languages

MDPI

Article

Children's Interpretation of Conditional Connectives

Duygu Sarısoy [1,*], Semih C. Aktepe [1,2] and Sena Gül [1,3]

[1] Department of Foreign Language Education, Middle East Technical University, 06800 Ankara, Turkey
[2] Department of Psychology, Philipps-University of Marburg, 35032 Marburg, Germany
[3] Department of Social, Political and Cognitive Sciences, University of Siena, 53100 Siena, Italy
* Correspondence: duyguo@metu.edu.tr

Abstract: Previous studies have shown that the uni-conditional marker *if* can be interpreted biconditionally in some contexts. Similarly, the biconditional marker *unless* may receive a biconditional interpretation in positive quantificational contexts (e.g., every) and a uni-conditional reading in negative quantificational contexts (e.g., no). However, exceptive accounts expect *unless* to yield a biconditional meaning in all contexts. Our aim in this preliminary study is to provide experimental evidence about how children interpret these conditional connectives. A recent study conducted with adult Turkish speakers found that *unless* was not semantically biconditional in either positive quantificational contexts or negative quantificational contexts (Evcen et al. 2019). We used a similar paradigm with a child-friendly adaptation to test how *if (-sA)*, *if not (değilse)*, and *unless (-mAdIkçA)* would behave with 5-year-old children acquiring Turkish. Our preliminary results indicate that children, unlike adults, disregard the antecedent hosting the conditional connective but focus only on the consequent hosting the quantifier structure. We argue this may be related to the higher syntactic and semantic complexity in these structures incurring heavy working memory demands.

Keywords: conditionals; connectives; language development; reasoning

Citation: Sarısoy, Duygu, Semih C. Aktepe, and Sena Gül. 2024. Children's Interpretation of Conditional Connectives. *Languages* 9: 365. https://doi.org/10.3390/languages9120365

Academic Editor: Jaklin Kornfilt

Received: 29 September 2022
Revised: 1 May 2024
Accepted: 7 November 2024
Published: 28 November 2024

1. Introduction

Conditional statements are composed of an antecedent and a consequent clause that is often connected by a conditional connective such as *if*, *if not*, or *unless*. In *if p, then q*, *p* is the antecedent and *q* is the consequent. Such statements are very frequent in everyday communication, and conditional thinking is an integral part of human cognition. The types of inferences derived from conditional statements have been a recurring topic among logicians, linguists, philosophers, and cognitive scientists. Yet, how we reason or interpret conditional statements and how this ability develops is far from clear.

The theoretical issue revolves around whether the conditional connectives receive *uni-conditional* or *biconditional* meaning (Geis and Zwicky 1971; Higginbotham 1986; Leslie 2009; Quine 1982; von Fintel 1991). A connective is uni-conditional when a statement like *p, then q* is treated as false only if the antecedent *p* is false, while the consequent *q* is true; it is treated as true in all other cases. This is also called a process of *material implication*. Biconditional interpretation, on the other hand, requires that both the antecedent *p* and the consequent *q* are true or they are both false.

This also aligns with the experimental discussion regarding how adults interpret these connectives. While the logical meaning of an indicative conditional connective *if*, for instance, is taken to entail a material implication in logic textbooks, there is a great deal of literature showing that adults may assign a biconditional interpretation to *if* (Wason 1966; Baratgin et al. 2018, and the references therein). The same is true for *unless* (Evcen et al. 2019; Nadathur and Lassiter 2015), such that it does not receive a biconditional interpretation all the time. Thus, the conditions under which individuals pick uni-conditional or biconditional meaning for these connectives, as well as how these meaning assignments may vary cross-linguistically, are far from clear.

Furthermore, we are also far from establishing whether or not children behave similarly to adults. We know from studies on the development of logical connectives that children can make inferences using logical connectives such as *and*, *or*, and *not* from two to three years of age (Mody and Carey 2016; Reuter et al. 2018). However, when it comes to making conditional inferences using the logical connective *if*, Inhelder and Piaget (1958) state that this type of reasoning might continue developing until adolescence. According to this view, conditional reasoning is a late-developing ability because deriving conclusions from the antecedent and the consequent of the conditional sentences depends on their possible combination of truth values. Therefore, acquiring the truth value combinations of the antecedent and the consequent that make the conditional sentence true could be a late achievement for children.

Yet, there is also a reason to believe that conditional reasoning might be an early-developing competence. Indeed, even babies as young as 15–17 months of age can learn words through reasoning on the basis of the *mutual exclusivity assumption* (Markman et al. 2003, and the references therein). In such studies, encountering one familiar novel object, children can reason that a novel name they hear should not refer to the familiar, but to the novel entity, which is called *mutual exclusivity assumption*. This certainly involves conditional reasoning (i.e., the child should be reasoning as follows: *if this new term does not refer to the familiar object I know, then it should be referring to the novel object; i.e., if not p, then q*). In those studies, however, the caveat is that this involves non-verbal or implicit reasoning about the antecedent and the consequent, so this finding shows that children are engaged in conditional reasoning, but it does not tell us much about how children make inferences while processing spoken utterances with overt conditional connectives.

Most of the previous studies on successful reasoning via conditional utterances come from older children around 12 years of age (Barrouillet and Lecas 1999). Only a few studies report successful comprehension of conditional structures in younger children. For instance, Harris and Núntez (1996) found that children as young as three years of age could reason correctly in real-world situations, such as permission or obligation contexts (e.g., *you can play outside if you wear your coat*). Also, we know from a recent Turkish study that children as young as 4 years of age show adult-like real-time processing of indicative and counterfactual conditionals presented in simple conditional sentences (e.g., *If Ali takes the umbrella, he will not get wet* or *If Ali had taken the umbrella, he would not have gotten wet*) (Aktepe 2022; Aktepe and Sarısoy 2024). Some may argue that, in those studies, children make inferences not on the basis of the logic of conditionals, but rather on the basis of pragmatics or world knowledge. Nevertheless, this may not actually be the case as mutual exclusivity studies indicate that the seeds of nonverbal conditional reasoning are present even in babies (Markman et al. 2003).

In the present study, we aim to investigate how Turkish-speaking preschool children and adults interpret conditional utterances constructed by three different conditional connectives, namely *if (-sA)*, *if not (değilse)*, and *unless (-mAdIkçA)*. We embedded the conditional utterances in positive quantifier contexts. By doing this, we also address the theoretical issue pertaining to the exact meaning of these connectives in such contexts (Geis and Zwicky 1971; Higginbotham 1986; Leslie 2009; von Fintel 1991). Two previous studies have focused on how adults interpret *if not* and *unless* in English (Nadathur and Lassiter 2015) and in Turkish (Evcen et al. 2019), so we also aim to compare our findings to these studies and present how the child pattern can be compared to that of adults. It is important to emphasize from the outset that the present study is a preliminary attempt to address these issues. Future research with greater numbers of participants and test items may provide clearer insights into these matters.

In the remainder of this introduction, we present different accounts of the semantics of these conditional connectives in different quantifier contexts, findings on the interpretation of conditionals in adults and children, and then we present the aim of our study.

1.1. Semantics of Conditional Connectives

Jackson (1979) argues that the logical meaning of the connective *if* can be captured by the mechanism of *material implication*, which assumes that the conditional statement *if p, then q* is false only if the antecedent *p* is true, but the consequent *q* is false. That is, for the statement in (1), the conditional is rejected only if John washes the car but does not receive $10. The negative conditional *if not* in (2) is similar except that the expectations are negated, in which case the conditional statement is false only if John does not give $10, even if he does not wash the car. However, the exceptive conditional *unless* in (3) yields a biconditional interpretation, such that it is true only when the antecedent and the consequent are both true (i.e., *John not washing my car* and *John giving me $10* are both true), as in (3b), or they are both false, as in (3c). The biconditional interpretation would lead to the rejection of this exceptive statement otherwise (i.e., in situations where the antecedent is true while the consequent is false, as in (3d), or in situations where the antecedent is false while the consequent is true, as in (3e)).

