Non-uniformities in the Development of Presupposition Projection in *If*-Conditionals

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1. Introduction

Presupposed content differs from asserted content in characteristic ways. One hallmark of presuppositions is the way they "project" from the scope of truth-functional operators. Take negation as an example. The normal effect of negation is to take a truth value and return the opposite truth value. As shown below, when the atomic sentence in (1) is embedded under negation in (2), its asserted component is affected as expected. The presupposed content, in contrast, remains the same across the pair.

(1)   Phil's guitar is broken.
         Presupposition: There is a guitar that Phil owns.
         Asserted content: That guitar is broken.

(2)   Phil's guitar is not broken.
         Presupposition: There is a guitar that Phil owns.
         Asserted content: That guitar is not broken.

It appears, then, that when a presupposition-carrying atomic sentence is embedded under negation, its presupposition is preserved in the complex sentence.

Like negation, presuppositions triggered inside the antecedent of *if*-conditionals are also inherited wholesale by the complex sentence. In (3), for example, the presupposition triggered by the possessive expression *Phil's guitar* (i.e. that Phil has a guitar) ends up as the presupposition of the entire *if*-conditional when the possessive phrase occurs in the antecedent.

(3)   If Phil's guitar is broken, he will travel to London.
         Presupposes: Phil has a guitar.

At the same time, cases like (4) falsify the simple hypothesis that presuppositions in embedded contexts *always* become presuppositions of the entire sentence. In (4), the expression *Phil's guitar* occurs within the consequent clause, and the conditional as a whole presupposes a weaker proposition than what is triggered by the possessive in an atomic sentence. The presupposition takes a conditionalized form, where the matter of Phil's owning a guitar is contingent on the truth of the antecedent.

(4)   If Phil is a musician, he will bring his guitar to the party.
        Presupposes: If Phil is a musician, he has a guitar.

Environments such as negation and antecedents of *if*-conditionals are considered presupposition "holes" (Karttunen & Peters 1979), from which an embedded presupposition is inherited wholesale. By contrast, consequents of conditionals are considered "filters", which prohibits an embedded presupposition from percolating all the way through.

As part of mastering presuppositional phenomena, children have to figure out how presuppositions project from different environments, and as the data presented so far suggest, the learning task is non-trivial. Yet, at present, we have limited understanding of how children go about learning these projection patterns. Existing work examining children's knowledge of presupposition projection have focused primarily on negative environments and the findings suggest selective mastery (Dudley et al. 2015; Bill et al. 2016; Jasbi 2016; Zehr et al. 2016; Aravind & Hackl 2017). Bill et al. (2016) found that children treat negation as a projection "hole", like adults, in sentences like (5), which presupposes that the bear participated in the race. Zehr et al. (2016), on the other hand, found that children did not have adult-like expectations about presuppositions embedded in the scope of the negative quantifier *none*, as in (6). In this case, the presupposition of participation has to hold for every bear under discussion.

(5)   The bear didn't win the race.

(6)   None of the bears won the race.

In the present work, we aim to broaden our understanding of this under-studied area by examining children's understanding of how presuppositions project from conditional sentences. As mentioned, conditionals have the special property that they present two types of projection environments – a hole and a filter – within a single construction. They thus present an optimal candidate for evaluating whether certain types of projection environments are earlier acquired than others. Using a novel Outcome Evaluation Task, we probe children's expectations about presupposition projection from the antecedent and consequent of conditional sentences (Experiment 1), and compare them against adult behaviors in an age-appropriate version of the task (Experiment 2).
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2. Experiment 1
2.1. Participants

Forty-eight English-speaking children aged 4 to 6, recruited via online advertisements, participated; we set 4 as the lower-bound based on when the relevant complex sentences (Diessel 2004) and the existence presupposition of definite descriptions (Aravind 2018) are acquired. All data collection took place virtually via Zoom video-conferencing and was restricted to participants in the U.S. whose dominant language at home (> 80% of the time) is English.

