Scalar implicatures in a signed language

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This paper tests the calculation of scalar implicatures in American Sign Language (ASL) in one of the first experimental pragmatic studies in the manual/visual modality. Both native signers of ASL and native speakers of English participated in an automated Felicity Judgment Task to compare implicatures based on two traditional scales as well as "ad hoc" scales in their respective languages. Results show that native signers of ASL calculate scalar implicatures based on a prototypical scale <all, some> in ASL in the same pattern as native speakers of English, within the same experimental paradigm. There are similarly high rates of exact interpretations of numbers <three, two> in ASL as in English, despite the iconicity of the numerals in ASL. Finally, an ad hoc scale was tested showing fewer implicatures in English than on the conventionalized scales. In ASL, there was a trend toward increased implicatures on the ad hoc scale which made use of the unique ability of ASL to convey spatial information using the classifier system. Taken together, these results show that conventionalized scales in ASL have the same semantic/pragmatic scalar properties as in spoken languages, although in non-conventionalized scales the inclusion of additional information such as spatial location may affect pragmatic interpretation.

Keywords: experimental pragmatics, sign languages, scalar implicatures, exhaustivity, ad hoc scale

1. Introduction

This paper focuses on one of the most well-studied phenomena at the interface of semantics and pragmatics, and uses experimental methods to determine whether there is a corresponding phenomenon in American Sign Language and how properties specific to the visual/manual modality may be incorporated into semantic/pragmatic calculations. The phenomenon at the center of this investigation is the fact that when most people hear (1a), they will also consider (1b) to be true.

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(1) a. Mary ate some of the cookies.
b. Mary didn't eat all of the cookies.

According to an analysis originating with Grice (1967, 1989) and further developed by Gazdar (1979) and Horn (1989), among many others, the basic meaning of (1a) is that Mary ate *at least some* of the cookies. In other words, (1a) is technically true in any situation where she ate at least one cookie: maybe all of the cookies or maybe not all, but at least one. This is a rather weak statement: the only possibility that it rules out is that Mary didn't eat any cookies. Next, this basic meaning of (1a) gets pragmatically strengthened by the listener's consideration that if *Mary ate all of the cookies* were true, then the speaker should have said that, since it would have been just as easy to say as (1a) but it would have been a better description of the facts. Since the speaker didn't choose to say that, and participants in a conversation generally give the most informative description that they can easily provide (Grice's "Maxim of Quantity"), then it must be false. Hence, the listener concludes (1b). This extra inference (1b) is known as a "scalar implicatures": "scalar" because participants are considering what to say based on a scale of informativity (here, the scale <all, some>), and an "implicature" because (1b) doesn't follow from (1a) by necessity, it merely follows in certain semantic/pragmatic contexts.

Evidence supporting scalar implicatures comes not only from theoretical investigations, but also from controlled psycholinguistic experiments. Participants take longer to respond in behavioral and eye-tracking experimental tasks when they calculate scalar implicatures than where they do not (Bott & Noveck 2004; Storto & Tanenhaus 2005) and they also have more difficulty calculating scalar implicatures when their processing load is increased by a concurrent task, such as memorizing dot patterns (De Neys & Schaeken 2007). Preschool and early elementary school children often fail to reject underinformative uses of words like *some*, which has often been taken to mean that children calculate fewer implicatures than adults (Noveck 2001; Chierchia et al. 2001; Papafragou & Musolino 2003; but see Katsos & Bishop 2011).

The interface of semantics/pragmatics is particularly ripe for investigation in ASL because analog/non-discrete information (for example, the precise spatial configuration of a set of objects on a table) can be described within the grammatical confines of the language using a system of classifiers and spatial loci. Investigations of the morphological, phonological, and psycholinguistic properties of such systems have shown that sign language classifiers follows a clearly defined set of rules (Emmorey 2003), although we know very little about their pragmatic properties. By focusing on scalar implicatures, the goals of this paper are: (i) construct and verify a working experimental paradigm for testing scalar implicatures in the manual/visual modality; (ii) determine a baseline of implicature calculation for common scales in ASL by comparing signers of ASL and speakers of English on the same task in their respective languages; and (iii) test the flexibility of ad hoc scales in adults in both English and in ASL to better understand the relationship of contextual knowledge and implicature calculation, and the role that spatial information plays in this relationship.

In what follows, Section 2 presents three types of scales that will be the focus of the current study. Section 3 discusses the methods used, and Section 4 presents the results. Section 5 includes a discussion of the results and concludes the article.

2. Scale types

Scalar implicatures in ASL are tested via participants rating descriptions of situations that include one of the following: (a) a prototypical scale of quantifiers in English and in ASL (Section 2.1); (b) strongly scalar numbers (Section 2.2); and (c) an "ad hoc" scale (Section 2.3).

