal set*

(9) Most students came to class. But they all submitted a final paper. *restrictor set*

(10) #Most students came to class. They stayed home instead. *complement set*

On the contrary, CA is often reported to be licensed with downward monotonic quantifiers:

²Just like in mathematics, a complement set is a set that includes all the elements of the universal set that are not present in the given set. Here, we will use complement set to refer to individuals that are in the restrictor but not in the nuclear scope of the quantifier.

(11) (Very) few students came to class. They stayed home instead. *complement set*

Thus, quantifier monotonicity seems to affect CA licensing. Is it the only relevant factor? In what follows, we will see that iconicity has the opposite effect of monotonicity in ASL, licensing CA with positive quantifiers (and will see the same with iconic co-speech gestures too).

2.2. The role of iconicity

Based on data from spoken languages, the correct predictor for the availability of CA seems to be downward monotonicity, i.e., whether a quantifier is negative. However, data from ASL suggest that iconicity plays a role in CA licensing too. To establish an anaphoric antecedent, sign languages like American Sign Language (ASL) make use of *loci*, which are specific locations in signing space. After establishing the loci, the signer then points back at them (an indexical sign IX) to establish pronominal reference. The use of space can be either default, or iconically motivated.

In the case of default loci, the signer establishes a default locus (in the signing space in front of them) and then refers back to it by pointing. CA with default loci that do not take advantage of spatial iconicity in sign language work like in spoken languages. In these cases, positive quantifiers are reported to be degraded with CA (Schlenker 2012):³

(12) *POSS-1 STUDENT MOST a-CAME CLASS. IX-arc-a a-STAY HOME.
Intended: ‘Most of my students came to class. They stayed home.’

The relevant sentence can be found between seconds 0:25 and 0:31 in this video. The signer does not use a locus to represent the set of students, but instead simply uses the signs MOST and STUDENT. Then he uses a plural pronoun, IX-arc-a, to refer to the complement set. This is an unacceptable sentence, just like it would be in English with the positive quantifier *most*.

What if non-default and iconic loci, i.e., loci in marked locations of signing space, are used? In this case, another anaphoric strategy would be used. More specifically, the signer would establish a large plural locus *A*, the restrictor, denoting the set of all students, and then a sub-locus *a*, the maximal set, denoting the students who came. In contrast to the default case, Schlenker (2012) reports that this strategy makes available a locus for the complement set, i.e., $A - a (= b)$. The notation in the gloss is *A as ab* (since $A = a \cup b$):⁴

(13) POSS-1 STUDENT IX-arc-ab MOST IX-arc-a a-CAME CLASS. IX-arc-b b-STAY HOME
‘Most of my students came to class. They stayed home.’

The relevant sentence can be found between seconds 0:00 and 0:08 in this video. The signer establishes a big set in space, IX-arc-ab, the set of students. Then, he establishes a subset of that big set, IX-arc-a, the set of students who came. Finally, he points, using plural pointing, to the complement set, IX-arc-b.

Interestingly, when the signer explicitly signs the superset that is the restrictor and the subset that is the maximal set, denoting the intersection of the restrictor and the scope, CA becomes available. Choosing this depictive non-default strategy of signing loci makes CA felicitous with

³Schlenker (2012); Schlenker et al. (2013) gives acceptability judgments on a 7-point Likert scale. (12) received an average of 2.8/7. For the sake of comparison with our previous examples, we notate it as a star (*).

⁴Again, for reference the numeric judgments was 6.3/7.

positive, upward monotone, quantifiers like *most* which otherwise do not support CA.

3. Testing the effect of co-speech gestures

We have seen that quantifier monotonicity plays a role in CA licensing. We also saw that the depictive use of space makes a locus for the complement set available in ASL. The natural question is whether this is a language specific fact (about ASL), a language modality fact (about sign languages), or a semiotic fact (about depictive iconicity). To this end, we test the effect in iconic co-speech gestures to English sentences and ask: would CA be licensed then?

3.1. Research Question

The ASL data show that iconicity found in sign language loci can support licensing of CA. Can we replicate the pattern in spoken language, with *iconic co-speech gestures* playing the role of iconic loci? In other words, can iconicity license CA in spoken languages too?

To address this question, we designed a study involving gestural near-equivalents to the iconic loci used in the ASL examples. We thus had a wide gesture introducing the reference set, a contrastive co-speech gesture to the right introducing the maximal set, and a contrastive co-speech gesture to the left introducing the complement set (see Figure 1 below). This sort of gesture does not depict directly in the way of manner or size and shape depictions (e.g. a gesture for the size of a large plate for example) but indirectly, via a diagram in space. To interpret any iconicity in the gesture, we need to first map the set-theoretic relations between discourse referents from space to a diagram and then interpret the diagram, mapping it to relations between discourse referents (Schlenker et al. 2013). Thus, we used (indirectly depictive) iconic co-speech gestures directly mirroring what the iconic loci were doing in the ASL case.⁵

We hypothesized that *CA is licensed by positive/upward monotone quantifiers only when accompanied by iconic co-speech gestures*. The latter would play the role of iconic non-default loci in spoken language in depictively establishing an antecedent for the complement set. If this is the case, then this would suggest that it is not a property of sign language loci that made CA available in the ASL case. If it replicates with co-speech gestures, then it is rather a property of iconic use of space, which makes the relevant discourse referent available.

We further hypothesized that, *when co-speech gestures are added, CA licensing with negative/downward monotone quantifiers may be less natural* due to the incompatibility of iconic language with negation (Ebert and Ebert 2016; Kuhn 2020; Davidson 2023; Ebert 2023), which in the case of negative quantifiers is part of their meaning. To test these hypotheses, we designed an experiment testing the acceptability of CA using the presence/absence of iconic co-speech gestures and quantifier monotonicity as the relevant factors.

3.2. Experimental Design

We designed an online survey (administered via Qualtrics software) with 4 monotone increasing and 4 monotone decreasing quantifiers in pairs, counterbalanced via Latin square:

⁵The only difference is that in the co-speech gestures the palm is open rather than using a pointing index finger. This is because pointing in ASL is grammaticalized, but not in co-speech gesture; in fact, our intuitions were that pointing in co-speech gestures has to be directly (or indirectly) referential, and was thus odd in our examples, where the relevant discourse referents are not in front of the speaker.