(1) a. If John washes my car, I will give him $10.
b. I gave John $10; therefore, he washed my car.
c. If and only if John washes my car, I will give him $10.

(2) a. If John does not wash my car, he will give me $10.
b. John gave me $10; therefore, he did not wash my car.
c. If and only if John does not wash my car, he will give me $10.

(3) a. Unless John washes my car, he will give me $10.
b. John did not wash my car; therefore, he gave me $10.
c. John washed my car; therefore, he did not give me $10.
d. John did not wash my car but he did not give me $10.
e. John washed my car but he gave me $10.

However, although each of these conditional connectives seems to have a well-defined meaning, we know from the psychology of conditional reasoning that even adult speakers do accept fallacious conditional statements (e.g., Evans 1993). For instance, reading the statements in (1a) and (2a), adult speakers of English fall into the fallacy of *affirming the consequent* where they assume that the antecedent must always be true when the consequent is true, as shown in (1b) and (2b). This boils down to the misinterpretation of the uni-conditional as a biconditional, as shown in (1c) and (2c). A similar pattern is observed for the exceptive conditional *unless* when it leads to a uni-conditional interpretation as in (3d) and (3e). Geis and Zwicky (1971) named this mechanism as *conditional perfection*. The sentence structure in which the conditional is embedded (e.g., connective type, tense, modifier, or quantifier structure) has been shown to influence the meaning of the conditional. Higginbotham (1986), for instance, realized that embedding the conditional statement in a positive nominal quantifier context (*every*), as in (4a), leads to a material implication interpretation while embedding in a negative quantifier context (*no*), as in (4b), cannot be interpreted as a material implication but as a conjunction such that it means there is no student who goofs off and be successful.[1]

(4) a. Every student will succeed if he works hard.
b. No student will succeed if he goofs off.

For *unless*, the picture is slightly more complicated, and there is no settled analysis of what exactly it means. While the classical approaches take it as *if not* (Quine 1982), Higginbotham (1986) underlines that this approach does not hold for the negative quantifier conditions (c.f., Clark and Clark 1977; Dancygier 1985; Fillenbaum 1986). He suggests that embedding it under a positive (5a), but not negative (5b), quantifier entails a material implication interpretation (Higginbotham 1986). This renders *unless* the same as *if not*

in positive quantifier conditions. Geis and Zwicky's (1971) analysis disagrees with this as it states that *unless* cannot be interpreted as *if not*, but it rather means *if and only if not* (Geis and Zwicky 1971) or *except if* (Geis 1973). For von Fintel (1991) too, *unless* is equated to *except for* and it should have a biconditional interpretation across the board in all quantifier domains. On the other hand, Leslie (2009) provides a counter-example suggesting that there may be some exceptions for the situation in (5b), where there may be a student who cannot succeed no matter how hard he works. This results in a biconditional interpretation for *unless* under the positive quantifier *every* while leading to uni-conditional interpretation under the negative quantifier *no*.

(5) a. Every student will succeed unless he goofs off.
b. No student will succeed unless he works hard.

Nadathur and Lassiter (2015) suggest that there is a similar conditional perfection mechanism for *unless* that is observed for *if*. On the basis of the examples they found from naturally occurring data, as in (6), they state that *unless* can be interpreted uni-conditionally in some contexts.

(6) Mantaou is always late unless she is already out before we meet, but she is often just less late then (Nadathur and Lassiter 2015, p. 449).

They use such examples to argue that uniqueness, just like *conditional perfection*, may actually be a generalized conversational implicature that is always at work unless it is overtly canceled. Thus, for *unless*, biconditionality is a default interpretation that arises via a pragmatic inference, but it is flexibly defeasible as observed in other generalized conversational implicatures. This view also underlines that assuming a binary truth conditional content would not reflect the patterns of interpretation for the conditional structures; instead, they suggest a pragmatic mechanism entertaining multiple possibilities (e.g., both uni-conditional and biconditional interpretation for *unless*) in line with context.

1.2. Interpretation of Conditional Connectives in Adult Speakers

To our knowledge, two studies have addressed the theoretical question above with adult speakers. Nadathur and Lassiter (2015) conducted an experimental study with English-speaking adults where they presented the participants with the scenes of twenty marbles either in red or blue color and with or without dots in them to investigate the interpretation of *if not* and *unless* statements, *Every marble has a dot unless/if it is (not) red*. They also had the target color marbles with and without dots with varying ratios (0.0, 0.2, 0.4, 0.6, 0.8, and 1.0). Their data showed that participants endorsed the biconditional interpretation of *unless* and *if not*, both for the positive and negative quantifier conditions in the positive across-the-board ratios by accepting the scenes where all of the target marbles (and none of the competitor marbles) had a dot. In the negative across-the-board ratios where neither the target nor the competitor marbles had dots, while participants found it acceptable for *if not* condition, they rejected it in *unless* condition for the positive and negative quantifier condition. However, for the intermediate range of target proportions (where all of the target colors and some of the competitor colors have dots), while the participants did not find these cases totally unacceptable, they found these cases more acceptable for *if not* condition compared to *unless* condition; and the cases for *unless* were more acceptable in the positive quantifier condition compared to the negative quantifier condition, where they did not observe such an asymmetry between *if not* and *unless*. This led them to conclude that "the difference between *unless* and *if not* under *every* appears to involve graded factors affecting felicity, rather than categorical factors involving truth" (p. 11).

Evcen et al. (2019) replicated Nadathur and Lassiter's (2015) study with Turkish-speaking adults. For the positive quantifier conditions, the participants judged *unless* but not *if not* biconditionally, such that they found ratio 1.0 trials more acceptable in *if not* than in *unless*, while *unless* and *if not* behaved similarly for the negative quantifier conditions. The pattern in Turkish was similar to English except that Turkish speakers accepted the pictures

where no marbles had dots in the negative quantifier condition in a manner, suggesting that they ignored the conditional clause but focused on the quantifier clause.

1.3. Conditional Reasoning in Children

Previous studies on children's reasoning using conditional utterances focused mostly on older children. In their study, Barrouillet and Lecas (1999) presented 9, 12, and 15-year-old adolescents a rule, *if you wear a white shirt, then you wear green trousers*, and four pictures of possible cases such as white shirt, green trousers *(p, q)*, white shirt, red trousers *(p, ¬q)*,[2] blue shirt, green trousers *(¬p, q)*, and blue shirt, red trousers *(¬p, ¬q)*, and asked them to select the appropriate pictures for the rule. The results showed that 9-year-old children only selected the conjunctive interpretation *(p, q)* cases, where there were white shirt, green trousers, while 12-year-olds also picked the biconditional interpretation cases, where there were *(¬p, ¬q)* cases, where there were blue shirt, red trousers, and 15-year-olds selected all three expected cases including the *material conditional (p, ¬q)* cases, where there were white shirt, red trousers.

Despite these studies reporting a late acquisition of conditional structures, we know from at least two studies that preschool children can actually interpret conditional utterances presented in structurally simple and pragmatically real-world situations. For instance, Harris and Núntez (1996) found that three-year-old children could reason conditionally in situations that are familiar to them from everyday situations (e.g., *you can play outside if you wear your coat*). Also, a recent study showed that four-year-old Turkish children can interpret indicative and counterfactual conditionals presented in simple utterances (e.g., *If Ali takes the umbrella, he will not get wet* or *If Ali had taken the umbrella, he would not have gotten wet*) (Aktepe 2022; Aktepe and Sarısoy 2024).

