Default biases in the interpretation of English negation, conjunction, and disjunction

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Abstract. Previous research has hypothesized default interpretive biases for three types of ambiguities with English logical words *and*, *or*, and *not*. First, disjunction (A or B) is hypothesized to be biased towardtoward an exclusive interpretation in upward-entailing environments and an inclusive interpretation in downward-entailing environments (Levinson 2000, Chierchia 2004, Breheny et al. 2005). A negated disjunction (not A or B) is claimed to be biased toward a "neither-nor" interpretation (i.e. wide scope negation: $\neg[A \vee B]$) and a negated conjunction is said to be biased toward an "either-not" interpretation (i.e. wide-scope negation: $\neg[A \wedge B]$) (Szabolcsi 2002, Szabolcsi & Haddican 2004). We tested these hypotheses within the same experimental paradigm with 149 English-speaking participants and found disjunction to be biased toward an inclusive interpretation across three different entailment environments: episodic declaratives, questions, and conditional antecedents. Our results also confirmed that English negated disjunction is biased toward a "neither-nor" (wide scope negation) interpretation but the results did not show an "either-not" bias (wide scope negation) for negated conjunction.

Keywords. implicature; disjunction; conjunction; negation; scope; psycholinguistics; semantics; pragmatics

1. Introduction. Negation, conjunction, and disjunction have played important roles in shaping current theories of semantics and pragmatics. For a long time connective words such as *and*, *or*, *not* and their combinations were considered ambiguous and dissimilar to the semantics of the logical operators in classical logic (Tarski 1941). However, Grice (1989) presented an alternative theory in which connective words have meanings similar to their logical counterparts, and the apparent ambiguities in their interpretations stem from factors extrinsic to the semantics of the words themselves. We discuss three such ambiguities in this study.

First, linguistic disjunction is ambiguous between an "inclusive" and "exclusive" interpretation. A disjunctive statement "A or B" is inclusive if it is interpreted as "A or B or Both", and exclusive if it is interpreted as "A or B, not both". For example "Abe is going to drink tea or coffee" is exclusive if it communicates that he is not going to drink both, and inclusive if it communicates that he may drink both. In most current theories of formal semantics and pragmatics, the meaning of *or* itself is represented by inclusive disjunction ($A \vee B$), and the exclusive interpretation is the result of a pragmatic enrichment called "scalar implicature". In the neo-Gricean approach (Horn 1972, Gazdar 1980, Levinson 2000), the exclusivity implicature follows logically from three assumptions: 1. That the speaker is cooperative, truthful, informative, relevant, and brief (The Gricean Maxims); 2. That the speaker could have used *and* instead (The Scalar Alternative); and 3. That the speaker is opinionated regarding whether the conjunction is true or not

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(Opinionatedness). In upward entailing environments, the sentence with *and* is more informative than the sentence with *or*, while in downward entailing environments this is reversed, so entailment environments are predicted to play a role in whether *or* receives an exclusive or inclusive reading.

Although quite different, roughly the same prediction is made in the grammatical approach (Chierchia 2004, Chierchia et al. 2012, Chierchia 2013), where the enrichment is the result of an exhaustivity operator that can appear in various syntactic positions in a sentence's Logical Form (May 1985, Fox 2008). Here too, there is an expectation that structural factors will play a role in interpretation: "the claim is that there are situations in which (standard) implicatures are by default present and situations in which they are by default absent, and such situations are defined by structural factors. By default interpretation, I simply mean the one that most people would give in circumstances in which the context is unbiased one way or the other" (Chierchia 2004). Entailment environment is one such structural factor: scalar implicatures (e.g. the exclusivity implicature) are present by default in upward entailing environments, but they are suspended in downward entailing environments or environments that license NPIs such as antecedent of conditions, questions, and the restriction of *every*. This approach predicts that the default interpretation of disjunction is "exclusive" in upward entailing environments and "inclusive" in downward entailing environments.

Second, when negation ($\neg$) and disjunction ($\vee$) co-occur in a sentence like "Abe doesn't drink tea or coffee", the sentence can be interpreted in two ways. The first interpretation is a negative disjunction ($\neg[A \vee B]$) which we call "the neither-nor interpretation": "Abe drinks neither tea nor coffee". The second interpretation is the disjunction of negatives ($[\neg A \vee \neg B]$) which we call "the either-not interpretation": "Abe either doesn't drink tea or doesn't drink coffee; I don't know which." Szabolcsi (2002) analyzed this ambiguity in terms of scope assignment, and argued that different languages have different default interpretive biases regarding the scope of negation and disjunction. She suggested that in some languages such as Hungarian, Russian, Serbo-Croatian, Slovak, Polish, Italian, and Japanese the default interpretation is "either-not". More specifically, in these languages the disjunction words (e.g. the Hungarian *vagy*) are Positive Polarity Items (PPI) and tend to be interpreted outside the scope of negation. In other languages such as English, Greek, Romanian, Bulgarian, and Korean, the disjunction words are not PPIs and tend to be interpreted in the scope of negation. Therefore, the default interpretation in these languages is "neither-nor".

