Children's comprehension of plural predicate conjunction*

To appear in *Journal of Child Language*

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March 28, 2017

Abstract

Previous developmental studies of conjunction have focused on the syntax of phrasal and sentential coordination (Lust 1977; de Villiers, Tager-Flusberg, & Hakuta 1977; Bloom, Lahey, Hood, Lifter, & Fiess 1980, among others). The present study examined the flexibility of children's interpretation of conjunction. Specifically, when two predicates that can apply simultaneously to a single individual are conjoined in the scope of a plural definite (*The bears are big and white*), conjunction receives a boolean, intersective interpretation. However, when the conjoined predicates cannot apply simultaneously to an individual (*The bears are big and small*), conjunction receives a weaker 'split' interpretation (Krifka 1990; Lasersohn 1995; Winter 1996). Our experiments reveal that preschool-aged children are sensitive to both intersective and split interpretations, and can use their lexical and world knowledge of the relevant predicates in order to select an appropriate reading.

For helpful feedback and discussion, we would like to thank the audience at the 2014 Rencontres d'Automne de Linguistique formelle (RALFe), as well as the linguists at the Ecole Normale Supérieure. We would also like to thank Zheng Shen for his assistance with adult participants, the preschools in Connecticut for allowing us to carry out our study, and Yael Seggev for the original drawing in Figure 1. L. Tieu's research was supported by the European Research Council under the European Union's Seventh Framework Programme (FP/2007-2013) / ERC Grant Agreement n.313610, ANR-10-IDEX-0001-02 PSL, ANR-10-LABX-0087 IEC, and the Australian Research Council Centre of Excellence in Cognition and its Disorders (CE110001021); E. Poortman and Y. Winter's work was partially supported by a VICI grant 277-80-002 of the Netherlands Organisation for Scientific Research (NWO); and J. Romoli's research was partially supported by the Leverhulme Trust, grant RPG-2016-100 ("Pluralised mass nouns as a window to linguistic variation").

1 Introduction

1.1 Conjunction in child language

Much of the existing acquisition literature on conjunction has focused on children's syntactic development of phrasal and sentential coordination structures. According to early transformational grammars, phrasal coordinations such as (1) were derived by the application of a deletion rule (*conjunction reduction*) to an underlying sentential coordination at deep structure (2) (for relevant discussion, see Chomsky 1957; Ross 1967; Dougherty 1968; Lakoff & Peters 1969; Dougherty 1970; Stockwell, Schachter, & Partee 1973; Harries 1973; Chomsky 1977; Williams 1978; Grosu 1979).

(1) Jack ate the apple and the banana.

(2) Jack ate the apple and Jack ate the banana.

Accordingly, developmental researchers sought to investigate the status of these forms of conjunction in child language, characterizing the nature of young children's coordinate structures (see, for example, Lust 1977; de Villiers, Tager-Flusberg, & Hakuta 1977; Bloom, Lahey, Hood, Lifter, & Fiess 1980; Lust & Mervis 1980; Ardery 1980; Hakuta, de Villiers, & Tager-Flusberg 1980; Greenfield & Dent 1981; Tager-Flusberg, de Villiers, & Hakuta 1982). Such studies examined children's production of phrasal and sentential coordinations, as well as the deletion patterns associated with phrasal coordinations. The resulting data, gathered mostly from elicited imitation tasks and spontaneous production corpora, were somewhat mixed, and on the whole did not provide compelling arguments for the primacy of sentential coordination.

Aside from structural considerations, other existing studies have examined the meanings and pragmatic functions children may assign to the conjunction. 'And' is reported to be the first connective that English-speaking children produce (Cromer 1968; Bowerman 1979), both for linking syntactic phrases (Bloom, Lahey, Hood, Lifter, & Fiess 1980) and as a kind of inter-sentential discourse connective (Peterson & McCabe 1987). Though children may produce conjunction quite early (around 25 months, according to Bloom et al. 1980), its initial meaning and function are reported to be quite general. Bloom et al. (1980) report that the earliest semantic relation expressed by conjunction is *additive*, allowing the child to join two events or states without necessarily conveying any dependency relation between them. The additive meaning encoded by young children's conjunction is then followed by a temporal meaning (see Reitz 2013 for discussion of children's temporal inferences arising from German 'und'); temporal meanings are subsequently followed by a causal meaning and then an adversative meaning (Bloom et al. 1980). Peterson & McCabe (1987, 1988) report that children use 'and' to link sentences together; on its inter-sentential use, 'and' appears as a kind of general discourse glue that allows the child to signal a thematic connection between her contiguous utterances.

Beyond the structural and pragmatic considerations described above, there has been far less attention devoted to children's logical interpretations of conjunction (although see, for example, Crain, Goro, Notley, & Zhou (2013) and Notley, Zhou, & Crain (2016) on scopal interactions between conjunction and negation in child language, and Paris (1973)

on children's reasoning with logical connectives). In this paper, we focus on a well-known puzzle in the formal semantics literature that, as far as we know, has received no attention in the acquisition literature. More specifically, plural predicate conjunction appears to give rise to both an intersective, so-called 'boolean' interpretation and a weaker 'split' interpretation, depending on whether the conjoined predicates are compatible or are incompatible.

