

Logical connectives: An extendable experimental paradigm

Overview The meaning of words like *not*, *and*, *or* and their relation to logical connectives such as negation, conjunction and disjunction has been an integral part of semantic and pragmatic theory (Grice 1978, Horn 1972, Gazdar 1980, etc.). Two central topics in this area are the status of exclusive interpretation of disjunction via implicature and the interpretation of negated conjunction and disjunction. Exclusivity implicatures can be viewed as default inferences (e.g. Levinson 2000) that are suspended in certain linguistic or grammatical environments such as questions and antecedent of conditionals (Chierchia 2004). Negated conjunction and disjunction are argued to follow de Morgan laws but vary in scope parameters cross-linguistically (Szabolcsi 2002, Szabolcsi & Haddican 2004, Crain 2012). Experimental studies have investigated these topics and the interpretation of connectives words separately (e.g. Chevallier et al. 2008; Lungu et al. 2021), but few have looked at them together within the same experimental paradigm and crosslinguistically.

We present a study that tests participant judgments, first here in written English, for different combinations of connectives *not*, *and*, *or*, and *either-or* across three different linguistic environments: questions, statements, and antecedent of conditionals, with the goal of extending the paradigm to other languages as well as spoken English and acquisition studies. First, there was not a large effect of these linguistic environments in shaping exclusivity inferences or connective interpretations generally, and across environments, disjunction was typically interpreted as inclusive. Second, while the negation of a disjunction ($\neg[p \vee q]$) was interpreted as the conjunction of negatives ($\neg p \wedge \neg q$), the negation of a conjunction ($\neg[p \wedge q]$) received two interpretations across environments: conjunction of negatives ($\neg p \wedge \neg q$) and disjunction of negatives ($\neg p \vee \neg q$). These results are compatible with theories that allow variable scope relations between English negation and conjunction (e.g. Winter 2000), and raise challenges for theories assuming uniform scope or default suspension of implicatures based on the linguistic environment.

Methods The study was designed as a card selection task to minimize metalinguistic task demands, with an eye toward future crosslinguistic/acquisition work. In each trial, participants (N=150) viewed six cards with the following cartoon images: 1.a cat 2.a dog 3.an elephant 4.a cat and a dog 5.a dog and an elephant and 6.a cat and an elephant. They also saw a written English sentence, and were asked to select “the cards that matched”. Participants could select any single or combination of these cards by clicking on each card. We varied the sentences to test three types of linguistic environments (between-subjects, N=50 per environment): questions (e.g. *which has a cat or a dog?*), statements (e.g. *Bob selected the cards that had a cat or a dog*), and antecedent of conditionals (e.g. *Select a card if it has a cat or a dog*). The cards stayed the same throughout the study and the verb combining with nominal (e.g. *cat*) was always *have*.

Given a linguistic environment, the study had 7 experimental trial-types, among which we expected more potential variation in answers: 1.simple positive (e.g. *has a cat*), 2.simple negative (e.g. *doesn't have a cat*), 3.positive disjunctive (e.g. *has a cat or a dog*), 4.negative disjunctive (e.g. *doesn't have a cat or a dog*), 5.complex positive disjunctive (e.g. *has either a cat or a dog*), 6.complex negative disjunctive (e.g. *doesn't have either a cat or a dog*), 7.and negative conjunctive (e.g. *doesn't have a cat and a dog*). There were also 7 control trial types (Figure 1, Left), among which we expected less variation, and which were presented in a randomized block after the randomized experimental block.

Results Since the results for all three linguistic environments were similar we only discuss the question environment here shown in Figure 1 (Right panel). In positive disjunctive trials (e.g. *has a cat or a dog?*), the majority of responses were compatible with an inclusive interpretation, as measured by inclusive disjunctive control trials (e.g. *has a cat or a dog or both?*). This was also the case in complex positive disjunctive trials with *either-or* (e.g. *has either a cat or a dog?*). We tested

