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# The Inclusion of Disjunction in Child Grammar: Evidence from Modal Verbs

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## 1.    Introduction

This study is concerned with the acquisition of the disjunction operator, *or*, in English. Two mutually inconsistent claims have been made about the acquisition of disjunction. One claim is that the acquisition of the adult truth conditions for logical connectives, including disjunction, is a late and not fully universal, achievement. With particular reference to disjunction, the findings from several studies are interpreted as showing that only the truth conditions associated with exclusive-*or* are available to young children (e.g., Beilin and Lust 1975; Braine and Rumain 1981, 1983; Paris 1973). There is a related claim, that even when children respond as if they have access to a broader range of truth conditions, namely those associated with inclusive-*or*, children's adult-like responses are the result of a failure to distinguish *or* from *and* (Paris 1973).

A different conclusion was reached in a recent study by Chierchia, Crain, Guasti and Thornton (1998), who conducted a series of experiments which revealed children's adult-like knowledge of logical connectives, including disjunction. To reconcile the findings from the Chierchia et al. study and those of previous research, Chierchia et al. (1998) draw upon a distinction between semantic and pragmatic knowledge. They argue that the acquisition of logical connectives is simply a process of mapping the appropriate truth conditions (associated with logical connectives in classical logic) onto the particular words of the language to which the child is exposed. In understanding sentences, however, children are also influenced by the pragmatic norms they follow. In many

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contexts, the use of *or* is felicitous only on the exclusive-*or* reading because of conversational implicatures (see Grice 1975). In other contexts, by contrast, *or* is felicitous in a broader range of circumstances, i.e. those associated with the inclusive-*or* reading (e.g. Chierchia and McConnell-Ginet 1990).

According to Chierchia et al. (1998), it is unwarranted to infer from previous tasks that children lack the inclusive-*or* reading, because children were tested in contexts that raised a conversational implicature, thereby making only the exclusive-*or* reading felicitous. For example, in a study by Braine and Rumain (1981) children were asked to «pick an X or a Y», and they generally picked either an X or a Y, but not both. This response is consistent with the exclusive-*or* reading, but it is likely that this reading arises because of a conversational implicature; if the speaker had wanted to ask the child to pick both an X and a Y, he would have used *and* instead of *or*. Therefore, children's preference for the exclusive-*or* reading does not indicate the unavailability of the truth conditions associated with inclusive-*or*. Perhaps the truth conditions of inclusive-*or* are available to children, but their interpretation of sentences is also influenced by pragmatic knowledge, i.e. by conversational implicatures.

As noted, however, there are contexts that suspend these implicatures, thus making the inclusive-*or* reading natural. Using a Truth Value Judgment task, Chierchia et al. found that children were able to assign the inclusive-*or* interpretation in one implicature-erasing context, which they called the Prediction Mode. The Prediction Mode introduces uncertainty as to which particular outcome (out of several alternatives) will take place. If it is uncertain whether X or Y, or perhaps both, will take place, then it becomes felicitous to use *or*, even if it turns out that both X and Y actually occur. The conclusion reached by Chierchia et al. is that children know the semantic properties of *or*, and they know the relevant conversational implicatures.

Although the data from the Chierchia et al. study support the view according to which connectives in adult and child language have the same meaning, there was a possible problem with the design of the study. If children accessed the inclusive-*or* reading, they were expected to respond «Yes» to the test sentences. However, in experimental contexts that require subjects to respond «Yes» or «No», they tend to say «Yes» if they are confused, or fail to understand a sentence, or cannot remember it (see Grimshaw and Rosen 1990 and Crain and Thornton 1998). Therefore, it is important to ensure, as far as possible, that children's adult-like «Yes» responses were not simply due to their failure to comprehend or recall the test sentences. Children might have given 'correct' responses for the wrong reason in the Chierchia et al. study, because the test sentence was uttered before the completion of the story. Therefore, there was a significant time delay between the assertion of the target sentence and its evaluation by the child. If children forgot the test sentence during this period, this could have resulted in adult-like «Yes» responses. A further limitation of the Chierchia et al. (1998) study was that it did not include control sentences to show that children distinguish between *and* and *or*. Consequently, their data do not directly address the claims by Paris (1973). The present study attempted to address both of these issues.[1]

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[1] The acceptability of the inclusive-*or* reading, and the distinction between *and* and *or* is also addressed in a study reported in Gualmini, Crain and Meroni (2000). The linguistic context in the Gualmini et al. study introduces disjunction in the antecedent of conditional sentences. To avoid the possible methodological problems of the Chierchia et al. study, the experiment takes the form of a game in which a