Given these conflicting findings, it is not clear when and under which conditions children interpret conditional utterances. It might be the case that previous studies that showed a later acquisition might have put children under a heavy processing load, or they might have expected them to think purely logically beyond everyday events.

We know, for instance, that children can use their pragmatic or world knowledge when making conditional inferences. Barrouillet and Lecas (1998) suggest that children's interpretation of conditional sentences might be context-dependent, such that they extract information from their mundane experiences. For example, when presented with a conditional sentence, *if the bird is female, then it has light plumage*, 12-year-old adolescents can make adult-like inferences such as *if the bird is male, then it has dark plumage*, since they know that a female bird must also have a male (binary) correspondent. On the other hand, when presented with non-binary context conditional sentences, *if they are roses, then we use white paper*, children did not show the same response pattern as the adults (Barrouillet and Lecas 1998).

In addition, Markovits and Barrouillet (2002) propose that when people hear a conditional sentence like *if it rains, then the street will be wet*, they can infer that *if it is sunny, then the street is dry*. On the other hand, they can reason that the street is wet even if it does not rain because a fire hydrant might have burst, or the street is dry even if it rains because the street is covered. Therefore, they state that the interpretation of conditional sentences is driven by pragmatics, given the retrieval of the real-world experiences of the people. This essentially problematizes the use of abstract examples where the individual does not have any experiential base to evaluate. One other important gap in the literature is that they treat these structures as unambiguous and expect a 'single correct response' that may not be possible even for an adult processor.

1.4. Present Study

In the present study, we investigate how Turkish-speaking children interpret conditional connectives *if, if not*, and *unless* in a study that is modeled after Nadathur and Lassiter (2015) and Evcen et al. (2019). Different from these studies, we do not focus on the difference between the positive and negative quantifier contexts because we believe that embedding the conditional structures under positive quantifier contexts should not

increase the complexity and should not pose a challenge for the age group we are testing, as positive quantifiers appear as young as 2 years of age, while the negative quantifiers are not fully adult-like until school age (Barner et al. 2009; Katsos et al. 2011). Crucially, this pattern is cross-linguistically validated among 31 languages, including Turkish (Katsos et al. 2016).

The *material implication* interpretation would expect uni-conditional interpretation for all three connectives *(if, if not,* and *unless)*. Geis and Zwicky (1971), von Fintel (1991) and Leslie (2009) would all expect a *material implication* interpretation for *if* and *if not*, and biconditional interpretation for *unless* under positive quantifier contexts. The pragmatic view, on the other hand, would expect both uni-conditional and biconditional interpretation for *unless* (Nadathur and Lassiter 2015), and we reason that this view would expect that this flexible pattern would also be true for *if* and *if not*.

2. Materials and Methods

2.1. Participants

Sixteen children aged between 4;06 and 5;06 years old (M_{age} = 5;02, SD = 0;3, 9 girls, 7 boys) and fifteen adults (M_{age} = 27.26, SD = 6.60, 9 females, 6 males) were recruited as the control group for the experiment. Children were reported to be typically developing with no physical, neurological, or behavioral diagnosis. The participants were native speakers of Turkish and naïve to the purpose of the study. We recruited the child participants from the Middle East Technical University (METU) Nursery School in Ankara. Before recruiting for the experiment, we asked for written consent from their parents for participation. We also asked for oral consent from the children just before the experiment. The parents of other children who participated in another experiment at the METU Language and Cognitive Development Lab served as our adult control participants. Their participation was voluntary, and they were also asked for written consent.

2.2. Stimuli and Design

We modeled our study after Nadathur and Lassiter's (2015) marble experiment described above to examine the interpretation of *if (-sA), if not (değilse),* and *unless (-mAdIkçA)*. Since marble scenes might be too abstract for children to interpret, we adapted our experiment to a child-friendly paradigm. Our paradigm included animals of different colors and their favorite items (e.g., yellow or white rabbits with or without a carrot). In our test items, we varied the connector type among *if, if not,* and *unless*, and the ratio of the animals with the favorite item among 0.0, 0.4, and 1.0 to see whether the degree of acceptability varies in line with the ratio (see Appendix A for all sentences). Both factors were manipulated within-subjects so all participants saw all sentence types and ratios. To simplify the task for our child participants, we only included three ratios that were reported to yield significant differences in the previous studies while omitting the intermediate levels of ratios (i.e., 0.2, 0.6, and 0.8) that yielded no differences (Evcen et al. 2019; Nadathur and Lassiter 2015).

In the experiment, participants first saw a scene where animals of different colors had their favorite items in a varying ratio (Figure 1). Then, they heard a conditional utterance including one of the three conditional connectives (*if (-sA)* (7a), *if not (değilse)* (7b), and *unless (-mAdIkçA)*) (7c). Their task was to decide whether the utterance they heard described the scene correctly or not. This binary response constituted our dependent variable.

In our visual scenes, there were six animals and each had a favorite item, so there were six animal–item pairs (e.g., rabbit–carrot, dog–bone, cat–ball, monkey–banana, mouse–cheese, and bear–honey). In each scene, there were ten of the same animals in two different colors (e.g., 5 yellow, and 5 white rabbits) (Figure 1). Animals of a certain color were considered as the target animals, and this was specified by the color adjective used in the conditional sentence. As mentioned above, we used three different connectives (*if (-sA)* (7a), *if not (değilse)* (7b), and *unless (-mAdIkçA)*) (7c). Thus, the target color did not change with the connective type. For instance, the target color is white for the sentences constructed by *if*, (e.g., *Every rabbit has a carrot if their color is white*), *if not* (e.g., *Every rabbit has a carrot if their color is not white*) or by *unless* (e.g., *Every rabbit has a carrot unless their color is white*).

However, it is important to note that the color of the animal that had the favorite item did change with respect to the connective. For the conditionals with *if*, the target animals had the favorite items, whereas for the conditions with *if not* and *unless*, the non-target animals had the items. The location of the target animals was also counterbalanced so that they appeared on the right or on the left side of the screen equally frequently. This whole setting gave us 72 pictures in total.

As for the number of items, there were 6 items for each connective type, and each of these items appeared in three different scenes because of the ratios described above. All items were counterbalanced according to the connective and the ratio of the animals with or without the favorite object. Participants were randomly assigned to one of the three lists where the order of the items was randomized to avoid any order effect. In each list, the favorite items appeared with 6 different animals in 3 different connectives in 2 different ratios. This gave us 36 test items (trials) in each list.[3] No trial containing the same animals was presented to make the children think that the scene had changed, potentially avoiding any recall effect. Considering the limited attention span of the child participants, no filler or distractor items were used in the experiment to decrease the complexity of the study and to decrease the number of total items that our participants saw. There are studies using no filler or distractor items when there are multiple conditions tested within-subjects (e.g., Degen and Tanenhaus 2016).