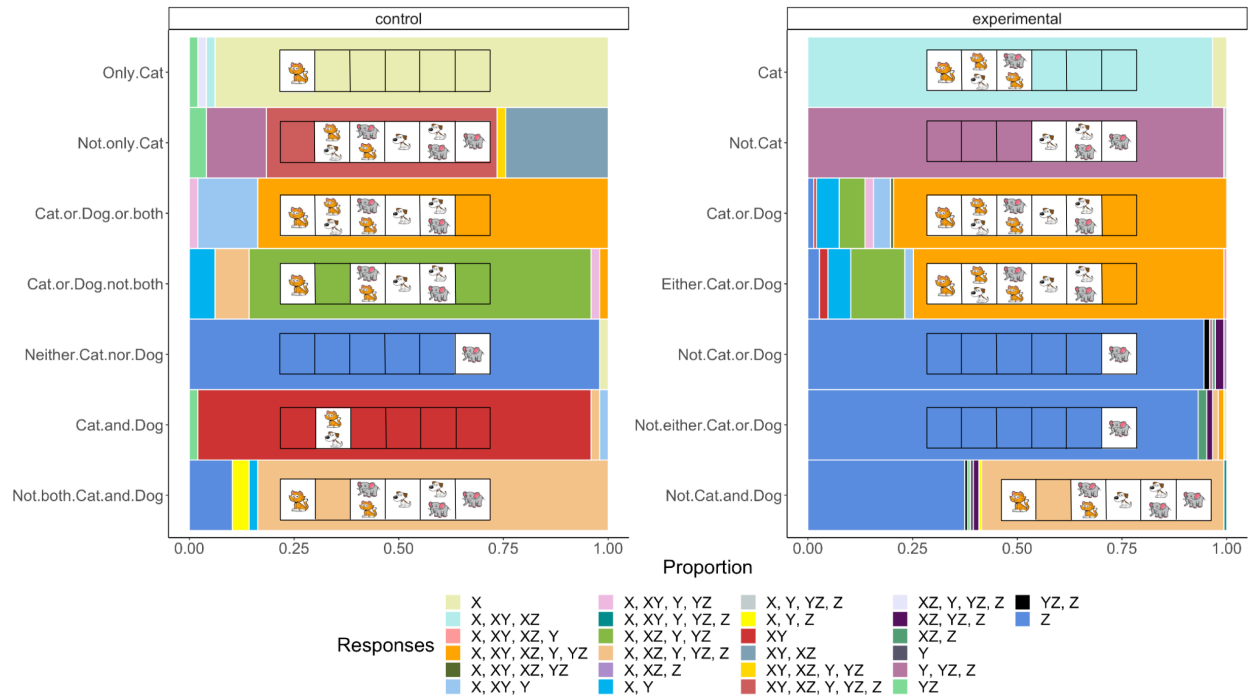


Figure 1: Results for the question environment for control (left) and experimental (right) trials. The x-axis shows proportion responses and the y-axis the trial-types with example sentences. Majority responses are annotated with the card selection. Given example sentences here, the legend's choices of cards (Responses) should be interpreted as X=cat, Y=dog, Z=elephant.

whether participants included the card with both animals in the disjunctive trials using a Bayesian mixed-effects logistic regression with random intercepts and slopes for subjects and fixed effect of trial-type (or vs. either-or) and linguistic environment (question, statement, conditional) and did not find evidence for the effect of *either* or linguistic environment in exclusivity inferences (95% CIs for all coefficients contained zero, 4 chains, 2000 iterations, 1000 warm-up, $\hat{R}=1$).

In negative disjunctive trials, whether simple (e.g. *doesn't have a cat or a dog?*) or complex (e.g. *doesn't have **either** a cat or a dog?*), responses were similar to complex negative trials with *neither-nor* (e.g. *has neither a cat nor a dog?*). In other words, the negation of a disjunction ($\neg[p \vee q]$) was interpreted as the conjunction of negatives ($\neg p \wedge \neg q$). However, in negative conjunctive trials (e.g. *doesn't have a cat and a dog?*) responses were consistently split between a *neither-nor* interpretation and a *not-both* interpretation in all linguistic environments (e.g. *doesn't have both a cat and a dog?*). In other words, the negation of a conjunction ($\neg[p \wedge q]$) was either a disjunction of negatives ($\neg p \vee \neg q$) or conjunction of negatives ($\neg p \wedge \neg q$).

Although limited in (imageable/existential) scenarios, this task provides a unified way to test the interaction of logical operators that allows for comparisons across languages and development.

References Chevallier, Noveck, Nazir, Bott, Lanzetti, & Sperber. 2008. Making disjunctions exclusive. *Quarterly Journal of Experimental Psychology*. Chierchia, G. 2004. Scalar implicatures, polarity phenomena, and the syntax-pragmatics interface. In: Belletti (ed), *Structures and Beyond*. Crain, S. 2012. *The emergence of meaning*. CUP. Gazdar, G. 1980. Pragmatics and logical form. *Journal of Pragmatics*. Grice, H P. 1978. Further notes on logic and conversation. In Cole P. (eds): *Pragmatics*. Horn, L. R. 1972. On the semantic properties of logical operators in English. *UCLA Dissertation*. Levinson, S. C. 2000. *Presumptive meanings: The theory of generalized conversational implicature*. MIT press. Lungu, Falus, Panzeri. 2021. Disjunction in negative contexts: across-linguistic experimental study. *Journal of Semantics*. Szabolcsi & Haddican 2004. Conjunction meets negation: A Study in Cross-linguistic Variation. *Journal of Semantics*. Winter, Y. 2000. On some scopal asymmetries of coordination. In Bennis, Everaert, & Reuland (eds), *Interface Strategies*.