The Semantics and Pragmatics of Logical Connectives: Adults' and Children's Interpretations of *And* and *Or* in a Guessing Game

Masoud Jasbi
masoudj@stanford.edu
Department of Linguistics
Stanford University

Michael C. Frank
mcfrank@stanford.edu
Department of Psychology
Stanford University

Abstract

The development of the ubiquitous logical connectives *and* and *or* provides a window into the role of semantics and pragmatics in children's linguistic development. Previous research has suggested that adults and children might differ in their interpretation of *or* in two ways. First, unlike adults, children might interpret *or* as logical conjunction, akin to *and*. Second, children might interpret *or* as inclusive disjunction while adults interpret it as exclusive. We report experimental studies that probe interpretations of *and* and *or* in adults and children using truth value judgements as well as children's spontaneous linguistic feedback. Both truth judgements and linguistic feedback showed that four-year-olds do not interpret *or* as *and*. While children's truth judgments suggested that they did not derive exclusivity implicatures, however, their corrective feedback showed signs of sensitivity to the implicature, suggesting that the truth value judgement task could have underestimated children's pragmatic competence. More generally, four-year-olds' interpretation of logical connectives may not be as different from adults as previously supposed.

Keywords: language development; semantics; pragmatics; logical connectives; disjunction; conjunction.

Introduction

An airport sign reads "*If you see something, say something.*" Taken literally, this is a trivial request, but readers infer an interpretation that goes far beyond the literal meanings of the words. How much of what we interpret is due to literal meaning (semantics) and how much due to our general-purpose inferential abilities (pragmatics)? In this paper, we address this question by investigating adults' and children's interpretation of the logical words *and* and *or*.

Despite their simple appearance, *and* and *or* have been a major source of insight into the contributions of semantics and pragmatics to language interpretation. The meaning of *and* has always been unambiguously associated with logical conjunction. For example, "*There is a cat and a dog in the house.*" is true when the house has both a cat and a dog but false if only one or neither. The meaning of *or*, however, has two interpretations: **inclusive** disjunction and **exclusive** disjunction. The inclusive interpretation suggests the house has either a cat, a dog, or both. The exclusive one suggests only a cat or dog, not both. Until Grice (1975), it was generally assumed that *or* is ambiguous between these two meanings.

Grice (1975) argued against this ambiguity account. He maintained that the core meaning of *or* is inclusive disjunction but we often derive an exclusive interpretation (*exclusivity implicature*) by reasoning about what the speaker could have said. If the speaker meant to communicate that both a cat and a dog are in the house, s/he could have used the connective *and*. S/he chose *or* instead, so s/he did not mean to communicate that both animals are in the house. In the Gricean account, the exclusivity implicature is not part of *or*'s meaning, but rather the result of our reasoning on speaker's connective choice.

The advent of Gricean pragmatics shifted the focus of research in child language to the differences between adults and children in semantic vs. pragmatic aspects of interpretation. In a series of influential studies, Stephen Crain and colleagues argued that unlike adults who have an implicature-rich exclusive interpretation of *or*, children as young as three years old, interpret the meaning of *or* as inclusive disjunction (Chierchia, Crain, Guasti, Gualmini, & Meroni, 2001; Crain, 2012). They argued that children develop the semantics of *or* before its pragmatics: they interpret *or* as inclusive disjunction but fail to enrich it with the exclusivity implicature the way adults do. Therefore, the main difference between children and adults is that children interpret *or* as inclusive, but adults interpret it as exclusive.

Recent investigations have added a new level of complexity to this line of research. Tieu et al. (2017) and Singh et al. (2016) argued that a large group of children in their studies (30-40% of the participants) interpreted *or* as logical conjunction. In other words, these children did not differentiate between *and* and *or*. They argue that this conjunctive interpretation of *or* is due to non-adult-like pragmatic reasoning: children interpret *A or B* as *A or B or both, but not only A, and not only B*; therefore *both A and B*.