Third, when negation ($\neg$) and conjunction ($\wedge$) co-occur in a sentence like "Abe doesn't drink tea and coffee", they can also be interpreted in two ways. The first interpretation is negative conjunction ($\neg[A \wedge B]$) which is similar to when *both* is used with *and*: "Abe doesn't drink both tea and coffee. He drinks one or the other." This interpretation is essentially the "either-not" interpretation discussed before: "Abe either doesn't drink tea or doesn't drink coffee, or both". The second interpretation is the conjunction of negatives $[\neg A \wedge \neg B]$) which is equivalent to the "neither-nor" interpretation: "Abe doesn't drink tea and coffee; he drinks neither." Szabolcsi & Haddican (2004) proposed that "English disjunction and conjunction happily scope below a c-commanding negation and dutifully obey the de Morgan laws, whereas the Hungarian counterparts either must scope above the c-commanding negation or fail to obey the de Morgan laws. Such contrasts are not restricted to English and Hungarian. Similar to English is German; similar to Hungarian are Russian, Serbian, Italian, and Japanese, among other languages". More specifically, they argued that with sentences, quantifiers, and predicates, negated conjunction has a default "either-not" bias.

The claims regarding the three ambiguities and their default interpretive biases discussed above are in nature probabilistic. It is easy to show that in each case, both interpretations exist in some context in a given language as examples (1-3) show for English with (a) and (b) continuations. At issue is whether in neutral contexts (i.e. contexts that do not bias the interpretation one way or another), we can find a general bias toward one interpretation rather than another. Therefore, while informal and intuition-based judgments can be helpful in forming working hypotheses, a definitive assessment of such probabilistic and empirical claims requires careful psycholinguistic experiments. The next section summarizes prior experimental research on these ambiguities.

(1) Abe drinks tea or coffee.
   a. But not both. $[A \vee B]$
   b. And sometimes both. $[A \oplus B]$

(2) Abe doesn't drink tea and coffee.
   a. He hates them both. $[\neg A \wedge \neg B]$
   b. He likes only one of them, I forget which one. $\neg[A \wedge B]$

(3) Abe doesn't drink tea or coffee.
   a. He hates them both. $\neg[A \vee B]$
   b. He likes only one of them, I forget which one. $[\neg A \vee \neg B]$

2. Previous Research. Previous experiments on the inclusive vs. exclusive bias for positive disjunction have had mixed results. Paris (1973) tested the comprehension of disjunction and other linguistic connectives in children and college students using truth value judgments. In the adult sample, cases of disjunction with *or* were interpreted as inclusive about 75% percent of the time and those with *either-or* were inclusive about 67.5% of the time. In two experiments each with 24 participants, Evans & Newstead (1980) found that "either p or q" type rules are more likely inclusive (52% of the time in experiment 1 and 57% of the time in experiment 2). On the other hand, Braine & Rumain (1981) used both a give-object task and a truth-value-judgment task and found that adults interpreted disjunction as exclusive most of the time in both experiments (91% and 73% exclusive in the give-object task depending on the phrasing and 41% exclusive in the truth-value-judgment task). Noveck et al. (2002) suggested that lower levels of exclusive interpretations in earlier studies were due to higher task complexity. They collected truth-value judgments from 20 French-speaking adults on abstract logical arguments such as: "if there is a P then there is a Q and an R; there is a P, therefore there is a Q or an R". They reported that the majority of the participants (75%) rejected such conclusions because they interpreted the disjunction as exclusive. However, as the authors pointed out, the paradigm was not neutral and encouraged exclusivity implicatures by highlighting the conjunction in the premise of the linguistic stimuli.

Chevallier et al. (2008) used a truth-value-judgment task with 59 French-speaking participants. Testing constructions like "there is an A or a B", they found that the majority of the responses (about 75%) were inclusive. Davidson (2013) used a felicity-judgment task in which 12 English-speakers saw an image and were presented with a sentence like "a spoon is in the mug or a spoon is in the bowl." Participants responded by choosing a smily face or a frowny face to indicate (dis)satisfaction with the linguistic description. The majority of responses (about 80%)

showed dissatisfaction with a disjunction when both disjuncts were true which suggests an exclusive interpretation. However, it is also possible that part of the dissatisfaction was due to ignorance implicatures: an utterance of disjunction is odd when the speaker and the addressee already know what is true. Jasbi & Frank (2021) tested children and adults' comprehension of disjunction in similar existential sentences to Chevallier et al. (2008) using binary and ternary forced-choice truth-value judgments. In the binary task (wrong vs. right) the majority of participants provided an inclusive interpretation (about 80%) but in the ternary task participants chose the intermediate option of "kinda right" more often, which could be interpreted as exclusive. Jasbi et al. (2019) varied the number of response options and replicated these findings showing that different rates of exclusivity implicatures can also be due to different number of response options in the truth-value-judgement task. Previous experiments have also reported that disjunction tends to be more inclusive in downward-entailing environments (Noveck et al. 2002, Schwarz et al. 2007, Chemla & Spector 2011).

