The Acquisition of Disjunctions: Evidence from German Children[1]

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Abstract. Adults' interpretation of disjunction *or* depends on the sentential environment in which disjunction occurs. Putting aside numerous special cases (see e.g. Klinedinst and Rothschild 2012, Meyer 2012, 2016), adult behavior can be summarized as such: In downward entailing contexts, *or* is interpreted logically as the inclusive disjunction OR. But in upward entailing contexts, *or* is interpreted pragmatically as the exclusive disjunction XOR. Summarizing recent work on the acquisition of disjunction, children around age 5 seem to differ slightly: In downward entailing and free choice contexts, children seem to interpret disjunction like adults as inclusive OR (Chierchia et al. 2001, Crain 2008, Su and Crain 2013, Tieu et al. 2016). But in upward entailing, non free choice contexts, children have been found to interpret disjunction sometimes conjunctively as AND (Singh et al. 2016, Tieu et al. 2017).

Singh et al. (2016) advocate an account of the AND interpretation of *or* in terms of scalar implicature (or exhaustivization). In this paper, we present evidence for a novel alternative account based on lexical ambiguity. Specifically, we test the following prediction of the implicature account: Whenever implicatures are obligatory, children should obligatorily interpret *or* as AND. We show that the ambiguity theory makes the opposite predictions, and that the prediction of the ambiguity theory is borne out in data from German children.

Keywords: disjunction, implicature, acquisition, German, coordination, propositional logic

1. Introduction

Disjunction might be considered one of the *lab animals* of pragmatics. But despite the fact that pragmaticists have talked about disjunction at least since Grice's 1975 work, recent work has exposed several new aspects of the meaning and use of disjunction. In particular, Bowler (2015), Meyer (2012, 2016), Singh et al. (2016), and Tieu et al. (2017) argue that unembedded disjunction can be strengthened to a conjunctive interpretation in some cases for at least some groups of speakers. Our interest in this paper is primarily children's interpretation of disjunction. We set out to experimentally compare two possible accounts of the child data: The first account is the *implicature theory*, which is proposed for the child data by Singh et al. (2016) and derives from work by Fox (2007) and Kratzer and Shimoyama (2014) on free choice disjunction. The other account, the ambiguity theory, builds on the assumption that children consider a word such as *or* ambiguous between the *or* and the *and* interpretation, before they know the adult interpretation. In the remainder of this introduction, we consider both accounts in a little more detail. We then describe how an experimental design originally used by Tieu et al. (2017) tests a difference in prediction between the two accounts. While Tieu et al. (2017)

Proceedings of *Sinn und Bedeutung 21*
Edited by Robert Truswell, Chris Cummins, Caroline Heycock, Brian Rabern, and Hannah Rohde

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report results from French and Japanese, we discuss results from German children in this paper.

The implicature theory assumes that adults and children associate different alternative sets with *or*: While Alt(A *or* B) = {A, B, A ∨ B, A ∧ B} for adults (Sauerland 2004 and others), for children Alt(*A or B*) = {A, B, A ∨ B}. This predicts that adults strengthen the interpretation of *A or B* to exclude A ∧B when implicatures are computed. But children are predicted to strengthen *A or B* by excluding A ∧ ¬B and B ∧ ¬A, which predicts the conjunctive interpretation.

When implicatures are optional, children are predicted to assign either a logical *OR* interpretation to *or* when they don't compute an implicature, or a strengthened *AND* interpretation when they compute an implicature. The implicature theory predicts therefore that the conjunctive interpretation should be obligatory when implicature computation is obligatory.

The Ambiguity Theory provides an alternative account of the child data as we understand it. The account is in part motivated by the observation reported to us that French children should not be familiar with the disjunction marker *soit ... soit* that Tieu et al. (2017) included in their experiment. The implicature theory assumes though that children know that a morpheme is interpreted as logical disjunction and then strengthening to conjunction applies, which then explains the conjunctive interpretation observed by Tieu et al. (2017). If children aren't familiar with a connective, though, the starting point is already different.

We propose that *or* is ambiguous for children between two interpretations, a disjunctive and a conjunctive interpretation. The restriction to these two interpretations we see at this point as a preliminary assumption that is up to further discussion. In part, the assumption is motivated by the fact that many languages lexicalize these to binary boolean operators while operations such as NAND, NOR, and exclusive disjunction XOR are to the best of our knowledge not lexicalized in the languages. The ambiguity theory assumes furthermore that children apply the strongest meaning principle (SMP) in (1) to resolve the ambiguity.

(1)   *SMP:* If S is ambiguous between interpretations α and β with $\alpha \rightarrow \beta$ then the weaker interpretation β is inaccessible (Dalrymple et al. 1998 and others).