The current paper seeks to fill two gaps in the current literature. First, previous research has focused on children's interpretation of *and* and *or* in complex sentences – for example with other logical words such as quantifiers *every* and *none*. In this paper we test children and adults' understanding of *and* and *or* in simple existential sentences like "*There is a cat or a dog*." Second, previous research has tested children and adults using the binary truth value judgment task (Crain & Thornton, 1998). In such tasks participants are asked whether a puppet's statement is right or wrong. In this study, we allow participants to make use of three options: *wrong*, *kinda right*, and *right*. Katsos & Bishop (2011) argued that ternary judgment tasks are better suited for assessing children's pragmatic competence.

This paper addresses two main questions. First, do children interpret *or* as logical conjunction (similar to *and*)? Second, do children understand *or* as inclusive disjunction, or exclusive disjunction? We conduct two experiments to answer these questions. Experiment 1 tests adults' interpreta-

tions and sets the benchmark for our child study. Experiment 2 investigates children's truth value judgments in a guessing game as well as their spontaneous linguistic feedback in the same task. Considering the first question, neither children's truth value judgement nor their linguistic feedback support the hypothesis that a large group of them interpret *or* as logical conjunction. For the second question, children's judgments suggest that unlike adults, they do not derive exclusivity implicatures and interpret *or* as inclusive disjunction. However, children's spontaneous linguistic feedback shows signs of sensitivity to the exclusivity implicature of *or*.

The next two sections present experiments 1 and 2 and the last section discusses the implications of these findings for theories of semantic and pragmatic development. For further details of the methods as well as the data and statistical analyses, please visit the paper's online repository.[1]

Experiment 1: Adults

Methods

Participants We recruited 52 English speaking adults online using Amazon's Mechanical Turk (MTurk).

Materials and Design The experimental game included several cards with cartoon images of either one or two animals. The animals included a cat, a dog, and an elephant. Figure 1 shows two example cards. The game also used three types of guesses: **simple** (e.g. *There is a cat*), **conjunctive** (e.g. *There is a cat and a dog*), and **disjunctive** (e.g. *There is a cat or a dog*). Pairing the cards with the guesses resulted in 6 types of card-guess scenarios. Figure 1 shows examples for four critical scenarios. Overall, the animal labels used in the guess and the animal images on the card may have no overlap (e.g. Image: dog, Guess: *There is a cat or an elephant*), partial overlap (e.g. Image: Cat, Guess: *There is a cat or an elephant*), or total overlap (e.g. Image: cat and elephant, Guess: *There is a cat or an elephant*). Crossing the number of animals on the card, the type of guess, and the overlap between the guess and the card resulted in 12 different trial types.

Procedure The experiment had three phases: introduction, instruction, and test. In the introduction, participants saw six sample cards and read that they will play a guessing game with them. Then a blindfolded cartoon character named Bob appeared on the screen and they were told that in each round of the game, they will see a card and Bob is going to guess what animal is on it. We emphasized that Bob cannot see anything. We asked participants to judge whether Bob's guess is *wrong*, *kinda right*, or *right*. In the instruction phase, participants saw a card with the image of a dog and were told that Bob guessed *There is a cat on the card*. All participants (correctly) responded with *wrong*.

In the test phase, participants saw one trial per trial type for the total of 12 trials. Within each trial type, the specific card-guess scenario was chosen at random. The order of trial types was also randomized.