2.1 Quantifiers

Two ASL quantifiers, SOME and ALL (Figure 1), served here as a prototypical test case for scalar implicatures in a sign language because they are each a single lexical sign and are also usually translated straighforwardly into English as 'some' and 'all'. Although there is a small iconic component of these signs, especially SOME (where the dominant hand partitions the area in the palm of the nondominant hand), there is no reference to the ASL spatial classifier system. In other words, these quantifiers show minimal modality-specific properties, and thus can be directly and easily compared to their English counterparts. Given their similarities with the English quantifiers, and the fact that similar quantifiers in other languages typically pattern alike (Noveck 2001; Papafragou & Musolino 2003, among others), these were expected under a properly working experimental paradigm to generate behavioral results similar to results based on the <all, some> scale in English. As such, sentences based on the <all, some> scale were included both to test the overall experimental paradigm and provide a baseline for comparison with the more modality-specific scales mentioned below.

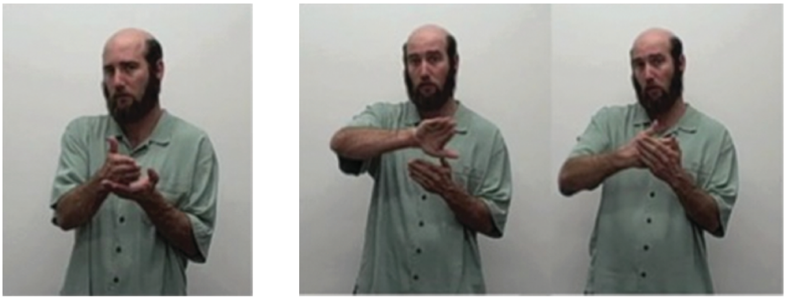


Figure 1. SOME and ALL used in the Quantifier sentence type.

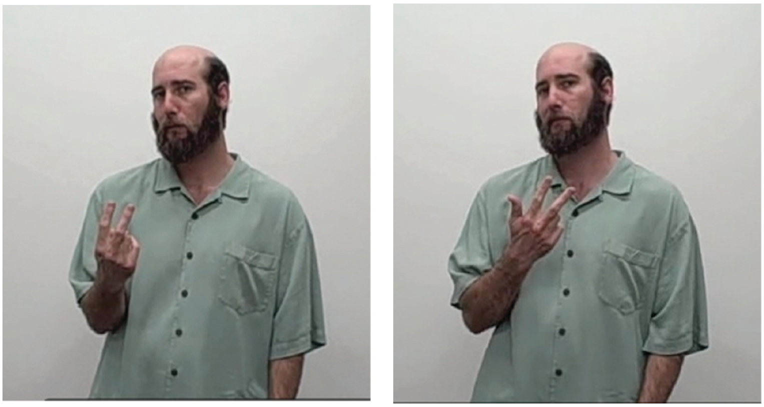
2.2 Numbers

In experimental research on scalar implicatures in spoken languages, numerals (specifically, the cardinal natural numbers <…, three, two, one>) are more consistently rejected in underinformative situations than are quantifiers by adults: the inference from (2a) to (2b) is particularly strong.

(2) a. There are two bowls.
    b. There are not three bowls.

Underinformative uses of numbers (i.e. *two* when there are actually three bowls) are also more consistently rejected by children who otherwise fail to reject underinformative sentences involving prototypical scales like quantifiers <all, some>. This has been taken to be an indication that the "strengthened" meaning of numbers is not pragmatic but semantic (Papafragou & Musolino 2003), while others have taken it to mean that pragmatic strengthening is more robust in numbers because the numbers scale is more accessible to children than other scales (Barner et al. 2010).

The current paper tested numbers in ASL to add a new dimension to this debate, because in ASL the signs for numerals *one* through *five* are comprised of a handshape configuration in which the number of extended fingers is equal to the meaning of the sign (Figure 2). Consequently, there is a more transparent mapping between the form and the meaning in ASL numerals — they are more "iconic". Note that the signs themselves are both fixed and arbitrary, in that the sign for 'three' must include the thumb, and not the ring finger, as shown in Figure 2. We currently know very little about the effects of increased iconicity on implicature calculation, and so this scale was included to test whether iconicity, which appears to be more frequent in the visual-manual modality, alters implicature calculation. However, because numbers are usually already rejected when used in underinformative situations, it will only be possible to see a difference if implicatures are decreased. We also included numbers because they are such a frequently studied scale in spoken languages, and a high and accurate rejection rate by participants on numbers in ASL and English would indicate success of the experimental paradigm.



TWO THREE

Figure 2. TWO and THREE used in the Number sentence type.

2.3 Ad hoc scale

Both sentence types described above, quantifiers and numbers, are based on scales that are generalizable to a variety of contexts, i.e. ALL is an alternative to SOME in most situations and THREE is an alternative to TWO in most situations. An open question is how much of the interpretation of sentences with scalar items depends on the generalizability of the scales. In the current study, which aims to investigate the role of language modality on semantic/pragmatic reasoning, it is also an open question whether modality affects interpretations based on these generalizable scales in the same way as similar inferences that arise only in a specific context. The former is clearly learned linguistic knowledge, while the second may be more heavily influenced by extra-linguistic factors. To investigate this issue, the third sentence type investigated in this experiment was an ad hoc scale ("ad hoc" is used here in the same sense as in Stiller et al. (2011)). In an ad hoc scale, the scalemates are alternatives *because* of the given context. For example, in a situation where a candle, a globe, and a wallet are three relevant objects, then *candle, globe, and wallet* is a salient alternative to *candle and globe*, and (3a) implies (3b).

