Routledge Handbook of Theoretical and Experimental Sign Language Research
Chapter *on Implicatures: Theoretical and Experimental Perspectives*
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1. Formal pragmatics and the theory of implicature

The study of natural language meaning revolves around the problem of how one person can communicate their thoughts to another successfully, even when there are in principle infinitely many thoughts, many of which the speakers will have never attempted to previously communicate. To do this successfully, two people engaged in a conversation must understand the structure of their language: how the underlying syntactic structure supports semantic combinations to build meaning for new sentences that speakers may have never heard before. Understanding how this works is the domain of *lexical semantics* (word level) and *compositional semantics* (phrase/sentence level). In addition to the logical meaning, however, two people attempting to communicate new thoughts must also know something beyond the literal, logical, meaning of a sentence. They must know what a given sentence means in a particular context, because most sentences have different meanings in different contexts - this is the domain of *pragmatics*. The problem of how language users apply contextual information to literal meanings to finally arrive at the intended meaning, i.e. the semantics/pragmatics interface, is one of the most challenging problems not just in linguistics, but in cognitive science more broadly. This chapter is concerned with one of the most well-studied phenomena at the semantics/pragmatics interface, known as *implicature*.

The term *implicature* was first used by the philosopher H. Paul Grice (1970), who was interested in the semantics/pragmatics interface problem: what part of the meaning of a sentence is hard-coded, and what part is context dependent? This is a particularly important problem for formal semanticists, following in the tradition of Montague (1973) and his followers tying formal semantics to syntax, and who analyze natural language using an underlying system of formal logic. To see why, consider the example of the English word *or*: in a formal logic class, *or* is usually translated using the disjunctive operator (symbolized $\vee$). In this system, $A \vee B$ is true if A is true, or if B is true, or if both A and B are true. However, in natural language, many people take *She drank coffee or tea* to mean that she either drank coffee, or she drank tea, but she didn't drink both. There is a tension, therefore, between the most natural logical translation of some terms in natural language and their actual interpretation by users of languages (in this case, whether *or* rules out the possibility of *both*).

Grice's solution to this problem was to keep the meaning of natural language expressions as close as possible to their logical equivalents. In doing this, he argued that much of linguistic meaning comes about through pragmatic reasoning about the intentions of speaker, after and above the literal, logical meaning of a sentence has been computed. He suggested that the way interlocutors reason about each others' language use can be characterized by four maxims of conversation that users expect each other to be following:

1. **The maxim of quantity**: Be as informative as possible: gives as much information as is needed, and no more.
2. **The maxim of quality**, Be truthful, do not give information that is false or that is not supported by evidence.
3. **The maxim of relation**, Be relevant, say things that are pertinent to the discussion.
4. **The maxim of manner**, Be as clear, as brief, and as orderly as one can in what one says, and avoid obscurity and ambiguity.

In the case of *or*, speakers try to be as informative as possible (following the maxim of quantity) while still being truthful (following the maxim of quality). Grice suggested that if a speaker already know both of the things that *or* connects to be true (e.g. that Mary drank coffee, and also that Mary drank tea), then they should use a more informative term than *or*: they should have used *and* (i.e. by saying *Mary drank coffee and Mary drank tea*). Since any English speaker that uses *or* always has *and* also at their disposal, then usually when they say *or*, they aren't able to say *and* without violating the maxim of quality, and so generally *or* is interpreted pragmatically as *A or B but not both*. Thus, *or* has a basic, logical meaning (where one or the other or both disjuncts can be true, equivalent to $\vee$) as well as a pragmatically enriched meaning (where one or the other disjunct can be true, *but not both*). The difference between these meanings, Grice suggested, is due to a scalar implicature: an unsaid implication that use of a weaker term implies that use of the stronger term would have been false.

It's possible to see already that Grice's (and many others') view of this classic problem at the semantic/pragmatic interface was English/Indo-European-centric: not all languages have translation equivalents to English *and* and English *or*. The Yuman language Maricopa famously uses a simple juxtaposition of noun phrases to mean either conjunction (1a) or disjunction (1b) (Gil 1991), and a similar morpheme or construction used for both meanings has also been reported for Japanese (Ohori 2004), American Sign Language (Davidson 2013) (2), Warlpiri (Bowler 2014), and Cheyenne (Murray to appear).

(1) a. *John-s Bill-s v?aawuum.*
John-NOM Bill- NOM 3.COME.PL.FUT
'John and Bill will come.'
b. *John-s Bill-s v?aawuumsaa.*
John- NOM Bill- NOM 3. COME.PL.FUT.INFER
'John or Bill will come.'

(2) a. *Context: I know that everyone had exactly one drink at the party. I wonder what Mary chose to drink at the party, and ask my friend. She replies*:
IX_{Mary} DRINK TEA COORD COFFEE.
'She (Mary) drank tea or coffee.'
b. *Context: I see that Mary looks very caffeinated and sick! I wonder how much caffeine she may have had, and ask my friend. She replies:*
IX_{Mary} DRINK TEA COORD COFFEE!
'She (Mary) drank tea and coffee!'

In fact, the pattern seen in (2) in American Sign Language is available with multiple possible forms of syntactic coordination, both coordination on the hands (Fig 1a) and coordination through placement in space (Fig 1b). Either of these strategies can be used both for conjunction ("and") and disjunction ("or") in the example in (2), and can be used for coordinating noun phrases, verb phrases, and even full clauses (Davidson 2013).