[1] https://github.com/jasbi/cogsci2017

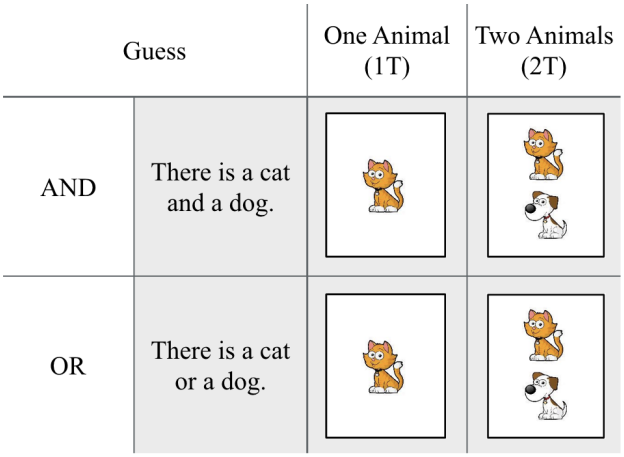

Figure 1: Critical trials with example cards.

Results

Here we focus on the results of the critical trial types, pictured in Figure 1.[2] We identify these trials using two features: 1. the connective used for guessing (AND vs. OR) 2. the number of true conjuncts/disjuncts, which corresponds to the number of animals on the card. When only one animal is on the card, only 1 conjunct/disjunct is true (1T) and when two animals are on the card, both conjunct/disjuncts are true (2T).

Adult responses differed both by the connective used and the number of true conjuncts/disjuncts (Figure 2). First, the response pattern in AND trials is different from the one in OR trials. For AND, the responses were on the extremes of *right* and *wrong* while for OR, they were distributed on *kinda right* and *right*. This pattern suggests that adults interpret *and* and *or* differently. Second, the responses were different between the trials where one disjunct/conjunct was true (1T) and those where both disjuncts/conjuncts were true (2T). This difference was greater for conjunction than disjunction. Adults showed a small preference for the use of disjunction when only one disjunct was true. This pattern suggests a small preference for an exclusive interpretation of *or* in the guessing game.

Individual Responses In order to understand how participants interpret disjunction, Tieu et al. (2017) and Singh et al. (2016) categorized participants as a function of their responses to the disjunctive trials. Here we perform a similar analysis. In this study, none of the adults considered a disjunctive guess *wrong* when one or both of the animals were on the card. However, the participants' *kinda right* and *right* responses divided them into four categories.

The largest group of participants (23 out of 52) considered the disjunctive guess *right* when one animal was on the card

[2] For the data, full results including non-critical trials, and statistical analyses visit the paper's online repository.

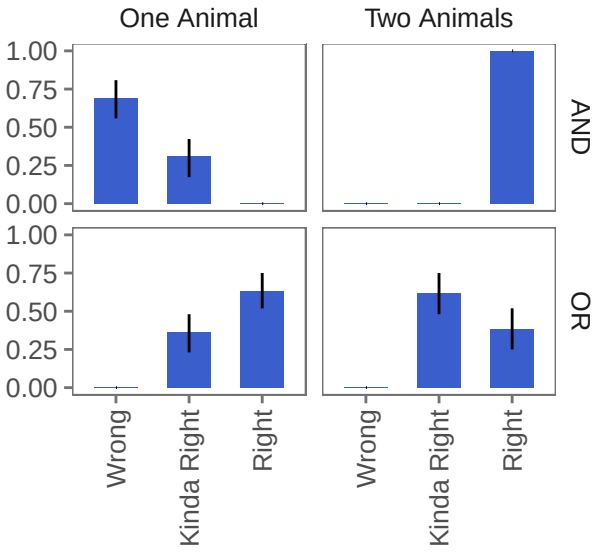

Figure 2: Adult judgments in critical trials of Experiment 1. Error bars represent 95% confidence intervals.