1.2 The flexibility of plural predicate conjunction

Sentences containing plural definite subject noun phrases and conjoined predicates appear to give rise to two possible readings of conjunction: a so-called boolean (Partee & Rooth 1983) or intersective reading as in (3), and a weaker 'split' interpretation as in (4).

(3) a. The bears are big and white.
b. ≈ *The bears are both big and white*

(4) a. The bears are big and small.
b. ≠ *The bears are both big and small*
c. ≈ *Some of the bears are big and some of them are small*

To account for the apparent ambiguity between these strong and weak meanings of conjunction, Winter (2001b) proposes the principle in (5), which is meant to be an extension of the Strongest Meaning Hypothesis (originally proposed by Dalrymple, Kanazawa, Mchombo, & Peters 1994; Dalrymple, Kanazawa, Kim, Mchombo, & Peters 1998) to account for an ambiguity in the interpretation of reciprocal expressions.

(5) **The Extended Strongest Meaning Hypothesis (ESMH):** A complex plural predicate with a meaning that is derived from one or more singular predicates using singular quantification is interpreted using the logically strongest truth conditions that are generated from its basic universal meaning and that are not contradicted by known properties of the singular predicate(s).
(Winter 2001b:342, (17))

Since the strong interpretation in (4b) would be contradictory to our knowledge that a bear cannot be both big and small at the same time, we assign the sentence (4a) the weaker interpretation in (4c). A strong reading of (3a), on the other hand, is not contradictory to our knowledge, and thus we prefer to assign the strong meaning to conjunction. A similar contrast between the strong, intersective meaning of conjunction and the weaker, split interpretation can be seen in (6).

(6) a. The ducks are swimming and flying.
b. The ducks are swimming and quacking.

On the strong interpretation, (6a) would be contradictory to our knowledge that ducks cannot swim and fly at the same time. Thus we assign it a weaker interpretation, so we judge (6a) to be a true description of Figure 1, i.e. *Some of the ducks are swimming and the other ducks are flying.* A strong reading of (6b), on the other hand, is not contradictory with our knowledge, and thus we prefer to assign to it the strong meaning that the ducks

are both swimming and quacking, so we judge (6b) to be a false description of Figure 1.

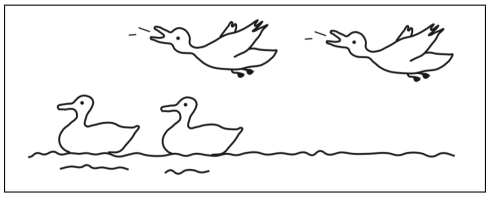

Figure 1: Figure from Winter 2001b (page 341, Figure 2, reproduced here with permission from Oxford University Press).

In short, the ESMH principle stated in (5) ensures that the meaning of a complex predicate (that is itself composed of lexical predicates holding of atomic entities) is assigned the strongest truth conditions that do not contradict the lexical properties of the simple predicates it contains.

More recently, Poortman (2014, Submitted) has shown experimentally that the choice between the weak and strong meanings is not as categorical as the ESMH principle might predict. She presents experimental evidence of a continuum of acceptability values for non-boolean interpretations like (4c), which correlate with the perceived typicality of a given instance of the complex predicate. The less typical that speakers perceive the complex predicate to be, according to a boolean interpretation, the weaker the interpretation they assign to the sentence. To explain this finding, Poortman extends the Maximal Typicality Hypothesis proposed in Kerem, Friedmann, & Winter (2009) to predicate conjunction: the less typical it is for two predicates to apply simultaneously to each individual in the plural subject, the more accessible the weaker interpretation becomes.

1.3 The present study

Previous developmental studies on conjunction have tended to focus on the syntax of coordination or the pragmatic functions that underlie conjunction. As far as we know, no previous study has examined children's sensitivity to the apparent flexibility of 'and' discussed above. In order to address the associated learnability question of how children acquire an adult-like semantics of conjunction, a first step is assessing what young children know about conjunction. Existing studies may tell us that preschool-aged children have a grasp of the syntax underlying coordination, and are capable of using 'and' to link thematically-related phrases and sentences. However, the existing data clearly do not provide the full picture of children's knowledge of the semantics of (predicate) conjunction. Not only must children acquire the cross-categorial boolean semantics of conjunction, which yields the strong, intersective meaning, as well as the basic lexical semantics of each of the conjoined predicates, they must also accumulate sufficient experience with the world to determine how likely it is for any two predicates to hold simultaneously of the same individual.

It is also not entirely clear what predictions we should make, on the basis of the existing literature. Earlier developmental studies, working within the framework of transformational grammar, sought to characterize the potential primacy of sentential (vs. phrasal) conjunctions. But such transformational accounts clearly cannot fully capture the facts; for example,

the phrasal predicate conjunction in (7a) is clearly not equivalent to the sentential conjunction in (7b), and (8) is incorrectly predicted to be equivalent to the ungrammatical sentence *John met and Mary met* (Winter 2001a).

(7) a. Some woman danced and sang.
b. Some woman danced and some woman sang.

(8) John and Mary met.