(3) a. There is a candle and a globe on the table.
b. There is not a wallet on the table.

In a different situation in which the three relevant items on the table are a candle, a globe, and a sock, then *candle, globe, and wallet* is no longer a salient alternative to *candle and globe*, and we do not draw the implicature in (3b). Such ad hoc scales have been studied very little even in spoken languages, although there are suggestions that they do differ from traditional scales in children's interpretations (Katsos & Bishop 2011; Stiller 2011). Here, we ask whether adult native speakers of English calculate fewer implicatures when the scale is not conventionalized, as in this ad hoc case.

Furthermore, listing of items such as in these ad hoc scales are of particular interest in ASL because a natural way to sign a description of (3) is to use the system of spatial loci and classifiers. This system takes advantage of the manual/visual modality to include information about the physical and geometrical properties of the objects and space being described, though it is very much still linguistic; for example, handshapes are constrained to a finite list, and each object is matched with an obligatory specific handshape (Emmorey 2003; Sandler & Lillo-Martin 2006). By comparing ad hoc scales in ASL to ad hoc scales in English, we can assess whether information about space (not directly related to quantity) affects pragmatic interpretation.

The ad hoc scale-based sentences in this experiment began with a deictic sign (THERE) and then each item in the list was signed in its citation form in neutral space, followed by a location classifier (notated "CL", following Sandler & Lillo-Martin 2006) to indicate both the size and shape of the item (notated by what follows the colon, which indicates the handshape, e.g. "B", "C", "5(claw)") and where in the space the item was located (notated using variable subscripts, e.g. "X", "Y", and "Z"). For example, in (4), the signer uses two signs THERE and WALLET, and then a spatial classifier which has a **B**-handshape to represent the wallet, placed in the first location ("X"). This is followed by the sign CANDLE and a classifier with the **C**-handshape to represent the candle, placed in location Y. Finally, this is followed by the sign GLOBE followed by a classifier in the clawed 5-handshape, placed in location Z.

(4) THERE WALLET CL:B_X CANDLE CL:C_Y GLOBE CL:5$(\text{claw})_Z$
'There is a wallet, a candle, and a globe.'

Two examples of "ad hoc scalar items" (everything following the deictic) are also shown frame-by-frame in Figure 3, a two-item trial in Figure 3a and the three-item trial in (4) in Figure 3b.

a.

b.

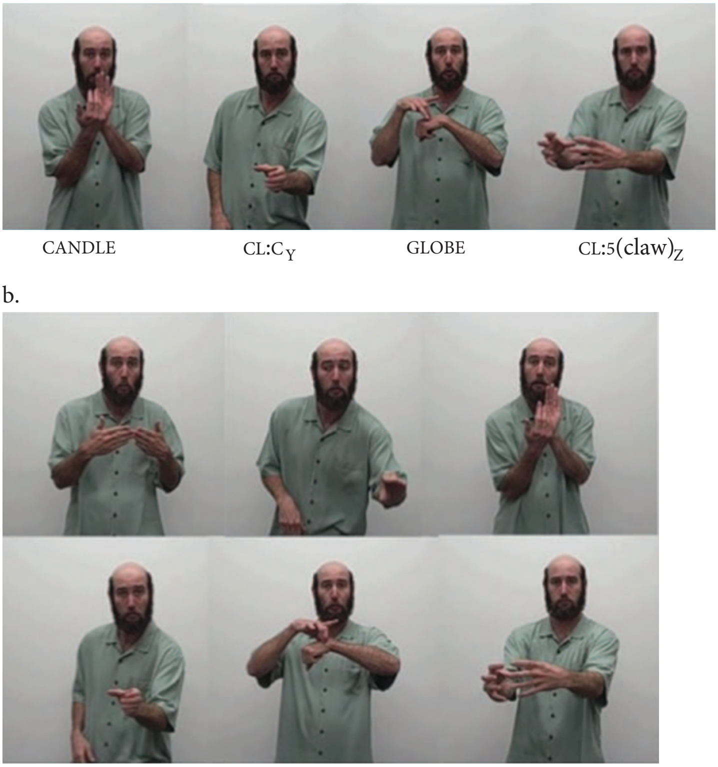


Figure 3. Two item (a) and three item (b) trials used in the ad hoc sentence type.

To be clear, there are multiple ways to incorporate the spatial classifier system in ASL into sentences involving implicatures, but here the goal was to show one of these ways, and to test whether and how this affected pragmatic interpretation.

Since experimental pragmatics, especially the study of implicatures, has yet to have been studied in sign languages, one of the goals of investigating this sentence type is to see whether the addition of the information about the spatial relationship of objects affects pragmatic interpretation. If it does, we may see more implicature calculation in the ad hoc sentence type in ASL than in English. If, however, it does not play a role in pragmatic calculations like quantity implicatures, then we expect to see equal implicature calculation in ad hoc sentence test trials in ASL and in English.