2.2. Design, materials, and procedure

Our Outcome Evaluation task was presented in a child-friendly manner, as a 'dress-up' game, where a cartoon character (a bear) was instructed to put on a certain set of clothes. Child participants were told that the bear was not always very good at following instructions, so she may get something wrong, and it is the child's job to tell her if she did a good job following instructions. The child was also instructed that the bear is "very picky" about her style, so no changes should be made unless it really helps the bear follow the instructions.

At the start of each trial, an experimenter introduced the clothing items in the closet (Fig 1a), and then provided the test sentences as instructions to the bear. The door closed (Fig 1b). When it opened again, the outcome was presented to the child participant (Fig 1c) and the test sentences were repeated. The child was asked if the character followed instructions, part of which was a presuppositional conditional. If not, the child was then invited to fix it. Child participants received a star for helping the bear regardless of their response (Fig 1d)
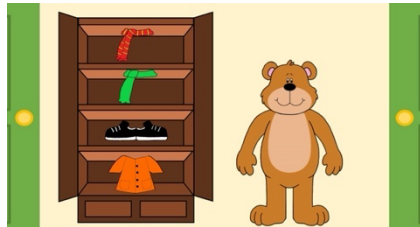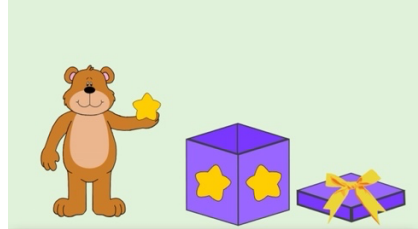

(a) Scene 1: Closet
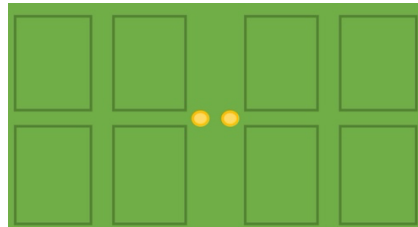
(b) Scene 2: Door closed
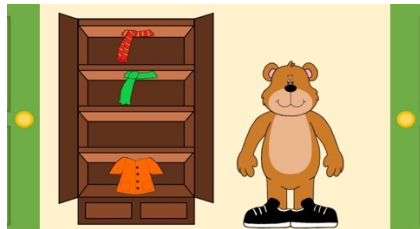
(c) Scene 3: Outcome

(d) Scene 4: Reward

Figure 1: Workflow of a critical trial

The experiment began with a training phase. There were a total of 4 training trials, half of which have Yes as the expected response and the other half No. The child received feedback from the experimenter (with scaffolding if necessary) during the training phase. The goal of training was to make sure the child understood the basics of the task: that the bear doesn't always get it right/wrong, that they could give the bear items from the closet and/or remove items from the bear, that they did not have to give the bear every piece of clothing mentioned in the test sentences (e.g., Ex (7)), and that nothing should be changed so long as the instructions are already followed.

(7)   Training trial: You can put on a shirt, but it's okay if you don't. You can put on pants, but it's okay if you don't. But if you put on BOTH a shirt and pants, you have to put on shoes.
        <u>Closet provides</u>: shirt, pants, shoes
        <u>The bear wears</u>: pants

Our critical trials were created with the goal of detecting the presupposition projected out of *if*-conditionals. The embedded presupposition, "there is a scarf you put on", is not satisfied in the outcome of the bear's dress-up. This has divergent consequences depending on the environment: it is problematic (i.e., a presupposition failure) only if the presupposition-carrying expression was in the antecedent clause, a projection "hole".

(8)   Critical trial (Antecedent): You have to put on shoes. If the scarf you put on is striped, you do have to put on a coat.
        <u>Closet provides</u>: shoes, striped scarf, green scarf, coat
        <u>The bear wears</u>: shoes

If, for the child, the embedded presupposition projects all the way through in this environment, then the child should respond No to (8), and point out that both the striped scarf and the coat should be given to the bear in order to fix the mistake.

