

Child's interpretation of OR and AND: either or both?

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Περίληψη

Η παρούσα έρευνα εξετάζει την κατάκτηση των λογικών τελεστών 'ή' και 'και' στα Ελληνικά. Προηγούμενες έρευνες από άλλες γλώσσες έχουν δείξει ότι η κατάκτηση της διάζευξης διαφέρει από το λόγο των ενηλίκων ως προς το ότι τα παιδιά δεν προτιμούν την αποκλειστική σημασία σε κύριες προτάσεις, σε περιβάλλοντα δηλαδή διαβαθμισμένων υπομνημάτων. Επιπλέον, σε περιβάλλοντα εγκλειστικής σημασίας του 'ή', τα παιδιά απορρίπτουν την πρόταση όταν και τα δυο μέρη δεν είναι αληθή, αποδίδοντας δηλαδή συζευκτική σημασία. Η παρούσα μελέτη έχει στόχο να εξετάσει την κατάκτηση και των δυο τελεστών καθώς και αν υπάρχει συσχέτιση μεταξύ των δύο κατά τη διαδικασία ωρίμανσης τους.

Λέξεις – κλειδιά: κατάκτηση διάζευξης, κατάκτηση σύζευξης, διαβαθμισμένα υπονοήματα

1 Introduction

The interpretation of disjunctive OR has been associated with Scalar Implicatures (SI).

(1) John met with Maria or Helen.

Adults' conclusion of (1) is that John met with either Maria or Helen (exclusive meaning) without ruling out the possibility of John meeting with both Maria and Helen (strict semantic inference). Although the mechanism the hearer employs in reaching the exclusive meaning in sentence (1) is far from trivial to account for, it is in general assumed that the strict semantic inference is excluded roughly on the shared assumption that the speaker would have not used OR in a case in which another lexical item, namely AND, would allow the hearer to reach the most informative conclusion (Pragmatic Inference-SI).

In a sentence with the conjunctive operator AND (2), such an inference does not arise.

(2) John met with Maria and Helen.

In propositional logic, the conjunction AND uniformly conjoins expressions in the form of $(A \wedge B)$ whose truth-value is strictly associated with the truth-value of each part. Thus, (2) can be true only as long as John met with both Maria and Helen.

Previous studies on the development of disjunction have shown that children go through a developmental stage in which their understanding of the logical operator OR relies on strict semantic computation, ignoring pragmatic principles that give rise to the adultlike exclusive inference of OR (e.g. Paris 1973, Braine and Romain 1981, Noveck 2001, Gualmini et al. 2001, Chierchia et al. 2004, Singh et al. 2015 a.o.). On the other hand, the development of AND has received limited attention (e.g. Paris 1973, Chierchia et al. 2001, Goro et al. 2004 a. o.), most likely due to its high success

rates in absolute terms, and its apparent ‘unproblematic’ interpretation compared to the development of OR.

The present study aims to shed light on the development of both logical forms, focusing on potential interdependencies between the two. It addresses two main questions: a) to what extent (if at all) the development of AND interplays with the development of OR and, b) whether the interpretation of OR and/or AND is affected by the number of the disjuncts/conjuncts in sentences like ‘John ate an apple, an orange or/and a banana’.

We argue that the development of AND is a key in understanding the divergence in children’s development of OR. The findings of our experimental study show that there is a strong correlation between the development of the two operators.

2 Previous studies on the development of OR

It has been reported that children go through a developmental stage at which they know the meanings of the disjunctive logical operator but they fail to assign the adult interpretation in the contexts in which the basic meaning of the operator has been strengthened pragmatically, giving rise to the exclusive meaning of OR (SI; see Noveck, 2001 and much work since).

Accordingly, children seem to perform better on OR in Downward Entailing (DE) environments. A number of studies provide evidence that in such contexts, children understand OR as inclusive disjunction, i.e. in an adult-like fashion (Chierchia et al. 2001, Gualmini et al. 2003, Chierchia et al. 2004, Goro et al., 2005, Crain 2008, Notley et al. 2012, inter alia).

In addition, there is evidence that children not only fail to reach the SI meaning (i.e. the exclusive OR) but they also seem to understand OR as conjunction in matrix disjunctions. Paris (1973) tested second-graders who were shown pictures accompanied by a verbal description and they were asked to evaluate if the utterance they heard (e.g. ‘the bird is in the nest or the shoe is on the foot’) was true or false. Children’s responses were adult-like when both parts were true (98% accuracy), as well as when both parts were false (98%). This is compatible with an inclusive disjunction. However, when only one part was true, the accuracy-rate dropped down to 30%. The latter is expected if children assign a conjunctive meaning to the inclusive OR in these contexts.