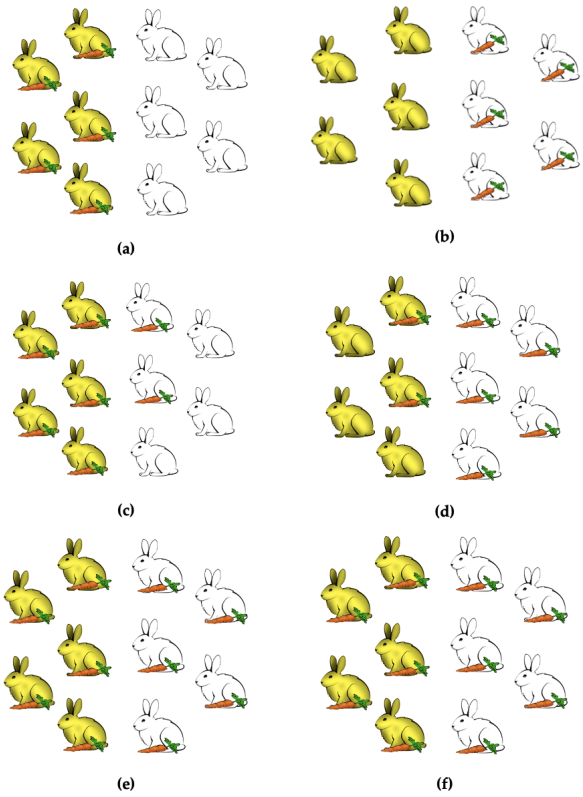

Figure 1. Visual scenes seen in the experiment. Left hand side pictures were shown in *if not* and *unless* trials, right hand side pictures were shown in *if* trials. Pictures (**a**,**b**) were presented in ratio 0.0 trials, (**c**,**d**) in the ratio 0.4 trials, and (**e**,**f**) in the ratio 1.0 trials.

(7) a. Tavşan-lar-ın reng-i beyaz-sa her tavşan-da havuç var.
rabbit-Plu-Gen color-Poss.3 white-if every rabbit-Loc carrot-Nom have
Every rabbit has a carrot if the rabbits' color is white.

b. Tavşan-lar-ın reng-i beyaz değil-se her tavşan-da havuç var.
rabbit-Plu-Gen color-Poss.3 white not-if every rabbit-Loc carrot-Nom have
Every rabbit has a carrot if the rabbits' color is not white.

c. Tavşan-lar-ın reng-i beyaz ol-madıkça her tavşan-da havuç var.
rabbit-Plu-Gen color-Poss.3 white be-unless every rabbit-Loc carrot-Nom have
Every rabbit has a carrot unless the rabbits' color is white.

We created the visual scenes by copying and pasting different animals and their favorite items from a previous study (Özge et al. 2019). The experimental sentences were voiced by a female native speaker of Turkish. The recording was made using *Audacity*, an open-source audio editing and recording software. The audio files were recorded on a mono channel at 44,100 Hz sampling frequency to eliminate the imbalance between right and left ear sound levels. We also cleaned the noise and normalized the audio level among the recordings using the same software.

2.3. Norming the Test Items

To norm the items we used in our experiment, we asked thirty native speakers of Turkish aged between 21 and 47 years old ($M_{age} = 25.86, SD = 5.61$, 23 females, 7 males) to rate the acceptability of our 18 test items (6 items per connective type). We also added 18 grammatical and 18 ungrammatical control sentences to make sure there were enough items with very high and very low ratings. Thus, there were a total of 54 items in this norming task. Grammatical controls were the same as the experimental sentences (repeated in (8)), but the quantified singular noun (e.g., *her tavşan*) in the consequent was replaced with a quantifier *hepsi* (*all* in English), referring to the plural noun in the antecedent as in (8b). Ungrammatical controls were the same as grammatical controls, but their antecedent was divided by the consequent as in (8c).

(8) a. Tavşan-lar-ın reng-i beyaz-sa her tavşan-da havuç var.
rabbit-Plu-Gen color-Poss.3 white-if every rabbit-Loc carrot-Nom have
Every rabbit has a carrot if the rabbits' color is white.

b. Tavşanların rengi beyazsa hepsinde havuç var.
rabbit-Plu-Gen color-Poss.3 white-if all-Loc carrot-Nom have
All have a carrot if the rabbits' color is white.

c. *Tavşanların rengi hepsinde havuç var beyazsa.
rabbit-Plu-Gen color-Poss.3 all-Loc carrot-Nom have white-if
*If the rabbits' color all have a carrot is white.

A cumulative link mixed model was fit to analyze the norming data using *ordinal* package (version 2022.11-16) (Christensen 2022), and pairwise comparisons were performed using *emmeans* package (version 1.8.4-1) (Lenth et al. 2019). The results[4] showed that there was no significant difference between experimental and grammatical sentences in the corresponding connectives. That is, experimental *if*, *if not*, and *unless* sentences were rated similarly as grammatical control *if*, *if not*, and *unless* sentences, respectively. On the other hand, experimental *if, if not*, and *unless* sentences were rated similarly, which was also valid for grammatical *if, if not*, and *unless* sentences and ungrammatical *if, if not*, and *unless*. Finally, ungrammatical control sentences were rated significantly less than grammatical control and experimental sentences in each connective. Thus, we can conclude that our test items were as acceptable as grammatical control items, and this rate did not change with respect to the connective type.

2.4. Procedure

Our participants participated in the experiment in a silent room at the nursery school or at the METU Language and Cognitive Development Laboratory. They sat in front of a computer screen running at a 144 Hz refresh rate. The participants saw the visual stimuli on this screen and they heard the spoken utterances. Their task was to decide whether or not the utterances described the scenes correctly. The auditory stimuli were presented by

external speakers. The volume level was adjusted for the participants so that they could hear the stimuli comfortably.

Prior to the experiment, the experimenter gave the child participants the following instruction: *"In this task, you will see a picture and hear an utterance related to that picture. If you think that the utterance is correct for the picture, say 'correct'. If not, say 'wrong' "*. The experimenter used a button box to register the responses of the child participants, which was to prevent dual-tasking. Adult participants were given the same instruction, except that they were asked to press a specified button using the button box to code in their own responses. Participants were able to listen to the auditory stimuli as many times as they wanted. Before the experimental items were introduced, the participants were shown two training items to familiarize themselves with the task. The whole session took approximately fifteen minutes.

3. Results

Figure 2 shows that children found the ratio 1.0 trials where both the target and non-target animals had their favorite item more acceptable than the trials with the other ratios. The acceptability in the ratio 0.0 and 0.4 trials was at the 50% band, such that children did not consistently accept or reject the conditional sentences in those ratios regardless of the connective type. On the other hand, adult participants accepted the utterances with *if* connective more than the other connectives irrespective of the ratio. In *if not* and *unless*, they found the ratio 0.0 trials more acceptable than the ratio 0.4 and 1.0 trials. To statistically evaluate these patterns, we fitted a Bayesian generalized linear mixed model using *brms* package (version 2.21.0) (Bürkner 2017) in *R* statistical programming language environment (R Core Team 2021).

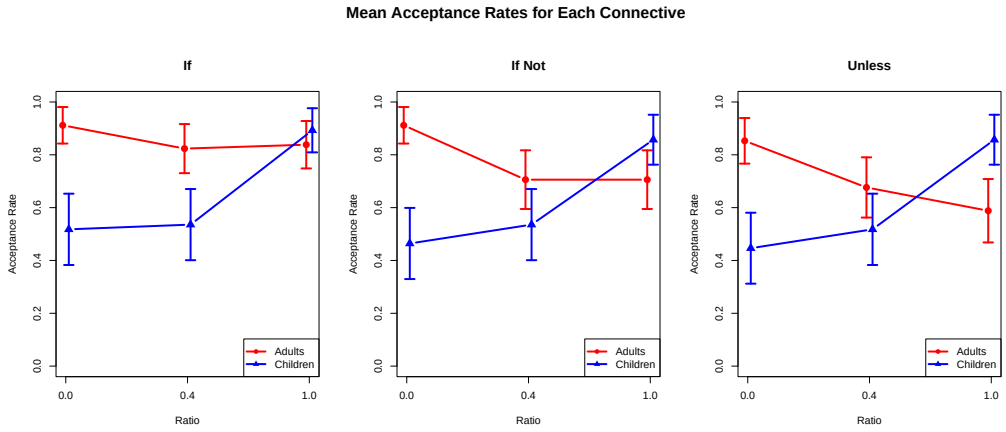

Figure 2. Mean acceptance rates for each connective (with 95% confidence interval).