Figure 1a: COORD-L

Figure 1b: COORD-shift

The pattern posed by ASL and other languages where conjunction and disjunction can be pronounced in the same way raises new questions for a Gricean theory of implicature: if a language conveys two separate concepts without the use of two contrasting lexical items, do scalar implicatures still arise? In other words, are users of these languages more likely to get the very "logical" meaning of "or", that one or the other *or maybe both* disjunctions is true, when they mean disjunction, given that there isn't a stronger contrasting term *and*? And further, what should be the underlying meaning (the semantics) for these kinds of items: are they just ambiguous and happen to be pronounced the same, or is there a single shared meaning, such that what seems like disjunction or conjunction comes about through the pragmatics? This is important because users of these languages might arrive at a logical meaning for *or* not because of a lack of implicatures, but just because the same term can also mean *and*. In what follows, we will take ASL as a case study to see how users of ASL actually interpret these constructions.

Before moving on, though, we'll discuss one further note about scalar implicatures. If all of this discussion were about the pair of logical words <or, and>, we might consider all of this theoretical machinery about maxims, etc. to be overkill. In fact, though, the same kind of reasoning can be applied to a very wide range of terms that stand in the same entailment

relationship to each other (meaning that use of one term is strictly stronger than another, in the way that logical *and* is strictly stronger than logical *or*). Some other examples are positive quantifiers <some, all> (3)-(4), negative quantifiers <few, no>, numbers <one, two, three, four, …>, temperatures <warm, hot>, verbs <like, love>, and modals <can, must>.

(3) Mary drank **some** of the tea. (English)
Implicates: Mary did not drink **all** of the tea.
(4) IX_{Mary} DRINK **SOME** TEA (ASL)
Implicates: Mary did not drink **all** of the tea.

Consider (5)-(7). One signature of implicatures in general, and scalar implicatures in particular, is that they can be canceled (5a)-(7a) and strengthened (5b)-(7b).

(5) a. Mary drank coffee or Mary drank tea, but not both.
b. Mary drank coffee or Mary drank tea, and maybe both.
(6) a. Mary drank some of the tea, but not all.
b. Mary drank some of the tea, and maybe all.
(7) a. Mary likes tea, but doesn't love it.
b. Mary likes tea, and maybe even loves it.

This kind of strengthening and canceling is traditionally a marker of setting off the pragmatic inferences of implicatures from *entailments,* which are part of the semantic/logical meaning of a sentence. Consider (8)-(10), where the scalar items (<or, and>, <some, all>, <like, love>) from (5)-(7) are reversed. Here, the cancellations and strengthenings are nonsensical because the stronger term *entails* the weaker one, so you can't defeat (a) or strengthen (b) the result. Thus, the relationship between items in a scale is asymmetrical.

(8) a. #Mary drank coffee and Mary drank tea, but not either.
b. #Mary drank coffee and Mary drank tea, and maybe either.
(9) a. #Mary drank all of the tea, but not some.
b. #Mary drank all of the tea, and maybe some.
(10) a. #Mary loves tea, but doesn't like it.
b. #Mary loves tea, and maybe even likes it.

Traditionally, the difference between the canceling and strengthening ability of the implicature and the inability to do so in entailments served to place the former squarely in the domain of post-compositional pragmatics, and the latter in the domain of semantics. Recent work, however, has raised the possibility of a more grammatical type of implicature, still able to be canceled and strengthened, but triggered by something in the syntax/semantics of the structure, not just in post-processing pragmatic reasoning. Chierchia, Fox, and Spector (2009) point out some examples of what they suggest are *embedded scalar implicatures*, as in (11).

(11) John believes that Mary drank coffee or tea.
Implicates: John believes that Mary drank coffee or tea but not both.

In cases like (11), Chierchia et al. argue that the strengthened meaning of *or* cannot have arisen simply as a result of the processes of reasoning using Grice's maxims because such maxims should apply to entire utterances, after their logical meaning is computed. In (11), the "stronger" version one must compare to is something smaller than the entire utterance, in fact is the clause embedded within the matrix clause, under *believe*. They take this to suggest that the strengthened version of *or* cannot always simply arise via two interlocutors following conversational maxims about quantity, but rather that the language must also include operators in the syntax that act specifically to do the work of the implicature in the formal semantics. That is, they suggest that what was thought to be reasoning about how people use language (pragmatic phenomena) are sometimes actually arising from the (literal, logical) language itself, through the presence of what amounts to a "silent *only*" operator, also known as an exhaustivity operator, making (11) logically equivalent to (11').

(11') John believes that Mary drank [only] coffee OR tea.

This kind of argumentation has a number of consequences. For example, we saw earlier that scalar implicatures differ from entailments in that they are cancelable. So, what is it that causes a scalar implicature to arise, and why it is optional? A grammatical theory of implicature must deal with this problem, and so is obligated to postulate linguistic triggers of implicatures. One way to do this is to say that if a particular word belongs to a scale, then the fact that it has scalar alternatives means that the exhaustivity operator can apply. So, a word like *some* combines with the exhaustivity operator in a meaningful way because *some* has the scalar alternative *all*, while other words like *Mary* or *drink* does not (at least, in a basic context without further information). This raises new questions: does the shape of alternatives matter? Do they have to have separate articulations, or just possible separate meanings?

Sign languages have the potential to provide answers to some of these questions. We saw above that in ASL, conjunction and disjunction can be expressed with the same COORD (COORD-shift or COORD-L). This raises the question of whether they are ambiguous, i.e. *and* and *or* just happen to be pronounced alike in ASL (like the English financial and river *bank*). Another possibility is that they are two translations of a single underlying lexical item that has a more general meaning (something like "collect these into a set"). A third possibility is that another trigger, such as nonmanual marking (movements of the face, torso, etc. not including the hands) provides the distinction, and if this is the case, raises the question of whether nonmanual marking can distinguish two items for the purposes of a scale. Davidson (2013) provides theoretical arguments to rule out ambiguity, but the latter two possibilities remain.