The present study consists of two experiments, using the Truth Value Judgement task. The first experiment investigates another linguistic context in which conversational implicatures are cancelled, namely in sentences with a generic interpretation. In such contexts, the inclusive-*or* reading of disjunction should be felicitous. In addition, the experiment was designed to overcome the possible methodological problems associated with the Chierchia et al. study. In the present experiment, the target sentences were uttered by the puppet upon completion of the stories, so the child was in a position to evaluate the truth or falsity of each test sentence immediately after hearing it. The second experiment investigates a linguistic context in which the truth conditions associated with the inclusive-*or* are unavailable, but not because of a conversational implicature; rather, the reduction in truth conditions is occasioned by the linguistic content of the sentence.

This last feature of the second experiment makes the results significant for the Modularity Matching Model (Crain and Steedman 1985; Crain and Thornton 1998; Crain and Wexler 1998). According to this model, the language processing system has modular architecture such that operations at lower levels of linguistic representation cannot be influenced by operations at higher levels. Referring to the syntax/semantics interface, Crain and Steedman (1985) propose that «syntax proposes, semantics disposes». Extending the model to the semantics/pragmatics interface, it follows that pragmatic principles cannot influence semantic interpretation; pragmatic principles merely adjudicate among alternatives that are licensed by the semantics. Presumably, all but one of the semantic alternatives is discarded. If only a single interpretation is licensed by the semantics, then operating principles within the pragmatic component will not be engaged. Therefore, the Modularity Matching Model predicts that conversational implicatures may be preempted by semantic principles, which are executed before the perceiver attempts to match the sentence to the extralinguistic context. The role of the pragmatics is limited to seeing if the sentence is felicitous or not in the extralinguistic context, on the unique semantic interpretation.

## 2.     Disjunction in generic sentences

A modal verb such as *can* may be used to express the possibility of an agent performing a certain action. As shown by Higginbotham (1991), when it is combined with *or*, the modal verb *can* makes available the full set of truth conditions associated with disjunction in standard logic. For example, (1) is true in each of the circumstances described in (2).

(1)     Batman or Spiderman can finish a puzzle.

(2)     Batman can finish a jigsaw puzzle but Spiderman cannot.
        Spiderman can finish a jigsaw puzzle but Batman cannot.
        Batman and Spiderman can each finish a jigsaw puzzle.

        Now consider (3):

(3)     John or Paul can lift the piano.

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puppet guesses what is hidden behind the curtain of a stage; the contents of the stage are immediately revealed.

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In a situation in which John and Paul can lift the piano together but neither can lift it alone, (3) is false. As this shows, disjunction is distributive; a collective reading of the operator *or* is not tolerated.[2] Providing a complete explanation of the contrast between (1) and (3) is beyond the scope of this paper. Still, it is important to consider some alternatives. Let's start by considering what makes the inclusive-*or* reading available in (1).

The inclusive-*or* reading is available in (1) presumably because the generic interpretation introduces a degree of uncertainty about the events that will transpire in the future: a number of eventualities make the sentence true. By contrast, in describing an event that has already taken place, the inclusive-*or* interpretation becomes less acceptable, as illustrated in (4).

(1)     Batman or Spiderman can finish a puzzle.

(4)     Batman or Spiderman finished a puzzle.

Intuitively, (1) delineates a set of possible outcomes. There is no reason to expect both Batman and Spiderman to finish a puzzle, but there is no reason to reject this possibility either. By contrast, if (4) is used to describe a situation about which the relevant details are known to the speaker, then if both Batman and Spiderman actually finished a puzzle, it would be more felicitous to describe the situation using conjunction, as in (5).

(5)     Batman and Spiderman finished a puzzle.

Of course, (4) is also a true description of the situation described by (5), but it is not a felicitous description, due to a conversational implicature.

Returning to (3) (repeated here as 6), there are at least two ways to explain why this sentence does not allow the collective interpretation. First, one might invoke a conversational implicature. On this proposal, the use of conjunction rather then disjunction would result in a more cooperative statement.

(6)     John or Paul can lift the piano.