In the semantics literature, there has been continued discussion and evolving proposals concerning the apparent flexibility of conjunction (see, for example, Keenan & Faltz 1985; Hoeksema 1987; Winter 2001b), but the literature on child language acquisition has generally not engaged with these lines of research. In the present study, we aim to take a first stab at the question of how children handle the flexibility of conjunction, by directly testing their interpretation of sentences like (3) and (4).

2 Experiment 1

Our first experiment tested the interpretation of phrasal predicate conjunctions. We used a 2x2 design with group (adults vs. children) as a between-subject factor and compatibility of the conjoined predicates (compatible vs. incompatible) as a within-subject factor. In the remainder of the paper, we will use the label COMPATIBLE to refer to the condition in which the conjoined predicates were compatible, and INCOMPATIBLE to refer to the condition in which the conjoined predicates were incompatible.

2.1 Method

2.1.1 Participants

We tested 26 English-speaking children ($3;02-5;02$, $M = 4;05$), who were randomly assigned to the two conditions. Seven additional children (mean age 3;09) were tested but were excluded from analysis for failing to score at least 75% accuracy on control and filler trials (9/12 correct). We decided on this exclusion criterion before data collection began. We also tested 22 adult native speakers of English, who were likewise randomly assigned to the two test conditions. All adults successfully passed the control trials.

2.1.2 Procedure

We used a Truth Value Judgment Task (Crain & Thornton 1998, 2000). Participants were presented with a series of cartoon pictures on a laptop computer. Pre-recorded videoclips of a puppet watching and playing along with the game created the ruse that the puppet was participating in the game via webcam. A short introduction to each picture was provided, to encourage the child to pay attention to the full set of objects in the picture. The puppet was then asked to describe something about the set of objects. The participant's task was to decide whether the puppet's description was right or wrong. Participants were asked to fill out a scorecard for the puppet. Follow-up justifications were elicited after each

response, e.g., *Why was Ellie wrong? / How do you know Ellie was right?* Children gave verbal justifications, while adults were asked to write out brief justifications for each of their responses.

2.1.3 Materials

Each participant received two training items. These were simple true and false statements designed to familiarize the participant with the task. Subsequently participants received a randomized sequence of four target items, eight control items, and four filler items. These items were presented in two orders (one the reverse of the other). The full list of test sentences is provided in the Appendix.

Target items corresponded to sentences containing a plural subject noun phrase and two conjoined adjectival predicates, which were either compatible or incompatible. To create the predicate pairs for the INCOMPATIBLE condition, we selected gradable adjectives that were antonyms. More concretely, two adjectives A and B were considered *incompatible* if being A entailed being not-B; for example, being 'big' entails being 'not small', and being 'small' entails being 'not big'. For the COMPATIBLE condition, we chose to pair gradable adjectives with color adjectives, in order to ensure that the intersective interpretation was possible, and even natural; the colors were chosen in such a way as to be natural for the relevant objects (for example, brown or white bears, as opposed to pink bears). Notice that the *incompatible* pairs would fail the entailment test mentioned above: being 'big' does not entail being 'not white', and being 'white' does not entail being 'not big'.

An example image is given in Figure 2; an example trial is described in (9). If participants accessed the stronger intersective meaning, they were expected to find the INCOMPATIBLE target contradictory, and reject it.[1] Similarly, participants were expected to reject the COMPATIBLE target, as the strong meaning made the target sentence a false description of the picture. If participants accessed weak meanings, they were expected to accept both kinds of target sentences.

(9) Example test trial (accompanying Figure 2)
Experimenter: What a beautiful day. Look at all the bears on the mountainside! Ellie, can you tell us something about the bears?

a. INCOMPATIBLE condition
Puppet: Hmm. . . the bears are big and small!

b. COMPATIBLE condition
Puppet: Hmm. . . the bears are big and white!

[1] An anonymous reviewer objects that a *no*-response to the INCOMPATIBLE target is difficult to interpret, because we cannot know whether the participant is rejecting the intersective interpretation of "The bears are big and small", or simply the incompatibility of simultaneously being big and small. As we will see, participants generally accepted the INCOMPATIBLE targets. However, we would note that the alignment of the antonymy of *big* and *small* with the rejection of the intersective interpretation is precisely what we capitalize on in this experiment; if participants access an intersective interpretation of (9a), they must necessarily reject the sentence, precisely because it is impossible to be simultaneously short and tall. Only if participants access a non-intersective interpretation can they provide a *yes*-response. In this way, participants' *yes*-/*no*-responses allow us to infer which interpretation they have accessed for the target sentences.

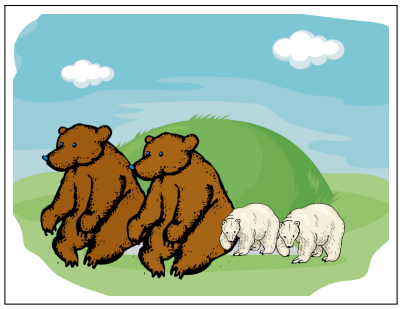

Figure 2: Image accompanying the INCOMPATIBLE *The bears are big and small* and the COMPATIBLE *The bears are big and white*. The two bears to the left are simultaneously big and brown, and the two bears on the right are simultaneously small and white.