The ambiguity theory predicts all the data that have motivated the implicature theory. Consider first *or* in an antitone context.[2] (2) from Chierchia et al. (2001) is predicted to be ambiguous for children between α and β. But because reading β logically entails α, α is correctly blocked by the SMP.

(2)   Every dwarf who chose a banana **or** a strawberry received a jewel.
          *α: Every dwarf who chose a banana *and* a strawberry received a jewel.
          β: Every dwarf who chose a banana *or* a strawberry received a jewel.

But in an isotone context, the entailment relationship is the reverse. Therefore the OR-interpretation is blocked in (3).

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[2]We use the order-theoretic terms *isotone* and *antitone* of e.g. Birkhoff (1940) instead of the terms *upward* and *downward monotone* of elementary calculus, which are more popular in the linguistic literature.

(3)   Every boy is holding an apple **or** a banana. (Singh et al. 2016)
        α: Every boy is holding an apple **and** a banana.
        *β: Every boy is holding an apple **or** a banana.

But the ambiguity theory makes different predictions from the implicature theory for cases where implicatures are obligatory. As discussed by Spector (2014) and others, *exh* is ungrammatical when it cannot exclude any alternatives. The same constraint applies to *only*, and causes the ungrammaticality of **I ate only ALL*. Since AND is the maximally strong item in an UE context, obligatory exhaustivization blocks the AND-interpretation. Therefore the ambiguity theory predicts that only the OR-interpretation can be available when implicatures are obligatory.

2. Previous study: Tieu et al. (2016)

Spector (2014) and Nicolae and Sauerland (2016) argue that complex disjunctions, such as French *soit–soit* and English *either–or* involve obligatory exhausitivization. This predicts that children arrive at the strengthened *AND* more frequently with complex form of disjunction than with their simple counterpart, *ou* in French or *or* in English. An example from Japanese experiment is shown below.

(4)   a.   Osaru-san-ga mado-**ka**   doa-o   aketa.
              monkey-Nom window-KA door-Acc opened
              'Monkey opened the window or the door.
        b.   Osaru-san-ga mado-**ka**   doa-**ka**-o   aketa.
              monkey-Nom window-KA door-KA-Acc opened
              'Monkey opened the window or the door.'

Tieu et al. (2016) report an experiment (truth-value judgment task), testing this prediction. They conducted the experiment in French (complex *soit–soit* vs. simple *ou*) and in Japanese (complex *ka–ka* vs. simple *ka*). They replicated the earlier finding by Singh et al. (2016) in both French and Japanese and found that young children accept the use of disjunction in 2DT contexts. Their main findings were that (1) children, as previously observed by Singh et al. (2016), accept the use of disjunction in both context where one or where both of the disjuncts are true, whereas adults accepted only the exclusive interpretation (i.e. that rejected the sentence when both disjuncts were true, but accepted it when only one was true).

On the one hand, this is expected: according to the impicature analysis, children do not have $\{A \land B\}$ as the alternative for the disjunction, and hence, when they exhaustivize the meaning of disjunction, they end up with only the conjunctive interpretation, AND. On the other hand, that there was no difference between simple and complex disjunction is puzzling, if we take the implicature analysis literally.

This puzzle lead us to test the disjunction in German, which has different morphological and syntactic characteristics from French *soit–soit/ou* and Japanese *ka–ka/ka*. In both French and Japanese, the complex disjunction involves a repetition of the same form. In German, however, the complexity is indicated by the morpheme *entweder*, which is distinct from a simple form

and only occurs as part of the complex disjunction.

3. Experiment: Truth-Value Judgment Task

In the present experiment, we tested children's comprehension of *oder* vs. *entweder–oder*. We adopted the design of Tieu et al. (2017) to German. The two experimental conditions were the 1DT (one disjunct true) and 2DT (two disjuncts true) scenarios. For sentence (5), the two scenarios are described in (5a) and (5b).

(5)   Monkey (either) opened the window or the door. (translated from German)
    a.   **1DT:** Monkey opened only the door (or Monkey opened only the window)
    b.   **2DT:** Monkey opened both the window and the door

In addition, we varied across subjects whether the items included complex *either–or* or simple *or*. Participants were randomly assigned to one of the two conditions.

3.1. Method

3.1.1. Participants

64 monolingual German speaking children (4;2-8;6) and 21 adults participated in this study. We divided children into two age groups: 31 4-6 year olds (4;2-6;11, *M*=5;2), and 38 7-8 year olds (7;0-8;6, *M*=7;8). Child participants were recruited at one day care center and two public schools in Berlin, Germany. Adult speakers were recruited from the participant pool of Humboldt University, Berlin. Child participants received a sticker for their participation. Adult participants received 5 euro for their participation in the study.