Regarding the scope of negation and disjunction, Lungu et al. (2021) studied four languages experimentally and reported that they did not support the PPI parameter hypothesis of disjunction (Szabolcsi 2002, Szabolcsi & Haddican 2004). They tested 30 French speakers, 43 Italian speakers, 27 Romanian speakers and 37 English speakers. Participants read sentences with simple negative disjunction (e.g. "Mary didn't invite John or Suzi") and had to judge their naturalness on a 7-point Likert scale. Each sentence had a narrow scope and a wide scope continuation (e.g. "She's upset with both of them" vs. "I don't know which of them" respectively). In addition to negation, they tested the effect of other anti-additive operators such as *without*, *few*, *doubt*, and *rarely*. They found that in all four languages, disjunction exhibits PPI behavior to a certain degree. They concluded that the narrow/wide scope of disjunction is never ruled out completely in a language, and languages differ with respect to the degree to which a particular scope is dispreferred.

3. Current Study. This study builds on previous research and improves on it in multiple ways. First, it is the first study to test the default biases in the interpretation of negation, conjunction, and disjunction within the same experimental paradigm. Second, it uses a card selection task that avoids metalinguistic truth-value judgments and their issues. Third, the paradigm avoids linguistic scales (true vs. false, right vs. wrong) that are language dependent and potentially problematic for a cross-linguistic investigation. Fourth, it avoids forced-choice responses and allows for a wider range of responses and interpretations. Fifth, it also tests the effect of downward-entailing environments on default interpretive biases for negation, conjunction, and disjunction. Sixth, the paradigm is extremely simple and does not a-priori bias interpretations one way or another.

3.1. METHODS. The experiment was designed as a card selection task. Participants saw the same six cards to choose from throughout the experiment (Figure 1). In each trial, they were presented with a different sentence and were asked to select the cards that best matched it.

3.1.1. LINGUISTIC STIMULI. We used the words *and*, *or*, and *not* to create 14 logical constructions in English. Seven constructions were experimental (Table 1) and seven constituted control trial-types (Table 2). All constructions used *have* as the main verb and combined it with one or two of the following nouns: *cat*, *dog*, or *elephant*. For experimental trials, we first considered simple positive and negative constructions. These are constructions like *has a cat* (positive) or *doesn't*

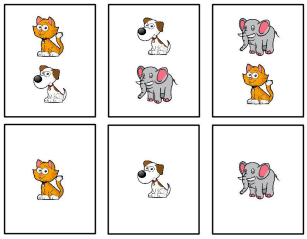

Figure 1: Participants read a sentence prompt (e.g. *which has a cat or a dog?*) and selected among the cards above.

Experimental Trial-Types	Linguistic (Logical) Construction
Simple Positive	*has a* [Noun]
Simple Negative	*doesn't have a* [Noun]
Simple Positive Disjunction	*has a* [Noun1] *or a* [Noun2]
Complex Positive Disjunction	*has either a* [Noun1] *or a* [Noun2]
Simple Negative Disjunction	*doesn't have a* [Noun1] *or a* [Noun2]
Complex Negative Disjunction	*doesn't have either a* [Noun1] *or a* [Noun2]
Simple Negative Conjunction	*doesn't have a* [Noun1] *and* [Noun2]

Table 1: English logical constructions used in the experimental trials. "Noun" was selected from the set of "cat", "dog", or "elephant".

have a cat (negative), which compose negation with a simple clause. They help us understand to what extent speakers would interpret the clause exhaustively (e.g. "has only a cat") vs. non-exhaustively (e.g. "has a cat and possibly some other animal"), and what the effect of negation would be on their meanings and exhaustification.

We also considered two types of positive disjunction constructions. One in which the nouns are conjoined only by *or* (e.g. *has a cat or a dog*), and one in which they are conjoined by *either* as well as *or* (e.g. *has either a cat or dog*). We call the first construction simple positive disjunction and the second complex positive disjunction. We included the negative variants of both simple and complex disjunction by simply negating the main verb *have* to *doesn't have*. This way we added two negative disjunction constructions: simple negative disjunction (e.g. *doesn't have a cat or a dog*) and complex negative disjunction (e.g. *doesn't have either a cat or a dog*). Finally, we included the simple negative conjunction construction in the experimental trials. Simple negative conjunction was similar to simple negative disjunction, except that instead of the disjunction word *or* we used the conjunction word *and* (e.g. *doesn't have a cat and a dog*).

For control trials, we first added the word *only* to the simple positive trials (e.g. *has only a cat*). We call these trials "exhaustive simple positive" and use them as controls for "simple positive" trials to capture exhaustive interpretations in our experimental paradigm. We also included their negative versions for the sake of completeness (e.g. *doesn't have only a cat*) and called them "exhaustive simple negative" trials. We created "inclusive disjunction" trials by adding the phrase *or both* to simple disjunction trials (e.g. *has a cat or a dog or both*). Exclusive disjunction trials were created by adding *not both* to the simple disjunction construction (e.g. *has a dog or an ele-*

Control Trial-Types	Linguistic (Logical) Construction
Exhaustive Simple Positive	*has only a* [Noun]
Exhaustive Simple Negative	*doesn't have only a* [Noun]
Inclusive Disjunction	*has a* [Noun1] *or* [Noun2] *or both*
Exclusive Disjunction	*has a* [Noun1] *or* [Noun2] *not both*
Complex Negative	*has neither* [Noun1] *nor a* [Noun2]
Simple Positive Conjunction	*has a* [Noun1] *and* [Noun2]
Complex Negative Conjunction	*doesn't have both a* [Noun1] *and a* [Noun2]

Table 2: English logical constructions used in control trials. "Noun" was selected from the set "cat", "dog", and "elephant".