We see two problems with this proposal, however. First, if an implicature is responsible for the unavailability of the collective reading, speakers should judge (6) to be infelicitous, rather than false. Notice, however, that adding a qualifying statement to the effect that, together, John and Bill have lifted the piano on several occasions, has no effect on the truth value of (6). Second, if conversational implicatures are responsible for the unacceptability of (6), then it should be possible to find a context in which implicatures do not arise, since one of the defining properties of conversational implicatures is that they do not arise in certain contexts, e.g., contexts of uncertainty. But

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[1] Throughout this paper, the term 'collective' is used in the same way as it is used in the literature on formal semantics (see Link 1983 and Schwarzchild 1996). However, the term is used differently in some studies of child language (e.g. Philip 1995, but cf. Avrutin and Thornton 1994), where it refers to an interpretation in which an existential quantifier has scope over a universal quantifier.

there is no apparent difference in the interpretation of (6) as a prediction rather than as a description.

For these reasons, it seems more appealing to account for the difference between (1) and (6) by invoking grammatical principles. In particular, we will follow Chierchia (1998), who argues that the collective interpretation of verbs places a specific restriction on the kind of semantic objects that can be part of their denotation. Intuitively, pluralities (e.g. entities like {a, b} in Chierchia (1998)) are possible elements of the denotation of verbs on a distributive reading but not on a collective reading, in which case objects like g{a, b} are required.[3] Without going into detail, this provides a theoretically motivated explanation of why the coordinated NPs in (1) and (6) result in different readings.

(1)     Batman or Spiderman can finish a puzzle.
(6)     John or Paul can lift the piano.

To conclude, the collective interpretation is incompatible with a disjunctive noun phrase, so sentences like (6) can only be evaluated on a distributive reading; in the present example, assuming that neither John or Paul could lift the piano, the sentence is false.

The next section describes two experiments that were designed to determine whether or not children also distinguish between sentences like (1) and (6). In particular, the first experiment was designed to establish the extent to which children (and a control group of adults) allow the inclusive-*or* reading of disjunction. Following that, a second experiment is described. This experiment was designed to determine whether children know that disjunction can only be assigned a distributive interpretation.

## 3.     Experimental Data

We present the results of two experiments using the Truth Value Judgement task. For each experiment we will consider the results obtained with children as well as those of a control group of adults. The children who participated in the experiments were students at the Center for Young Children at the University of Maryland at College Park; the adults were undergraduates at the same university.

The Truth Value Judgement task is a research tool for investigating children's understanding of the meaning of a sentence. It typically involves two experimenters (see McKee and Crain 1985 and Crain and Thornton 1998). One experimenter acts out stories in front of the child, using toy characters and props. The second experimenter manipulates a puppet who watches the stories along with the child. At the end of the story, the puppet tells what he thinks happened in the story. The puppet's statements are prefaced by a review of the characters (e.g., «That was a story about …») and an indication that the target statement is forthcoming (e.g., «I know what happened in the story...»). The child's task is to decide whether the puppet «said the right thing». If so, the child rewards the puppet with a coin; if the puppet's description is not what happened

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[1] We can view g{a, b} as an abstract object which is derived applying the function *g* (the group forming function) to the set {a, b} and we can read g{a, b} as ' the group formed by *a* and *b*'. To explain why the group reading is not available for complex NPs which include disjunction, we could argue that the function *g* is only defined if applied to an object like {a, b}, whereas the denotation of a coordinate NPs containing the disjunction operator is a different set, something like {{a, b}, a, b}.

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in the story, then the child gives the puppet a reward of lesser value, as a 'reminder' to pay closer attention. Whenever a child makes a negative judgement, the experimenter asks the child «what really happened» in the story. The child's explanation is recorded and analyzed, to ensure that the child is rejecting the puppet's statements for the right reasons. To make the generic reading salient, the linguistic introduction to the target sentences was designed to make it clear that the sentence was not a mere description of what happened. Before each of the target sentences, the puppet said: «I learned something in this story...».[4]

## 3.1.    The Distributive Reading

This experiment was designed to investigate two aspects of child language. First, we wanted to see if children are able to assign the inclusive-*or* reading to the disjunctive operator, *or*. As argued above, the relevant conversational implicature is expected to be cancelled in the present study, due to the (generic) meaning conveyed by the modal verb *can*. Second, we wanted to determine if children distinguish *and* from *or*. To address these questions, sixteen children, ranging in age from 4.1.22 to 6.1.25 (mean age 4.11.24), were interviewed. Each child was presented with 12 sentences, in two sessions. The sentences included three warm-ups, three fillers, three sentences which were true only under the inclusive-*or* reading of disjunction, two sentences which were true under the exclusive-*or* reading, and one sentence containing the coordinating conjunction *and*.