Downward monotone	Upward monotone
Few	A few
Not nearly enough	Most
Hardly any	Some
Nearly no	Nearly every

Table 1: Tested quantifier pairs.

Each quantifier appeared with and without gesture, giving rise to four conditions. In the gesture condition, inspired by the use of non-default loci, a wide gesture in the neutral space introduced the reference set, a marked gesture to the right the maximal set, and another gesture to the left the complement set, as shown in Figure 1:

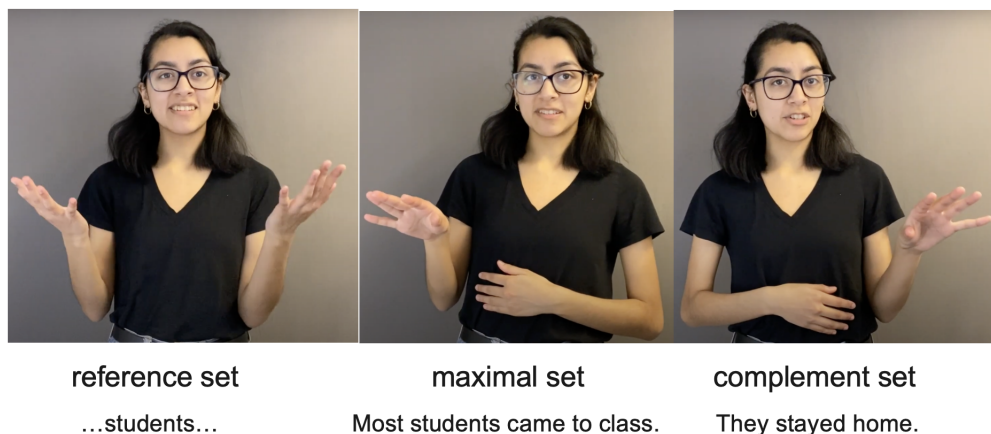


Figure 1: Gesture condition.

So as not to entirely confound the quantifier with the scenario in which it was used, we created pairs of two different scenarios in which it was natural to use each quantifier pair. The semantics of the quantifiers is such that we could not use the same scenario for every quantifier, but by at least having ratings for each quantifier in two different scenarios, and contrasting monotonicity for each scenario, we were able to generalize our findings beyond one specific scenario. Full materials, plots and details of the statistical analysis can be found on our OSF site.

Each participant saw all 8 quantifiers (rotated by scenario 1 or 2) with or without gesture. All items involved incompatible statives, to ensure only a complement set interpretation was targeted. We also had 4 practice and 4 control items, 2 of each involving gesture (mis)match and 2 without gesture, with (in)felicitous sentences. In the practice items, participants were given explicit feedback. For example, if the sentence was entirely grammatical, but the co-speech gesture did not match what is said, participants were given the following feedback:

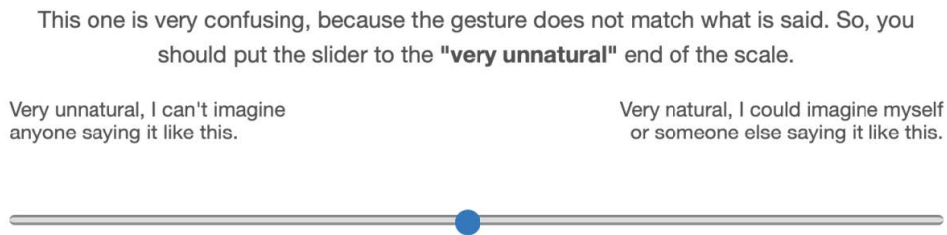


Figure 2: Feedback on practice items

Finally, our exclusion criterion was failing two or more controls, based on which we had 6 exclusions.⁶ We collected acceptability judgments using Davidson’s 2023 methodology, which is inspired by acquisition research asking children to “teach” their language to puppets; here, we asked adults to “help an alien learn to blend in” to their speech community, using the following scenario:

An **alien** from another planet has disguised themselves as a human and they’re **trying to blend in** among us. They need your help! They are asking **if the following videos seem “natural” to you**. Remember the alien needs to know which video is “natural” and which isn’t, so that they can perfectly blend in among us.

You should move the slider bar to the right if you think it’s something that you or someone else who speaks fluent English might say. You should drag the bar to the left if you think that it’s not something you or someone else who speaks fluent English might say. Use intermediate values when it is neither entirely natural nor entirely unnatural.

Figure 3: Help an alien learn to blend in!

We decided to use the scenario above, because we wanted participants to judge the utterance as a whole, including the co-speech gesture. In this way, something is “natural” if co-speech gestures and the relevant utterance are aligned, and something may be “unnatural” even if the sentence uttered is grammatical, namely when there is a mismatching co-speech gesture. As explained above, we also gave them explicit feedback during the practice trials, indicating that they should take co-speech gestures into account. Looking ahead, our results, and the variability across quantifiers, show that participants did indeed take co-speech gestures into account, as well as that they used the scale. We collected continuous ratings from “very unnatural” to “very natural”, using the scale in Figure 2. Participants ($n = 125$) were recruited via Prolific and compensated \$1.2 (\$12.97/hr) for their time.

3.3. Results

The results were along the lines we expected. We found an effect of gesture, an effect of quantifier type as well as an interaction between the two, as visualized in the following graph:

⁶‘Failing’ is interpreted in terms of directionality, i.e., dragging the slider bar towards the right end of the scale.