We introduced the participants' responses as our dependent variable to the model. The responses of the participants were coded as 1 if they said *correct* and 0 if they said *wrong*. Thus, the data had a binomial distribution. Group, type of conditional connective, and the ratio were introduced as our independent variables to the model. The levels of the independent variables were dummy coded, such that the intercept of the model corresponds to the mean of children, connective *if*, and ratio 0.0. We also introduced the subject and the item as our random effects. The most complex model we fitted included the interaction of the fixed effects, the random slope of the type of connective, ratio, and their interaction for subject, and the random slope of group for item. The random intercepts and slopes were also correlated (Barr et al. 2013). The final model's syntax was $response \sim group{*}connective{*}ratio + (1 + connective{*}ratio|subject) + (1 + group|item)$.

For the intercept and slopes in our model, we selected 0 mean and 2.5 standard deviation Student's t-distribution prior with 3 degrees of freedom. We also specified an LKJ prior for the correlation matrix of the random effects with the shape parameter of 4,

which avoids extreme correlations around 1 and −1 (Lewandowski et al. 2009). In model fitting, we sampled 1000 posterior samples after 1000 warm-up iterations per each of the four chains. The samples after warm-up iterations were removed from the final sample. The convergence was evaluated based on the $\hat{R}$ values, such that all computed $\hat{R}$ values were below 1.05, indicating that the chains converged to the target distribution.

The results of the model showed that adults had a greater acceptance rate than the children ($\beta = 4.15$, 95% $CrI = [1.60, 6.76]$, $P(\beta < 0) < 0.001$).[5] This indicates that adults were more flexible in their interpretation of different connectives both uni-conditionally or biconditionally, so they were more flexible in adapting different conditional reasoning types. Also, ratio 1.0 trials led to more acceptance rates than the ratio 0.0 and 0.4 trials ($\beta = 2.96$, 95% $CrI = [0.88, 5.13]$, $P(\beta < 0) < 0.01$). The ratio 0.4 trials did not lead to more acceptance rates than the ratio 0.0 trials ($\beta = -0.07$, 95%$CrI = [-1.34, 1.16]$, $P(\beta > 0) = 0.46$). As to the type of connectives, there was high uncertainty regarding the effect of the connectives, such that the type of connective did not have an effect on the acceptance of the participants. Although *if not* and *unless* had negative estimates, participants did not accept *if not* and *unless* trials particularly less than *if* trials (see Appendix B for the full fixed effects summary of the model. The summary table of the random effects can also be found in the article's repository).

To interpret the interaction patterns and pairwise differences between the children and the adults in different connective and ratio combinations, we ran a posterior predictive simulation. Unlike the individual effects of the type of connective and ratio, Figure 3 shows that there was no difference between the responses of the participants irrespective of the connective type and irrespective of the ratio type. This points out that there is more uncertainty when the effects interact with each other. In addition, the adults accepted the ratio 0.0 trials more than the children in every connective with less uncertainty. This indicates that adults were more likely to adopt a biconditional interpretation irrespective of the connective type compared to children who might have ignored the conditional clause. On the other hand, children accepted the ratio 1.0 trials with less uncertainty compared to the adults especially in *if not* and *unless* trials. This suggests that children focused more on the consequent with the positive quantifier clause and expected that all animals should have their favorite item regardless of the conditional clause.

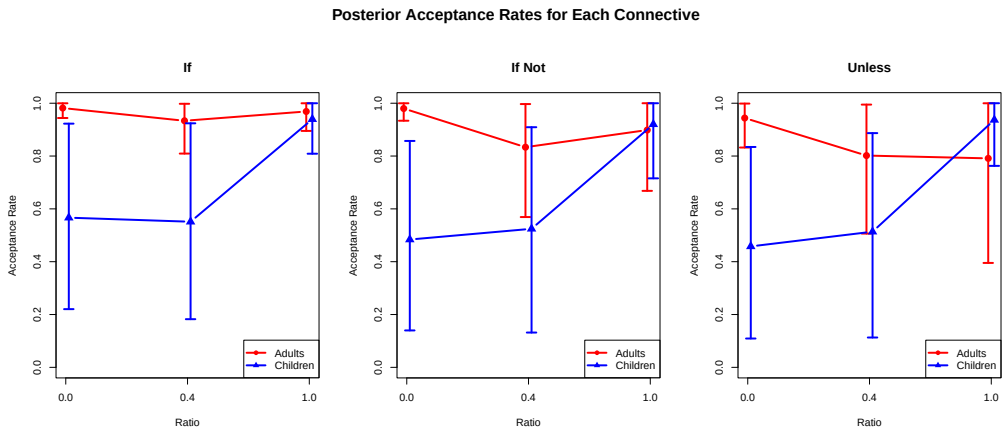

Figure 3. Posterior predictive samples. Points indicate the mean of the sample. Error bars indicate the 95% credible intervals.

As evident in Figure 3, children accepted the ratio 1.0 trials where all target and non-target animals had their favorite items (pictures e and f in Figure 1) more than the ratio 0.0 and 0.4 trials (pictures a and b, and c and d in Figure 1, respectively). However, there was no difference between the ratio 0.0 and 0.4 trials. On the other hand, for adults, although the ratio 0.0 trials were accepted slightly more than the ratio 0.4 and 1.0 trials with less uncertainty, which indicates a biconditional interpretation across the board. This

pattern did not show any clear difference among the ratios. These results suggest that, unlike adults, children disregard the antecedent and evaluate the utterance on the basis of the consequent clause (i.e., quantifier clause) only. In other words, they accepted the sentences only if all animals had their favorite items irrespective of having target color. Adults, on the other hand, rated different conditional reasoning styles (i.e., uni-conditional or biconditional) equally acceptable.

Finally, we considered any potentially influential items which were accepted more or less than average, and participants who accepted the sentences more or less than average. To diagnose that, we checked the mean acceptance rates of every item, and we found that no particular item was accepted differently than the others. However, there were one child and five adult participants who accepted all the sentences. When we excluded these participants from the data and fitted the model with this subset data, we saw that the results did not vary in a way to change the interpretation (see Appendix B for the full fixed effects summary of the model).

4. Discussion

We set out to investigate how Turkish children and adults interpret conditional connectives *if*, *if not*, and *unless* in the positive quantifier contexts. We adapted our comprehension task from two previous adult studies by Nadathur and Lassiter (2015) and Evcen et al. (2019). For the positive quantifier contexts, the *material implication* interpretation would predict similar uni-conditional interpretation for all of the connectives we tested, while Geis and Zwicky (1971), von Fintel (1991), and Leslie (2009) predicted the *material implication* interpretation only for *if* and *if not*, but a biconditional interpretation for *unless*. If these connectives were interpreted by a pragmatic mechanism, we would predict no difference between uni-conditional and biconditional interpretation irrespective of the connective type both in adults and in children.

Our adult participants rated the ratio 1.0 trials slightly higher than the ratio 0.0 and 0.4 trials. This pattern was different from Evcen et al. (2019), which showed a slight difference between *unless* and *if not* for the positive quantifier conditions in some ratios. This difference may also be due to the fact that Evcen et al. (2019) employed a different exceptive connector for *unless*, namely *-mAdIğI sürece*, while in the present study, we used *-mAdIkçA*. Furthermore, neither Evcen et al. (2019) nor Nadathur and Lassiter (2015) tested indicative conditions in their studies, since their aim was to compare how *if not* and *unless* behaved in positive and negative quantifier contexts.