We have described three different structures in ASL in which we will assess different properties of scalar implicatures: (i) a prototypical scale <all, some> to determine whether scalar implicatures occur in a signed language in the same frequency and pattern that they occur in spoken language; (ii) a scale with increased transparent mapping between meaning and form (iconicity) to determine if this affects pragmatic interpretation, using the numbers scale in ASL <three, two> ; and (iii) spatial classifiers to determine if use of the spatial loci and classifier system can affect pragmatic interpretation, using a non-generalizable context-dependent ad hoc scale in ASL.

3. Methods

3.1 Participants

Participants were twenty adults from the greater San Diego area. Eight were adults who self-identify as deaf and have been learning and using American Sign Language since birth because they had at least one deaf parent. All eight were unable to hear normal speech, and consider ASL to be their first language. These participants were recruited through email requests from a labortory database of interested participants or indirectly through recommendations by their friends, and received reimbursement in cash or gift cards. These eight participants will be referred to as "native signers of ASL". The twelve remaining participants were hearing undergraduate students at the University of California who were monolingual native speakers of English and had no exposure to ASL. These participants received course credit for participating in the experiment; they will be referred to as "native speakers of English".

3.2 Materials and procedure

Each testing session lasted 30–35 minutes. The participant sat in front of a 13 inch Macbook laptop either at UCSD or, for some native signers of ASL, at various meeting places throughout San Diego county. Both the instructions and the task itself were presented in video form, by a native signer of ASL (ASL version, for native signers of ASL) or a native speaker of English (English version, for native speakers of English). Participants were instructed that for each trial of the experiment, a picture will appear on the screen, and that after they look at the picture, they should press the Space Bar key and a video description will begin to play next to the picture. Participants were told to press the smile face (the "1" key covered with a smile face sticker, directly below the picture of a smile face on screen) if they are "satisfied that the description matches the picture". If they are "not satisfied, and think that the description does not match the picture", they were instructed to press the frown face (the "0" key covered with a frown face sticker, directly below the picture of the frowning face on screen) (Figure 4). It was impossible to replay a video.

Participants viewed three practice trials to acquaint them with the task: (1) a picture of a red bowl, and a video description (*THAT BOWL, RED* 'The bowl is red'); (2) a picture of a white shoe, and a video description (*THAT SHOE, BLACK* 'The shoe is black'); (3) a picture of a wooden spoon, and a video description (*THAT SPOON, WOODEN* 'The spoon is wooden'). Participants had an opportunity to ask questions at this point if anything about the task or playing the videos was unclear. Practice trials were followed by further instructions, and a confirmation that the task was understood. Finally, 48 trials were presented, of which 12 were unrelated to the current experiment and 36 were experimental trials consisting of 3 sentence types: (a) quantifiers; (b) numbers; and (c) ad hoc scales. Responses were recorded using Psyscope software.

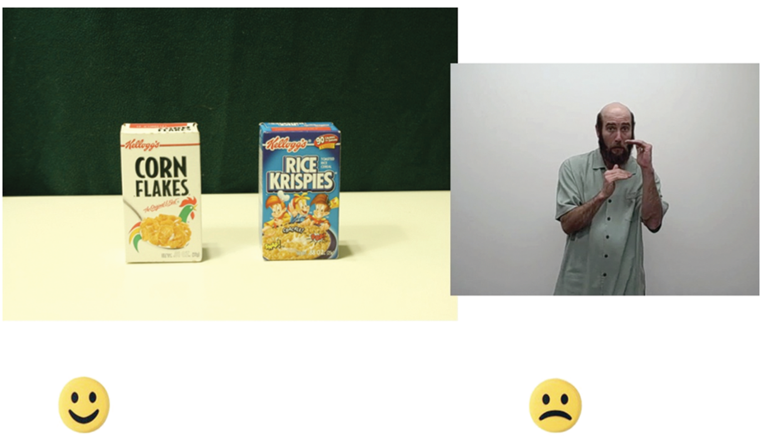


Figure 4. Screenshot during an ASL Number experimental trial. In both the ASL and English versions, the picture was always on the left, and the video description of the picture appeared on the right after the Spacebar key was pressed.

In the quantifier trials, each picture consisted of a set of objects of which either some of them or all of them fulfilled a characterization about that object (red cans, lit candles, full glasses, etc.). A schema is shown in Figure 5, and the entire list is provided in the Appendices. Under the **Match** condition, the characterization applied to all of the objects (e.g. three cans, all red), and the description was true (e.g. *CANS, ALL RED* 'All of the cans are red'). Under the **Mismatch** condition, the characterization applied to a proper subset of the objects (e.g. three cans, only two are red), and the description was false (e.g. *CANS, ALL RED* 'All of the cans are red'). Finally, under the **Test** condition, the characterization applied to all of the objects (e.g. three cans, all red), and the description was not maximally informative (e.g.