Entailment Environment	Construction	Example
Question	Which ...	*... has a cat or a dog?*
Positive Episodic	Bob selected the card(s) which ...	*... had a cat or a dog*
Conditional Antecedent	Select a card if ...	*... it has a cat or a dog*

Table 3: The three entailment environments tested in this study.

phant, not both). These control trials were used to determine when a simple or complex disjunction trial was interpreted as inclusive or exclusive.

We created the "complex negative" and "complex negative conjunction" trial-types as controls for negative disjunction and negative conjunction trial-types respectively. The complex negative trial-type used the connective "neither-nor" (e.g. *has neither a cat nor an elephant*). This construction unambiguously selects for a reading in which both propositions are negated by a connective. Complex negative conjunction trials used the word *both* in addition to negation and conjunction (e.g. *doesn't have both a dog and an elephant*). We hypothesized that this construction selects the (wide scope) negation of conjunction in English ($\neg[A \wedge B]$). We used simple conjunction (e.g. *has a cat and a dog*) as a control trial as well.

Finally, the control and experimental constructions were embedded in three types of entailment environments: questions, conditional antecedents, and positive episodic statements (Table 3). Questions were formed using the question word *which*, for example *which has a cat or a dog?*. Positive episodic statements were reports of actions taken by an imaginary character named "Bob", for example *Bob selected the card(s) which had a cat or a dog*) and participants were asked to copy what the character (i.e. Bob) did. With conditionals, the logical construction was in the antecedent and the consequent had the phrase *select a card if ...*, for example *select a card if it has a cat or a dog*. This allowed us to experimentally manipulate the entailment environment of these connectives and observe potential effects on the interpretation of the connectives.

3.1.2. PARTICIPANTS. We recruited 149 participants online via prolific.co. The study had a between-subjects design for entailment environments; 50 participants saw the linguistic constructions in questions, 50 in conditional antecedents and 49 in positive episodic declaratives (1 participant was excluded from the declarative environment for not finishing the task). In each entailment environment, the study had a within-subjects design and all 50 or 49 participants saw all experi-

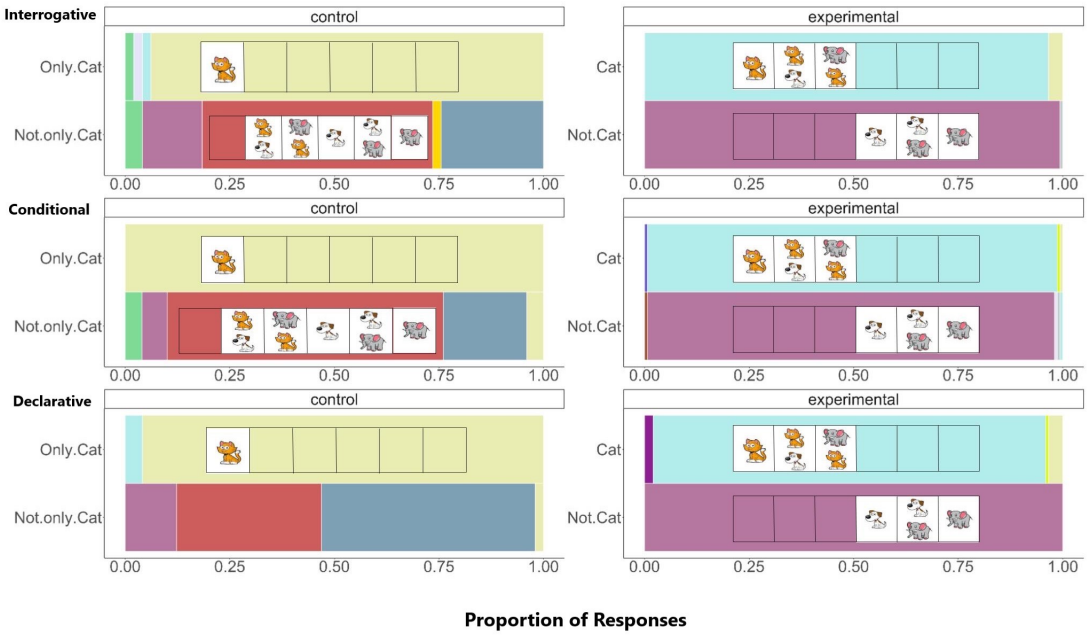

Figure 2: The results for the control (left) and experimental (right) simple positive and negative trials. The x-axis shows the proportion of responses and each color fill a selection of cards. The y-axis shows different trial-types with an example utterance.

mental and control constructions. 95 participants reported that they had no prior training in logic. 101 participants were bilingual, 22 monolingual, and 25 multilingual.