The following sections will look at experimental work investigating these issues by looking at the interpretation of scalar words in American Sign Language. Sign languages can shed light on these important questions about scalar implicatures in a number of ways, including the grammatical versus pragmatic debate, as well as what kinds of lexical items can form alternatives for each other. Within the field of sign language research, experimental investigation of scalar implicatures can also help uncover the ways that the modality of

language communication influences pragmatic inferences that are drawn, which is currently a very open question. For example, does the use of space in general, and spatial loci in particular, influence inferences about the maxim of quantity? We turn to these issues next.

2. Experimental investigations of implicatures

In spoken languages, scalar implicatures are one of the most experimentally well-studied phenomena at the interface of semantics and pragmatics, for a number of good of reasons. First, it was discovered that children behave differently than adults when it comes to interpretations of scalar items: they seem to interpret sentences more "logically", i.e. with a weak reading (*some* as *some and maybe all)* without the strengthening provided by the scalar implicature (*some* as *some and not all*). (Noveck 2001; Papafragou and Musolino 2003; Huang and Snedeker 2009, a.o.). Within sign languages, it is still an open question whether young children learning ASL behave in the same way, although given that the pattern holds in many languages, we would expect that it would be. (There has been some investigation on the acquisition of scalar implicatures by deaf adults who are late learners of a sign language, compared to deaf adults who are native signers, which we will return to later.) A second reason that scalar implicatures have been studied so extensively using experiments within spoken languages is that even adults' interpretation can be manipulated by a variety of factors, including cognitive load (De Neys and Schaeken 2007) and linguistic and extralinguistic context (Bott and Noveck 2004; Grodner, et al. 2010, a.o.), and so provide an informative area for understanding the relationship between cognition and language meaning.

A third reason, important from the perspective of a theoretical linguist, is that the interpretations given by speakers in carefully controlled contexts can help determine the right choice among competing theories of the grammar of scalar implicature. Since Chierchia (2006), Fox (2007), and Chierchia, Fox, and Spector (2008) argued for the possibility that scalar implicatures are grammatical, there has been an explosion of research to determine how adults' interpretations vary, and whether they form an integrated part of sentence meaning in the same way as other grammatical/compositional parts.

Given the high interest in the psycholinguistics of scalar implicatures within experimental linguistics, it is therefore natural to ask whether the same occurs in sign languages, and whether the sign language modality can help answer any questions that have been raised by experimentalists and theoreticians. So far, American Sign Language seems to have been the only sign language with experimental work on scalar implicature, and this has only been studied in adults in a single series of three studies: one focused on modality (Davidson 2014) which we focus on in the next section; one on the issue of alternatives with conjunction and disjunction (Davidson 2013) that will be the focus of the following section; and a third, which we turn to finally, on an acquisition study of late learners that begins to extend the study of scalar implicatures in children to questions about the effects of late first language acquisition among deaf adults (Davidson and Mayberry 2015).

3. Scalar implicatures in the sign modality

A Gricean theory view of scalar implicatures makes universal predictions about natural language pragmatics: in any context in which a language has terms that can be strictly ordered through entailment (e.g. <some, all>, <or, and>, etc.), then use of a weaker term will implicate that use of the stronger term would violate the maxim of quality (i.e. would be false). This should be how any participants in a discussion expect interpretation to proceed if both are following the maxims. Because these maxims are not specific to the spoken language modality, it is reasonable to expect to discover similar behavior in sign languages. There is, however, very little work on the pragmatics of the visual/manual use of space for communication, whether in gesture with spoken languages or in sign languages, and so it is quite possible that there are semantic/pragmatic phenomena involved specifically with the use of space that may be uncovered in work on scalar implicatures in sign languages.

In a first study to address the issue of scalar implicatures in a sign language, Davidson (2014) compared English native speakers' interpretations of sentences in English to ASL native signers' interpretations of sentences in ASL in a computer-based behavioral study. Three types of scales were compared across the two languages in this study. The first two, *quantifiers* and *numerals*, are two of the most well studied scales in English, and so counterparts in ASL acted as controls, and were tested in a way that made no use of three-dimensional space. These were hypothesized to lead to similar interpretations between the English and the ASL groups. A third scale was tested that would rely more on the manual/visual modality: a list of items was said in order in English (e.g. "There is a candle and a globe"), while the same items were listed and assigned to locations in space in ASL using referential loci ("There is a candle at point *a* and a globe at point *b*"). *Ad hoc* scales can be constructed from lists of items, so that if in fact three items were present (e.g. a wallet, a candle, and a globe), but the target sentence only mentioned two of them, then that sentence was being underinformative, similar to using "some" to describe a situation when *all* is true. Investigating any differences between English speakers' and ASL signers' interpretations of such underinformative descriptions could help shed light on the pragmatics of assigning spatial loci in ASL. Controls were created for each underinformative test case: these controls involved a match between description and picture ("Match controls"), or a Mismatch (Figure 2). Each trial in the experiment consisted of a picture and a video (with a native speaker of English or a native signer of ASL, depending on the participant group), and participants were simply asked whether they were "satisfied that the picture matched", in which case they should press the "smile" button, otherwise press the "frown" button (inset, Figure 2).