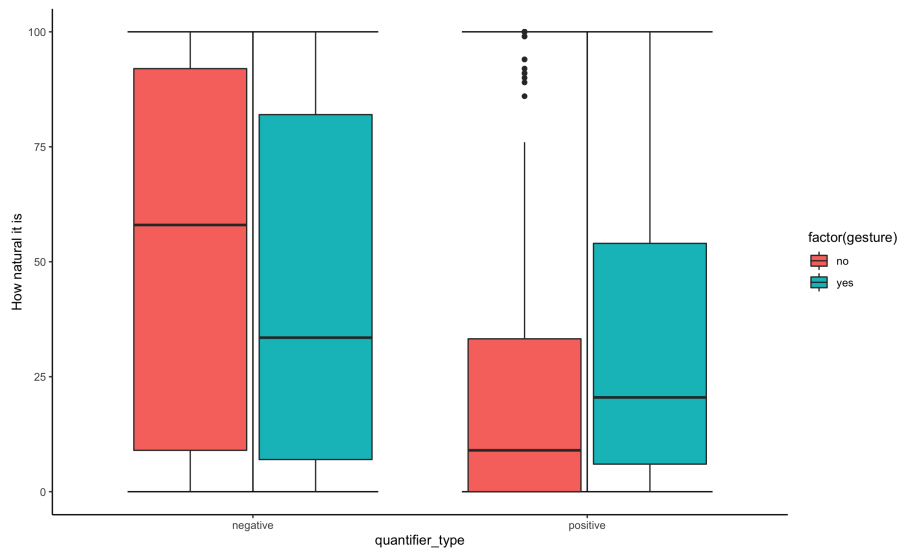


Figure 4: Results by quantifier type.

The main effect of quantifier type is successfully replicated (Moxey and Sanford 1993; Sanford et al. 1994), since negative quantifiers are acceptable than positive ones. Yet, the presence or absence of an iconic co-speech gesture significantly biases acceptability too. As hypothesized, we found a main effect of gesture: gestures increase acceptability for positive and decrease acceptability for negative quantifiers. There is also an interaction between gesture and quantifier type, which have inverse effects. While gestures increase acceptability for positive quantifiers, quantifier type decreases it, and vice versa for negative quantifiers. Finally, participants successfully used the scale, as evidenced by the variation across quantifiers:⁷

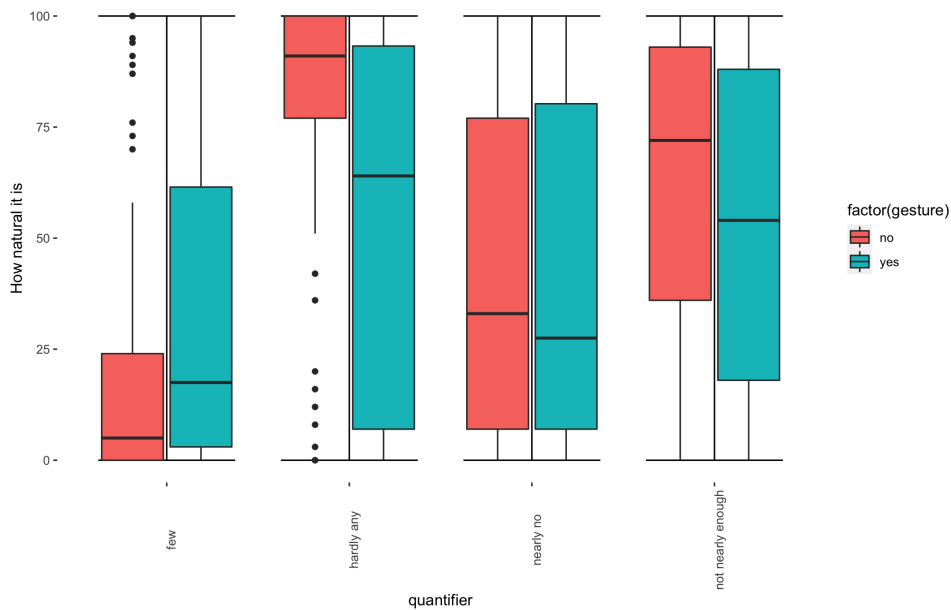


Figure 5: Negative quantifiers.

⁷Note that half items in scenario 1 of the positive quantifier ‘a few’ were recorded with the quantifier ‘most’ due to an error. These data were relabeled as scenario 3 of ‘most’. See the Items section of the OSF site.

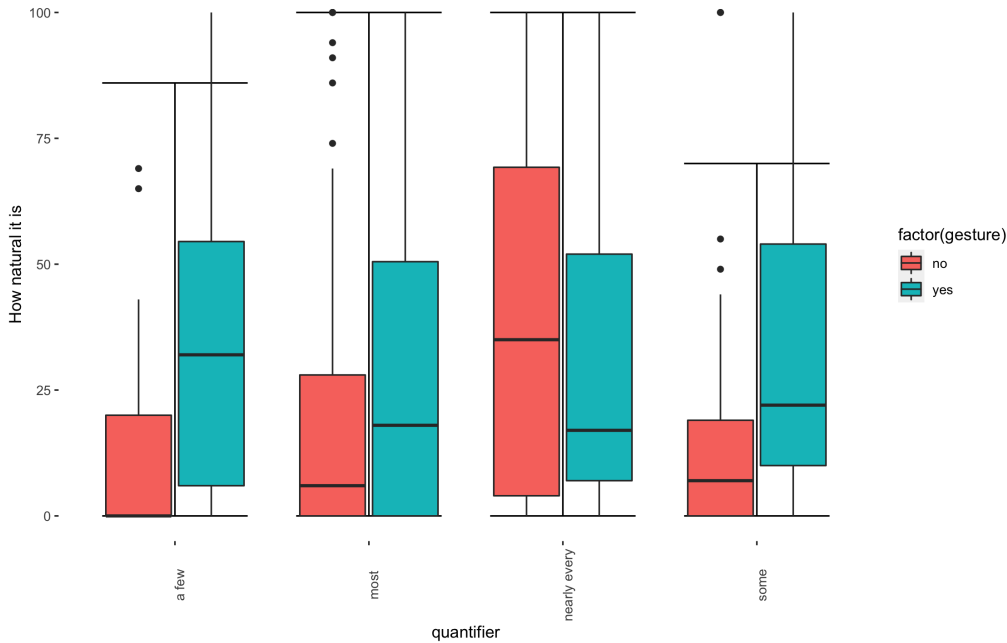


Figure 6: Positive quantifiers.