The expectations are different for the Consequent environment, as in (9). If for the child (as for the adult), only a conditionalized presupposition is projected from this environment, the child should deem this outcome adherent to the instructions; no fix will be required.

(9)   Critical trial (Consequent): You have to put on shoes. If you put on a coat, the scarf you put on has to be striped.
        <u>Closet provides</u>: shoes, striped scarf, green scarf, coat
        <u>The bear wears</u>: shoes

Thus, the expectation for adult-like behavior is asymmetric: a "No" response in the Antecedent environment and a "Yes" response in the Consequent environment. But we can also imagine other possibilities. If initially, children work with a simpler hypothesis of uniform projection across environment, we

might find either (i) uniform "Yes" responses, suggesting that a weaker presupposition projects from both environments, or (ii) uniform "No" responses, indicating that the stronger presupposition projects across-the-board.

Each participant saw 4 critical trials, pseudorandomized across 12 test items. We also included presuppositional control trials with unambiguously satisfactory or unsatisfactory outcomes (e.g., Ex (10) and Ex (11)), to ensure that children are able to evaluate the presuppositional conditionals in contexts where the presupposition is satisfied across-the-board. Environment (i.e., presupposition trigger in Antecedent vs. Consequent) was a between-subject factor.

(10)   Presuppositional control (Antecedent): You have to put on shoes. If the scarf you put on is striped, you do have to put on a coat.
        <u>Closet provides</u>: shoes, striped scarf, green scarf, coat
        <u>The bear wears</u>: shoes, striped scarf

(11)   Presuppositional control (Consequent): You have to put on shoes. If you put on a coat, the scarf you put on has to be striped,
        <u>Closet provides</u>: shoes, striped scarf, green scarf, coat
        <u>The bear wears</u>: shoes, coat, green scarf

2.3. Results

We excluded trials on which the child's fix(es) suggested failure to understand the task, such as removing items that satisfy the first part of the instruction, or giving extraneous items not mentioned in the instruction. We also excluded trials on which the experimenter uttered the instruction incorrectly, and trials in which the child was clearly not paying attention or was distracted by the parent, as noted by a coder based on video recordings of the test sessions.

Our primary dependent measure is the Yes-response rates. Across all age groups, children were fully adult-like on the presuppositional control trials, saying Yes nearly 100% of time for the True trials and 0% for the False trials (Table 2).

Table 2: Yes-response rates for control and critical trials

	Presupposition Control: True	Presupposition Control: False	Critical: Antecedent	Critical: Consequent
4-yos	96.67%	0%	63.33%	64.52%
5-yos	100%	0%	65.63%	93.10%
6-yos	100%	0%	81.25%	90.32%

For critical trials, we fit the data to a mixed-effects logistic regression model, with Environment and Age as fixed effects, and Participants and Items as random effects. We used the *glmer* function from the *lme4* package for R (Bates et al. 2015; R Core Team, 2021) to compute the most maximally specified random-effect model that would converge, following Barr et al. (2013). The model revealed main effects of Environment ($z = -2.036$, $p < .05$) and Age ($z = 2.819$, p