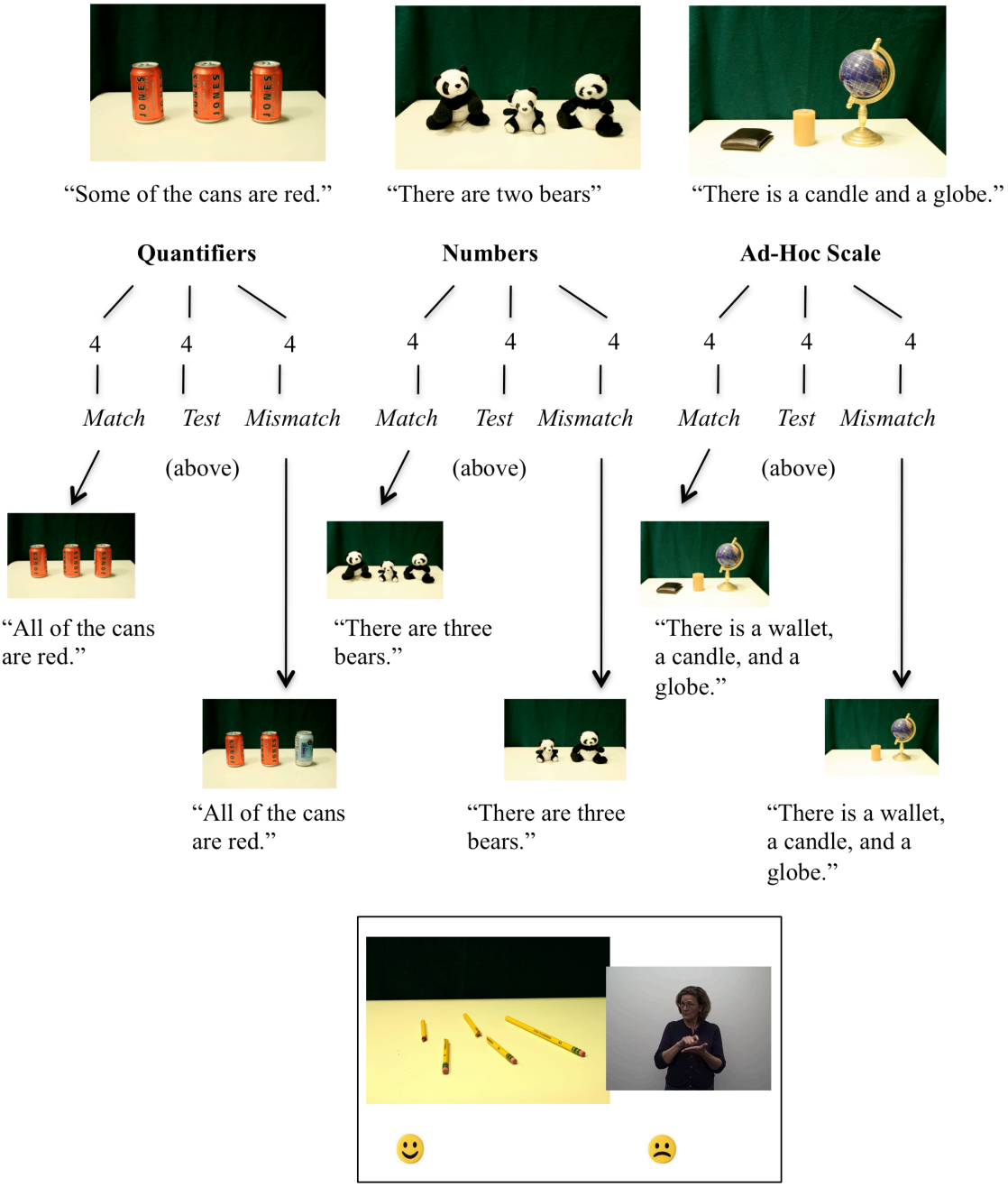

Figure 2: A scheme of the experimental design for the study in Davidson (2014). The numbers ("4") indicate how many of each trial type were seen by each participant; trials were counterbalanced using the Latin Square method such that each situation (colored cans, number of bears, etc.) only appeared in one trial type per participant. Inset shows a screenshot of what participants viewed during a single (quantifier) trial.

The results of this study showed that, as expected, the Quantifier and Number scales elicited scalar implicatures (rejections of underinformative descriptions) in both English and in ASL, with no significant differences between the two groups on either scale. On the Ad Hoc scale, however, where the ASL sentences made use of 3-dimensional space in assigning items to loci, there were (marginally) more rejections by signers in ASL than by speakers of English in underinformative examples. In other words, when the stimulus stated that there was a candle and a globe (and in ASL assigned these to locations in space), signers in ASL were more

likely to reject this description when there was also a wallet than English speakers were. On all control items, English speakers and ASL signers behaved similarly (Table 1).

Table 1: Mean rejection rates for each sentence type in English and in ASL from Davidson (2014), with standard deviations following in parentheses.

		Match (Control)	Mismatch (Control)	Underinformative (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)

This initial study of scalar implicatures in the sign language modality served two purposes. First, it shows that whatever principles of conversation and language use, such as Grice's Maxims, lead English speakers to reject underinformative descriptions on quantifiers and numbers, the same behavior is found among ASL signers, so they are no indications that these principles differ between spoken and sign languages. Second, there are some indications that when space can be used in ASL, it may have pragmatic consequences. This raises many more questions than answers, and first among these is whether co-speech gesture accompanying English sentences would have the same result. Hopefully future research can determine whether this is a property of linguistic loci in particular, or a more general pragmatic use that is also found in co-speech gesture. Another question this research raises is what happens when a scale looks very different between ASL and English in a way that is unrelated to space? For some answers to this question, we'll turn in the next section to experimental work on the interpretation of conjunction and disjunction in ASL.

4. Scalar implicatures based on conjunction/disjunction in ASL

Sometimes sign languages can inform natural language linguistics not just because they occur in a different modality, but simply because they provided a rich new source of understudied languages. As we noted above, English has separate words for conjunction ("and") and disjunction ("or"), but other languages are able to use the same syntactic coordinator to express either of these meanings. This is the case for at least a few understudied spoken languages, as well as American Sign Language (ASL). Davidson (2014) uses this property of ASL to understand the role of scalar alternatives in implicature calculation: given that <or, and> is one of the most well-studied scales in English (along with quantifiers and numbers, which we just saw behave similarly in ASL and in English), we would expect similar implicature patterns in ASL under normal conditions. However, because ASL has what Davidson calls "general use coordinators" that simply perform syntactic coordination but do not specify the logical relationship of either disjunction or conjunction, it is quite possible that the pattern of implicatures looks very different for the coordination scale in ASL.