On the other hand, similar to Evcen et al. (2019) and Nadathur and Lassiter (2015), we found that our adult participants did not assign an across-the-board biconditional interpretation for *unless*. This pattern is in line with Nadathur and Lassiter (2015) and Evcen et al. (2019) in showing that *unless* is not a strictly biconditional connective. We additionally found that adult participants flexibly accepted both uni-conditional and biconditional interpretations for all three connectives, which is in line with previous findings where adults flexibly accept the biconditional interpretation of *if* (Baratgin et al. 2018, and the references therein).

Different from adults, our child participants found the ratio 1.0 trials where all of the referents had the object of interest more acceptable compared to the ratio 0.0 and ratio 0.4 trials. Crucially, this response pattern did not change across the conditional connective type. This is an interesting finding that is different from the adult pattern in the present and the previous studies in English (Nadathur and Lassiter 2015) and Turkish (Evcen et al. 2019). This pattern may be reflecting that children at the age of five disregard the antecedent hosting the conditional clause and focus on the consequent hosting the positive quantifier clause in conditionals embedded under quantificational contexts (Ferreira et al. 2002). This might be due to the fact that the consequent that hosts the quantifier clause is the most recently available information that is still active in their working memory.

There may be a couple of possible interpretations of this pattern. One possibility is that children at this age cannot process conditional structures, but they can interpret a

positive quantifier that indicates a totality (i.e., *every*), which we know is a quantifier type that is acquired relatively early (Katsos et al. 2016). If this interpretation is correct, then this indicates a late acquisition of even the indicative conditionals *if* and *if not*. We do not think that this is very likely as we know from previous studies showing early interpretation of indicative or counterfactual conditionals (Aktepe 2022; Aktepe and Sarısoy 2024; Harris and Núntez 1996).

Another possibility is that children can actually interpret conditional statements and positive universal quantifier structures independently but they find it difficult to combine the semantic and pragmatic meanings contributed by these two semantically complex structures in one utterance. Given the pattern in adults as well, it is clear that conditional structures under quantifier contexts include a great deal of ambiguity that requires a more advanced pragmatic mechanism to tackle, which may be an ability that develops rather late in children (Naigles 2002).

An alternative account, which remains at a stipulation level, would link this pattern to the limited working memory abilities of children rather than their inability to interpret conditional structures (Johnson-Laird and Byrne 1991). It may be the case that children actually understand the meaning of the conditional sentence as they hear it on the fly during the course of the utterance, yet they do not recall their initial interpretation by the time they process the quantifier clause in the consequent, which is the most recent information they hear. Thus, it may be the case that they relied on the most recent information they heard while ignoring the first clause that was available. Given the recent findings showing early interpretation of even the counterfactual conditionals, we conjecture that this might be a plausible speculation about the findings here. Indeed, the fact that children found the pictures where all of the referents had the object of interest more acceptable rules out the possibility that children had a total comprehension failure upon hearing these complex utterances. We think this pattern rather indicates that they understood these utterances only focusing on the most recent piece of information while ignoring the parts that were available earlier in the utterance. If this analysis were correct, then presenting the conditional structure within the most recent clause or testing these structures in online paradigms reflecting real-time processing of the structures should improve the interpretation. Future studies might address these possibilities.

In conclusion, our findings from adults align with the previous studies in English (Nadathur and Lassiter 2015) and Turkish (Evcen et al. 2019), suggest a pragmatic mechanism flexibly adopting both uni-conditional and biconditional interpretation. Different from those studies, we did not find any difference between *unless* and *if not*, and we further showed that this pragmatic mechanism should also be at work not only for *unless* but also for *if* and *if not*. Our results do not concur with the *material implication* view or with the accounts predicting a uni-conditional interpretation for *if* and *if not* and a biconditional interpretation for *unless* under positive quantifier contexts (Geis and Zwicky 1971; Leslie 2009; von Fintel 1991). Importantly, the patterns we found in our adult participants also highlight that one should not expect a binary truth-conditional interpretation when generating experimental expectations about the processing of conditional connectives, and there indeed seems to be a pragmatic mechanism, rendering both uni-conditional and biconditional meanings acceptable for all three connectives. This is the most important finding of our study. In this respect, we agree with the view of trivalent logic that makes it possible to rate a sentence as *IRRELEVANT* (Baratgin et al. 2018) or *NOT SURE/MAYBE*, in addition to *TRUE* and *FALSE* (Barrio and Égré 2023, and the references therein). Adopting this trivalent system of logic might enable us to better account for the findings from adult and child studies so far.

Finally, this has been, to our knowledge, the first study testing how conditional and biconditional connectives *if*, *if not*, and *unless* in positive quantifier contexts are interpreted at preschool age. We could not see any evidence for a successful interpretation of these conditional connectives within a quantifier structure. As discussed above, no effect of con-

ditional connectives under quantification does not necessarily rule out early interpretation of these structures.

We believe that the present results should be taken with caution because of the small sample size and the limited number of items in this study. Another limitation is that there was not an independent task with simpler structures, and therefore we cannot rule out the possibility that our child participants ignored these structures due to the high structural and semantic complexity.[6] Thus, the pattern depicted here could be a reflection of good-enough processing (Ferreira et al. 2002). Despite these limitations, we believe that the present study still provides insight into a topic with a limited number of experimental studies. Future studies should aim to tackle these limitations and test a greater number of children at a greater age range in experimental paradigms incurring less processing demands for children.

Author Contributions: Conceptualization, D.S.; methodology, D.S. and S.C.A.; formal analysis, S.C.A.; investigation, S.C.A. and S.G.; data curation, S.C.A.; resources, S.C.A.; writing—original draft preparation, D.S. and S.C.A.; writing—review and editing, D.S. and S.C.A.; visualization, S.C.A.; supervision, D.S.; project administration, D.S.; funding acquisition, D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Scientific and Technological Research Council of Turkey (TÜBİTAK) 1001 Project #218K184 on Conditionals awarded to D. Sarısoy. We thank TÜBİTAK for their support.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Human Subjects Ethics Committee of Middle East Technical University (Protocol Number: 2018-EGT-102, Date of Approval: 12 September 2018).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The dataset and the analysis code are openly available online at https://osf.io/yugze/.

Acknowledgments: We would like to thank Fatma Nur Öztürk for their help with the data collection, and Ezgi Bayramoğlu for voice recordings.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

Poss.3	Third person possessive agreement
Plu	Plural
Gen	Genitive
Acc	Accusative
Loc	Locative
Nom	Nominative

Appendix A. List of Experimental Sentences

If (-sA) sentences

1. Tavşanların rengi beyazsa her tavşanda havuç var.
   Every rabbit has a carrot if their color is white.
2. Köpeklerin rengi sarıysa her köpekte kemik var.
   Every dog has a bone if their color is yellow.
3. Kedilerin rengi siyahsa her kedide top var.
   Every cat has a ball if their color is black.
4. Maymunların rengi turuncuysa her maymunda muz var.
   Every monkey has a banana if their color is orange.

5. Farelerin rengi griyse her farede peynir var.
   Every mouse has cheese if their color is gray.
6. Ayıların rengi siyahsa her ayıda bal var.
   Every bear has honey if their color is black.