For our analysis we used a mixed effects linear model in *R* with an interaction between quantifier type (positive/upward monotone vs. negative/downward monotone) and gesture (present/absent). We fit a mixed effects linear model in *R* with an interaction between quantifier type (upward vs. downward monotone) and gesture (present/absent) ($lmer(measurement \sim Gesture * Quantiertype + (1|ID))$). Our Anova model comparison found this model significantly improved compared to the model without Gesture ($p < 0.05$). As expected, quantifier type has a significant effect to the model, since our Anova model comparison found the model $lmer(measurement \sim Gesture + Quantiertype + (1|ID))$ significantly improved compared to the model without Quantiertype ($p < 0.001$). Finally, there was a significant interaction ($p < 0.01$) between gesture and quantifier type, the model with the interaction $lmer(measurement \sim Gesture * Quantiertype + (1|ID))$ being better at predicting the results than the model without it $lmer(measurement \sim Gesture + Quantiertype + (1|ID))$.

Our main hypothesis stated that positive/upward monotone quantifiers will be more acceptable with gesture. We thus subseted the data to positive/upward monotone quantifiers and ran a linear model $lm(measurement \sim Gesture)$, which revealed that iconic gesture has a significant effect ($p < 0.01$) increasing acceptability. Our secondary hypothesis stated that negative/downward monotone quantifiers will be less acceptable with gesture. We thus subseted the data to negative/downward monotone quantifiers and ran the same linear model, which revealed an effect of gesture ($p < 0.05$) decreasing acceptability.

Finally, as already mentioned, each quantifier was tested in two scenarios. More specifically, we had two scenarios for each quantifier pair in Table 1, so as not to entirely confound the quantifier with the scenario in which it was used. We ran a secondary analysis of the data, excluding quantifiers which had an effect of scenario, i.e. N1(=few) and P4(=nearly every), therefore looking only at the subset of quantifiers where scenario had no effect. The results are

very similar, with the effect of gesture as well as the interaction between the two factors being even stronger:

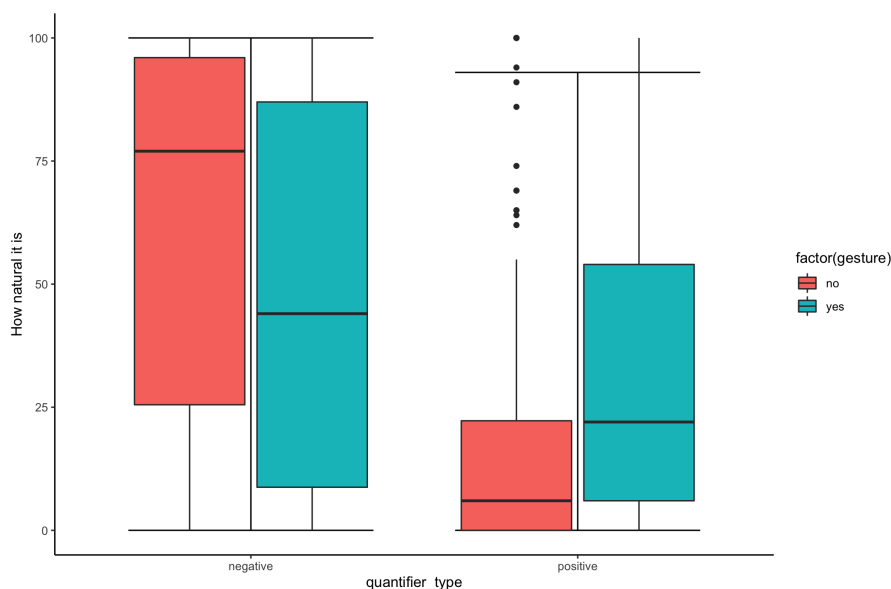


Figure 7: Results excluding quantifiers with effect of scenario.

We again ran the same mixed effects linear model in *R* with an interaction between quantifier type (positive vs. negative) and gesture (present/absent). Our Anova model comparison yielded the same results, the model with *Gesture* being significantly improved compared to the model without it ($p < 0.001$). Quantifier type had again a significant effect to the model, the model with *Quantifiertype* being significantly improved compared to the model without it ($p < 0.001$). Finally, there was again a significant interaction ($p < 0.001$) between gesture and quantifier type, the model with the interaction being better at predicting the results than the model without it. If we subset the data to positive quantifiers, we find a significant effect of iconic gesture ($p < 0.001$) increasing acceptability. If we subset the data to negative quantifiers, gesture has a significant effect ($p < 0.01$) decreasing acceptability.

3.4. Conclusions

Overall, we replicated the main effect of quantifier type from prior literature, found a new result that gesture also significantly affected acceptability, and found an interaction between gesture and quantifier type. These effects are further amplified if we exclude quantifiers with significant variation across scenarios. We conclude that iconic co-speech gestures increase acceptability of complement anaphora with positive/upward monotone quantifiers, and decrease acceptability of complement anaphora with negative/downward monotone ones. To the extent that the same iconicity is at play in both ASL iconic loci and the gestures tested in the experiment, we can conclude that the effect is not specific to ASL or even to sign languages, but is related to iconic use of space more broadly. In other words, the effect of iconicity is modality-independent, since it can be found both in sign and in gesture with spoken language.

What is more, negative/downward monotone quantifiers are overall more acceptable than positive/upward monotone ones, replicating the effect found in other studies (Moxey and Sanford

1993; Sanford et al. 1994) and reported in the literature from introspective judgments (Nouwen 2003). Finally, the fact that there is a significant interaction shows that iconicity has the inverse effect of monotonicity; it increases acceptability for positive quantifiers, while monotonicity decreases acceptability for them, and vice versa for negative ones.

4. Interpretation of the results

Our results raise many interesting questions. First of all, why do positive quantifiers become more acceptable with iconic co-speech gestures? There is often a presumption that acceptability stays fixed such that gestures merely affect implications (Tieu et al. 2019), or at most degrade acceptability, as under negation (Ebert and Ebert 2016; Davidson 2023; Ebert 2023). However, in our experiment gestures improved an otherwise unacceptable linguistic structure, namely complement anaphora with positive quantifiers. This implies a mechanism through which the linguistic structure interacts with gesture, and raises the interesting question of how: Is this simply a case of the gesture providing information via a context (e.g. making salient something for reference that was unavailable without gesture) or is this acceptability related to a more tight link integrating gestural and linguistic structure? Through what mechanism does this happen, and what does it suggest for the interaction between gestures and speech?