To test whether this linguistic difference leads to different patterns of implicature, a group of native speakers of English and a group of native signers of ASL (a different group from the previous study) participated in an experiment using the same methods described above to study modality and scalar implicatures. The only difference this time was the scales compared: quantifiers <some, all> were still a baseline, but now they were compared with coordination. In English, coordination was instantiated with <or, and>, while in ASL, the same concepts were conveyed through nonmanually distinguished COORD-shift (Figure 3).

CUP_a COORD-SHIFT(AND) $BOWL_b$

a.

CUP_a COORD-SHIFT(OR) $BOWL_b$

b.

Figure 3: Nonmanual differences between conjunctive interpretations of COORD-shift (3a) and disjunctive interpretations (3b).

The results of this study were surprising and robust: while both groups (English speakers and ASL signers) treated quantifiers in the same way, calculating scalar implicatures in the crucial underinformative test trials, they differed in their treatment of the coordination scale. English speakers calculated scalar implicatures for coordinators <or, and> just like they did for quantifiers <some, all>, both at the same rate of 77%. However, ASL signers, who robustly calculated scalar implicatures for quantifiers <SOME, ALL> (at a rate of 90%), did not do so for coordinators, which they only rejected as underinformative (when COORD-shift(OR) was used even though both disjuncts were true) at a rate of 35%. This is particularly surprising given that they generally accepted the Match controls (at a rate of 80%) and rejected the Mismatch controls (at a rate of 83%) for the coordination scale, which both also used nonmanual markings, just like in the Test case, so the results could not have been obtained just by ignoring nonmanuals. Taken together, this pattern suggests that while nonmanuals were salient and used for purposes of truth conditions, they did not contribute enough of a contrast to form a pragmatic scale for purposes of scalar implicature calculation. We can conclude, then, that a scale must be formed of two separate lexical items, and that other information (nonmanuals, context, etc.) is not enough to provide contrast for the purpose of creating scalar alternatives. Along with other properties of these coordinations, these results suggest a formal semantic analysis of general use coordination that involves a single underspecified semantics for conjunctive and disjunctive interpretations (Davidson 2013).

Table 2: Mean rejection rates for each sentence type in English and in ASL from Davidson (2013), with standard deviations following in parentheses.

		Match (Control)	Mismatch (Control)	Underinformative (Test)
English	**Quantifiers**	0	1	0.77 (0.38)
	Coordination	0.02 (0.07)	0.92 (0.16)	0.77 (0.36)
ASL	**Quantifiers**	0.05 (0.16)	0.98 (0.08)	0.90 (0.13)
	Coordination	0.20 (0.20)	0.83 (0.17)	0.35 (0.21)

The consequences of this study for the theory of scalar implicature are cross-linguistic: the finding wasn't primarily due to the modality of the language (a signed language), but rather the fact that ASL is a language other than English that has this particular property of coordination alternatives (ASL). Therefore, we would expect that other languages mentioned that show the same use of general use coordinators would exhibit the same pattern. However, it does seem to be the case that many sign languages make use of general use coordinators, many of them in the same way, either a list buoy (Liddell 2003) (COORD-L) or simply juxtaposing coordinates that are associated with referential loci (COORD-shift). Future research would do well to explore whether the same patterns hold across other sign languages, and how many use a form of coordination of this kind.

5. Acquisition of scalar implicatures: Theory

We've seen so far that adult native speakers of English and adult native signers of ASL show similar rates of scalar implicature calculation in each language for a typical scale like quantifiers. Although differences appear when space becomes involved (in ASL) or scales have a different lexical structure (general use coordination), it seems clear that adults follow the same process for calculation of typical scalar implicatures, in both sign and spoken languages. This shouldn't be taken for granted, as there are some groups who do *not* show the same pattern of scalar implicature calculation, most notably young preschool-aged children.

One foundational study in scalar implicature acquisition was carried out by Papafragou and Musolino (2003), who provided children with a truth/felicity judgment task. The experimenter acted out a situation that involved toys in front of the children, and then described the scene; the child participant then either accepted or rejected this description of the scene. In a crucial trial example, an experimenter would show three horses, and all three would jump over a fence. Then the experimenter would comment that "some of the horses jumped over the fence." Adults would overwhelming reject this description of such a situation (at a rate greater than 90%), while children would overwhelmingly accept it (rejecting it less than 20% of the time). The same pattern was seen with <start, finish>, while children would accept "start" as a description of a situation that could also be described by "finish", while adults would reject it. On numbers (<two, three>), children were much more likely to reject an underinformative description than in the other scales, though still to a lesser extend than adults.

In recent years, much work has been spent trying to understand why children's behavior is so different in this domain from adults, seemingly more "logical" (less pragmatic) in accepting the literal meaning. One hypothesis is that children simply lack the cognitive processing capacity to do this task in the way that it is presented. Chierchia et al. (2001) and Gualmini et al. (2001) provided children with alternative descriptions, and asked which was better (e.g. for above, "some" or "all" of the horses), and found that when explicitly given the choice between a felicitious and an underinformative description, children performed much closer to adult-like behavior. Katsos and Smith (2010) and Katsos and Bishop (2011) proposed instead that children have a different tolerance for pragmatic infelicity than adults. They argue this based on an experiment in which children are given more than three possible responses, instead of just the usual binary accept/reject: they can reward a puppet with a small, medium, or large fruit. These authors found that children frequently given a medium sized fruit to a puppet who expresses a true but underinformative utterance, suggesting that children do differentiate these both from false examples (for which they give a small fruit) and true and felicitous examples (for which they give the best, large fruit). Finally, Barner et al. (2011) argue that children have the appropriate cognitive capacity and do not have a different tolerance, but merely cannot call up or do not know the appropriate scalar alternatives. They illustrate this with children's success on *ad hoc* trials, which are merely contextual scalar alternatives (like the aforementioned <candle and globe, wallet and candle and globe>), and for which children behave just like adults (Papafragou and Tantalou 2004; Stiller et al. 2011).