CANS, SOME RED 'Some of the cans are red'). In this way, the weak scalar term SOME was only evaluated by participants in the Test condition, so that they were never directly comparing use of the term in this condition to use of the term when it was maximally informative. While perhaps removing some of the natural contrast between felicitous and nonfelicitous uses of SOME, this has the advantage of more clearly testing whether participants create an automatic contrast between SOME and ALL. Trials for quantifiers, numbers, and the ad hoc scale were counterbalanced so that each sentence frame (e.g. red cans) appeared in only one trial type (Match, Test, Mismatch) for each participant, and each third of participants saw the sentence frame in a different trial type.

In the number trials, each picture consisted of a set of either two or three of the same kind of object (animals, pencils, etc.). In the **Match** condition, there were three objects, and the description was true (e.g. *BEARS, HAVE THREE* 'There are three bears'). Under the **Mismatch** condition, there were only two objects, but the description said there were three (e.g. *BEARS, HAVE THREE* 'There are three bears').

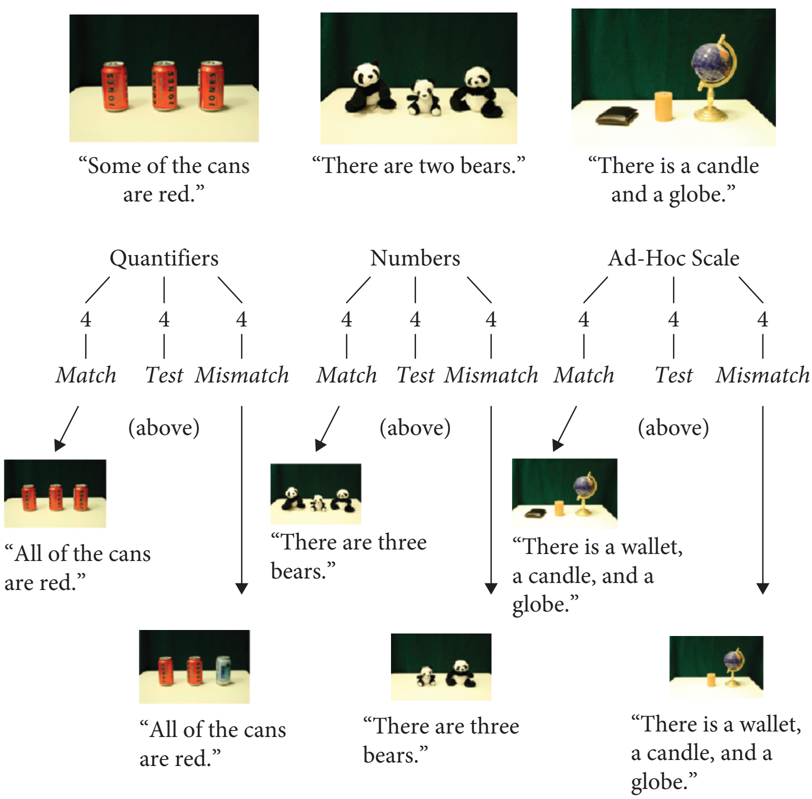


Figure 5. Design of 36 experimental trials, shown in English: 12 Quantifier trials, 12 Number trials, 12 Ad hoc trials

Finally, under the **Test** condition, there were three objects, and the description was not maximally informative (e.g. *BEARS, HAVE TWO* 'There are two bears').

In ad hoc trials, each picture consisted of a set of either two or three different kinds of objects (a wallet, a candle, and possibly a globe, for example). In the **Match** condition in these trials, there were three different objects, and the description was true (e.g. *THERE WALLET CL:B*$_X$ *CANDLE CL:C*$_Y$ *GLOBE CL:5(claw)*$_Z$ 'There is a wallet, a candle, and a globe'). Under the **Mismatch** condition, only two of these objects appeared in the picture, but the description was the same as the Match condition, indicating that there should be three (e.g. *THERE WALLET CL:B*$_X$ *CANDLE CL:C*$_Y$ *GLOBE CL:5(claw)*$_Z$ 'There is a wallet, a candle, and a globe'). Finally, under the **Test** condition, there were three different objects in the picture (just like in the Match condition), and the description was not maximally informative (e.g. *THERE CANDLE CL:C*$_Y$ *GLOBE CL:5(claw)*$_Z$ 'There is a candle and a globe').

The description used in each trial was elicited by asking either the native signer (ASL) or native speaker (English) who appeared in the stimuli to view a scene on a laptop screen and describe what they saw using the given vocabulary and sentence frame, with natural prosody. Each scene that they described appeared as the picture in some trial in the experiment. For example, to elicit "All of the cans are red/CANS, ALL RED", the picture with all red cans was shown, and to elicit "Some of the cans are red/CANS, SOME RED" the picture with only some of the cans being red was shown. In the Match trials, the elicited description and picture were shown together, while in the Test and Mismatch trials, the description was shown with the reverse picture. Importantly, no items in the pictures in the ad hoc scale were moved when there were 2 items compared to 3, and in the ASL trials, the native signer was careful to sign items in the correct locations (and not, for example, to move the 2 items to more central locations, which could potentially contribute to increased rejections due to falsity, not underinformativity).