If not (-değilse) sentences

1. Tavşanların rengi beyaz değilse her tavşanda havuç var.
   Every rabbit has a carrot if their color is not white.
2. Köpeklerin rengi sarı değilse her köpekte kemik var.
   Every dog has a bone if their color is not yellow.
3. Kedilerin rengi siyah değilse her kedide top var.
   Every cat has a ball if their color is not black.
4. Maymunların rengi turuncu değilse her maymunda muz var.
   Every monkey has a banana if their color is not orange.
5. Farelerin rengi gri değilse her farede peynir var.
   Every mouse has cheese if their color is not gray.
6. Ayıların rengi siyah değilse her ayıda bal var.
   Every bear has honey if their color is not black.

Unless (-mAdIkçA) sentences

1. Tavşanların rengi beyaz olmadıkça her tavşanda havuç var.
   Every rabbit has a carrot unless their color is white.
2. Köpeklerin rengi sarı olmadıkça her köpekte kemik var.
   Every dog has a bone unless their color is yellow.
3. Kedilerin rengi siyah olmadıkça her kedide top var.
   Every cat has a ball unless their color is black.
4. Maymunların rengi turuncu olmadıkça her maymunda muz var.
   Every monkey has a banana unless their color is orange.
5. Farelerin rengi gri olmadıkça her farede peynir var.
   Every mouse has cheese unless their color is gray.
6. Ayıların rengi siyah olmadıkça her ayıda bal var.
   Every bear has honey unless their color is black.

Appendix B. Summary of the Generalized Linear Mixed Models

Table A1. Results of the full data.

Fixed Effects:							
Parameter	**Est.**	**Est.Err**	**l-95%**	**u-95%**	**Rhat**	**Bulk**	**Tail**
Intercept	0.32	0.90	−1.43	2.19	1.00	1286	1688
adult	4.15	1.31	1.60	6.76	1.00	1381	2086
ifnot	−0.39	0.51	−1.40	0.60	1.00	3899	3174
unless	−0.51	0.53	−1.53	0.55	1.00	3327	2745
ratio 0.4	−0.07	0.64	−1.34	1.16	1.00	2930	3035
ratio 1.0	2.96	1.08	0.88	5.13	1.00	2858	2447
adult:ifnot	0.34	0.85	−1.29	2.02	1.00	4152	3068
adult:unless	−0.70	0.86	−2.38	1.01	1.00	4060	3471
adult:ratio 0.4	−1.36	1.00	−3.31	0.59	1.00	2876	2933
adult:ratio 1.0	−3.35	1.55	−6.36	−0.34	1.00	2821	3042
ifnot:ratio 0.4	0.26	0.74	−1.21	1.73	1.00	3729	2750
unless:ratio 0.4	0.33	0.75	−1.12	1.81	1.00	3996	3534
ifnot:ratio 1.0	0.24	1.03	−1.64	2.46	1.00	4447	3240
unless:ratio 1.0	0.73	1.13	−1.31	3.19	1.00	3748	3082
adult:ifnot:ratio 0.4	−1.34	1.12	−3.50	0.77	1.00	3601	3236
adult:unless:ratio 0.4	−0.49	1.09	−2.62	1.65	1.00	4238	3362
adult:ifnot:ratio 1.0	−1.45	1.44	−4.39	1.37	1.00	4087	2869
adult:unless:ratio 1.0	−1.77	1.55	−4.97	1.24	1.00	3924	2919

Table A2. Results of the subset data.

Fixed Effects:							
Parameter	**Est.**	**Est.Err**	**l-95%**	**u-95%**	**Rhat**	**Bulk**	**Tail**
Intercept	−0.03	0.75	−1.51	1.45	1.00	1996	2559
adult	3.21	1.14	1.02	5.57	1.00	2252	2730
ifnot	−0.37	0.50	−1.35	0.63	1.00	4602	3453
unless	−0.53	0.52	−1.59	0.46	1.00	4399	3074
ratio 0.4	−0.06	0.61	−1.31	1.12	1.00	3753	2666
ratio 1.0	2.86	1.03	0.93	4.96	1.00	3493	2846
adult:ifnot	0.29	0.88	−1.37	2.03	1.00	4354	3378
adult:unless	−0.75	0.89	−2.54	1.00	1.00	4134	3447
adult:ratio 0.4	−1.51	0.97	−3.50	0.39	1.00	4063	3442
adult:ratio 1.0	−3.55	1.49	−6.47	−0.63	1.00	2971	2779
ifnot:ratio 0.4	0.24	0.72	−1.18	1.64	1.00	5055	3036
unless:ratio 0.4	0.31	0.71	−1.06	1.74	1.00	4343	3106
ifnot:ratio 1.0	0.23	1.06	−1.73	2.48	1.00	4278	3030
unless:ratio 1.0	0.67	1.13	−1.42	2.96	1.00	4083	3191
adult:ifnot:ratio 0.4	−1.35	1.14	−3.62	0.84	1.00	4741	3275
adult:unless:ratio 0.4	−0.51	1.11	−2.63	1.64	1.00	4133	3019
adult:ifnot:ratio 1.0	−1.53	1.46	−4.49	1.29	1.00	4767	2939
adult:unless:ratio 1.0	−2.18	1.62	−5.61	0.78	1.00	4826	2888

Notes

1 Higginbotham posed this as a counterexample to compositionality and since then most semantic accounts have tried to propose analyses that solve the puzzle without sacrificing the principle of compositionality (e.g., Higginbotham 2003; Leslie 2009; Pelletier 1994; von Fintel 1998; von Fintel and Iatridou 2002). We will not review these accounts here (for a review, see Huitink 2010), as our focus is not to investigate the difference between embedding the conditionals under positive versus negative quantifiers but to understand how children interpret different conditional connectives under positive quantifiers.

2 The symbol, ¬ is used to represent negation.

3 The participants saw 36 pictures, and heard 36 sentences in 3 connectives and 6 sentences, which makes 18 sentences in total, and they heard these sentences twice ($18 \times 2 = 36$ sentences match 36 pictures) with different animals. For example, they heard the sentence, *"tavşanların rengi sarıysa, her tavşanda havuç var"* with a particular picture, say (rabbit scene with ratio 1.0), they heard the same type of sentence with a different animal, e.g., *"kedilerin rengi siyahsa, her kedide top var"*, and a related picture in the same ratio (cat scene with ratio 1.0 in this case). Please note that we also counterbalanced the names and favorite items of the animals.

4 The data and full analysis can be accessed from the article's repository, https://osf.io/yugze/.

5 $P(\beta < 0)$ corresponds to the probability that the effect is negative for the positive effects. On the other hand, $P(\beta > 0)$ corresponds to the probability that the effect is positive for the negative effects.

6 We thank our reviewer for bringing this issue to our attention.

References

Aktepe, Semih Can. 2022. Incremental Processing of Morphosyntax for Counterfactual Reasoning: An Eye-Tracking Study with Turkish-Speaking Children and Adults. Master's thesis, Middle East Technical University, Ankara, Turkey.