A study by Braine and Romain (1981) provides further evidence for a conjunctive interpretation. According to their methodology, children (5-6 year-olds) were shown boxes with toys in them, and a puppet uttered a statement about the scene (e.g. ‘either there’s an X or a Y in the box’). The participants were asked to characterize puppet’s utterance as right or wrong. Their findings, similarly to Paris’s (1973) study, showed that children responded ‘right’ to AVB when both A and B were true (95%) and ‘false’ to AVB when both parts were false (around 95%). However, when only one disjunct was true, only 18% responded ‘true’. This result is not expected if the participants interpret AVB simply as inclusive-disjunction.

Chierchia et al. (2004) presented children with a story asking children to evaluate a disjunctive statement ($A \vee B$) describing the story. When both A and B were true, children accepted the disjunction description 95% of the time, but when only one of the parts was true, they accepted AVB only 78%. Again, this result is expected if roughly 20% of responses relied on a conjunctive understanding of AVB.

In a more recent study, Singh et al (2016) designed an experiment to examine whether these results are replicable and whether children's comprehension would be affected by embedding OR in upward monotone environments. According to their findings, the majority of their participants understood disjunctive sentences like 'the boy is holding an apple or a banana' as if those were conjunctive sentences. Their crucial finding, replicating previous results, is that a child will reject AVB when only one of the disjuncts is true. The data they report show evidence for such conjunctive readings not only in matrix disjunctions but also for disjunctions that are embedded under 'every' as in the example 'every boy is holding an apple or a banana'; children showed clear preference for the pictures in which every boy was holding both an apple and a banana. As they claim "It seems clear that the difference between the child and adult cannot be reduced to a difficulty with computing scalar implicatures, for this difficulty should not lead to 'false' judgments for $A \vee B$ when just one disjunct is true" (Singh et al. 2016).

In a similar vein, Tieu et al. (2017) found that almost half of the children participating in their study accessed a conjunctive interpretation of disjunction on both languages tested, i.e. French and Japanese.

Taken everything together, the findings of the aforementioned studies provide evidence that children's interpretation of OR in DE contexts reveal knowledge of OR as inclusive disjunction but in non-DE environments, in which SI strengthens the meaning OR to exclusive meaning, the child seems to strengthen the meaning of OR, not towards exclusivity as with adults, but towards conjunctivity (cf. Singh et al. 2016).

3 Previous studies on the development of AND

The development of AND has received limited attention. The first study, to the best of my knowledge, on the acquisition of AND was conducted by Paris (1973). In this study, second graders (mean age 7;9) were presented with pictures and they were asked to judge whether the description of the pictures was right or wrong. Children looked at 8 pictures for 15-20 seconds and they would hear sentences like 'the boy is riding the bicycle and the dog is lying down'. The findings reveal that children correctly judge conjunctive when both parts were true (success rate 98%) and when both parts were false (success rate 100%). However, the correct response rate dropped down to 87% when only one part was true.

Chierchia et al. (2001) tested comprehension of AND in a study with 9 children (mean age 5;5) and 22 adults. Participants were asked to evaluate as right or wrong the sentences that described what happened in a story. In the stimulus, only one conjunct was true, and children accepted them at a rate of 16%. In the same study, Chierchia et al. included a second experiment, testing whether children show a delay of pragmatic knowledge (Pragmatic Delay Hypothesis) regarding the Axiom of Quantity. For this purpose, a Felicity Judgement task was used. Participants were presented with alternative description of an event/story, differing only with respect to their appropriateness with respect to the specific context. For example, the experimenter would describe a story in which every farmer would clean the horse and the rabbit. Two puppets would give their description of what happened, offering two options to the children to pick the most appropriate description as in (3a) and (3b).

- (3) a. Every farmer cleaned a horse or a rabbit.

b. Every farmer cleaned a horse and a rabbit.

15 children participated in this task (mean age 4;8) and at a rate of 93% children picked sentence (3b) as the most appropriate description in the case that the farmer had cleaned both the horse and the rabbit.