3.1.3. PROCEDURE. The study had four blocks of questions: the practice block, the experimental block, the control block, and the debriefing block. At first, we asked participants two practice questions. For example in the question environment we asked: 1. Which cards have only one animal?, and 2. Which cards have two animals? Participants were asked to select among the six cards shown in Figure 1. These trials helped participants understand the task and know that they can select multiple cards. Next, we presented 21 experimental trials randomly (7 trial-types of Table 1, 3 trials per trial-type). After the experimental block, participants saw 7 control trials (7 trial-types of Table 2, 1 trial per trial-type). The control block followed the experimental block to avoid biasing participant responses. Seeing control trials like "cat or dog, or/not both" could potentially bias participants to think more consciously about the inclusive and exclusive interpretations of disjunction. Finally, we asked participants whether they were mono/bi/multi-lingual and whether they had any prior training in formal logic. We hypothesized that multilingualism or prior training in logic could affect participant responses.

3.2. RESULTS. Figure 2 shows the results for the control (left) and experimental (right) simple positive and negative trials in the interrogative, conditional antecedent, and (positive episodic) declarative environments. The left panels show positive exhaustive (e.g. *has only a cat*) and negative exhaustive control trials (e.g. *doesn't have only a cat*). The right panels show simple positive

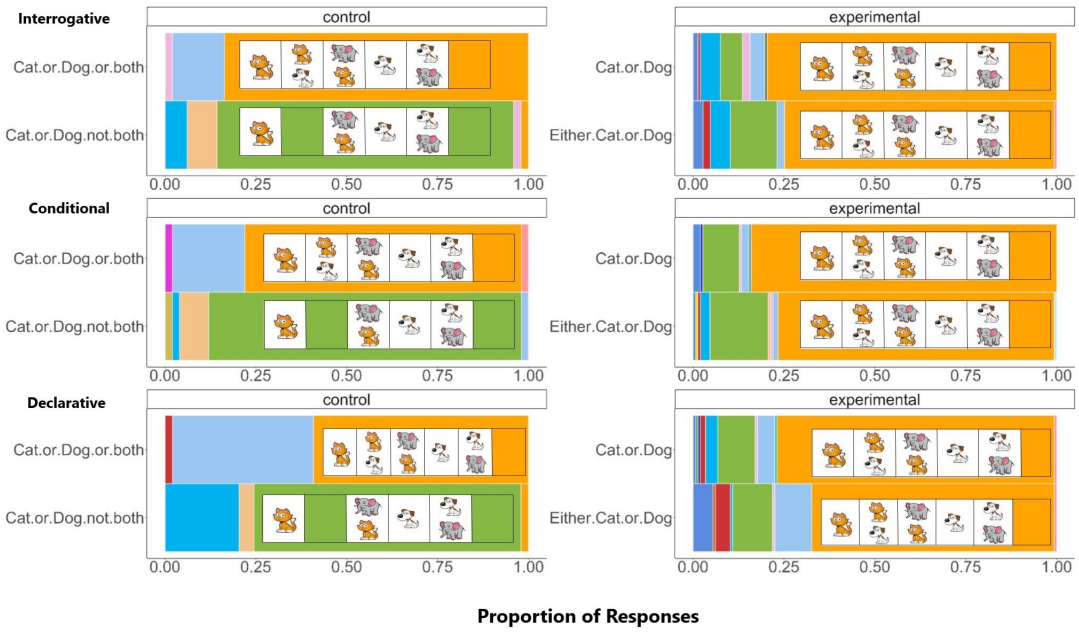

Figure 3: Results for the control (left) and experimental (right) simple and complex positive disjunction trials. The x-axis shows the proportion of responses and each color fill a selection of cards. The y-axis shows different trial-types with an example utterance.

(e.g. *has a cat*) and simple negative (*doesn't have a cat*) experimental trials. The results for experimental trials do not match exhaustive controls and instead reflect the basic semantics of simple positive and negative statements without pragmatic enrichment or exhaustification. Negative exhaustive trials (e.g. *doesn't have only cat*) were (at least) two way ambiguous in all environments: 1. presupposing the prejacent (e.g. has a cat) and asserting the existence of another animal (e.g. dog or elephant); and 2. not presupposing the prejacent (e.g. selecting all cards except the one with a single cat). The presuppositional interpretation was more prevalent in the (positive episodic) declarative environment than the question or the conditional antecedent environments. The presuppositional interpretation was more prevalent in the declarative environment but it was not fully cancelled in the question and conditional antecedent environments either.

Figure 3 shows the results for the positive simple and complex disjunction trials for the interrogative, conditional antecedent, and declarative environments. The left panels show the inclusive (*or both*) and exclusive (*not both*) control trials and the right panels show the experimental trials with simple (e.g. *has a cat or a dog*) and complex (e.g. *has either a cat or a dog*) trials. Both the simple and complex instances of disjunction were more often (above 75%) inclusive (orange color) than exclusive (green color), but not completely inclusive or exclusive. We used a Bayesian mixed-effects logit model with random intercepts and slopes for participants and the fixed effects of disjunction type (simple, complex, inclusive control, exclusive control), entailment environment (question, conditional antecedent, and declarative), and their interaction. The model predicted whether participants included the card with both animals in their selection (i.e.