Secondly, focusing on the effect of gesture on negative quantifiers, we can ask what makes negative quantifiers become less acceptable with iconic co-speech gesture. Contrasting them with positive ones, one wonders why gesture does not facilitate the structure in this case as well. What we see instead is that gestures decrease acceptability of an otherwise acceptable linguistic structure, lending initial skepticism to the idea that gestures affect acceptability entire via providing possible reference in a context.

One possible interpretation of our results is that we are not dealing with complement anaphora at all but rather that the pronoun receives its interpretation deictically. This depends on how we define deixis; if by deixis we mean that the referent has to be present in the context, the stimuli in our study clearly do not involve deixis, but we might want to allow for a broader/less direct notion of deixis. The challenge then becomes: how does the referent (of deictic pointing) become available only when we point to it? In our view, if we need to expand our notion of deixis to involve this level of abstraction (such that this is no longer “complement anaphora” in the traditional sense), then our results are equally interesting: they suggest that this kind of abstract deixis introduces a discourse referent, namely the complement set. That said, one reason we hesitate to see this exactly as deixis is that the same gesture we used in our experiment could be quantified over, which argues against a deictic analysis:

- (14) I usually have [many students]-*a* in my classes. Whenever I teach a new class, the first week [most students]-*b* come. [They]-*a-b* usually have a time conflict.
(Here, *a*, *b*, *a – b* should be read as gestural loci, where *b* is a strict subset of *a* and *a – b* is the complement set.)

Thus, we’re inclined to interpret the main effect of gesture as suggesting that spatial iconicity allows for the complement set to become an available discourse referent, as observed for iconic loci in ASL (Schlenker 2012; Schlenker et al. 2013). This shows, consistent with the approach taken by Schlenker et al. 2013, that the ASL facts are not sign language specific, i.e., they have to do with the properties of space in introducing discourse referents via abstract uses of space (“loci”) rather than a sign language specific use of that space. Similarities between loci and

gestures have been pointed out in Schlenker and Chemla (2018), and along with our result, this supports research investigating *gestural loci* and their properties to better understand exactly how it is that discourse referents can be iconically introduced via iconic loci or co-speech gestures.

As for the main effect of quantifier type, we replicated results from prior literature, namely that CA is more available with negative than with positive quantifiers. Thus, we conclude that in order to understand CA and the mechanism through which the complement set becomes an available referent, relevant factors will be quantifier monotonicity as well as iconicity, and that in fact these interact.

Finally, we can ask what drives the interaction, i.e., why is it that iconicity and monotonicity have the inverse effect? We suggest that the interaction is the result of the incompatibility of negative quantifiers with iconic co-speech gestures. One might have expected that iconic co-speech gestures would increase acceptability no matter what the quantifier type is. However, what we observe is that iconic co-speech gestures decrease acceptability with negative quantifiers. We suggest that this is the result of an incompatibility between negative quantifiers and iconic depictions, as seen in prior literature for cases of sentential negation (Ebert and Ebert 2016; Kuhn 2020; Davidson 2023; Ebert 2023). In what follows, we suggest that (a) for CA to be felicitous the complement set must be guaranteed to be non-empty, and (b) iconic co-speech gestures trigger iconic inferences of existence, following suggestions by Kuhn (2020) for iconic loci in sign languages. The iconic co-speech gestures thus satisfy the non-emptiness requirement through the iconic inference of existence; this in turn explains why they make CA with positive quantifiers more felicitous than they were without the gesture.

4.1. Non-emptiness of the complement set

As noted in Nouwen (2003), CA is dispreferred out of the blue and needs to be supported pragmatically, and in particular the complement set needs to be the only set that can resolve anaphoric reference. Otherwise, there is generally a preference for the reference or the maximal set instead. We designed our experiment with this in mind, constraining the resolution of the pronoun to reference to the complement set by using predicates incompatible due to world knowledge. Our results further suggest that in addition to CA working only when there isn't competition from the maximal or reference set, CA requires the complement set to also not be potentially empty. Nouwen (2003) was working in an Optimality Theory (OT) framework, and he proposed an *Emptiness* constraint to explain the general unavailability of CA with positive quantifiers:

- (15) **Emptiness:** As the antecedent of an expression do not choose a set which is potentially empty, except when this set is the reference set of a quantificational sentence.

We suggest that a similar pragmatic constraint is at play, allowing a pronoun to resolve reference to the complement set only when the latter is guaranteed to be non-empty. Indeed, this would predict the quantifier type asymmetry, since given the semantics of the quantifiers, the complement set is guaranteed to be non-empty with negative, but not with positive quantifiers:

- (16) Most students came to class. In fact, maybe they all did, I didn't take attendance.
(17) Very few students came to class. #In fact, maybe they all did, I didn't take attendance.

Thus, negative quantifiers are better suited for CA without gesture, since they guarantee the

non-emptiness of the complement set. What is more, positive ones cannot satisfy the pragmatic constraint described above, since the complement set is potentially empty. Thus, they are not well suited for CA without gesture. This explains the monotonicity effect. What changes once we add gestures? In the following subsection, we argue that iconic co-speech gestures trigger iconic inferences of existence, thus satisfying the constraint against non-emptiness of the complement set.

4.2. Iconic inferences of existence

Kuhn (2020) proposed for sign language (based on data from ASL and LSF) that there is an *iconic inference of existence* associated with iconic loci. More specifically, he argued that the iconic use of space in sign language invites an iconic inference regarding what discourse referents exist in the global context. A presupposition of existence in the global context is triggered when space is used iconically, i.e., a discourse referent presupposes existence when it involves loci due to their iconicity. He makes use of this presupposition to explain, among other phenomena, the relationship between negative quantifiers and loci in sign languages.