In the Singh et al. (2016) study 25 children out of 56 were excluded as they fail to succeed on the control items of the study related to conjunction. More specifically, they included four conditions with OR and the equivalent four conditions with AND. The latter were intended to be used as controls to ensure children were paying attention to the questions being asked; the researchers decided to exclude the participants from the analysis who did not perform above chance on these conjunctive control sentences.¹

The overall picture provides indications that the development of AND is not adult-like at that stage; children show ceiling performance when both conjuncts are true and when both are false, but their understanding somehow deviates when only one of the conjuncts is true, which clearly suggests that children may assign a different meaning to AND.

4 Our study

4.1 Hypothesis and rationale

We address the question as to whether the development of OR correlates to the development of AND. The all-purpose design of the current study is to:

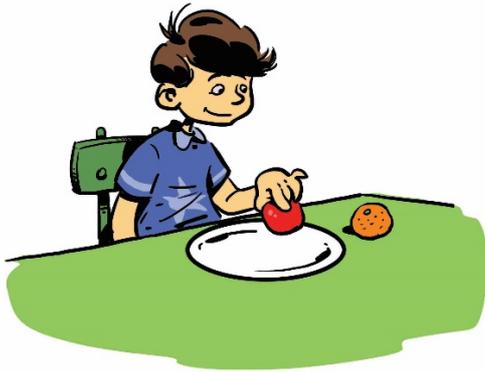
- a) test conjunction and disjunction on the same group of participants,
- b) compare conjunction and disjunction interpretation in sentences with two conjuncts/disjuncts (*two-part condition*) to performance in sentences with three conjuncts/disjuncts (*three-part condition*) and,
- c) examine whether the semantic properties of the disjunct/conjunct (i.e. NP versus DP as in the examples ‘*He ate an apple or an orange*’ versus ‘*He ate the apple or the orange*’) reinforces the exclusive interpretation.

Given the issues that AND raises with respect to its development (section 3) and the conjunctive interpretation of OR (section 2), we explore experimentally if the role of AND is the missing link in understanding Scalar Implicatures on OR.

4.2 Methodology and Procedure

In an act-out task, children were asked to place either one or two or three objects in a spot. Prior to the act out task, a training session was taking place on how to play the game with the two experimenters who were participating. Children were asked to place a choice of fruits on a plate or a choice of animals in a barn. There were seven different types of food (tomato, apple, banana, strawberry, peach, orange and carrot) and multiple pieces of food were available except for the items testing the effect of the definite article; in these instances, single objects were available matching the uniqueness requirement of the Definite article.

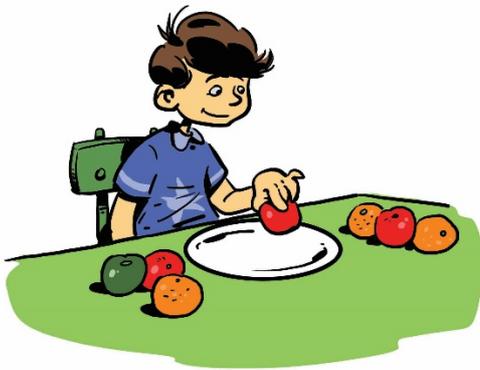
¹ Note that Singh et al. (2016) report that that their main findings do not change if they had included the whole sample.



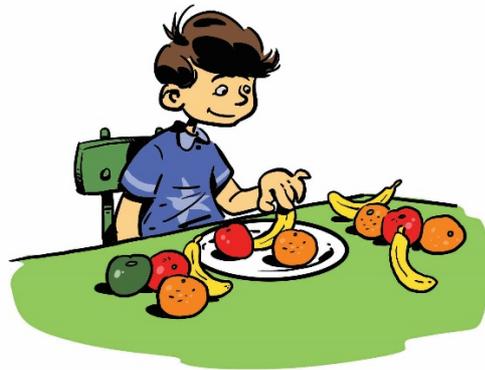
Picture 1 | Example of Disjunction condition with two definite-NPs (i.e. ‘put the apple or the orange on the plate’).



Picture 3 | Example of Disjunction condition with three NPs (i.e. ‘put an apple or an orange or a banana on the plate’).



Picture 2 | Example of Disjunction condition with two indefinite-NPs (i.e. ‘put an apple or an orange on the plate’).



Picture 4 | Example of Conjunction condition with three NPs (i.e. ‘put an apple and an orange and a banana on the plate’).

4.3 Participants

The participants were all monolingual Greek native speakers (privately recruited from the area of Attica), aged 4 to 5;6 years old (mean age 4;9). Originally the participants were 36 children, of which 27 children completed all trials and tasks of the study (still in progress).