< .005). Overall, children were less likely to respond in the affirmative manner when an embedded presupposition was unfulfilled in the Antecedent compared to the Consequent, but their Yes-response rates increased across-the-board with age. Pairwise comparisons showed an asymmetry of Environment in 5-year-olds, with the consequent environment yielding significantly higher Yes-rates ($\chi^2 = 6.850$, p < .01). A subset of 5-year-olds who uniformly responded No in the Antecedent environment; none responded this way in the Consequent environment. 6-year-olds reached high Yes-rates in both environments, with no statistically reliable difference between them ($\chi^2 = 0.447$, p = .504). Finally, 4-year-olds also showed no asymmetry between environments ($\chi^2 = 0.225$, p = .635), but with higher No-rates across-the-board compared to 6-year-olds. An intercept-only logistic mixed-effect regression model with random intercepts for Participants and Items revealed that overall, the 4-year-olds' Yes-rates were above-chance (z = 2.293, p < .05), but this seems to have been driven by a subset (3 in antecedent; 4 in consequent) who responded "Yes" on all critical items; the others were more inconsistent in their responses.
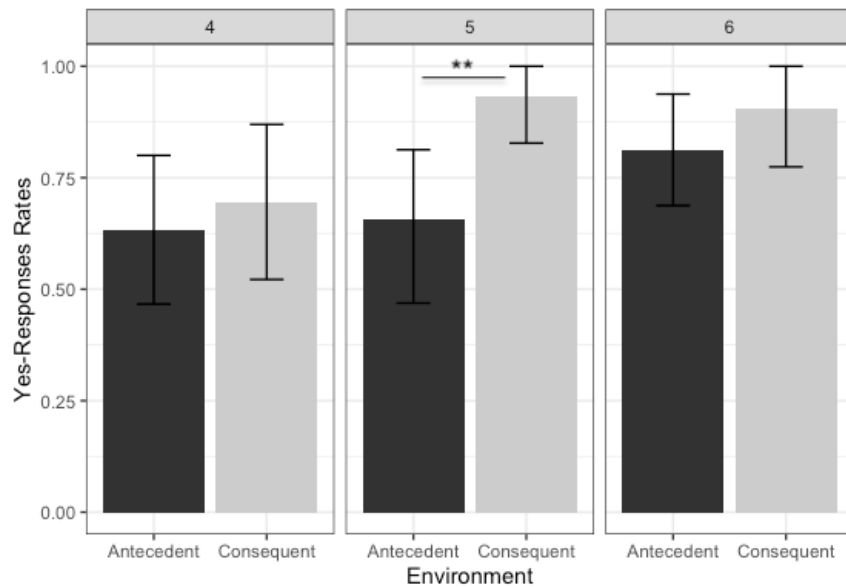

Figure 2: Yes-response rates per Environment per Age Group

As a secondary dependent measure, we recorded children's fixes after a No response. In the presuppositional control trials with an unsatisfactory outcome, children fixed the scene by adding the item mentioned in the consequent clause (Ex (10)), or when the presupposed item was given in the wrong color, they fixed the outcome by swapping it with the item in the correct color (Ex (11)). In the critical trials (Ex (8–9)), where neither item mentioned in the conditional was

given, children who responded No fixed the scene by giving both items to the bear, irrespective of Environment.

2.4. Discussion

Results from Experiment 1 suggest that the non-uniform presupposition projection patterns of *if*-conditionals are mastered at least by age 5. The response pattern of 5-year-olds revealed the expected environment-based asymmetry: while all 5-year-olds in the Consequent environment overwhelmingly responded Yes to the critical trials, a subset of 5-year-olds in the Antecedent environment uniformly rejected the outcome scene, resulting in a statistically reliable difference between the two environments in terms of Yes-response rates. One way of understanding this environment-based asymmetry is that at least some 5-year-old children are able to distinguish the projection patterns in the antecedent and the consequent of *if*-conditionals: the antecedent is a presupposition projection "hole", from which presuppositions are inherited wholesale; the consequent, on the other hand, is a "filtering" environment, from which a conditionalized presupposition obtains.

The youngest age group, 4-year-olds, reported lower Yes-response rates for both the Antecedent and the Consequent environments, with no asymmetry between them. This age group also differed from the older children in showing greater within-participant inconsistency in their responses. We do not think that the 4-year-old patterns result from a failure to understand the task: recall that they do perform adult-like on the control trials (Table 2). At the same time, their responses are neither adult-like, nor adherent to a straightforwardly categorizable pattern. We cannot rule out the possibility of a non-adult interpretation of conditionals (e.g., a conjunctive interpretation; Evans & Over 2007, Barrouillet & Lecas 1999, Lecas & Barrouillet 1999, Lin 2020; a.o.), which may in turn result in a different set of expectations about presupposition projection. As such, we hesitate to interpret further their response patterns.