We suggest that the same iconic inference of existence arises with iconic gestures, and that therefore this inference is not sign language or loci-specific, but more generally stems from how we interpret spatial iconicity. The intuition behind this is, as Kuhn put it, that “one cannot demonstrate the nonexistence of an entity by pointing at something” (Sober 1976; Kuhn 2020). The same holds for abstract pointing in space, as seen in iconic loci and co-speech gestures.

Extending Kuhn’s proposal for sign language loci to the similar use of space in co-speech gesture, we argue that there is an obligatory pragmatic inference triggered when an iconic co-speech gesture to a locus is used that the set it refers to exists, and thus, is non-empty. The pragmatic principle triggering this presupposition could be the following:

(18) **Non emptiness:** do not iconically depict aspects of something that might not exist.

Such a pragmatic pressure results in a presupposition of existence in the global context whenever space is used iconically both in sign and in gesture. Following this line of reasoning, the use of iconic loci with gestures can support the introduction of a discourse referent; in our case, the complement set. This suggests that gestures interact with the linguistic system, being able to introduce discourse referents iconically. There is a deeper, very interesting question: why is there such a correlation between space and discourse referents, and what property of space triggers it? We leave this open for future research. For our purposes, we argue that the iconic inference of existence triggered by the co-speech gesture introduces the complement set as a discourse referent, satisfying the requirement for non-emptiness of the complement set. Thus, CA becomes more acceptable with positive quantifiers when an iconic co-speech gesture is used.

Why are gestures not increasing acceptability for negative quantifiers as well? One would expect that negative quantifiers should become even more acceptable when co-speech gestures are added, since there are two factors guaranteeing the non-emptiness of the complement set, namely the negative polarity of the quantifier itself and the co-speech gesture to a locus that supports existence of the referent. However, we observe just the opposite; co-speech gestures decrease acceptability for negative quantifiers.

We argue that the oddness of these examples comes from gesturing while uttering a downward

monotone quantifier with a negative meaning. For example, it is the overlap of the iconic co-speech gesture with “hardly any” in “Hardly any senators voted in favor of it” that is behind the decreased acceptability. When the gesture occurs at the same time as the quantifier (i.e., hardly any), it has to refer to the maximal set (i.e., the senators who voted in favor), which is potentially empty in the case of negative quantifiers. Just like the complement set was potentially empty for positive, but not for negative quantifiers, the maximal set is potentially empty for negative, but not for positive quantifiers:

- (19) Hardly any senators voted in favor of the new bill. In fact, maybe nobody did, I didn't pay attention.
- (20) Most senators voted in favor of the new bill. # In fact, maybe nobody did, I didn't pay attention.

However, if the situation was parallel to positive quantifiers and the complement set, we would predict that the co-speech gesture triggers an iconic inference of existence and thus presupposes that the maximal set is non-empty. In other words, whatever happens with positive quantifiers and the complement set should happen with negative ones and the maximal set. Both should result in increased acceptability and a presupposition that the depicted set is non-empty. The iconic inference of existence from the co-speech gesture should press in favor of a non-empty complement set for positive and a non-empty maximal set for negative quantifiers. This does indeed happen for positive, but not for negative quantifiers. In the case of the latter, we observe decreased acceptability instead. To make this more concrete, when we hear “hardly any senators voted in favor of it” and we see a gesture, we should understand “hardly any senators voted in favor of it but some did”. Why do we observe a decrease in acceptability instead?

We argue that there is an additional factor blocking this interpretation, namely the attested incompatibility of negation or negative meanings more in general with iconic depiction. We had hypothesized that this would be the case, since prior literature suggests that such an incompatibility exists for sentential negation (Ebert and Ebert 2016; Esipova 2019; Kuhn 2020; Davidson 2023). In our data, the same incompatibility seems to extend to decreasing the acceptability of these gestures with negative quantifiers. Why is negation and negative meanings incompatible with iconicity? The answer could again lie in iconic inferences of existence, which introduce a discourse referent iconically; negative quantifiers do not want to introduce a discourse reference, and this conflicts with the iconic inference of existence resulting in decreased acceptability. To illustrate this, we can use the following examples from Kuhn (2020), where the quantifier *all* introduces a functional discourse referent, while *none* blocks such a discourse referent:⁸

- (21) All of the students read a different book, and all of them liked it.
- (22) *None of the students read the same book, and all of them liked it.

We suggest that iconic inferences of existence guarantee the non-emptiness of the complement set in the case of positive quantifiers, but cannot guarantee the non-emptiness of the maximal set in the case of negative ones, because the iconic inference of existence introduces a discourse referent when the quantifier does not. This results in a conflict, translated into decreased acceptability.

⁸The two sentences, up to the conjunct, are truth-conditionally equivalent as Kuhn (2020) notes.

Thus, what might be driving the interaction is the pragmatic pressure for non-emptiness of the complement set, which can be satisfied by the semantics of the downward monotone quantifiers or by the iconic inference of existence from the co-speech gesture, along with the incompatibility of negative meanings with iconicity.

5. Implications for theories of complement anaphora

How can our results inform our theorizing about CA? There are two main strategies in the literature to explain the availability of CA with negative quantifiers. Some theories, what we call as the “illusion account”, propose that speakers are confused thinking that the complement set is being referred to; it is rather an instance of restrictor anaphora instead (Corblin 1996; Geurts 1997; Kotek 2008). Other theories, what we call as the “genuine anaphora” account, state there is indeed genuine complement set anaphora, but it is a dispreferred anaphoric strategy, surfacing only in certain environments (Kibble 1997; Nouwen 2003; Schmitt et al. 2017). This section describes these strategies, arguing that our results support genuine anaphora accounts.

5.1. The illusion account

Illusion accounts claim that reference to the complement set is only apparent, and in reality reference to the *restrictor* set is made instead. Corblin (1996) calls this *pseudo*-reference to the complement set. He observes that reference to the complement set clashes with the generalization of Kamp and Reyle (1993) that subtracting one set from another is not a permissible operation for the formation of pronominal antecedents. Indeed, Kamp and Reyle (1993) give the following example (see also Partee (1989); Heim (1982)):

(23) Eight of the ten balls are in the bag. # They are under the sofa.