4. Results

On the prototypical scale of quantifiers, native speakers of English accepted the control Match sentences 100% of the time, and rejected the control Mismatch sentences 100% of the time, a clear indication that the task was understood (Table 1). The quantifier Test condition assessed scalar implicature calculation: recall that without the strengthened scalar implicature reading both the Test and the Match conditions are true and should thus be accepted. Under the scalar implicature reading, however, the Test case should be rejected. Consistent with previous research, in this experiment adult native speakers of English showed significantly more rejection (i.e. indications with the frown face) of Test sentences than the control Match sentences ($t(11) = 7.10$, $p < 0.0001$). This higher rate of rejection of the Test sentences by native English speakers indicates that they were drawing scalar implicatures, as we would expect. Individual behavior on the Test trials reveal eight 'pragmatic' English-speaking participants, who always rejected the underinformative use of "some", one completely 'logical' participant, who always accepted the Test case, and three participants who rejected only some of the trials.

Table 1. Mean rejection rates for each sentence type in English and in ASL, with standard deviations following in parentheses (larger standard deviations indicate more data points spread across a wider range, and the standard deviation can be added to and subtracted from the mean to determine a confidence interval of 95%)

		Match	Mismatch	Test
English	**Quantifiers**	0	1	0.77 (0.38)
	Numbers	0	1	0.96 (0.14)
	Ad Hoc	0	1	0.54 (0.45)
ASL	**Quantifiers**	0.19 (0.18)	1	0.84 (0.23)
	Numbers	0	1	1
	Ad Hoc	0.09 (0.19)	1	0.88 (0.35)

On the number trials, native speakers of English accepted the Match sentences 100% of the time, and rejected the Mismatch sentences 100% of the time. There was also significantly more rejection of the Test case than the Match case for numbers ($t(11) = 23.00$, $p < 0.0001$), indicating a strong, exact interpretation of the numbers. All but one participant behaved completely 'pragmatically', rejecting every number Test trial; the other participant (the same one as in the quantifier case) had a purely 'logical' interpretation, accepting each trial. Overall, these findings and the quantifier results indicate that the experimental paradigm was successful, as participants' rejection rates on both scales are in line with previous quantitative behavioral results for adult scalar implicature calculation in spoken languages (M = 0.77, SD = 0.37 for quantifiers, M = 0.96, SD = 0.14 for numbers).

Turning to the English ad hoc scale, the Match condition was accepted 100% of the time and the Mismatch condition was rejected 100% of the time. Participants rejected the Test case significantly more often than the control Match case ($t(11) = 4.17$, $p < 0.001$), indicating that ad hoc implicatures do appear robustly in a felicity judgment task in spoken language, despite being contextually dependent and not based on two contrasting words. However, their interpretations seem to be of a more flexible nature than the other scales: there were quantitatively less implicatures drawn on the ad hoc scale than on the quantifier scale (M = 0.54 for ad hoc compared to M = 0.77 for quantifiers), and significantly fewer than on the number scale ($t(11) = 3.25$, $p < 0.01$). Individual results show quantitatively more 'purely logical' users in English, with only five purely 'pragmatic' users, three purely 'logical' participants, and four participants who were a combination.

In ASL, control Match trials for the prototypical quantifiers scale varied somewhat more than the corresponding trials in English (perhaps due to yet unknown variables involved in the still new use of experimental linguistics in ASL), but were still accepted at a high rate (M = 0.81, SD = 0.18), and 100% of the Mismatch trials were rejected. As for the Test case of scalar implicatures, in ASL there was also significantly more rejection of Test quantifier sentences than the control Match sentences ($t(7) = 6.25$, $p < 0.001$) among signers, an indication that scalar implicatures occur in ASL just as in spoken languages. Individually, five participants were 'pragmatic' users who always rejected the Test quantifier case, none were totally 'logical' participants, with the final three rejecting only some of the trials. Even stronger results were obtained for the numbers scale, where native signing participants accepted 100% of the Match trials, rejected 100% of the Mismatch trials, and — crucially — rejected 100% of the test trials.

Finally, in the ad hoc scale in ASL, the Match condition was also overwhelmingly accepted (M = 0.91, SD = 0.19) and the Mismatch case was rejected 100% of the time, while participants rejected the Test case significantly more often than the control Match case in ASL ($t(7) = 6.06$, $p < 0.001$). Comparing ASL to English, there is a marginally significant difference in rejection rates of test sentences between the ad hoc scale in ASL and in English ($t(18) = 1.76$, $p = 0.09$), the only scale showing any indication of a difference: on the quantifier scale there was no significant difference in rejection rates of test sentences between English and ASL ($t(18) = 0.49$, $p > 0.2$) and the same also holds for numbers ($t(18) = 0.81$, $p > 0.2$). However, significance was not reached in a two-way ANOVA with Language (ASL vs. English) and Sentence Type (quantifiers vs. ad hoc) and their interaction as factors ($F(3,36) = 1.70$, $p = 0.18$), so while we cannot conclude that there is an interaction of language and scales, there may be a trend worthwhile investigating in future research. Participants were clearly internally consistent: individual results show seven of the participants answering purely 'pragmatically' (rejecting all underinformative utterances), while only one was purely 'logical' (accepting the utterances).