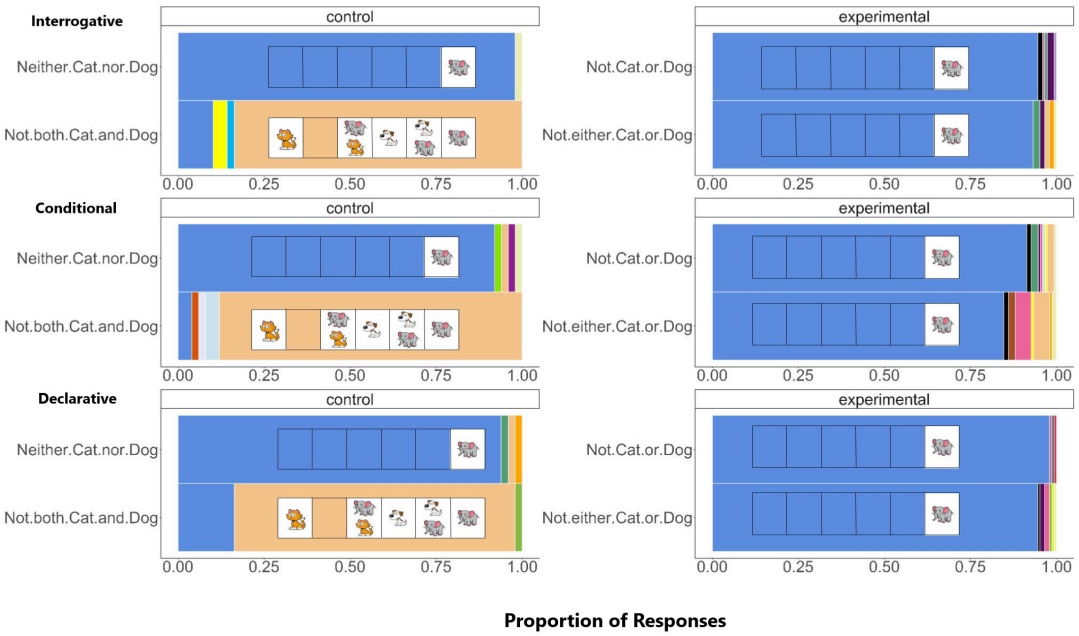

Figure 4: Results for the control (left) and experimental (right) simple and complex negative disjunction trials. The x-axis is the proportion of responses and each color fill a selection of cards. The y-axis shows different trial-types with an example utterance.

had an inclusive interpretation)[1]. The model estimated a positive coefficient for inclusive control disjunction trials compared to simple disjunction trials suggesting that simple disjunction was not completely inclusive ($\beta = 12.00, 95\% CI = [3.60, 24.31]$) However, a negative coefficient was estimated for exclusive control disjunction compared to simple disjunction suggesting that simple disjunction was not completely exclusive either ($\beta = -15.56, 95\% CI = [-27.45, -7.93]$). The rate of exclusive interpretations did not differ between simple and complex disjunction or between the different entailment environments (positive episodic declarative vs. question vs. conditionals). In all these cases the 95% credible intervals for the relevant coefficients contained zero.

Figure 4 shows the results for the negative simple and complex disjunction trials in each linguistic environment. The left panels show the control "neither-nor" (e.g. *has neither a cat nor a dog*) and "either-not" (e.g. *doesn't have both a cat and a dog*) interpretations. The right panel shows the experimental trials for simple negative disjunction (e.g. *doesn't have a cat or a dog*) and complex negative disjunction (e.g. *doesn't have either a cat or a dog*). The vast majority of responses in both experimental trials received a "neither-nor" interpretation in all three linguistic environments (blue color). We ran a similar Bayesian mixed-effects model as in positive disjunction trials, this time predicting the participants' choice of the "neither-nor" interpretation over other interpretations. The model did not find a difference between negative simple disjunction, negative complex disjunction, and the control "neither-nor" trial-type, since the 95% cred-

[1] All our Bayesian models used 4 chains, each with 4000 iterations and 2000 as warm-up. For all reported models the chains converged and it was the case that $\hat{R} = 1$.