 The response pattern of the oldest age group, 6-year-olds is on first blush puzzling: they reached very high Yes-rates in both the Antecedent and the Consequent environments, with no asymmetry between them. In other words, there was a lack of asymmetry in the Yes-response rates for 6-year-olds, which was observed for the younger 5-year-olds, specifically due to the fact that the older children were actually *accepting* the trials where the instruction involves an embedded presupposition in the Antecedent environment. But since these trials involve an unfulfilled presupposition in the outcome scene, we would anticipate the outcome being rejected by 6-year-olds just as the 5-year-olds did. So why are the Yes-response rates so high for the 6-year-olds in the Antecedent environment?

Since the 5-year-olds' behavior suggests competence, it seems unlikely that 6-year-olds have non-adult assumptions about presupposition projection. On the contrary, we suspect that the 6-year-olds' behavior indicates more sophistication than that of the younger groups. Specifically, we suggest that the high acceptance in the Antecedent environment is due to the availability of "local accommodation" (Heim 1983), an additional process that conflates presuppositions with asserted

content when embedded under logical operators. When local accommodation is invoked, a sentence like (2) *Phil's guitar is not broken* would be re-interpreted as "It's not the case that [there is a guitar that Phil owns] and [that guitar is broken]", contrasting with the standard reading where the presupposition escapes negation. Similarly, for our critical trials in the Antecedent environment, applying local accommodation generates a re-interpretation of the test sentence as the following:

(12)   If <u>the scarf you put on</u> is striped, you have to put on a coat
        Local accommodation reading: If *there is a scarf that you put on* and it is striped, you have to put on a coat.

This re-interpretation will then allow the 6-year-olds to endorse the outcome scene in the Antecedent environment, where neither a scarf nor a coat is given. Importantly, it has been shown that very young children do not apply local accommodation at the same rates as adults (Zehr et al. 2016; Tieu et al. 2018). It may very well be the case that the local accommodation mechanism only available to adults and older children, but not younger children such as 4- and 5-year-olds.

If our speculation that local accommodation is at play in the Antecedent environment for the 6-year-olds is on the right track, we should be able to observe the same Yes-response pattern with adult English speakers, who should also be competent in accessing local accommodation when needed. An adult control group could be further informative, as previous experimental work on presupposition processing has shown that local accommodation comes with an online processing cost. Parses of sentences consistent with local accommodation showed response time latencies during real-time comprehension in comparison to non-local-accommodation readings (Chemla & Bott 2013; Romoli & Schwarz 2015; Zehr & Schwarz 2016). If our hypothesis is on the right track that saying "Yes" on the critical condition in the Antecedent environment implicates a local accommodation process, we expect to find corresponding response time latencies. We test this hypothesis in Experiment 2.

3. Experiment 2

We conducted an experiment with adult English speakers, whose results would provide a baseline for understanding the child experiment, especially the 6-year-olds. Experiment 2 was hosted on PCIbex Farm (Zehr & Schwarz 2018) using sentences and with procedures highly similar to Experiment 1.

120 adult participants who were self-reported native speakers of English from the U.S. were recruited via Prolific, and were compensated monetarily for their participation. Participants first saw a set of instructions on how to dress up a stick figure, a key portion of which took the form of conditional sentences. On a new page, they were then shown an "outcome" image of how the stick figure had been dressed. Participants had to assess whether the outcome was instruction-compliant by pressing the Yes or No button within 6 seconds of seeing the outcome image.

The environment where the presupposition-carrying expression appeared (Antecedent vs. Consequent) was a between-subject factor.