4.4 Material

Each condition was tested by four items (2 in the scenario with animals and 2 in the fruit scenario). We used Imperatives in our test, which were uttered in a command/request mood and importantly the intonation was kept constant in all items. In the view of testing the ‘majority-effect’, we included the three-part condition in our experiment. The types of the testing sentences are exemplified in (4)-(9).

OR-2indefinite condition

- (4) Vale ena milo i ena portokali sto piato
Put an apple or an orange on the plate.

- OR-2definite condition
- (5) Vale to milo i to portokali sto piato
Put the apple or the orange on the plate.
- OR-3indefinite condition
- (6) Vale ena milo i ena portokali i mia banana sto piato
Put an apple or an orange or a banana on the plate.
- AND-2indefinite condition
- (7) Vale ena milo ke ena portokali sto piato
Put an apple and an orange on the plate.
- AND-2definite condition
- (8) Vale to milo ke to portokali sto piato
Put the apple and the orange on the plate.
- AND-3indefinite condition
- (9) Vale ena milo ke ena portokali ke mia banana sto piato
Put an apple and an orange and a banana on the plate.

5 Results

Figure (1) shows that there is a significant difference between the two-part condition and the three-part condition on Indefinite NPs. However there seems to be no significant difference between the two-part-definite and two-part-indefinite NPs, despite the fact that children perform better on the sentences with definite NPs. The rates of exclusive interpretation of OR are comparable to those of previous studies on OR in main clauses, lending further support to previous studies on other languages. The rate of the three-part condition, which is to the best of my knowledge the first time to be examined, shows significantly lower rate of exclusivity. Interestingly, the majority of the mistakes that children made regarding this condition, involve two disjuncts rather than three.

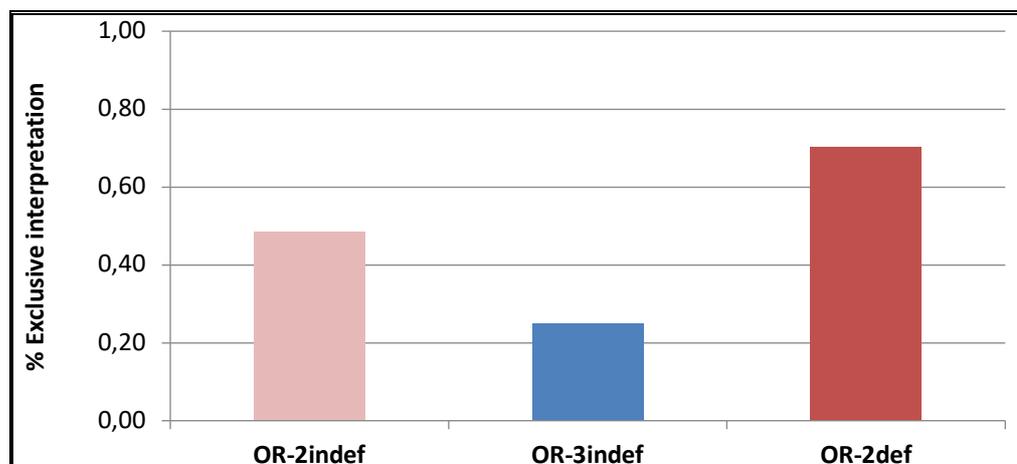


Figure 1 | Children's exclusive interpretation of OR in all three conditions

Figure (2) shows that children’s performance on AND is overall significantly better than on OR. The rate on two-part definite NP is comparable to the findings of previous studies. No significance was found across the AND-conditions. The difference between the two-part-indefinite NPs to the two-part-definite NPs (first and third bar respectively) is somehow surprising although it is not significant. We believe that the presence of the definiteness, associated with the uniqueness requirement reinforces the conjunctive meaning and facilitated children’s understanding of the experimental task in the sense that only one of the items were available. The lower percentage on the three-part condition involved mostly mistakes with two conjuncts rather than one.