One problem facing studies of children's behavior regarding semantics and pragmatics in general, and scalar implicatures in particular, is that children's cognitive and social development is inextricably linked to their linguistic development. Just as they are developing the cognitive maturity to hold and consider multiple possibilities at once, they are developing the social norms of their communities that would teach them about appropriate pragmatic tolerance, and they are also developing the linguistic knowledge of what alternatives form scales in their language. It would be helpful, therefore, to be able to dissociated some of these pieces of development from each other. This has been the goal behind recent work on scalar implicatures in children and adults with autism, which has shown no differences between adults with and without autism diagnoses – a surprise, given young children's behavior and the seemingly crucial role of pragmatics (Pijnacker et al. 2009, Chevallier et al. 2010). It has also prompted recent studies on scalar implicatures in adult Broca's aphasics, who have experienced the cognitive and social development of neurotypical adults, but then impaired language; this group also shows no significant impairments on scalar implicatures (Kennedy et al. to appear). The next section focuses on yet another group where different aspects of development are dissociated: Deaf adults with delayed first language exposure.

6. Scalar implicature and age of first language acquisition: Experiment

One way to dissociate language experience from cognitive and social maturity would be to look at individuals who learned language at different ages. For example Slabakova (2010)

investigated scalar implicatures in adults' learning a second language, namely Korean learners of English. Finding, yet again, mostly success for this group of adults, they were nevertheless not able to conclude whether language exposure was not important, because most scalar items are very easily translated from one language to another. As we saw above, both ASL and English show similar behavior with quantifiers so it would be easy for adult second language learners to perform the task for most scales in one's native language and simply translate back for the purposes of the task. Therefore, the key would be to test individuals who learned a language late in life, but did not have a first language to fall back on. Davidson and Mayberry (2015) aimed to do just that through investigating scalar implicatures in Deaf adults whose first language was all ASL, but who were exposed to ASL at varying ages.

Figure 4 illustrates the heterogeneity in the participants in the study in Davidson and Mayberry (2015). As can be seen, participants included 8 native signers (who were exposed to ASL from birth/age 0), 6 "early nonnative" signers who were first exposed to ASL as children, and 7 "late nonnative" signers who were all exposed to ASL after puberty. Although all participants, living in the United States, also had significant exposure to English, all self-reported that ASL was both their dominant and first language on a variety of measures. Participants were tested in the same experimental paradigm as discussed above (and in fact, the native signers were the same group of signers as reported in the coordination study). The goal of the study was both to understand (a) the effect of delayed first language on scalar implicature calculation and (b) an understanding of how delayed first language can effect semantic/pragmatic competence, given the long line of research showing that deaf signers exposed to a sign language at an earlier age outperform peers exposed to sign at later ages on a wide variety of language measures both in sign languages and in subsequently learned spoken languages (Mayberry et al. 2002, Boudreault & Mayberry 2006, a.o.). This study was the first to target the level of semantics and pragmatics.

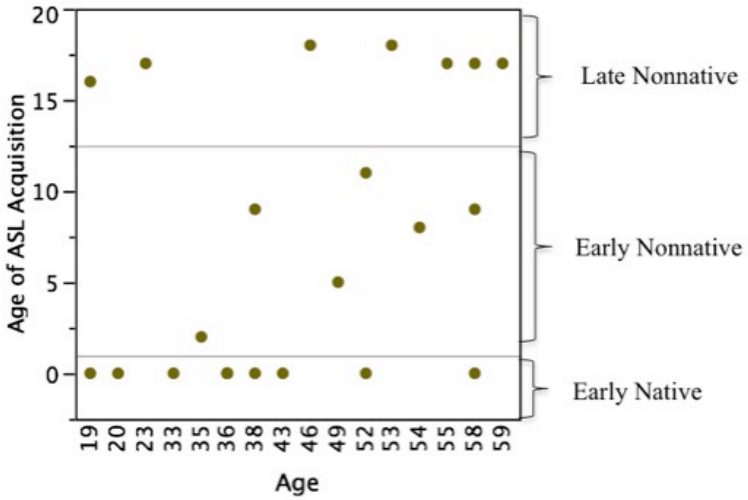

Figure 4: The age at time of testing, and age of first exposure to ASL, of the participants in Davidson and Mayberry (2015)

Results showed that early native signers were not significantly different from nonnative signers, so late nonnative signers (N=7) were compared to early (both native and nonnative) signers a single group (N=14). These two groups generally performed similarly across a wide variety of implicatures, with both showing more success than children typically do on such a task. However, there was one area in which late learners did not calculate as many implicatures as early/native signers, on the Test case in the quantifiers scale (recall, this is the prototypical case of scalar implicature <some, all>). In other underinformative cases, like the spatial *ad hoc* scale and the coordination scale, both of which had ASL specific properties that could not have been transferred from English (the use of space and the underdetermined <or, and> scale, respectively), the two groups showed no differences. This suggests that all participants were indeed proficient and dominant in ASL, and yet there seems to be a slight advantage for native signers to have early language input to have the strongest rates of scalar implicature calculation in places that children also struggle with (e.g. scalar quantifiers).

Table 3: Mean rejection rates for each sentence type in ASL by each group of signers from Davidson and Mayberry (2015), with standard deviations following in parentheses.