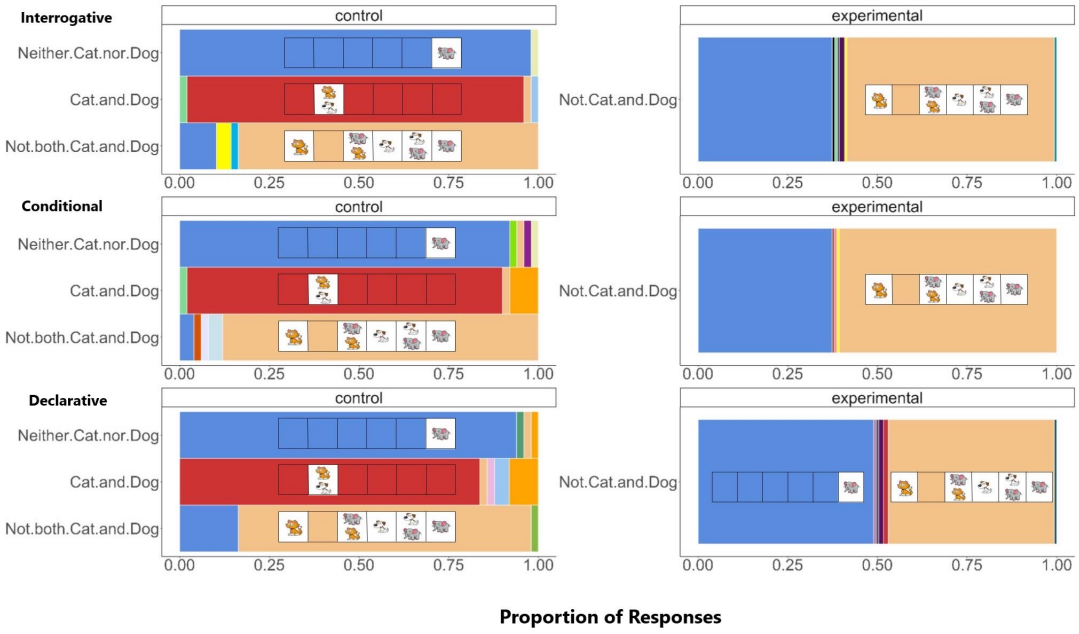

Figure 5: Results for the control (left) and experimental (right) negative conjunction trial-type. The x-axis is the proportion of responses, each color fill a selection of cards. The y-axis shows different trial-types with an example utterance.

ible intervals for the relevant coefficients contained zero. However, for the "either-not" control trial-type (e.g. *doesn't have both a cat and a dog*) the model estimated a negative coefficient, suggesting that participants chose the "neither-nor" interpretation less often in these control trials ($\beta = -17.60, 95\%CI = [-27.02, -11.34]$).

Finally, Figure 5 shows the results for positive and negative conjunction trials in each linguistic environment. The left panels show the control "neither-nor" and "either-not" interpretations again, as well as the positive conjunction trials (e.g. *has a cat and a dog*). The right panels show the negative conjunction (e.g. *doesn't have a cat and a dog*) trials. The negative conjunction trials show a clear pattern of ambiguity in all three linguistic environments between the "neither-nor" (blue color) and the "either-not" interpretations (beige color). We ran a similar Bayesian mixed-effects model as before to predict participant choices of "neither-nor" interpretations for negative conjunction trials. The model estimated a positive coefficient for the "neither-nor" control trial-type ($\beta = 13.01, 95\%CI = [7.17, 21.54]$) and a negative coefficient for the "either-not" control trial-type ($\beta = -8.20, 95\%CI = [-19.10, -2.51]$). This suggests that participant interpretations of negative conjunction was somewhere between the "neither-nor" and the "either-not" interpretations. The proportion of these interpretations did not vary between different linguistic environments, since the 95% credible intervals for the relevant coefficients contained zero. As expected, participants provided consistent responses to the the positive conjunction trials by choosing the card with both mentioned animals (e.g. cat and dog). We also tested possible effects of mul-

tilingualism and prior logical training on participant judgments and did not find any effect on the comparisons of interest reported above.

4. Discussion. This study tested three hypotheses regarding the proposed default biases in the interpretation of the English logical words *and*, *or*, and *not*. First, a disjunction can be interpreted inclusively or exclusively, and most theories of scalar implicature have suggested that disjunction is biased toward the exclusive interpretation in upward-entailing environments and the inclusive interpretation in downward-entailing environments (Levinson 2000, Chierchia 2004, Breheny et al. 2005). However, this study found that participant interpretations of simple and complex disjunction were biased toward an inclusive interpretation, regardless of the entailment environment.

Second, a negated disjunction can be interpreted with the negation scoping above the disjunction ($\neg[A \vee B]$) or vice versa ($[\neg A \vee \neg B]$). Previous research had hypothesized that English is biased toward wide scope negation with disjunction ($\neg[A \vee B]$) or the "neither-nor" interpretation (Szabolcsi 2002). Our study confirmed this hypothesis by finding a strong interpretive bias toward the "neither-nor" interpretation in all entailment environments. Third, a negated conjunction can be interpreted with negation scoping above the conjunction ($\neg[A \wedge B]$) or vice versa ($[\neg A \wedge \neg B]$), and previous research had suggested that in English wide scope negation or the "either-not" interpretation is preferred (Szabolcsi & Haddican 2004). The results, however, did not show such a preference and the responses were split between the two interpretations. The entailment environment did not affect the scope of negation with conjunction and disjunction either.