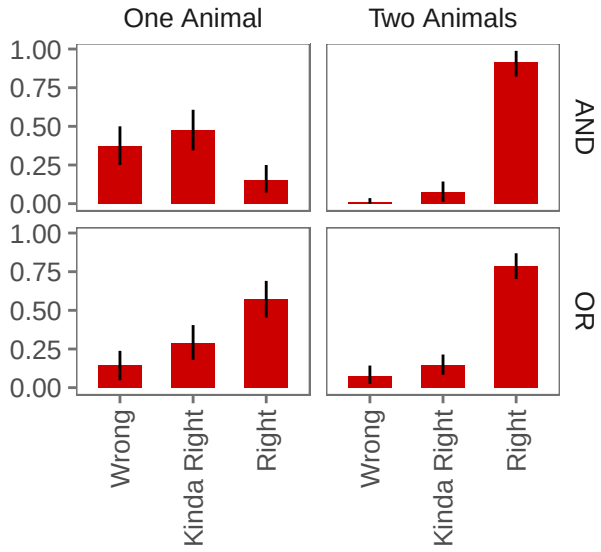

Figure 3: Children's judgments for critical trials in Experiment 2. Error bars represent 95% confidence intervals.

(1T), but *kinda right* with both animals were present (2T). This pattern is consistent with an interpretation of "or" with an exclusivity implicature. The use of disjunction when both disjuncts are true is not *wrong* but it is nevertheless infelicitous and not completely *right*. For these participants, *kinda right* captures the violation of such a pragmatic expectation.

The other 29 participants divided almost equally into three groups. Ten participants rated disjunctive guesses as *right* in both scenarios where one or two animals were on the card. This pattern is consistent with an inclusive interpretation of *or*, in which adults do not derive an exclusivity implicature. It is also compatible with some adults being tolerant towards violations of the exclusivity implicature.

Nine other participants rated disjunctive guesses as only *kinda right* in both one-animal and two-animal trials. In other words, disjunctive guesses were dispreferred regardless of the outcome. This response pattern is consistent with the violation of another pragmatic expectation in the context of a guessing game: the guesser must choose the most specific guess possible. Under this expectation, guesses that cover several possible outcomes are punished. A disjunctive guess never picks a specific outcome and it is possible that for these participants, *kinda right* captures the violation of this specificity expectation.

Finally, nine participants (17% of participants) reported a disjunctive guess as *right* when both animals were on the card, but only *kinda right* when only one of the animals was on the card. In other words, these participants preferred the guess when both disjuncts where true rather than only one. It is possible to interpret such a response profile as some adults interpreting *or* as logical conjunction. However, it is also possible that these adults considered the goal of the game to be choosing the right animals and did not think the choice of the connective should matter for the purposes of the guessing game. In other words, they may have interpreted a *right* guess as one that picks the correct animals out of the possible set of animals in the game, regardless of the connective used.

The analysis of individual response profiles shows that there is a good deal of variability in the response profiles of adults. However, since we have not systematically manipulated the possible interpretations mentioned above and accounted for noise and chance variation, we remain cautious in our interpretation of participants' response profiles here.

Discussion

In this study, we tested adult interpretations of the connective words *and* and *or* in the context of a guessing game. Adult participants interpreted these words differently and depending on how many disjuncts/conjuncts were satisfied. Overall, a guess with *and* was considered right if both conjuncts were true and wrong if only one was true. A guess with *or* was not wrong in either case, yet adults were more likely to consider it as right when only one of the disjuncts was true. Grouping individuals based on their response profiles, we found that some participants dispreferred disjunctive guesses whether one or both disjuncts were true, some considered them better when both disjuncts where true, and some others considered them right in either case.

The results are consistent with the dominant view on the division of labor between semantics and pragmatics in the interpretation of connective words. The semantics of *and* is captured by logical conjunction and *or* by inclusive disjunction. *And* is true when both conjuncts are true and false when only one is true. *Or* is true in both cases but is not the best option as a connective when both disjuncts are true. In Experiment 2 we examine preschool children's interpretation of these connectives in the context of the same guessing game.

Experiment 2: Children

Methods

Participants We recruited 42 English speaking children from the Bing Nursery School at Stanford University. Children were between 3;02 and 5;02 years old (Mean = 4;04).