Based on this, Corblin (1996) argues that complement anaphora is in reality restrictor anaphora. He suggests that speakers confuse the restrictor with the complement set. For example:

(24) Peu d'électeurs français ont voté pour le candidat du parti communiste. Ils
Few of-voters French have voted for the candidate of party communist. They
ont voté pour le candidat de droite à 40% environ.
have voted for the candidate of right at 40% around.
'Few voters voted for the candidate of the communist party. Approximately 40% of
the voters voted for the right-wing candidate.'

He argues that this cannot be complement set reference, since “approximately 40%” would make the sentence with such a reference false. Thus, the idea in Corblin (1996) is that complement set reference is an illusion; what is really going on is restrictor set reference under an implicit restrictive modifier. Geurts (1997) provides an alternative “illusion account” based on *collective reference*. This is a common phenomenon with plural definite descriptions:

(25) The students resisted the police.

(26) The soldiers withstood the attack.

Crucially, these sentences can be true even if they are not true for each member of the plural DP. In other words, the students could have resisted the police, even if one student individually did not. Similarly for the soldiers. Both constitute examples of *sloppy reference*. For Geurts (1997), when CA is possible, there is no genuine reference to the complement set. Instead, reference is *sloppy* in the same way as for plural definite descriptions. The plural pronoun

“they” in (11), repeated below as (27) for reference, refers to the set of students as a whole, the restrictor set, which is collectively held responsible for not coming to class.⁹

(27) (Very) few students came to class. They stayed home instead.

All in all, the idea behind “illusion accounts” is that referring to the restrictor set means referring to a majority of things not satisfying the nuclear scope. Consequently, we confuse restricted reference to the restrictor set with complement set reference.

5.2. Problems with illusion accounts

Nouwen (2003) provides arguments against an illusion analysis, of which we will mention the most compelling ones. First of all, the example above in (24) merely illustrates that restrictor set anaphora is possible, not that it is the only strategy available. Secondly, it is unclear why speakers should confuse restrictor with complement set reference. In psychological experiments (e.g., Moxey and Sanford (1993)) where people were asked to explicitly give their personal judgment on what they had referred to, they picked the complement set. What is more, the use of *instead* indicates reference to a complementary distribution:

(28) Very few students came to class today. They stayed at home instead.

This complementary distribution is accounted for if this is genuine complement set anaphora as opposed to restrictor anaphora instead. Finally, Nouwen (2003) takes issue with Corblin’s (1996) claim that CA is really reference set anaphora reporting on the smallness of the reference set. In fact, the latter does not have to be small. Moxey and Sanford (1993) show that some determiners license CA without a smallness judgment:

(29) Not quite all of the teachers attended the meeting. They stayed home instead.

The analysis of Corblin (1996) predicts that “they” refers to the restrictor set. However, “they” reports on a minority of teachers.

What is more, Schmitt et al. (2017) provide a mixed account, arguing that some instances of CA are illusory and some involve genuine reference to the complement set.¹⁰ Using German data, they show that not all CA cases are illusory. They use *die anderen* ‘the others’ as a control, assuming it presupposes the maximal set of some plural quantifier to be divided between a salient subset and its complement. Their logic is that if ‘the others’ can be used, then there is a discourse referent denoting the complement set. Indeed, this is true for the following example:

- (30)
- a. Nicht alle Buben haben ihren Kuchen gegessen.
Not all boys have their cake eaten.
‘Not all boys ate their cake.’
 - b. Sie haben ihn (stattdessen) weggeworfen.
They have it instead throw-away.
‘They threw it away (instead).’
 - c. Die anderen haben ihn (aber) sehr schnell gegessen.
The others have it but very fast eaten.

⁹Kotek (2008) also argues that genuine reference to the complement set does not exist. She specifically proposes that it is maximal set anaphora instead, since the maximal set must be independently calculated, and introduced as a presupposition. Thus, she argues, for economy, the maximal is preferred as an antecedent.

¹⁰Based on German data, they propose a mechanism to refer to the complement set whenever there is a negation c-commanding the quantifier. For details we refer the reader to Schmitt et al. (2017).

‘The others ate it very fast (however).’

5.3. The genuine anaphora account

Having presented arguments against illusion accounts, we will briefly present Nouwen’s 2003 account, arguing that CA involves genuine reference to the complement set. We call this the *genuine anaphora* account. This is not the only genuine anaphora account (see e.g., Schmitt et al. (2017)), but for reasons of space we focus on this one. Nouwen (2003) proposes that there is pragmatic preference for the reference set as opposed to the complement one. Thus, CA is avoided whenever the anaphoric relation can be resolved in another way. Indeed, in the following example *they* refers to the few balls that are blue rather than the many that are not:¹¹

(31) Few of these balls are blue. Can you point them out for me?

However, this pragmatic preference can be overruled by semantic considerations. As we noted above, Nouwen (2003) proposes OT constraints to account for the facts in a semantic OT framework. Roughly, the system is set up so that the domain of quantification of a determiner is preferably the reference set, except to avoid a contradiction with previous discourse. As an illustration, notice that in the following example the reference set is used as a restrictor for *three* in interpreting the second sentence:

(32) Ten students attended the meeting. Three spoke.

Crucially, there is a constraint, which Nouwen calls *Emptiness* and formulates as follows:

(33) **Emptiness:** As the antecedent of an expression do not choose a set which is potentially empty, except when this set is the reference set of a quantificational sentence.

Given this, what can the pronoun ‘they’ in the CA cases refer to? *Emptiness* blocks it from taking a potentially empty antecedent. In other words, if the complement set is potentially empty, it cannot be the antecedent of the pronoun. What is more, there is a pragmatic preference for the reference set to be the antecedent of the pronoun. However, if resolving the pronoun to the reference set gives rise to a contradiction given the previous discourse, then to avoid a contradiction we resolve the reference to the complement set. The idea is that only to avoid a contradiction do we resort to the last solution which is complement set anaphora. This would explain why it is in general hard to get, especially if some other kind of anaphora can provide an antecedent for the pronoun. To illustrate how this works, consider the following example:

(34) Most students went to the party. #They went to the beach instead.