Consider first the availability of the inclusive-*or* reading. Each child encountered three sentences (for a total of 47 trials[5]) which were true only under the inclusive-*or* reading of disjunction. Children correctly answered «Yes» to these sentences 40 times out of 47 trials (85%).[6] Three control sentences were included to determine if children distinguish between *and* and *or*. First, each child was presented with two sentences containing the disjunction operator, *or*, in a situation in which only one of the characters was able to perform the action described in the sentence. If children interpreted *or* as *and*, they should have rejected these sentences. However, children correctly answered «Yes» 18 times out of 28 trials (64%).[7] In addition, children were presented with one sentence (15 trails) containing *and* in a context in which only one of the two conjuncts was true. Children correctly rejected this control sentence, 13 times (87%), again revealing a distinction in their grammars between *or* and *and*.

In short, the present experiment provides evidence that children's interpretation of disjunction conforms to classical logic. Other support for this claim can be found in

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[4] On the importance of providing a linguistic antecedent in an experiment, see Crain and Thornton (1998).

[5] One child did not want to participate in the second session, so the only data we have for this child are the two sentences of this kind presented in the first session.

[6] This level of accuracy is slightly lower than the percentage which is usually assumed to be meaningful when running a Truth Value Judgement task (see Crain and Thornton 1998). But since the experiment was investigating the felicity of a sentence rather than its grammaticality, we think the finding is significant.

[7] This percentage is also lower than expected (see footnote 6). In the present case, however, there may be a reason why children did not consistently accept a sentence like *A or B can do X* in a situation in which only one of the two characters could perform the described action. This might indicate an infelicity in mentioning a second character which clearly failed to perform the action mentioned in the sentence. Braine and Rumain (1981) found a similar pattern in their Experiment 3 and interpret their data along the same lines.

recent studies by Chierchia et al. (1998) and Gualmini, Crain and Meroni (2000), using different materials and with support from extralinguistic context (e.g., the Prediction Mode). In the present study, by contrast, the inclusive-*or* interpretation of disjunction is not induced because of the extralinguistic setting, but rather because the modal verb *can* is assigned a generic interpretation that renders conversational implicatures ineffective. Finally, the findings present additional evidence that young children distinguish *and* and *or*. This finding challenges the claim by Paris (1973).

The next topic is the results from English-speaking adults. Our prediction was that adults too would understand the logical connective, *or*, in the truth conditions ascribed to it by standard logic. This expectation was not entirely borne out, however. Like children, the adult subjects were each presented with three sentences (for a total of 57 trials) which were true only under the inclusive-*or* reading of disjunction. As expected, adults responded «Yes» to these sentences the majority of the time, on 49 trials (86%). However, adults provided unexpected responses to the control sentences which were designed to see if subjects distinguish *or* and *and*. Again, there were two sentences in contexts in which only one of the two characters could perform the described action. As we saw, children consistently accepted the control sentences in such contexts. However, the adult subjects rejected these sentences 100% of the time. Of course, adults correctly rejected the sentence containing *and* 100% of the time when only one of the two conjuncts was true.

Paradoxically, the one unexpected finding from this study was from adults who, at first glance, seem to fail to distinguish between *and* and *or*. Before we jump to this conclusion, however, a different explanation should be pursued. In our view, the main reason adults consistently rejected a disjunction when only one of the characters could perform the described action was due to conversational implicatures. Adults and children were presented with a story in which one character could perform a certain action but in which another character could not perform the same action. Describing this situation with a disjunction, saying that «X or Y can do Z» when only X did Z, is misleading because, in this case, disjunction is also consistent with an interpretation which is false. A more cooperative description would be «X can do Z».

If this interpretation of the finding is on the right track, then the experimental results challenge any account which defines the meaning of connectives in natural languages on the basis of their entailment relations, a position which Braine and Rumain (1983) attribute to Pelletier (1977). For example, *p* entails *p or q*. However, adult speakers of English do not accept a sentence like «X or Y can do Z» in a situation in which only «X can do Z» is true.

In the next experiment, we turn to children's responses to sentences with disjunction in circumstances that support a collective reading, but not the distributive reading.

## 3.2. The collective reading

In the second experiment the experimental contexts made sentences with the operator *or* true on collective interpretation, but false on the distributive interpretation. If children or adults allow a collective reading of disjunction, therefore, they should respond affirmatively. However, if this reading is ruled out by the grammar, then subjects should respond negatively. To illustrate, let us describe a typical trial, which consisted of a story

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that was acted out in front of the child. In one story, Tigger and Pooh Bear were driving a jeep in the desert. Then, one of the tires of the jeep went flat. Tigger and then Pooh Bear each took a turn trying to fix the flat tire, but neither of them could take the wheel off, because it was on too tightly. They then decided to join forces and, together, they successfully removed the tire. At this point, the test sentence was presented:

(7)     Tigger or Pooh Bear can take off the wheel.