3.1.2. Material

We used simple (*oder* 'or') and complex (*entweder–oder*) disjunctions in German, and constructed two versions of experiments, using only one type of disjunction for each version. An example of the test material is shown below.

(6)   Das Huhn   hat das Flugzeug oder den Bus geschubst.
    the chicken has the plane   or   the bus pushed
    'The chicken has pushed the plane or the bus.'

(7)   Das Huhn   hat entweder das Flugzeug oder den Bus geschubst.
    the chicken has either   the plane   or   the bus pushed.
    'The chicken has pushed either the plane or the bus.'

Participants were introduced to the context in the form of a story. On the first slide, the stroy

was told from the iPad. On the second slide, a puppet appeared on the monitor and predicted what might have happened next. The prediction contained a disjunction. On the third slide, the end of the story, which was either 1DT, 2DT, or 0DT, was shown. Participants were then asked whether the puppet made the right prediction: whether what the puppet said matched the ending of the story or not. They put a stamp on the answersheet (under a smily face when matched, under a sad face otherwise). When the story and the prediction did not match, the participants were asked to state what was wrong with the puppet's prediction. The whole experiment was audio-recorded, and later checked for the responses and explanation children made.

3.2. Result

Let us first consider children's responses for the 1DT contexts (in which only one of the disjuncts was true). Let us first consider the participants who were 4 to 6 years old, which is more comparable to the previous study by Tieu et al. (2017).

With simple disjunction, younger participants accepted the use of disjunction in 1DT context 73.3% of the time (44/60), and older participants accepted it in the same context 88.9% of the time (64/72). The difference between the two age groups was significant (Fisher's Exact test, $p < 0.05$). With a complex disjunction, younger children accepted the use of disjunction in 1DT context 85.7% of the time (48/56), and older children did so 80.9% of the time (55/68). The difference in the ratio between acceptance and rejection between the two age groups was not significant (Fisher's exact test: $p = 0.6313$). No other comparisons were significant.

Next consider children's responses for the 2DT context (in which both of the disjuncts were true). With simple disjunction, younger participants accepted its use in 2DT context 67.8% of the time (40/59), whereas the older participants did so 52.8% of the time (38/72). The difference in the ratio between acceptance and rejection between the two age groups was not significant ($p = 0.1074$). With complex disjucntion, younger participants accepted the use of disjunction 58.9% of the time (33/56), and older participants did so 39.7% of the time (27/68). The difference in ratio between the two groups was statistically significant ($p < 0.05$). No other comparisons were significant. Most importantly, as is the case in French and Japanese, the difference between simple and complex disjunctions was not significant.

Let us now combine the results from both conditions and plot where each individual falls. In figure 1, we have plotted, for each individual, the score for 2DT contexts along the Y-axis, and the score for 1DT contexts along the X-axis. Let us first explain what the chart shows. When a speaker is in the XOR corner, that is when they accepted the use of disjunction in 1DT while rejecting its use in 2DT. When a speaker is in AND, on the other hand, it means that the speaker accepted the use of disjunction in 2DT context, while they rejected its use in 1DT context. A speaker in the OR corner accepted the use of disjunction in both 2DT and 1DT contexts. As expected, the adults are mainly in the XOR corner because of the implicature and only one is in the OR corner, and one rejected all conditions with *oder*. Children are distributed over three different corners except for the double rejection corner on the bottom left. However, especially among the 4–5 year old children only 2 are in the AND corner at this point. Instead it seems
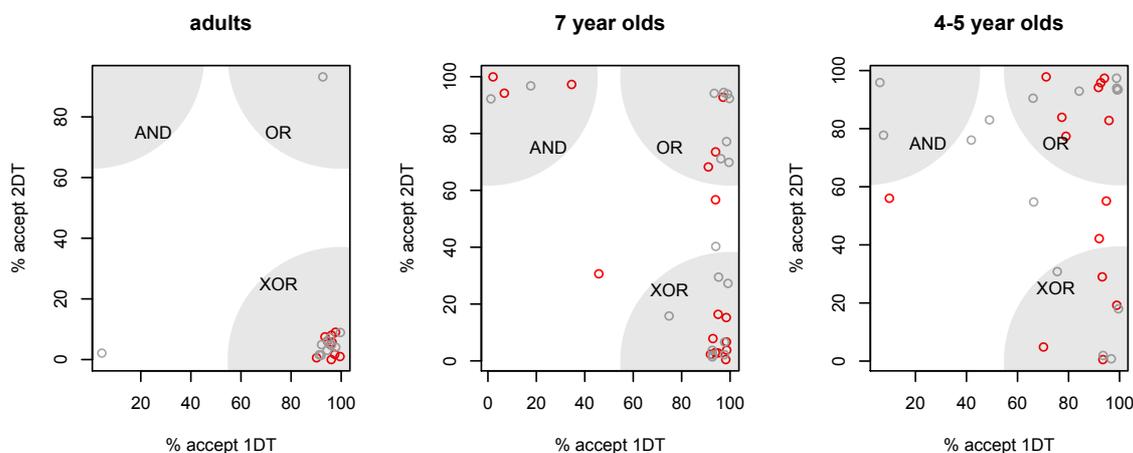
Figure 1: Distribution of subjects by acceptance of 1DT (*x*-axis) and 2DT (*y*-axis) acceptance across the three age groups. Each grey dot represents a participant of the simple *oder* group, each red dot one of the *entweder–oder* group. Some random 'jitter' is added to the plot to reduce overlap of dots, the actual values are at round multiples of 20%.