		Match (Control)	**Mismatch (Control)**	**Underinformative (Test)**
Early/Native Learners	**Quantifiers**	0.08 (0.18)	0.95 (0.10)	0.94 (0.11)
	Spatial	0	1	0.98 (0.06)
	Coordination	0.16 (0.18)	0.88 (0.16)	0.39 (0.26)
Late Learners	**Quantifiers**	0.14 (0.20)	1	0.75 (0.29)
	Spatial	0.04 (0.09)	1	1
	Coordination	0.14 (0.13)	0.79 (0.17)	0.32 (0.19)

The conclusions from this study point toward some influence of the still developing language component in children's difficulty with scalar implicature calculation, but still, these adults never looked like children in accepting a majority of underinformative descriptions. This suggests that at least some part of children's difficult does, then, lie in *being children* with regards to cognitive and social development. With regard to modules of language affected by delayed first language exposure, semantic/pragmatic effects seem to be present but limited, and especially limited to areas where learned lexical knowledge (e.g. the existence of the scalar contrast <some, all>) plays a crucial role; when deduction within context is enough (e.g. in the spatial ad hoc case), the differences between groups disappear. Certainly more work should be done to follow up and directly compare different levels of language exposure and development, and age of participants taking the study, as well as more direct comparisons to other atypical language development patterns, which can help illuminate both the semantic/pragmatic skills of these groups further, and also understand what occurs in typical language development both in sign and in speech.

7. Other implicatures based on modality

The focus of this chapter has so far been nearly all on one type of implicature, scalar implicature, based on Grice's Maxim of Quantity. However, sign languages are also

extremely fertile ground for testing and understanding more about conversational maxims generally and other kinds of implicatures; in return, such pragmatic investigations show immense promise for providing new light on longstanding puzzles in sign linguistics.

One example of an avenue for future research comes from the interaction of the language modality with the Maxims of Manner and Quality. Davidson (2015) discusses a formal semantics for classifier predicates, which along with a discrete morphological handshape can encode analog/gradient information about the location and movement of objects (Emmorey and Herzig 2003, Zucchi et al. 2012; see Zwitserlood 2012 for overview of classifiers). In Davidson's proposed semantics, the analog/gradient information is conveyed through a *demonstration*, the level of detail of which is pragmatically determined. To take one example, consider (12) in ASL, which involves each hand using an upright human classifier handshape (CL-1), in a neutral location, moving toward each other. The interpretation is that two people walked or went toward each other, and the default assumption is that it was a straight path, but this is only implicated pragmatically. If in fact they moved in a zig-zag pattern, this can be added information; the interlocutor need not deny the original statement (12a). However, if a marked manner or path is used, as in (12b) where the path is given as zig-zag, then if the interlocutor disagrees they must actually deny the original description (12b).

(12) a. Right hand: CL-1(straight movement toward center)
Left hand: CL-1(straight movement toward center)
'The two people walk toward each other.'
#Response: 'No, they went toward each other in a zigzag pattern!'
#Response: 'And actually, they went toward each other in a zigzag pattern!'

b. Right hand: CL-1(zigzag movement toward center)
Left hand: CL-1(zigzag movement toward center)
'The individuals walked toward each other in a zigzag pattern.'
Response: 'No, they went straight for each other!'

Much more detailed work should be done on the formal pragmatics of classifier constructions, and what kinds of information is asserted, implicated, and presupposed; this is merely a suggested beginning for an avenue for future research. New findings in this area would not only break open new understanding about classifiers, but also may raise new questions about how similar or different the inferential process is for their gradient spatial counterparts in co-speech gesture, helping to inform the longstanding puzzle of the relationship between sign, speech, and gesture.

8. Conclusions

Nearly all of the studies discussed in this chapter form a single path of research, conducted within communities using American Sign Language and English, and on a single type of implicature (scalar implicatures). It is mostly because this is a newly growing field within spoken languages, especially at the experimental level, that there remain a myriad of paths for sign language research to follow up on this work both in scope (across languages and types of

implicatures) and in depth (with larger populations and more complex stimuli). The value of a strong theory of semantics and pragmatics for a more general theory of natural language should be clear: understanding how language works means understanding how it allows us to communicate infinitely many thoughts with finite means.

Sign languages have been shown to have the same combinatorial finite means available to them as spoken languages, and so the question is as relevant for sign as for speech: how does the context contribute to the meaning of these parts? Moreover, sign languages may have additional means that have yet to be studied to a significant degree in spoken languages, such as the gradient/analog means of communication available in some parts of sign (e.g. the movement and locations in classifier predicates) and the gestures that accompany speech; understanding how these work in a three dimensional spatial system opens vast new areas of research that show great promise for providing a more complete picture of language as a communication system. Adding to this the new possibilities in language differences (e.g. general use coordination in ASL) and in language acquisition patterns make studying implicatures in sign languages an important contribution to natural language linguistics and psycholinguistics. Finally, and most importantly, the semantic/pragmatic interface has received significant attention by formal linguists only very recently, and has the potential to provide important information to theorists as well as users and educators about the development of language and meaning in Deaf signers with a variety of language backgrounds. This level of linguistic analysis should not be ignored, and the tools of formal pragmatics founded by Grice and developed over the decades since by many others can provide a valuable source for new information about sign language and language development.

(Word count: 6,975)

References

Barner, D., N. Brooks & A. Bale. (2011.) Accessing the unsaid: The role of scalar alternatives in children's pragmatic inference. *Cognition 118(1).* 84–93.

Bott, L., & Noveck, I. A. (2004). Some utterances are underinformative: The onset and time course of scalar inferences. *Journal of memory and language*,*51*(3), 437-457.

Boudreault, P., & Mayberry, R. I. (2006). Grammatical processing in American Sign Language: Age of first-language acquisition effects in relation to syntactic structure. *Language and Cognitive Processes, 21*, 608–635.

Bowler, M. (2014). Conjunction and disjunction in a language without'and'. In *Semantics and Linguistic Theory* (Vol. 24, pp. 137-155).