In addition to the target sentences, participants received three kinds of unambiguously true and unambiguously false control sentences, containing a singular subject noun phrase. Participants heard two false control sentences containing a singular subject and incompatible conjoined predicates (only one of the predicates was true of the object in the picture), two false control sentences containing a singular subject and compatible conjoined predicates (again, only one of the predicates was true of the object), and two true control sentences containing a singular subject and compatible conjoined predicates where both predicates were true of the object in the picture. These sentences can be found in the Appendix.

Finally, to balance the overall number of *yes*- and *no*-responses across the experiment, four filler items without conjunction were included, each of which could be associated with a *yes*- or a *no*-target.

2.2 Results

Both groups displayed above 93% accuracy across the various control and filler conditions. The performance by child and adult participants in the target conditions are presented in Figure 3, plotted as the percentage of *yes*-responses to the COMPATIBLE and INCOMPATIBLE targets. A two-way ANOVA revealed a significant main effect of the compatibility of the conjoined predicates ($F(1, 44) = 92.01, p < .001$), no effect of group, and no interaction between compatibility and group. Both adult and child participants were significantly more accepting in the INCOMPATIBLE condition than in the COMPATIBLE condition (Tukey HSD, both $p < .001$).

Participants were generally consistent in their responses, either accepting or rejecting at least three of four targets. Only four of the 26 children gave mixed responses (two *yes*-responses and two *no*-responses).

Children and adults gave similar justifications for their responses. These fell into three categories. Recall that *yes*-responses were indicative of the weaker, split interpretation. Justifications for accepting the INCOMPATIBLE targets indeed made reference to the two subsets of objects that verified the two predicates, e.g., *There are two short pants and two long pants* or *The green ones are tall and the yellow are short.*

No-answers were indicative of the strong, intersective reading. Justifications for rejecting the COMPATIBLE targets indeed made reference to the failure of the objects to satisfy both

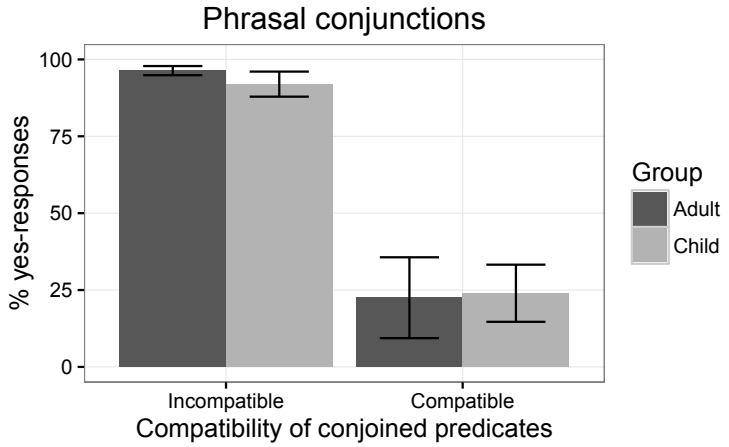

Figure 3: Percentage of *yes*-responses from children and adults in the phrasal INCOMPATIBLE and COMPATIBLE conditions. *Yes*-responses were indicative of weak readings, and *no*-responses were indicative of strong readings.

predicates, e.g., *These giraffes are tall but not yellow* or *The bears are big or white, not both.*

Finally, those participants who accepted the COMPATIBLE targets gave justifications similar to the justifications participants offered in the INCOMPATIBLE condition, making reference to the two subsets of objects that verified the two predicates, e.g., *Some are round and some are red* or *The grizzly bears are big, the polar bears are small.*

2.3 Summary

The results of Experiment 1 reveal that 4-year-olds and adults were alike in preferring strong readings of COMPATIBLE predicate conjunctions, but weak readings of INCOMPATIBLE predicate conjunctions. Two of the 11 adults and one of the 10 children in the COMPATIBLE condition consistently accepted the target sentences, apparently accessing the weak reading. If we assume that Poortman's (Submitted) typicality effect tolerates individual variation, it may not be so surprising that rejection in the COMPATIBLE condition was not absolute. Importantly, children's responses did not differ significantly from those of adults in either condition.

3 Experiment 2

In a second experiment, we tested participants' interpretation of the sentential versions of the INCOMPATIBLE predicate conjunctions from Experiment 1. We designed this additional experiment with two goals in mind.

First, given that previous developmental studies of conjunction have been somewhat equivocal about the relative primacy of phrasal vs. sentential conjunction in the child's grammar, we wanted to see whether children would also be adult-like in their interpretation of the sentential coordination equivalents of the predicate conjunctions.

Second, adding this follow-up experiment allowed us to further investigate two related predictions. Recall that both groups in Experiment 1 generally found the INCOMPATIBLE predicate conjunctions acceptable. One strategy that could have given rise to this pattern would involve interpreting the sentences, e.g., (10), as involving an underlying sentential conjunction (11), such that the two definite plurals could refer to two different sets of bears.

(10) The bears are big and small.

(11) The bears$_i$ are big and the bears$_j$ are small.