that the 4–5 year old children most frequently access the inclusive interpretation for *oder* and also *entweder–oder*. No clear difference is apparent figure in 1 between the grey dots of the subjects that received the *oder* condition and the red dots of those receiving the *entweder–oder* condition.

3.2.1. Discussion

At this point, we would like to compare the results from Tieu et al. (2017) on French and Japanese. Recall that this study did not find differences between simple and complex disjunctions, on the one hand, and between French and Japanese children, on the other hand. Comparing the results from the three languages in figure 2, we note that German children are distributed more in XOR and OR areas, whereas Japanese and French children are distributed more in AND and OR areas.

We ran a mixed model logistic regression, with complexity and language as dependent variables. We found that language is a factor ($p < 0.01$), although the complexity alone is not ($p = 0.081$). In addition, we found an interaction between the language and complexity, however, showing that German children are significantly more sensitive to complexity than Japanese children are.

Recall that according to the implicature theory, we expect that children should (1) accept the use of disjunction in 2DT context, and (2) reject the use of disjunction in 1DT context. Furthermore, adopting Spector (2014), we assume that complex disjunction necessarily involves exhaustivization. These assumptions combined predict that more children should be in AND
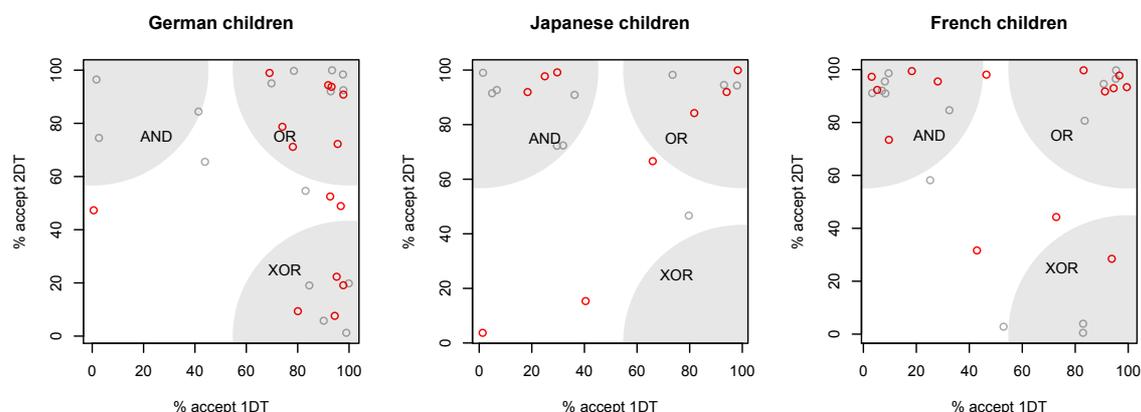
Figure 2: Comparison of the results from German, Japanese and French 4–5 year old. As in figure 1, each grey dot represents a participant of the simple disjunction group, each red dot one of the complex disjunction group.

area when tested with a complex disjunction than when tested with a simple disjunction. Since we didn't find any significant difference between the two types of disjunction, our result doesn't allow us to exclude the implicature theory. The ambiguity theory makes the opposite prediction as the implicature theory: more children should assign a conjunctive interpretation in the simple disjunction condition than the complex disjunction condition more frequently. Again our presently non-significant finding doesn't allow us to exclude this prediction.

Another prediction of the ambiguity theory, though, seems problematic in light of our results. Namely on the ambiguity theory, complex disjunctions involve obligatory exhaustivization, and therefore only the exclusive disjunction interpretation should be possible in the complex disjunction condition. Though we find some German children who assign an XOR interpretation, there is nevertheless a sizable group of children in all three languages who assign an inclusive disjunction interpretation to complex disjunction.

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