Why did entailment environment not affect the proportion of exclusivity implicatures as predicted? One possibility is that the task failed to properly manipulate the entailment environment and participants largely ignored it. However, such an explanation predicts that there should be no effect of the entailment environment in this study. This is not the case. The rate of presuppositional interpretations for negative exhaustive trials are affected. The exhaustivity of the disjuncts in the control trials of disjunction is also affected. Therefore, participants did not ignore the entailment environment altogether. A second possibility is that assuming an independent and default effect of entailment environment on pragmatic implicatures is too strong. Entailment environments can and do affect pragmatic implicatures but if only certain other pragmatic or contextual factors are also met. It is possible that different aspects of our experimental setup such as the choice of the main verb *have* or the task of selecting a group of cards itself has made the entailment environment a less relevant factor for the purpose of implicature computation.

Finally, this study does not take into account the role of prosody and intonation. It is possible to resolve the ambiguities discussed here using special intonation or at least bias the interpretation one way or another. For the design of this study we had deliberately set aside the issue of prosody to investigate it separately, and after we have a good understanding of how different logical constructions in our study are interpreted when prosody is not explicitly manipulated. Therefore, prosody remains a possible confound that we intend to address in future studies. We also plan to expand this paradigm to languages other than English - such as Hungarian and Mandarin Chinese - with rich literature on logical words.

References

Braine, Martin & Barbara Rumain. 1981. Development of comprehension of "or": Evidence for a sequence of competencies. *Journal of experimental child psychology* 31(1). 46–70.

Breheny, Richard, Napoleon Katsos & John Williams. 2005. Interaction of structural and contextual constraints during the on-line generation of scalar inferences. In *Proceedings of the annual meeting of the cognitive science society*, vol. 27 27, .

Chemla, Emmanuel & Benjamin Spector. 2011. Experimental evidence for embedded scalar implicatures. *Journal of semantics* 28(3). 359–400.

Chevallier, Coralie, Ira Noveck, Tatjana Nazir, Lewis Bott, Valentina Lanzetti & Dan Sperber. 2008. Making disjunctions exclusive. *Quarterly Journal of Experimental Psychology* 61(11). 1741–1760.

Chierchia, Gennaro. 2004. Scalar implicatures, polarity phenomena, and the syntax/pragmatics interface. *Structures and beyond* 3. 39–103.

Chierchia, Gennaro. 2013. *Logic in grammar: Polarity, free choice, and intervention*. OUP.

Chierchia, Gennaro, Danny Fox & Benjamin Spector. 2012. Scalar implicature as a grammatical phenomenon. In *Handbücher zur sprach-und kommunikationswissenschaft/handbooks of linguistics and communication science semantics volume 3*, de Gruyter.

Davidson, Kathryn. 2013. *And* or *or*: General use coordination in ASL. *Semantics & Pragmatics* .

Evans, Jonathan & Stephen Newstead. 1980. A study of disjunctive reasoning. *Psychological research* 41(4). 373–388.

Fox, Danny. 2008. On Logical Form. In Randall Hendrick (ed.), *Minimalist Syntax*, 82–123. Wiley-Blackwell.

Gazdar, Gerald. 1980. Pragmatics and logical form. *Journal of Pragmatics* 4(1). 1–13.

Grice, Paul. 1989. *Studies in the way of words*. Harvard University Press.

Horn, Laurence R. 1972. *On the semantic properties of logical operators in English*: UCLA dissertation.

Jasbi, Masoud & Michael C Frank. 2021. Adults' and children's comprehension of linguistic disjunction. *Collabra: Psychology* 7(1). 27702.

Jasbi, Masoud, Brandon Waldon & Judith Degen. 2019. Linking hypothesis and number of response options modulate inferred scalar implicature rate. *Frontiers in psychology* 10. 189.

Levinson, Stephen C. 2000. *Presumptive meanings: The theory of generalized conversational implicature*. MIT press.

Lungu, Oana, Anamaria Fălăuș & Francesca Panzeri. 2021. Disjunction in negative contexts: a cross-linguistic experimental study. *Journal of Semantics* 38(2). 221–247.

May, Robert. 1985. *Logical Form: Its structure and derivation*. MIT press.

Noveck, Ira, Gennaro Chierchia, Florelle Chevaux, Raphaëlle Guelminger & Emmanuel Sylvestre. 2002. Linguistic-pragmatic factors in interpreting disjunctions. *Thinking & Reasoning* 8(4). 297–326.

Paris, Scott G. 1973. Comprehension of language connectives and propositional logical relationships. *Journal of experimental child psychology* 16(2). 278–291.

Schwarz, Florian, Charles Clifton Jr & Lyn Frazier. 2007. Strengthening'or': Effects of focus and downward entailing contexts on scalar implicatures. *University of Massachusetts Occasional*

Papers in Linguistics 33(1). 9.
Szabolcsi, Anna. 2002. Hungarian disjunctions and positive polarity. In Istvan Kenesei & Peter Siptar (eds.), *Approaches to Hungarian*, vol. 8, University of Szeged.
Szabolcsi, Anna & Bill Haddican. 2004. Conjunction meets negation: A study in cross-linguistic variation. *Journal of Semantics* 21(3). 219–249.
Tarski, Alfred. 1941. *Introduction to logic and to the methodology of the deductive sciences*. OUP.