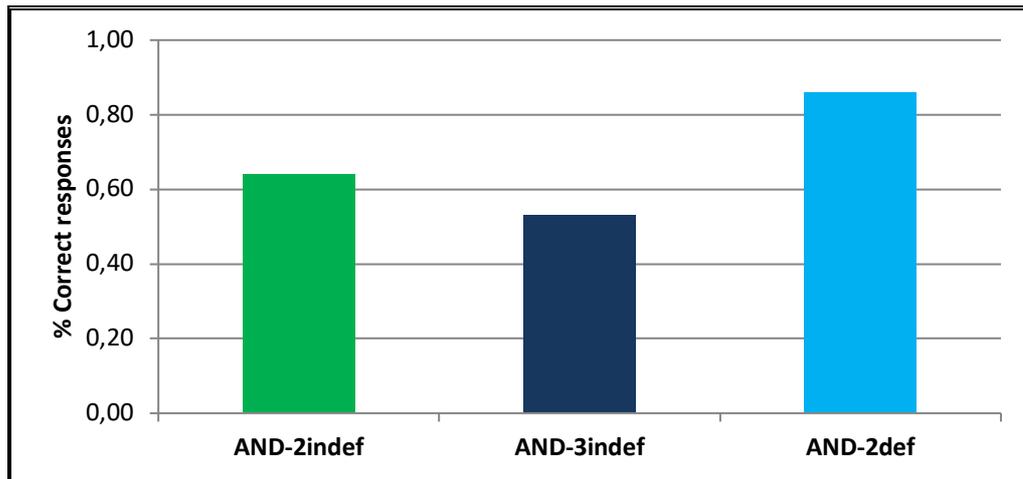


Figure 2 | Children’s correct responses on AND in all three conditions

Figure (3) depicts the overall results of the study. Most importantly there seems to be a strong correlation ($r=0,685$) between AND and OR across all conditions.

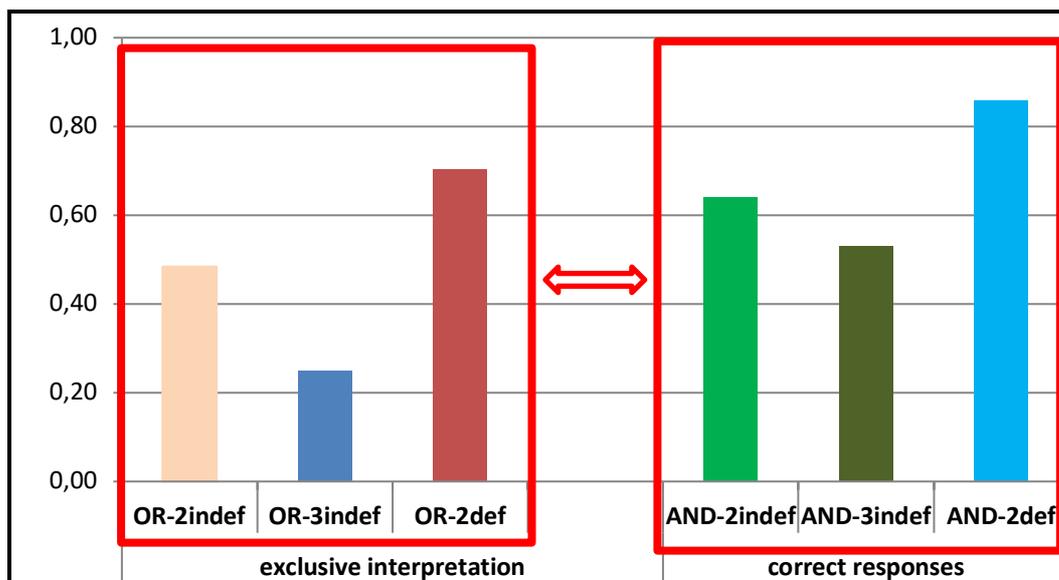


Figure 3 | Children’s overall results

6 Discussion

Children certainly perform better on AND than on OR. In this respect, the current study provides further evidence on previous studies on other languages. However, the development of AND is not adult-like at least up to the age of almost five. It definitely requires further research to inspect if our findings are attested in other languages and under different methodological approaches.

We explored whether there is a developmental interplay between AND and OR. For this purpose, we compare children's understanding of *OR* and *AND* in sentences with two conjuncts/disjuncts (*two-part condition*) and in sentences with three conjuncts/disjuncts (*three-part condition*). The reasoning behind our approach arose from qualitative data-responses during a pilot-study, in which both children and adults seemed willing to accept false-utterances with multiple conjuncts ($A \wedge B \wedge C \wedge D$) as long as the *majority* of them were true. Moreover, there are data in which the conjunction operator embedded under certain modals, seems to receive an inclusive-OR interpretation. Consider examples (10)-(11):

- (10) a. Boris/epitrepete na fas to milo ke to portokali ala oxi ke ta dio.
'You may/allowed to eat the apple and the orange but not both'
b. Boris/epitrepete na tu paris doro to vivlio, to podilato ke to trenaki ala oxi ke ta tria.
'You may/allowed to buy him the book, the bicycle and the little train as a present but not all three of them'.
- (11) An fai siko ke avgo, tha pathi alergia.
'If she eats figs and eggs will have an allergic shock.'