If this kind of 'reference shift' is behind the acceptability of the INCOMPATIBLE targets in Experiment 1, we should observe the same acceptibility for the sentential forms of these predicate conjunctions.

Winter (2001b), however, predicts that only (10) should be acceptable (and true in a context where half of the bears are big and half are small). On his account, speakers should only generate a contradictory reading of the sentential conjunction in (11), in the same context. This follows from the fact that the ESMH only applies at the predicate level. In (11), the ESMH applies in each sentential conjunct. Since the basic meaning in each conjunct doesn't result in any semantic violations or contradictions, the ESMH has no effect. The basic meaning of the sentence as a whole is therefore predicted to be incoherent. In contrast, the meaning assigned in (10) is coherent because predicate conjunction compositionally applies before predication, and before the application of the ESMH. The sentence is thus assigned the weakened meaning, making it coherent. Adding this follow-up experiment allowed us to further investigate this prediction.

3.1 Method

3.1.1 Participants

We report here on data from 14 children ($3;11 - 5;03, M = 4;07$) and 36 adult native speakers of English. An additional six adults were tested but excluded from analysis, as they reported being native speakers of languages other than English. One additional child began the task but did not finish it, and was not included in the analysis.

Due to practical constraints, the 14 child participants in Experiment 2 had all participated in Experiment 1. We sought to minimize contamination effects in the following ways. First, we ensured that a suitable time period elapsed between completion of Experiment 1 and participation in Experiment 2; on average, three weeks elapsed between the two experimental sessions. This was to ensure that children would not remember specific details of the experiment. In addition, the puppet participating in the task was changed from Ellie the Elephant to Raffie the Giraffe. The children were told that although the game would be similar, they would be playing with a different puppet, whose sentences they would also have to judge. This move was made to encourage children to treat the second session (Experiment 2) as a separate game from Experiment 1, and children were generally enthusiastic to have a chance to play the game with a new puppet. As a final precaution against contamination, we counterbalanced which condition the children of Experiment 2 had seen in Experiment 1; half had participated in the COMPATIBLE condition and half in the INCOMPATIBLE condi-

tion. This was simply to ensure a balance of participants in Experiment 2, rather than, for example, having an entire group of children who had only seen the INCOMPATIBLE condition.

3.1.2 Procedure

We used the same Truth Value Judgment task as in Experiment 1. Participants were presented with a series of pictures on a laptop computer, and had to judge a pre-recorded puppet's descriptions of the objects in the pictures. Again, participants were asked to fill out a scorecard for the puppet. Follow-up justifications were elicited from children and adults after each response.

3.1.3 Materials

The target and control sentences from Experiment 1 were modified minimally to contain sentential rather than phrasal conjunction. Only the four singular conjunction-less filler sentences remained unchanged. Each participant received two training items, followed by a pre-randomized sequence of four targets, eight controls, and four fillers. Again, the test items were presented in two orders, one the reverse of the other.

The four target sentences were the same as in Experiment 1, except that they contained sentential rather than phrasal conjunction. Each clause contained the same plural subject noun phrase, and the predicates in the two clauses were incompatible with each other. An example trial is given in (12); the accompanying image for this trial would be Figure 2.

(12) Example test trial (accompanying Figure 2)
Experimenter: What a beautiful day. Look at all the bears on the mountainside! Ellie, can you tell us something about the bears?
Puppet: Hmm... the bears are big and the bears are small!

In addition to the targets, participants were presented with three kinds of control sentences, which were formed by changing the phrasal conjunctions in Experiment 1 into sentential conjunctions. Participants heard two control sentences with incompatible predicates in the two clausal conjuncts (only one of the predicates was true of the object in the picture), two control sentences with compatible predicates in the two clauses (again, only one of the predicates was true of the object), and two control sentences with compatible predicates in the two clauses (where both predicates were true of the object in the picture).

Finally, to balance the number of *yes*- and *no*-responses, we included the same four conjunction-less fillers from Experiment 1, each of which could be associated with a *yes*-target or a *no*-target. All test sentences can be found in the Appendix.

3.2 Results

Both groups displayed above 93% accuracy across the various control and filler conditions. In Figure 4, we compare the children's and adults' performance in the INCOMPATIBLE sentential target condition with that of the INCOMPATIBLE phrasal target condition from Experiment 1. Adults and children generally accepted the sentential conjunction targets, contra the prediction of the ESMH. A 2-way ANOVA on the two incompatible conditions (phrasal and

sentential) revealed no main effects of conjunction type or group, and no interaction between conjunction type and group.

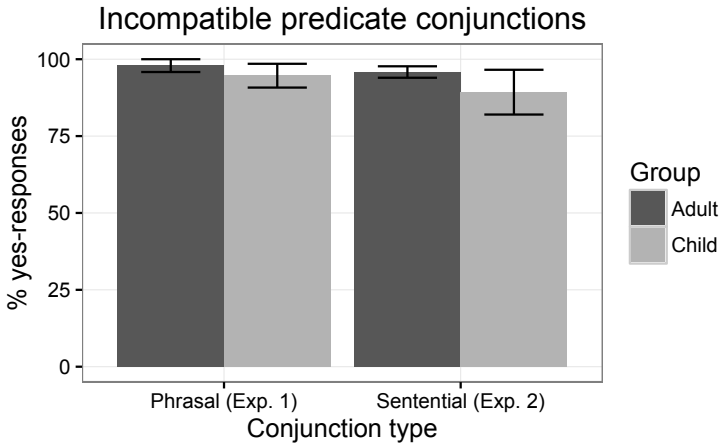

Figure 4: Percentage of *yes*-responses from children and adults in the *sentential* INCOMPATIBLE condition of Experiment 2, compared to the *phrasal* INCOMPATIBLE condition of Experiment 1. *Yes*-responses were indicative of weak readings, while *no*-responses were indicative of strong readings.