5. Discussion

Results of this experiment show that for a prototypical scale like quantifiers, ASL patterns just like English with regards to scalar implicatures: native signers reject underinformative descriptions more than they reject true sentences, and no significant differences were found between the languages on the quantifier scale. In a less prototypical scale, numbers, there was also no significant difference found between the two languages: a high rejection rate of the Test cases was found both in ASL and in English. Participants' behavior on both the quantifier and number sentence types suggests that when there is no difference in semantic content being conveyed, there is also no difference in pragmatic behavior in ASL and in English. The transparent mapping of the form to the meaning of the sign for numbers "one" through "five" in ASL had no effect on participants' interpretation of sentences using the terms. We conclude that native signers of ASL compute scalar implicatures and interpret number words just like native speakers of English. Results from these two scales provide a baseline from which to ask further questions about scalar implicatures that are unique to signed languages.

The one marginal difference found in the results presented here between English and ASL was in the case of sentences based on the ad hoc scales, where there was quantitatively a higher percentage of implicatures drawn based on ad hoc scales in ASL than ad hoc scales in English, and more signers in ASL responding 'pragmatically' on this scale than speakers in English did. The difference between the sentences in ASL and in English was the addition of information about the spatial layout in ASL. The same participants rejected quantifier and number scales at the same rate as their English counterparts, so this may suggest that the additional information conveyed about space through the classifier system can affect signers' pragmatic behavior. One possible explanation is that the addition of spatial information influences participants' perception of the issues that are at stake. A helpful framework for considering this idea is the Question Under Discussion framework (Roberts 1998; Büring 2003), which models a conversation as a series of questions and answers, so that each declarative statement is evaluated as a response to an (often implicit) question. For example, the English sentence "There is a wallet and a globe" could be likely answering the question "What is on the table?" or "What exists in this room?". In ASL, the use of locational classifiers could bias the possible question to be along the lines of "What configuration are the things on the table in?". In English, we could get a similar effect by adding spatial information as in (5).

(5) There is a wallet on the left side of the table and a globe on the right side of the table.

The difference seems to be between describing a scene and mentioning a few items. This isn't to say that the English sentence couldn't answer the same questions under discussion as the ASL sentence, but that the addition of spatial information may bias the possible questions under discussion that one is likely to be answering.

In addition to understanding scalar implicatures in ASL, another goal of this work was to create a paradigm for investigating the semantic/pragmatic interface in signed languages. Aspects of this paradigm that work particularly well were using non-linguistic based input (here, smile and frown faces) to remove some of the spoken/written language influence from the computer interface, and working with a native signer both to sign the stimuli and also, if the experimenter is not a native signer, to join in testing sessions for sociological and sociolinguistic purposes. Future research using this paradigm can be used to investigate other aspects of meaning in sign languages. These should also keep in mind one issue noted by a reviewer, that the simultaneous presentation of the picture and video could potentially increase the effect of iconicity in sign languages, because the language and picture are both visual and a mismatch would perhaps be more glaring.

The current stage of sign language linguistics research is such that we now know many ways in which sign language structure is similar to spoken language structure, as in phonology, syntax, semantics, and as the current work shows, pragmatic behaviors. It is certainly progress that this once surprising similarity between signed and spoken languages is becoming an established fact in linguistics. However, questions in the next stage of research are likely to be equally surprising: what is unique about communicating in the visual/manual modality, and what can this tell us about the human capacity for language in general? As suggested by the preliminary work shown here involving iconic and analog representations, formal semantics/pragmatics should have much to contribute to this area of research.

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Appendix A: Stimuli for the English version of the experiment

Quantifiers

All/Some of the balls are yellow.
All/Some of the books are open.
All/Some of the candles are lit.
All/Some of the cans are red.
All/Some of the pencils are broken.
All/Some of the bowls are yellow.
All/Some of the cards are black.
All/Some of the glasses are full.
All/Some of the hangers are brown.
All/Some of the shoes are black.
All/Some of the socks are brown.
All/Some of the spoons are wooden.