        Notice that in the same situation a sentence like:

(8)     Tigger and Pooh Bear can take off the wheel.

would be perfectly grammatical. Therefore, in addition to assessing the availability of the collective reading of disjunction, the present experiment provides another test of children's ability to distinguish between *or* and *and*.

    Thirteen children who were tested in the first experiment also participated in this second experiment. The children ranged in age from 4.01.22 to 6.01.25 (mean age: 5.01). Each child was presented with two sentences with disjunction and two sentences with conjunction, but the contexts were always the same, making the test sentences true on the collective reading, but false on the distributive reading. Out of the 26 trials with conjunction, as in (8), children correctly responded «Yes» 25 times (96%). By contrast, out of the 26 trials with disjunction, children correctly responded «No» only 13 times (50 %). A control group of 16 adult native speakers of English were tested. Adults correctly responded «Yes» 28 times out of 32 trials with conjunction (88%) and they produced the expected negative response to the 32 sentences with disjunction on every occasion.

    Concerning the distinction between *and* and *or* in child language, the present results add to the finding of the experiment described in section 3.1, as well as the finding reported in Gualmini et al. (2000), showing that young children distinguish between the logical connectives *and* and *or*, contrary to the claim by Paris (1973). As for the availability of the collective interpretation of disjunction, the data require careful consideration. In particular we need to explain the difference between children and adults. One aspect of children's responses is relevant here. Although, the overall level of acceptance was 50%, this figure is misleading. Only five children responded both «Yes» and «No». Four of the remaining eight children always rejected the sentences with disjunction in the present experiment, exactly like adults, whereas the other four children consistently accepted them.

    There are two possible explanations of the findings. First, some children might not have acquired knowledge of the relevant properties of the collective interpretation of verb phrases, namely that it is associated with a set containing groups rather than pluralities. Second, it is conceivable that children have acquired the relevant properties of collective readings but the level of acceptance of the inclusive-*or* reading of disjunction reflects a different phenomenon, namely some artifact of the experiment.

    Further investigation is required to identify the exact reason for children's responses. In our view, the second hypothesis is more likely. First, when asked to evaluate sentences with a disjunctive NP many children said the puppet was right but went on to make the unsolicited comment that the two characters could perform the depicted action only together, whereas the same did not happen in the trials with

conjoined NPs. Second, some of the children may not really understand the collective reading, simply because it is difficult to determine if an event is collective or not. It is worth noting, in this regard, that children in another study, by Avrutin and Thornton (1994), also were judged to lack adult-like understanding of the collective interpretation of a verb phrase.

## 4.    Conclusion

This paper presented the results of two experiments using the Truth Value Judgement task. One experiment was designed to test the availability of the inclusive-*or* reading of disjunction in generic sentences. The experiment attempted to cancel conversational implicatures in a different way than in the studies by Chierchia et al. (1998) and Gualmini et al. (2000). The results of this experiment highlight two aspects of child grammar. First, children can consistently access the inclusive-*or* reading of disjunction. Second, children know that *and* and *or* are associated with different truth-conditions.

The results of the second experiment point to a need for further research to understand children's comprehension of collective versus distributive readings. Even at this preliminary stage, though, we have established the distinction between contexts that raise or erase conversational implicatures, and semantic principles that have similar consequences for interpretation. The responses by adults support the proposed extension of the Modularity Matching Model to the semantics/pragmatics interface: a purely grammatical principle can eliminate one of the readings associated with a lexical item, before pragmatic principles come into play. The interpretation of children's responses is not so straightforward, however. It is possible that children failed to appreciate that the event they witnessed could take place only if the two characters performed an action together.

Extending the assumptions of the Modularity Matching Model to the semantics/pragmatics interface yields an interesting prediction. If we replicated the experiment described in section 3.2 in the implicature-erasing context used by Chierchia et al. (1998) we should fail to find any significant change in the rate of acceptance of the inclusive-*or* reading of disjunction. If the inclusive-*or* reading is ruled out by grammatical principles, then using the sentence in a context that (ordinarily) cancels implicatures (e.g., the Prediction Mode) should not affect its interpretation. This prediction follows from the assumption that the language processing system has a modular architecture and that principles at higher level (such as conversational implicatures) can only select among the alternatives proposed by the lower level. The context cannot make available an interpretation that is not already licensed by the grammar.

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