With the exception of one adult participant, all participants were generally consistent in their responses, either accepting or rejecting at least three of four targets.

Follow-up justifications fell into two categories. One of the 14 children in the sentential conjunction condition rejected all four targets (indicative of the strong reading), and justified these *no*-responses by making reference to the failure of the objects to satisfy both predicates, e.g., *She said square and round, they're really square* or *I think she said something silly ... there's some big and some small.* The remaining participants accepted the sentential conjunction targets (indicative of the weak reading), justifying their *yes*-responses by making reference to the two subsets of objects that verified the two predicates, e.g., *Yeah, because these bears are big and those bears are small.*

One might worry that the test sentences with sentential conjunction were too long or difficult for children to process; this might have led them to resort to a strategy where they simply looked for objects in the picture that would verify the predicates in the two clausal conjuncts (thereby leading to *yes*-responses in the experiment). We think this is highly unlikely, however, for two reasons. First, previous studies have reported production of sentential conjunction by children as young as 2-3 years of age (e.g., Lust 1977; Bloom et al. 1980). Second, recall that the 14 children in Experiment 2 had also participated in Experiment 1. Half of these children had participated in the COMPATIBLE condition of Experiment 1, and we went back and looked at how these seven children had responded to the COMPATIBLE targets. Six of the seven had rejected all four COMPATIBLE targets, even though there were objects in the picture that verified both predicates (e.g., long pants and blue pants). If these children relied on a strategy that allowed them to say *yes* as soon as they could find objects in the picture that verified the two predicates, they should also have accepted the COMPATIBLE targets in Experiment 1, contrary to fact.

4 Discussion

Our results can be summarized as follows. The 4-year-old participants in the study were adult-like in their comprehension of phrasal and sentential predicate conjunctions. Both children and adults allowed a weaker, non-boolean reading of incompatible predicate conjunction, and favored the stronger, intersective reading of compatible predicate conjunction. In the context of Winter's (2001b) theory, the results suggest that children apply the ESMH where appropriate; that is, in the case of incompatible predicates, they are adult-like in allowing for a weakened, non-intersective meaning of conjunction.

More generally, the present findings also suggest that for common adjectives that are both frequent and familiar to 4-year-olds (e.g., color and shape terms), these children have accumulated enough world knowledge about the compatibility of the associated properties, such that they can decide whether or not the linguistic conjunction of the two predicates is possible. For instance, children appear to understand that it is possible to ascribe to an entity the property of being both long and blue, but that it is not possible to ascribe to an individual the property of being both big and small. This may be considered a part of their lexical knowledge of the relevant adjectives; but it must surely interact with real world knowledge that they accumulate as they interact with entities that satisfy the different predicates. This is especially plausible in light of Poortman's (Submitted) findings that the acceptability of non-boolean interpretations correlates with the perceived typicality of the complex predicate. Through real world experience, the child must be able to modify her typicality values for different combinations of predicates.

The main developmental findings aside, the results of Experiment 2 also introduce a new puzzle. The lack of a difference between responses to the phrasal and sentential INCOMPATIBLE targets is compatible with the Maximal Typicality Hypothesis (Kerem et al. 2009; Poortman 2014, Submitted), but does not conform to the predictions of the ESMH (Winter 2001b). In particular, the ESMH is not expected to apply at the sentential level, and therefore the sentential INCOMPATIBLE targets would be predicted to give rise to contradictory readings. Yet both child and adult participants in Experiment 2 accepted the sentential targets. One possible explanation for this puzzling finding lies in the possibility of domain restriction, or reference shift. That is, one might posit that participants assigned different referents to the definite noun phrases in the two sentential conjuncts. A possible future study might use proper name conjunctions, which would prevent quick reference shifts; one might expect it to be harder to accept (13) (in a context where John and Bill are tall and Sue and Jane are short), compared to the targets in Experiment 2.

(13) John, Bill, Sue, and Jane are tall and short.

While there remain questions to be explored in future research, the present findings provide the first piece of empirical evidence that children are sensitive to both intersective and split readings of predicate conjunction, and can use their lexical and world knowledge of the relevant predicates in order to select an appropriate reading. This sophisticated knowledge goes well beyond understanding and using conjunction as a general, multi-purpose connective.