Materials and Design We used the same set of cards and linguistic stimuli as the ones in Experiment 1. The study used 8 trial types and 2 trials per trial type for a total of 16 trials. The trials were balanced to include the same number of one-animal and two-animal cards, the same number of simple and connective guesses, and the same number of expected true vs. false judgments. However, we made a few changes to make the design more suitable for children. Instead of Bob, a puppet named Jazzy played the game with the children. Jazzy wanted to guess what animals were on the cards without seeing them. So he had a sleeping mask on his eyes during the game. Children knew that Jazzy likes guessing but they did not know why Jazzy would choose to guess the way he does; namely, sometimes with simple sentences and sometimes with conjunctions or disjunctions. To introduce a three-valued reward scale similar to the verbal responses *wrong*, *kinda right*, and *right*, we placed a set of red circles, small blue stars, and big blue stars in front of the children. These tokens were used to reward the puppet after each guess.

Procedure The experiment was carried out in a quiet room and the sessions were videotaped. There was a small table and two chairs in the room. Children sat on one side of the table and the experimenter and the puppet on the other side facing the child. The groups of circles, small stars, and big stars were placed in front of the child from left to right. A deck of six cards was in front of the experimenter. Similar to the adult study, participants sat through three phases: introduction, instruction, and test.

The goal of the introduction phase was to show the animal cards to children and make sure they recognize the animals and know their names. The experimenter showed the cards to the children and asked them to label the animals. All children recognized the animals and could label them correctly. In the instruction phase, children went through three example trials. The experimenter explained that he is going to play with the puppet first so that the child can learn the game. He removed the six introduction cards and placed a deck of three cards face-down on the table. From top to bottom (first to last), the cards had the following images: a cat, an elephant, a cat and a dog. He put the sleeping mask on Jazzy's eyes and explained that Jazzy is going to guess what is on these cards. He then picked the first card and asked the puppet: "*What do you think is on this card?*" Jazzy replied with "*There is a dog*". The experimenter showed the cat-card to the child and explained that when Jazzy is *not right* he gets a circle. He then asked the child to give the puppet a circle. Rewards were collected by the experimenter and placed under the table to not distract the child. The second trial followed the same pattern except that the puppet guessed *right* and the experimenter invited the child to give the puppet a big star. In the final trial, the puppet guessed that there is a cat on the card when the card had a cat and a dog on it. The experimenter said that the puppet was *a little right* and asked the child to give him a little star.

In the test phase, the experimenter removed the three instruction cards and placed a deck of 16 randomized cards face-down on the table. In all trials of the study, the face of the card was shown to the child after the puppet's guess. The experimenter explained that it was the child's turn to play with the puppet.

Offline Coding of Linguistic Feedback We also coded children's spontaneous linguistic feedback to the puppet when they saw the card. There were four types of feedback: 1. None, 2. Judgments, 3. Descriptions, and 4. Corrections. **None** refers to cases where children did not provide any linguistic feedback. **Judgments** refers to linguistic feedback such as *you are right!*, *yes*, *nope*, *you winned*. Such feedback expresses whether the puppet was right or not. **Descriptions** were cases that the child simply mentioned what was on the card with no added lexical item or prosodic stress: *cat!*, *dog and elephant!*, *There is a cat and a dog!* etc. Finally, **corrections** referred to feedback that provided corrections to what the puppet had said using extra words or prosodic stress. Examples include: *cat AND dog* (with emphasis placed on *and*), *Both!*, *The two are!*, *Just a cat!*, *Only cat*.

Results

Figure 3 shows the results for the critical conditions in Experiment 2. Comparing the AND and OR trials (Figure 3 rows), we see that children distinguish between *and* and *or* in cases where one animal is on the card but not when both are. Given that the one-animal conjunction trials (top left) and the one-animal disjunction trials (bottom left) differ in truth conditions, the difference in response patterns suggests that children at this age have a different semantic knowledge for *and* and *or*. The two-animal conjunction and two-animal disjunction trials (top right and bottom right) do not differ in truth values, and the responses also show no difference.