Example (10a) and (10b) contain a conjunctive and an existential modal, while in (11) the conjunction is in a conditional operator context. It is possible to draw the inferences in (12) and (13) for (10) and (11) respectively.

- (12) a. You may eat the apple *or* the orange but not both of them.
b. You may buy him the book, the bicycle *or* the little train but not all of them.
- (13) If she eats figs will have an allergic shock and if she eats eggs will get an allergic shock, but it is not necessarily the case that she needs to eat eggs and figs at the same time to get an allergic shock.

This is quite puzzling; the conjunction operator, which is at large taken to uniformly conjoin expressions whose truth-value is strictly associated with the truth-value of each part, seems under certain modality contexts to allow a disjunctive inference.² I will call the inferences in (12)-(13) the 'not-required-to' inference (adopting the term from Tieu et al. 2015 in discussing disjunctive inferences).

² There is no doubt that the existential modal is responsible for the 'not-required-to' inference in (10) to (12). This becomes clearer when a deontic modal is present, in which only the conjunctive interpretation is available.

(i) Prepi na fas to milo ke to portokali
'You must eat the apple and the orange'.

Another set of data which provides evidence for an inclusive-OR interpretation of AND comes from environments in which multiple parts are conjoined, as in (9)-(10).

(14) Tha itan poli oreo doro to vivlio, to podilato ke to trenaki gia to Jiorgaki.

‘The book, the bicycle and the little train would be a very nice present for George’.

(15) Simvulepsu Giorgo, Niko ke Taki gia afto to thema.

‘Consult George, Nick and Takis on this issue’.

In ‘list-contexts’ as in (14) and (15), many Greek native speakers do not necessarily require a strict conjunctive meaning among the three parts that are conjoined. Instead, a possible interpretation of (14) is that ‘a book or a bicycle or a little train, or a combination of them would be a nice present’. Similarly, in (15), the speaker does not necessarily recommend talking to each one/all of them. In these cases, a ‘majority satisfaction effect’ comes into play and in this respect AND is compared to ‘almost ALL’. Note that in the corresponding episodic readings of (14)-(15) in (16)-(17), this effect disappears and the only interpretation available is the strict-conjunctive one.

(16) Itan poli oreo doro to vivlio, to podilato ke to trenaki gia to Jiorgaki.

‘The book, the bicycle and the little train was a very nice present for George’.

(17) Simvuleftike Giorgo, Niko ke Taki gia afto to thema.

‘She consulted George, Nick and Takis on this issue’.

The question raised by this discussion provides further evidence that the input children receive regarding the conjunctive operator is enriched by such inferences. It is then possible that children’s disjunctive alternatives on AND are affected in a way that they often misanalyse AND as OR.

If this is in the right track, it sheds light on child’s (in)ability to access and represent the alternatives generated by strengthening OR in an adult-fashion as the latter involves the analysis of the conjunctive operator. Recall that within the tradition that attempts to derive free-choice inferences as a kind of Scalar Implicatures (e.g. Fox 2007, Chemla 2009, Chierchia et al. 2012 a.o.), the main idea is that adults strengthen the ‘not both’ reading in (18) while children conclude that ‘the both’ reading is true.

(18) The boy ate an apple **or** a banana.

Adult interpretation: (A or B) and NOT(A and B)

Child interpretation: (A or B), A, B

As a result, adults by large interpret (18) exclusively, while children often allow for the conjunctive reading of (18). If in such an algorithm, children’s understanding of AND allows them to compute conjunction disjunctively, it is expected that they will fail to reach the exclusive meaning of OR in non-DE environments.

Our proposal is supported by the two main findings: a) the strong correlation that seems to emerge in the acquisition of the two connectives, and, b) the errors that

children produce in the *AND* conditions with two conjuncts and more prominently with three conjuncts. It is subject to further research what is the children's precise computation of *AND* and how it exactly intervenes in accessing strengthened inferences of *OR*.

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