Appendix: Test sentences

Experiments 1 & 2

(14) Training items

a. The box is black. (*target: yes*)
b. The coat rack is very tall. (*target: no*)

(15) Filler items

a. The box is striped (*target: no*) / The box is polka-dotted (*target: yes*)
b. The vase is blue (*target: no*) / The vase is pink (*target: yes*)
c. The bowl is yellow (*target: no*) / The bowl is blue (*target: yes*)
d. The box is fuzzy (*target: no*) / The box is wooden (*target: yes*)

Experiment 1 (Phrasal conjunction)

(16) Incompatible targets

a. *Context: 2 big brown bears, 2 small white bears*
INCOMPATIBLE: The bears are big and small. *(target: no)*
b. *Context: 2 long brown pants, 2 short blue pants*
INCOMPATIBLE: The pants are long and short. *(target: no)*
c. *Context: 2 tall green giraffes, 2 short yellow giraffes*
INCOMPATIBLE: The giraffes are tall and short. *(target: no)*
d. *Context: 2 round brown frames, 2 square red frames*
INCOMPATIBLE: The window frames are round and square. *(target: no)*

(17) Compatible targets

a. *Context: 2 big brown bears, 2 small white bears*
COMPATIBLE: The bears are big and white. *(target: yes)*
b. *Context: 2 long brown pants, 2 short blue pants*
COMPATIBLE: The pants are long and blue. *(target: yes)*
c. *Context: 2 tall green giraffes, 2 short yellow giraffes*
COMPATIBLE: The giraffes are tall and yellow. *(target: yes)*
d. *Context: 2 round brown frames, 2 square red frames*
COMPATIBLE: The window frames are round and red. *(target: yes)*

(18) Plural – true controls

a. The dinosaurs are big and green. *(target: yes)*
b. The buildings are tall and purple. *(target: yes)*

(19) Singular – false incompatible controls

a. The bowl is striped and polka-dotted. *(target: no)*
b. The pencil is long and short. *(target: no)*

(20) Singular – true compatible controls

a. The apple is small and red. *(target: yes)*
b. The balloon is big and colorful. *(target: yes)*

(21) Singular – false compatible controls

a. The bear is big and white. *(target: no)*
b. The heart is small and fuzzy. *(target: no)*

Experiment 2 (Sentential conjunction)

(22) Incompatible targets

a. *Context: 2 big brown bears, 2 small white bears*
INCOMPATIBLE: The bears are big and the bears are small. *(target: no)*
b. *Context: 2 long brown pants, 2 short blue pants*
INCOMPATIBLE: The pants are long and the pants are short. *(target: no)*
c. *Context: 2 tall green giraffes, 2 short yellow giraffes*
INCOMPATIBLE: The giraffes are tall and the giraffes are short. *(target: no)*
d. *Context: 2 round brown frames, 2 square red frames*
INCOMPATIBLE: The window frames are round and the window frames are square. *(target: no)*

(23) Plural – true controls

a. The dinosaurs are big and the dinosaurs are green. *(target: yes)*
b. The buildings are tall and the buildings are purple. *(target: yes)*

(24) Singular – false incompatible controls

a. The bowl is striped and the bowl is polka-dotted. *(target: no)*
b. The pencil is long and the pencil is short. *(target: no)*

(25) Singular – true compatible controls

a. The apple is small and the apple is red. *(target: yes)*
b. The balloon is big and the balloon is colorful. *(target: yes)*

(26) Singular – false compatible controls

a. The bear is big and the bear is white. *(target: no)*
b. The heart is small and the heart is fuzzy. *(target: no)*

References

Ardery, G. (1980). On coordination in child language. *Journal of Child Language*, *7*, 305–320.

Bloom, L., Lahey, M., Hood, L., Lifter, K., & Fiess, K. (1980). Complex sentences: acquisition of syntactic connectives and the semantic relations they encode. *Journal of Child Language*, *7*, 235–261.

Bowerman, M. (1979). The acquisition of complex sentences. In M. Garman, & P. Fletcher (Eds.) *Studies in language acquisition*, (pp. 285–305). Cambridge: Cambridge University Press.

Chomsky, N. (1957). *Syntactic structures*. The Hague: Mouton.

Chomsky, N. (1977). *Essays on form and interpretation*. Amsterdam, The Netherlands: North-Holland Publishing Company.

Crain, S., Goro, T., Notley, A., & Zhou, P. (2013). A parametric account of scope in child language. In S. Stavrakaki, M. Lalioti, & P. Konstantinopoulou (Eds.) *Advances in language acquisition*, (pp. 63–71). Cambridge: Cambridge Scholar Publishing.

Crain, S., & Thornton, R. (1998). *Investigations in Universal Grammar: A Guide to Experiments on the Acquisition of Syntax and Semantics*. Cambridge, Massachusetts: MIT Press.

Crain, S., & Thornton, R. (2000). *Investigations in Universal Grammar: A Guide to Experiments on the Acquisition of Syntax and Semantics*. Cambridge, Massachusetts: MIT Press.

Cromer, R. (1968). *The development of temporal references during the acquisition of language*. Ph.D. thesis, Harvard University.

Dalrymple, M., Kanazawa, M., Kim, Y., Mchombo, S., & Peters, S. (1998). Reciprocal expressions and the concept of reciprocity. *Linguistic and Philosophy*, *21*, 159–210.