Numbers

There are three/two bears
There are three/two bowls
There are three/two candles
There are three/two cereal boxes
There are three/two cups
There are three/two cans of juice
There are three/two markers
There are three/two movies
There are three/two mugs
There are three/two pencils
There are three/two shoes
There are three/two spoons

Ad hoc

There is a bottle, a oven mitt, and a book./ There is a bottle and an oven mitt.
There is a bowl, a movie, and sunglasses./ There is a bowl and sunglasses.
There is a cereal box, a can, and a measuring cup. / There is a cereal box and a can.
There is a football, a show, and a can./ There is a football and a can.
There is a glass, a plate, and a bowl. /There is a glass and a bowl.
There is a knife, a fork, and a spoon./ There is a fork and a spoon.
There is a marker, sunglasses, and a ball. / There is a marker and a ball.
There is a marker, a towel, and a wine glass. / There is a marker and a towel.
There is a red cup, a can of juice, and a spoon./ There is a can of juice and a spoon.
There are scissors, a bear, and a ruler. / There are scissors and a bear.
There is a shoe, a measuring cup, and a pineapple. / There is a measuring cup and a pineapple.
There is a wallet, a candle, and a globe./ There is a candle and a globe.

Appendix B: Stimuli for the ASL version of the experiment

Quantifiers

(N.B. the first noun is topicalized with brow raising nonmanual marking)

BALL, ALL/SOME YELLOW.
BOOKS, ALL/SOME OPEN.
CANDLE, ALL/SOME LIT.
CAN, ALL/SOME RED.
PENCIL, ALL/SOME BROKE.
BOWL, ALL/SOME YELLOW.
(Playing)CARD, ALL/SOME BLACK.
CUP, ALL/SOME FULL.
HANGER, ALL/SOME BROWN.
SHOE, ALL/SOME BLACK.
SOCK, ALL/SOME BROWN.
SPOON, ALL/SOME WOODEN.

Numbers

BEAR THERE THREE/TWO.
BOWL THERE THREE/TWO
CANDLE THERE THREE/TWO
CEREAL BOX THERE THREE/TWO
CUP THERE THREE/TWO
JUICE CAN THERE THREE/TWO
COLOR MARKER THERE THREE/TWO
MOVIE THERE THREE/TWO
COFFEE CUP THERE THREE/TWO
PENCIL THERE THREE/TWO
SHOE THERE THREE/TWO
SPOON THERE THREE/TWO

Ad hoc

(N.B. "CL" indicates a classifier construction; the symbol following the colon indicates the handshape of the classifier construction; the subscripts indicate placements to the left "X", center "Y", and right "Z" of the signer)

THERE METAL CUP CL:C$_X$, OVEN GLOVE CL:B$_Y$, BOOK CL:B$_Z$. /
THERE METAL CUP CL:C$_X$, OVEN GLOVE CL:B$_Y$.
THERE BOWL CL:C(reduced)$_X$, MOVIE CL:G$_Y$, GLASSES, CL:C(reduced)$_Z$. /
THERE BOWL CL:C(reduced)$_X$, GLASSES, CL:C(reduced)$_Z$.
THERE CEREAL BOX CL:C(reduced)$_X$, CUP CL:C$_Y$, CUP MEASURE CL:C$_Z$. /
THERE CEREAL BOX CL:C(reduced)$_X$, CUP CL:C$_Y$.

THERE FOOTBALL BALL CL:C$_{X}$, SHOE CL:B$_{Y}$, CUP CL:C$_{Z}$. /
THERE FOOTBALL BALL CL:C$_{X}$, CUP CL:C$_{Z}$.
THERE GLASS CUP CL:C$_{X}$, PLATE CL:C(reduced)$_{Y}$, BOWL CL:C(reduced)$_{Z}$. /
THERE GLASS CUP CL:C$_{X}$, BOWL CL:C(reduced)$_{Z}$.
THERE KNIFE CL:U$_{X}$, FORK CL:U$_{Y}$, SPOON CL:U$_{Z}$. /
THERE FORK CL:U$_{Y}$, SPOON CL:U$_{Z}$.
THERE COLOR PEN CL:1$_{X}$, GLASSES CL:C(reduced)$_{Y}$, BALL CL:5(claw)$_{Z}$. /
THERE COLOR PEN CL:1$_{X}$, BALL CL:5(claw)$_{Z}$.
THERE COLOR PEN CL:1$_{X}$, TOWEL CL:B$_{Y}$, WINE CUP CL:C$_{Z}$. /
THERE COLOR PEN CL:1$_{X}$, TOWEL CL:B$_{Y}$.
THERE RED CAN CL:C$_{X}$, DRINK CUP CL:C$_{Y}$, WOODEN SPOON CL:U$_{Z}$. /
THERE DRINK CUP CL:C$_{Y}$, WOODEN SPOON CL:U$_{Z}$.
THERE SCISSORS CL:V$_{X}$, BEAR CL:C$_{Y}$, RULER CL:U$_{Z}$. /
THERE SCISSORS CL:V$_{X}$, BEAR CL:C$_{Y}$.
THERE SHOE CL:B$_{X}$, CUP MEASURE CL:C$_{Y}$, PINEAPPLE CL:5(claw)$_{Z}$. /
THERE CUP MEASURE CL:C$_{Y}$, PINEAPPLE CL:5(claw)$_{Z}$.
THERE WALLET CL:B$_{X}$, CANDLE CL:C$_{Y}$, GLOBE CL:5(claw)$_{Z}$. /
THERE CANDLE CL:C$_{Y}$, GLOBE CL:5(claw)$_{Z}$.

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