Chevallier, C., Wilson, D., Happé, F., & Noveck, I. (2010). Scalar inferences in autism spectrum disorders. *Journal of autism and developmental disorders,* 40(9), 1104-1117.

Chierchia, G. (2006). Broaden your views: Implicatures of domain widening and the "logicality" of language. *Linguistic inquiry, 37*(4), 535-590.

Chierchia, G., Fox, D., & Spector, B (2009). The grammatical view of scalar implicatures and the relationship between semantics and pragmatics. *Semantics: An international handbook of natural language meaning,* Berlin: Mouton de Gruyter.

Chierchia, G., S. Crain, M. T. Guasti, A. Gualmini & L. Meroni. (2001). The acquisition of disjunction: Evidence for a grammatical view of scalar implicatures. In A. H.-J. Do, L. Domínguez & A. Johansen (eds.), *Proceedings of the 25th annual Boston University Conference on Language Development [BUCLD 25],* 157–168. Somerville, MA: Cascadilla Press

Davidson, K. (2013). And'or 'or': General use coordination in ASL. *Semantics and Pragmatics*, *6*(4), 1-44.

Davidson, K. (2014). Scalar implicatures in a signed language. *Sign Language & Linguistics*, *17*(1), 1-19.

Davidson, K. (2015). Quotation, Demonstration, and Iconicity. To appear in *Linguistics and Philosophy*.

Davidson, K., & Mayberry, R. I. (2015). Do Adults Show an Effect of Delayed First Language Acquisition When Calculating Scalar Implicatures?. *Language Acquisition*, (ahead-of-print), 1-26.

Emmorey, K. & Herzig, M. (2003). Categorical versus gradient properties of classifier constructions in ASL. In K. Emmorey (Ed.), *Perspectives on Classifier Constructions in Signed Languages*, Lawrence Erlbaum Associates, Mahwah NJ, pp. 222–246

Fox, D. (2007). Free Choice Disjunction and the Theory of Scalar Implicatures. *Presupposition and Implicature in Compositional Semantics.* U. Sauerland and P. Stateva. New York, Palgrave Macmillan: 71-120.

Gil, D. (1991). Aristotle goes to Arizona, and finds a language without *and*. *Semantics Universals and Universal Semantics,* 96-130.

Grice, H. P. (1970). *Logic and conversation* (pp. 41-58).

Gualmini, A., S. Crain, L.Meroni, G. Chierchia & M. T. Guasti. (2001). At the semantics/pragmatics interface in child language. *Proceedings of Semantics and Linguistic Theory XI*. Ithaca, NY: CLC Publications, Cornell University.

Huang, Y. T., & Snedeker, J. (2009). Semantic meaning and pragmatic interpretation in 5-year-olds: evidence from real-time spoken language comprehension. *Developmental psychology*, *45*(6), 1723.

Katsos, Napoleon & Dorothy V. M. Bishop. (2011). Pragmatic tolerance: Implications for the acquisition of informativeness and implicature. Cognition 120(1). 67–81.

Katsos, N. & N.Smith. (2010). Pragmatic tolerance and speaker-comprehender asymmetries. In K. Franich, K. M. Iserman & L. L. Keil (eds.), *Proceedings of the 34th annual Boston University Conference on Language Development [BUCLD 34],* 221–232. Somerville, MA: Cascadilla Press.

Kennedy, L., Romoli, J. , Bill, C., Folli, R., and Crain, S. (to appear) Presuppositions vs. Scalar Implicatures: the view from Broca's Aphasia. *Proceedings of NELS 45*, MIT, Cambridge

Liddell, Scott. (2003). *Grammar, gesture, and meaning in American Sign Language*. Cambridge: Cambridge University Press.

Mayberry, R. I., Lock, E., & Kazmi, H. (2002). Linguistic ability and early language exposure. *Nature, 417*, 38.

Montague, R. (1973). *The proper treatment of quantification in ordinary English* (pp. 221-242). Springer Netherlands.

Murray, S. E. (2013). Cheyenne Connectives.

De Neys, W., & Schaeken, W. (2007). When people are more logical under cognitive load: Dual task impact on scalar implicature. *Experimental psychology*, *54*(2), 128-133.

Grodner, D. J., Klein, N. M., Carbary, K. M., & Tanenhaus, M. K. (2010). "Some," and possibly all, scalar inferences are not delayed: Evidence for immediate pragmatic enrichment. *Cognition*, *116*(1), 42-55.

Noveck, I. A. (2001). When children are more logical than adults: Experimental investigations of scalar implicature. *Cognition*, *78*(2), 165-188.

Ohori, T. (2004). Coordination in mentalese. *Typological Studies in Language*, *58*, 41-66.

Papafragou, A., & Musolino, J. (2003). Scalar implicatures: Experiments at the semantics–pragmatics interface. *Cognition*, *86*(3), 253-282.

Papafragou, A. & N. Tantalou. (2004). Children's computation of implicatures. *Language Acquisition 12*. 71–82.

Pijnacker, J., Hagoort, P., Buitelaar, J., Teunisse, J. P., & Geurts, B. (2009). Pragmatic inferences in high-functioning adults with autism and Asperger syndrome. *Journal of autism and developmental disorders,* 39(4), 607-618.

Slabakova, R. (2010). Scalar implicatures in second language acquisition. *Lingua* 120(10). 2444–2462.

Stiller, A. N. D. Goodman & M. C. Frank. (2011). Ad-hoc scalar implicature in adults and children. *Proceedings of the 33rd Annual Meeting of the Cognitive Science Society*.

Zucchi, S., Cecchetto C., & Geraci, C. (2012). Event Descriptions and Classifier Predicates in Sign Languages. Presentation FEAST in Venice, June 21, 2011.

Zwitserlood, I. (2012). Classifiers. *In Sign language: An international handbook* (pp. 158-186). Mouton de Gruyter.