In the one-animal and two-animal trials, children show different response patterns when the guess contains the conjunction word *and* (top right vs. top left) but not when *or* is used (bottom right vs. bottom left). Since the truth values of one-animal and two-animal trials differ for conjunctive guesses but not disjunctive ones, the results suggest that children have different semantic knowledge for *and* and *or*. The similarity of the disjunctive guesses in one-animal and two-animal trials (bottom right vs. bottom left) can be interpreted as a lack of exclusivity implicatures in children.

Statistical Modeling We used the R package $\{rstan\}$ for Bayesian statistical modeling. We fit separate ordinal mixed-effects logistic models for children's and adults' judgments. The response variable had three ordered levels: *wrong*, *kinda right*, and *right*. The trial types *One-Animals-OR*, *Two-*

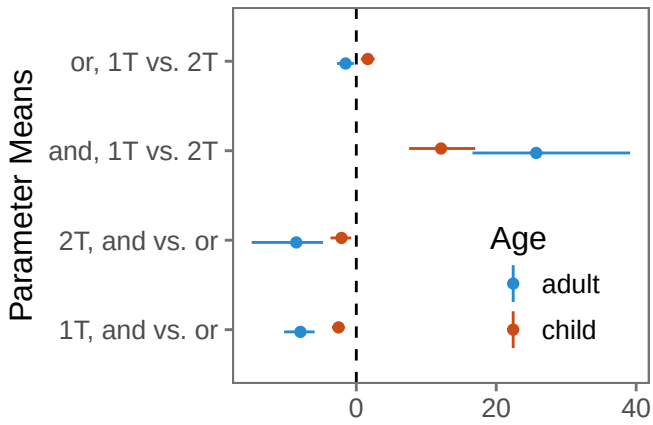

Figure 4: Coefficients capturing the relevant comparisons across conditions across the two experiments (see text). Error bars represent 99% regions of highest posterior density.

Animals-OR, *One-Animal-AND* constituted the (dummy-coded) fixed effects of the model with *Two-Animal-AND* set as the intercept. The model also included by-subject random intercepts. The priors over trial types and the random intercepts were set to $\mathcal{N}(0, 10)$. We also included parameters C_1 and C_2, the two cutpoints delimiting the logistic for 1) *wrong* and *kinda right* and 2) *kinda right* and *right* responses, drawn with the prior $\mathcal{N}(0, 1)$.[3] All four chains converged after 3000 samples (with a burn-in period of 1500 samples)

We make inferences based on the highest-posterior density (HPD) intervals for the coefficients estimated from each model. Because predictors are dummy-coded, we can examine contrasts of interest by computing the difference between coefficients for pairs of conditions we wish to contrast (Figure 4). Overall, adults' and children's estimated coefficients are similar in sign to one another, though adults are more extreme. The one notable exception to this pattern is for the contrast *or, 1T vs. 2T*, which shows the comparison between the disjunctive trials: both disjuncts are true vs. only one disjunct is true. On average, children are more positive for disjunction on two-animal trials, while adults are more negative. These estimates reflect the exclusivity implicature that adults compute, leading them to judge two-animal trials as more *kinda right*.

Individual Responses Children showed a wide variety of response profiles for disjunction trials. This was partly because each child responded to two trials per trial type: two one-animal disjunction trials and two two-animal disjunction trials. The largest group (10 out of 42) responded with *right* to all four trials. Six children responded with *right* to all trials except one one-animal trial that they responded to with *kinda right*. Six other children responded with *kinda right* to both one-animal trials and *right* to both two-animal trials.