Here, to avoid a contradiction we choose the complement set, but *Emptiness* rules this out, since it could be empty: the first sentence could be true in a situation where all the students went to the party. Crucially for Nouwen, the *Avoid Contradiction* constraint is ranked below *Emptiness*. Thus, because of *Emptiness*, we have to interpret the plural pronoun in the second sentence as referring to the reference set. Therefore, the continuation leads to a contradictory reading and infelicity. On the contrary, *Emptiness* does not rule this out with a negative quantifier since the complement set is non-empty thanks to the semantics of the quantifier. Thus, CA is felicitous:¹²

¹¹For the authors, this example is not very felicitous, and is significantly improved if the positive quantifier ‘a few’ is used. This would suggest that the proposed pragmatic preference for the reference set is stronger for positive than for negative quantifiers.

¹²The *Non emptiness* constraint we proposed in (18) is similar to Kuhn’s 2020 iconic inferences of existence. Just like a potentially empty set cannot be the antecedent of a pronoun, a potentially nonexistent discourse referent cannot be depicted iconically in space. In other words, placing a discourse referent in a marked location in space

(35) Few students went to the party. They went to the beach instead.

5.4. Support for genuine anaphora accounts

Our results provide support for genuine anaphora accounts, and specifically for Nouwen's 2003 idea behind his *Emptiness* constraint. We saw that in ASL and in English with gestures iconicity can help license CA. If CA is possible with positive quantifiers once iconicity is added, how can it be an illusory reference to the restrictor set? Indeed, illusion accounts assume reference to the complement set is never possible. Adding to the arguments against this assumption (e.g., (29) and (30)), we showed that CA is possible with positive quantifiers. Thus, given the ASL as well as the English data with gestures, we argue that in certain cases genuine reference to the complement set is possible. So far, theories of CA were focused on the monotonicity of quantifiers; a new desideratum we attempted to explain is the effect of iconicity.

6. Conclusion

Inspired by the felicity of CA with positive quantifiers when iconic loci are used in ASL, we experimentally tested the effect of iconic co-speech gestures on CA licensing with positive and negative quantifiers. In addition to replicating the main effect of quantifier type, we found a main effect of gesture, and an interaction between the two factors. We concluded that iconic co-speech gestures can significantly increase acceptability of CA with positive quantifiers. Iconicity had the inverse effect of monotonicity, negative quantifiers having significantly decreased acceptability when co-speech gestures are added. We interpreted the main effect of gesture as suggesting that the complement set can become an available discourse referent via the iconic use of space that supports inference that establish the complement set as available for anaphora, just as has been suggested for iconic loci in ASL (Schlenker 2012; Schlenker et al. 2013). We further argued that the interaction is the result of a pragmatic pressure for non-emptiness of the complement set (Nouwen 2003), which can be satisfied by the semantics of negative quantifiers or by the iconic inference of existence (Kuhn 2020) triggered by the gesture, along with the incompatibility of negative meanings with iconicity. Finally, we argued that our findings support genuine anaphora theories of CA, and that iconicity should be taken into account as a licensing factor of CA. We hope this paper will inspire more work on the interaction between iconicity and anaphora.

References

- Corblin, F. (1996). Quantification et anaphore discursive: la référence aux complémentaires. *Linguages* 123, 51–74.
- Davidson, K. (2023). Semiotic distinctions in compositional semantics. In *Proceedings of the 58th Meeting of the Chicago Linguistic Society*.
- Ebert, C. (2023). Semantics of gesture. *Annual Review of Linguistics* 10.
- Ebert, C. and C. Ebert (2016). The semantic behavior of co-speech gestures and their role in demonstrative reference, presentation, LSCP LANGUAGE seminar talk at the Institut Jean-Nicod, Département d'études Cognitives, ENS.
- Esipova, M. (2019). *Composition and projection in speech and gesture*. Ph. D. thesis, New York University, New York, NY.

is similar to using a pronoun for that referent.

- Geurts, B. (1997). Book review of linda m. moxey and anthony j. sanford. communicating quantities. *Journal of Semantics* 14, 87–94.
- Heim, I. R. (1982). *The semantics of definite and indefinite noun phrases*. University of Massachusetts Amherst.
- Kamp, H. and U. Reyle (1993). *From discourse to logic: Introduction to modeltheoretic semantics in natural language, formal logic and discourse representation theory*, Volume 1. Dordrecht: Kluwer Academic Publishers.
- Kibble, R. (1997). Complement anaphora and dynamic binding. In *Semantics and Linguistic Theory*, Volume 7, pp. 258–275.
- Kotek, H. (2008). Resolving complement anaphora. In C. Johansson (Ed.), *NEALT proceedings series: Proceedings of the second Workshop on Anaphora Resolution*, pp. 41–53.
- Kuhn, J. (2020). Logical meaning in space: Iconic biases on quantification in sign languages. *Language* 96(4), 320–343.
- Moxey, L. M. and A. J. Sanford (1993). *Communicating quantities. a psychological perspective*. Laurence Erlbaum Associates.
- Nouwen, R. W. F. (2003). Complement anaphora and interpretation. *Journal of Semantics* 20, 73–113.
- ParTEE, B. H. (1989). Binding implicit variables in quantified contexts. *University of Massachusetts Occasional Papers in Linguistics* 15(2), 12.
- Sanford, A. J., L. M. Moxey, and K. Patterson (1994). Psychological studies of quantifiers. *Journal of Semantics* 11, 153–170.
- Schlenker, P. (2012). Complement set anaphora and structural iconicity in ASL. *Snippets* 25, 15–17.
- Schlenker, P. and E. Chemla (2018). Gestural agreement. *Natural Language & Linguistic Theory* 36, 587–625.
- Schlenker, P., J. Lamberton, and M. Santoro (2013). Iconic variables. *Linguistics and philosophy* 36, 91–149.
- Schmitt, V., E. Onea, and F. Buch (2017). Restrictions on complement anaphora. In *Semantics and Linguistic Theory*, Volume 27, pp. 212–229.
- Sober, E. (1976). Mental representations. *Synthese* 33(1), 101–148.
- Tieu, L., P. Schlenker, and E. Chemla (2019). Linguistic inferences without words. *Proceedings of the National Academy of Sciences* 116(20), 9796–9801.