Aktepe, Semih Can, and Duygu Sarısoy. 2024. Children can interpret counterfactual conditionals incrementally using morpho-syntactic cues. In *Boston University Conference on Language Development*. Somerville: Cascadilla Press, pp. 17–30

Baratgin, Jean, Guy Politzer, David E. Over, and Tatsuji Takahashi. 2018. The psychology of uncertainty and three-valued truth tables. *Frontiers in Psychology* 9: 1479. [CrossRef] [PubMed]

Barner, David, Katherine Chow, and Shu-Ju Yang. 2009. Finding one's meaning: A test of the relation between quantifiers and integers in language development. *Cognitive Psychology* 58: 195–219. [CrossRef] [PubMed]

Barr, Dale J., Roger Levy, Christoph Scheepers, and Harry J. Tily. 2013. Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language* 68: 255–78. [CrossRef] [PubMed]

Barrio, Eduardo, and Paul Égré. 2023. Editorial introduction: Substructural logics and metainferences. *Journal of Philosophical Logic* 51: 1215–31. [CrossRef]

Barrouillet, Pierre, and Jean-François Lecas. 1998. How can mental models theory account for content effects in conditional reasoning? A developmental perspective. *Cognition* 67: 209–53. [CrossRef]

Barrouillet, Pierre, and Jean-François Lecas. 1999. Mental models in conditional reasoning and working memory. *Thinking & Reasoning* 5: 289–302. [CrossRef]

Bürkner, Paul-Christian. 2017. brms: An R package for Bayesian multilevel models using Stan. *Journal of Statistical Software* 80: 1–28. [CrossRef]

Christensen, Rune Haubo Bojesen. 2022. Ordinal—Regression Models for Ordinal Data. R Package Version 2022.11-16. Available online: https://CRAN.R-project.org/package=ordinal (accessed on 15 September 2022).
Clark, Herbert Herb, and Eve Vivienne Clark. 1977. Psychology and language. *Journal of Child Language* 4: b1–b3. [CrossRef]
Dancygier, Barbara. 1985. If, unless, and their Polish equivalents. *Papers and Studies in Contrastive Linguistics* 20: 65–72.
Degen, Judith, and Michael K. Tanenhaus. 2016. Availability of alternatives and the processing of scalar implicatures: A visual world eye-tracking study. *Cognitive Science* 40: 172–201. [CrossRef]
Evans, Jonathan St. B. T. 1993. The mental model theory of conditional reasoning: Critical appraisal and revision. *Cognition* 48: 1–20. [CrossRef] [PubMed]
Evcen, Ebru, Umut Özge, and Duygu Özge. 2019. Turkish "unless" is not biconditional unless the pragmatic context allows it. Paper presented at the 8th Experimental Pragmatics Conference, Edinburgh, UK, June 19–22.
Ferreira, Fernanda, Karl G. D. Bailey, and Vittoria Ferraro. 2002. Good-enough representations in language comprehension. *Current Directions in Psychological Science* 11: 11–15. [CrossRef]
Fillenbaum, Samuel. 1986. The use of conditionals in inducements and deterrents. In *On Conditionals*. Cambridge: Cambridge University Press, pp. 179–95.
Geis, Michael L. 1973. "if" and "unless". In *Issues in Linguistics: Papers in Honor of Henry and Renee Kahane*. Urbana: University of Illinois Press, pp. 231–53.
Geis, Michael L., and Arnold M. Zwicky. 1971. On invited inferences. *Linguistic Inquiry* 2: 561–66.
Harris, Paul L., and María Núntez. 1996. Understanding of permission rules by preschool children. *Child Development* 67: 1572–91. [CrossRef]
Higginbotham, James. 1986. Linguistic theory and Davidson's program in semantics. In *Truth and Interpretation: Perspectives on the Philosophy of Donald Davidson*. Cambridge: Blackwell, pp. 29–48.
Higginbotham, James. 2003. Conditionals and compositionality. *Philosophical Perspectives* 17: 181–94. [CrossRef]
Huitink, Janneke. 2010. Quantified conditionals and compositionality. *Language and Linguistics Compass* 4: 42–53. [CrossRef]
Inhelder, Bärbel, and Jean Piaget. 1958. *The Growth of Logical Thinking from Childhood to Adolescence: An Essay on the Construction of Formal Operational Structures*. East Sussex: Psychology Press, vol. 22.
Jackson, Frank. 1979. On assertion and indicative conditionals. *The Philosophical Review* 88: 565–89. [CrossRef]
Johnson-Laird, Philip Nicholas, and Ruth M. J. Byrne. 1991. *Deduction*. Mahwah: Lawrence Erlbaum Associates, Inc.
Katsos, Napoleon, Chris Cummins, Maria-José Ezeizabarrena, Anna Gavarró, Jelena Kuvač Kraljević, Gordana Hrzica, Kleanthes K. Grohmann, Athina Skordi, Kristine Jensen de López, Lone Sundahl, and et al. 2016. Cross-linguistic patterns in the acquisition of quantifiers. *Proceedings of the National Academy of Sciences* 113: 9244–49. [CrossRef]
Katsos, Napoleon, Clara Andrés Roqueta, Rosa Ana Clemente Estevan, and Chris Cummins. 2011. Are children with specific language impairment competent with the pragmatics and logic of quantification? *Cognition* 119: 43–57. [CrossRef]
Lenth, Russell, Henrik Singmann, Jonathon Love, Paul Buerkner, and Maxime Herve. 2019. Package 'Emmeans'. Available online: https://cran.r-project.org/web/packages/emmeans/index.html (accessed on 1 August 2022).
Leslie, Sarah-Jane. 2009. "if", "unless", and quantification. In *Compositionality, Context and Semantic Values*. Edited by Robert J. Stainton and Christopher Viger. Dordrecht: Springer, pp. 3–30. [CrossRef]
Lewandowski, Daniel, Dorota Kurowicka, and Harry Joe. 2009. Generating random correlation matrices based on vines and extended onion method. *Journal of Multivariate Analysis* 100: 1989–2001. [CrossRef]
Markman, Ellen M., Judith L. Wasow, and Mikkel B. Hansen. 2003. Use of the mutual exclusivity assumption by young word learners. *Cognitive Psychology* 47: 241–75. [CrossRef] [PubMed]
Markovits, Henry, and Pierre Barrouillet. 2002. The development of conditional reasoning: A mental model account. *Developmental Review* 22: 5–36. [CrossRef]
Mody, Shilpa, and Susan Carey. 2016. The emergence of reasoning by the disjunctive syllogism in early childhood. *Cognition* 154: 40–48. [CrossRef] [PubMed]
Nadathur, Prerna, and Daniel Lassiter. 2015. Unless: An experimental approach. *Proceedings of Sinn und Bedeutung* 19: 446–64. [CrossRef]
Naigles, Letitia R. 2002. Form is easy, meaning is hard: Resolving a paradox in early child language. *Cognition* 86: 157–99. [CrossRef]
Özge, Duygu, Aylin Küntay, and Jesse Snedeker. 2019. Why wait for the verb? Turkish speaking children use case markers for incremental language comprehension. *Cognition* 183: 152–80. [CrossRef]
Pelletier, Francis Jeffrey. 1994. On an argument against semantic compositionality. In *Logic and Philosophy of Science in Uppsala*. Dordrecht: Springer, pp. 599–610. [CrossRef]
Quine, Willard Van Orman. 1982. *Methods of Logic*. Cambridge, MA: Harvard University Press.
R Core Team. 2021. *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.
Reuter, Tracy, Roman Feiman, and Jesse Snedeker. 2018. Getting to no: Pragmatic and semantic factors in two-and three-year-olds' understanding of negation. *Child Development* 89: 364–81. [CrossRef]
von Fintel, Kai. 1991. Exceptive conditionals: The meaning of unless. In *North Eastern Linguistics Society*. Massachusetts: GLSA, UMass/Amherst, vol. 22, pp. 135–48.
von Fintel, Kai. 1998. Quantifiers and 'if'-clauses. *The Philosophical Quarterly* 48: 209–14. [CrossRef]

von Fintel, Kai, and Sabine Iatridou. 2002. If and when if-clauses can restrict quantifiers. Paper presented at the Workshop in Linguistics & Philosophy, Ann Arbor, MI, USA, November 8–10. Available online: https://web.mit.edu/fintel/fintel-iatridou-2002-ifwhen.pdf (accessed on 1 August 2022).
Wason, Peter C. 1966. Reasoning. In *New Horizons in Psychology*. Edited by B. M. Foss. London: Penguin Books, pp. 135–51.