However, the main goal of analyzing the response profiles was to find children that demonstrated conjunctive readings of *or*. In order to find such children, we adopted a (lenient) measure: any preference for *or* when both disjuncts were true was considered a conjunctive profile. More specifically, either the child responded with *wrong* when one disjunct was true but *kinda right* or *right* when both were true; or, the child responded with *kinda right* when one disjuncts was true but *right* when both were true. We found 10 children (24% of participants) that matched this profile. In Experiment 1 we found nine adults (17% of participants) who matched such a profile. Furthermore, as explained earlier, such a response profile is also compatible with a different construal of the guessing game in which the goal is to pick the right animals regardless of the logical connective. Therefore, we conclude that the analysis of participants' response profiles did not provide any evidence for the hypothesis that a large group of four-year-old children interpret *or* as logical conjunction.

Linguistic Feedback We next examined children's linguistic feedback to the puppet (Figure 5). In all critical trials, we found similar proportions of *None* responses: no comment on the puppet's guess and only rewarding the puppet. However, the proportions of other feedback categories differed between trial types. We performed chi-squared tests of homogeneity to compare the feedback distributions.

In the AND trials, a comparison of the feedback distribution in one-animal and two-animal conditions was statistically significant ($\chi(3, 167) = 35.99$, $p < .0001$), indicating different feedback for true vs. false sentences. In the OR trials, we find a similar significant difference between one-animal and two-animal trials, suggesting children's sensitivity to the exclusivity implicature of *or* ($\chi(3, 166) = 11.11$, $p = 0.01$). In both cases, children's corrective feedback increases for false (AND - one animal) and infelicitous trials (OR - two animals). There was no significant difference between these false and infelicitous trials ($\chi(3, 166) = 3.19$, $p = 0.36$).

The one-animal disjunctive trials (bottom left) showed the highest proportion of *Descriptions*. These are trials in which the guess is correct but not specific enough: it leaves two possibilities open. These trials were significantly different than the one-animal trials for conjunction ($\chi(3, 166) = 24.29$, $p < .0001$). Finally, the two-animal conjunctive trials (top right) showed the highest proportion of *Judgments* such as *you are right!*. This is not surprising given that in these trials represent the most optimal guessing scenario. These trials had a significantly different feedback distribution from the matching disjunction trials ($\chi(3, 167) = 42.37$, $p < .0001$).

Discussion

This study did not find evidence for the hypothesis that a large group of four-year-old children interpret the disjunction word *or* similar to its conjunctive counterpart *and*. To the contrary, both children's judgments and their linguistic feedback suggested that they differentiate these two connectives. Instead, children's judgments largely mirrored those of adults. We take this as a sign of children's adult-like semantics for

[3] We used a tight prior in this case to decrease posterior correlations between cutpoints and intercept.

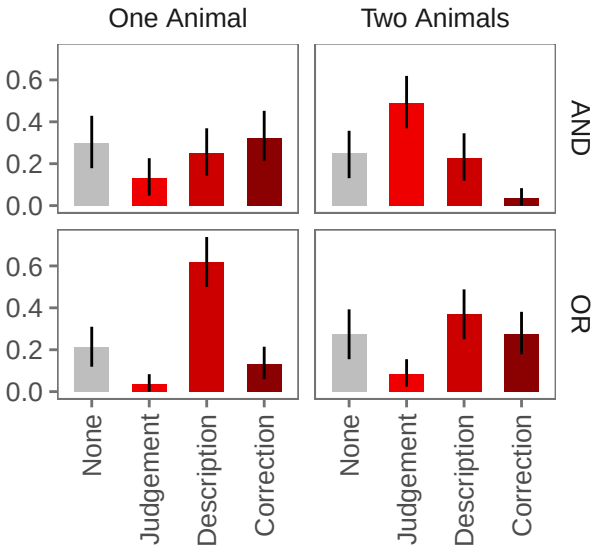

Figure 5: Children's Linguistic Feedback to Conjunction and Disjunction Trials. Error bars represent 95% confidence intervals.

and and *or*. Considering pragmatic inferences with *or*, children's truth value judgments did not differentiate between trials where one disjunct was true and those where both were true. However, their linguistic feedback to the puppet did differentiate these two trial types. Children provided more corrective feedback when both disjuncts were true, indicating sensitivity to the exclusivity implicature of *or*.