Dalrymple, M., Kanazawa, M., Mchombo, S., & Peters, S. (1994). What do reciprocals mean? In M. Harvey, & L. Santelmann (Eds.) *Proceedings of the 4th Semantics and Linguistic Theory Conference*.

de Villiers, J., Tager-Flusberg, H., & Hakuta, K. (1977). Deciding among theories of the development of coordination in child speech. *Stanford Papers and Reports on Child Language Development*, *13*, 118–125.

Dougherty, R. C. (1968). *A transformational grammar of coordinate conjoined structures*. Ph.D. thesis, Massachusetts Institute of Technology.

Dougherty, R. C. (1970). A grammar of coordinate conjoined structures, I. *Language*, *46*(4), 850–898.

Greenfield, P. M., & Dent, C. H. (1981). Pragmatic factors in children's phrasal coordination. *Journal of Child Language*, *9*, 425–443.

Grosu, A. (1979). Review of n. chomsky, essays on form and interpretation (new york: North-holland). *Journal of Linguistics*, *15*, 356–364.

Hakuta, K., de Villiers, J., & Tager-Flusberg, H. (1980). Sentence coordination in Japanese and English. *Journal of Child Language*, *9*, 193–207.

Harries, H. (1973). Coordination reduction. *Stanford University Working Papers on Language Universals*, *11*, 139–209.

Hoeksema, J. (1987). The semantics of non-boolean AND. *Journal of Semantics*, (6), 19–40.

Keenan, E. L., & Faltz, L. M. (1985). *Boolean Semantics for Natural Language*. Dordrecht: Reidel Publishing Company.

Kerem, N., Friedmann, N., & Winter, Y. (2009). Typicality effects and the logic of reciprocity. In E. Cormany, S. Ito, & D. Lutz (Eds.) *Proceedings of the 19th Semantics and Linguistic Theory Conference*, (pp. 257–274).

Krifka, M. (1990). Boolean and non-boolean 'and'. In L. Kálmán, & L. Pólos (Eds.) *Papers from the Second Symposium on Logic and Language*, (pp. 161–188). Budapest: Akadémiai Kiadó.

Lakoff, G., & Peters, S. (1969). Phrasal conjunction and symmetric predicates. In D. Reibel, & S. Shane (Eds.) *Modern Studies in English*. New York: Prentice-Hall.

Lasersohn, P. (1995). *Plurality, Conjunction and Events*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Lust, B. (1977). Conjunction reduction in child language. *Journal of Child Language*, *4*,

257–287.

Lust, B., & Mervis, C. A. (1980). Development of coordination in the natural speech of young children. *Journal of Child Language*, *7*, 279–304.

Notley, A. M., Zhou, P., & Crain, S. (2016). Children's interpretation of conjunction in the scope of negation in English and Mandarin: New evidence for the semantic subset maxim. *Applied Psycholinguistics*, *37*(4), 867–900.

Paris, S. G. (1973). Comprehension of language connectives and propositional logical relationships. *Journal of Experimental Child Psychology*, *16*, 278–291.

Partee, B. H., & Rooth, M. (1983). Generalized conjunction and type ambiguity. In R. Bäuerle, C. Schwarze, & A. von Stechow (Eds.) *Meaning, Use and Interpretation of Language*, (pp. 362–383). de Gruyter.

Peterson, C., & McCabe, A. (1987). The connective 'and': do older children use it less as they learn other connectives? *Journal of Child Language*, *14*, 375–381.

Peterson, C., & McCabe, A. (1988). The connective 'and' as discourse glue. *First Language*, *8*, 19–28.

Poortman, E. B. (2014). Between intersective and 'split' interpretations of predicate conjunction: The role of typicality. In J. Degen, M. Franke, & N. Goodman (Eds.) *Proceedings of Formal & Experimental Pragmatics 2014*, (pp. 36–42).

Poortman, E. B. (Submitted). Concept typicality and the interpretation of plural predicate conjunction. In Y. Winter, & J. Hampton (Eds.) *Compositionality and Concepts in Linguistics and Psychology*, Language, Cognition, and Mind. Springer.

Reitz, S. M. (2013). *Context-dependent interpretation of the conjunction und in different age-groups*. Ph.D. thesis, Johannes Gutenberg-Universität.

Ross, J. (1967). *Constraints on variables in syntax*. Ph.D. thesis, Massachusetts Institute of Technology.

Stockwell, R. P., Schachter, P., & Partee, B. H. (1973). *The Major Syntactic Structures of English*. New York: Holt, Rinehart and Winston, Inc.

Tager-Flusberg, H., de Villiers, J., & Hakuta, K. (1982). The development of sentence coordination. In S. Kuczaj (Ed.) *Language Development: Volume 1: Syntax and Semantics*, (pp. 201–243). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Williams, E. (1978). Across-the-board rule application. *Linguistic Inquiry*, *9*(1), 31–43.

Winter, Y. (1996). A unified semantic treatment of singular NP coordination. *Linguistics and Philosophy*, *19*(4), 337–392.

Winter, Y. (2001a). *Flexibility Principles in Boolean Semantics*. Cambridge, Mass.: MIT Press.

Winter, Y. (2001b). Plural predication and the Strongest Meaning Hypothesis. *Journal of Semantics*, *18*(4), 333–365.