General Discussion

We began with two questions. First, do adults/children differentiate *or* from *and*? Second, do adults/children interpret *or* as inclusive disjunction or exclusive disjunction? We presented two studies to address these questions.

For the first question, we reported truth value judgement results as well as results from children's linguistic feedback that suggested both adults and children differentiate *or* from *and*. Crucially, children showed different judgments for false vs. true guesses, suggesting that they understand the core semantics of these connectives.

For the second question, adult truth value judgments of *or* were split between an inclusive and an exclusive interpretation in the guessing game, with a slight advantage for the exclusive interpretation. Children's judgments suggested that they interpret *or* as inclusive disjunction and do not derive an exclusivity implicature. However, children's spontaneous linguistic feedback in the same task showed signs of sensitivity to the exclusivity implicature of *or*. In other words, when both disjuncts were true children considered the guess *right* but corrected the puppet with utterances such as *cat AND dog*, *both!*, *the two are!*.

Based on the truth value judgement results, it is possible to conclude that children, unlike adults, do not derive an exclusivity implicature for *or*. However, children's spontaneous linguistic feedback raises another possibility: while the truth value judgement task reflected children's semantic knowledge well, it could have underestimated children's pragmatic competence. We would like to explore this possibility more systematically in a future study.

Overall, our results point to the importance of assessing the semantics and pragmatics that children assign to connectives across a wide variety of contexts and using different measures. Although individual experimental trial types can appear consistent with multiple interpretations, the profile of responses across trial types can be revealing of the underlying representations. More broadly, the investigation of how children acquire semantic representations for logical connectives – and in particular, how they infer an inclusive semantics for *or* – is an important puzzle for future investigations of early word learning.

Acknowledgements

We would like to thank Eve V. Clark and Christopher Potts for their generous help and advice on this project. We would also like to thank the staff and children at Stanford's Bing Nursery School. This work was supported by NSF #1456077 and the Stanford University fellowship to Masoud Jasbi.

References

Chierchia, G., Crain, S., Guasti, M. T., Gualmini, A., & Meroni, L. (2001). The acquisition of disjunction: Evidence for a grammatical view of scalar implicatures. In *Proceedings of the 25th Boston University conference on language development* (pp. 157–168). Cascadilla Press Somerville, MA.

Crain, S. (2012). *The emergence of meaning*. Cambridge University Press.

Crain, S., & Thornton, R. (1998). *Investigations in universal grammar: A guide to experiments on the acquisition of syntax and semantics*. MIT Press.

Grice, H. P. (1975). Logic and conversation. In P. Cole & J. Morgan (Eds.), *Syntax and semantics* (Vol. 3: Speech Acts, pp. 43–58). Academic Press.

Katsos, N., & Bishop, D. V. (2011). Pragmatic tolerance: Implications for the acquisition of informativeness and implicature. *Cognition*, *120*(1), 67–81. Retrieved from http://www.sciencedirect.com/science/article/pii/S0010027711000758

Singh, R., Wexler, K., Astle-Rahim, A., Kamawar, D., & Fox, D. (2016). Children interpret disjunction as conjunction: Consequences for theories of implicature and child development. *Natural Language Semantics*, *24*(4), 305–352. http://doi.org/10.1007/s11050-016-9126-3

Tieu, L., Yatsushiro, K., Cremers, A., Romoli, J., Sauerland, U., & Chemla, E. (2017). On the role of alternatives in the acquisition of simple and complex disjunctions in french and japanese. *Journal of Semantics*, *34*(1), 127. http://doi.org/10.1093/jos/ffw010