There were two conditions that formed our key comparison (Table 3): (1) the **p_true** condition, where the embedded presupposition is satisfied in the outcome, and the outcome was otherwise fully instruction-compliant; (2) the **p_critical** condition, where an embedded presupposition is not satisfied in the outcome. We also included other presuppositional and non-presuppositional control conditions, ensuring that there are equal numbers of trials with a Yes and a No response overall, and that the expected responses are counterbalanced for multiple-object images as they are for one-object images (like in the p_critical condition), such that participants cannot use an image-based strategy to respond.

Table 3: Sample items for the key comparison

Condition	Antecedent	Consequent
p_true	You have to give him a hat. If the gloves you give him are red, you have to give him shoes.	You have to give him a hat. If you give him shoes, the gloves you give him have to be red.
p_critical	You have to give him a scarf. If the gloves you give him are red, you have to give him shoes.	You have to give him a scarf. If you give him shoes, the gloves you give him have to be red.

In the Antecedent version of the p_critical condition, the outcome scene would ordinarily render the sentence infelicitous: the embedded presupposition (i.e., "the gloves you give him") would be inherited wholesale by the conditional and is not fulfilled in the outcome. Adults may reject the outcome due to presupposition failure. Alternatively, they may accept the outcome if they have access to local accommodation. Local accommodation would let participants reanalyze the problematic instruction sentence as, "if there are gloves you give him and the gloves are red, you have to give him shoes." The outcome is compliant with this reinterpreted instruction. Based on our observations and speculations about the 6-year-olds in Experiment 1, we expected adults to show high Yes-response rates across environments in the critical condition, but in the response time data for Yes responses, we expected to observe processing costs associated with local accommodation in the Antecedent environment.

We collected Yes-response rates as well as response time data. For the fillers, participants performed at 93.70% – 99.09% accuracy rates across all filler types, with no obvious indication of a Yes-response bias or an image-based response strategy.

For the critical conditions, we were specifically interested in (i) whether adults would have high Yes-response rates across both environments, and (ii) whether the time it took for participants to respond Yes to the outcome scene differed significantly across Environments, with Antecedent showing processing delays compared to Consequent. Results lend support to our hypotheses. In terms of Yes-response rates, all key conditions have at-ceiling of Yes-response rates (Table 4; Figure 3). These high Yes-response rates across the board, with no difference between environments especially in the p_critical condition, are indeed what we observed for the 6-year-olds, bearing out the hypothesis that 6-year-olds were indeed being more adult-like in their responses compared to the younger children.
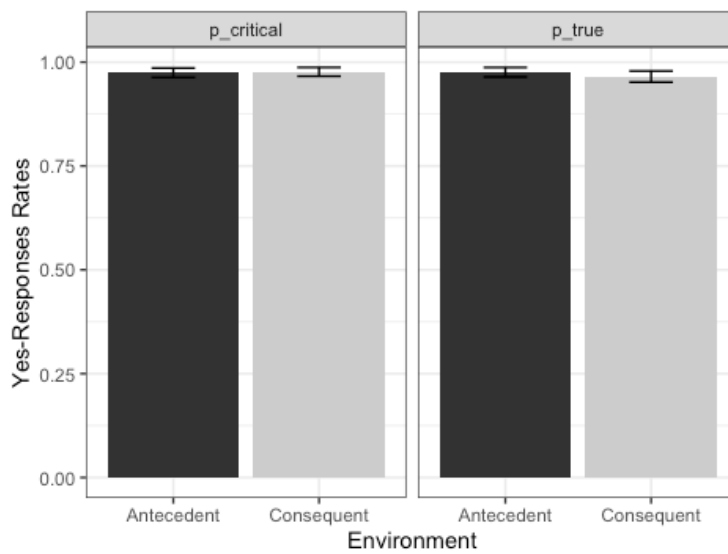

Figure 3: Yes-response rates

Figure 4 displays the times taken to arrive at a Yes response across conditions of interest. In the p_critical condition, response times in the Antecedent were 124.91 ms longer than the Consequent. This difference was 11.65 ms in the p_true condition, where the embedded presupposition is satisfied across-the-board.
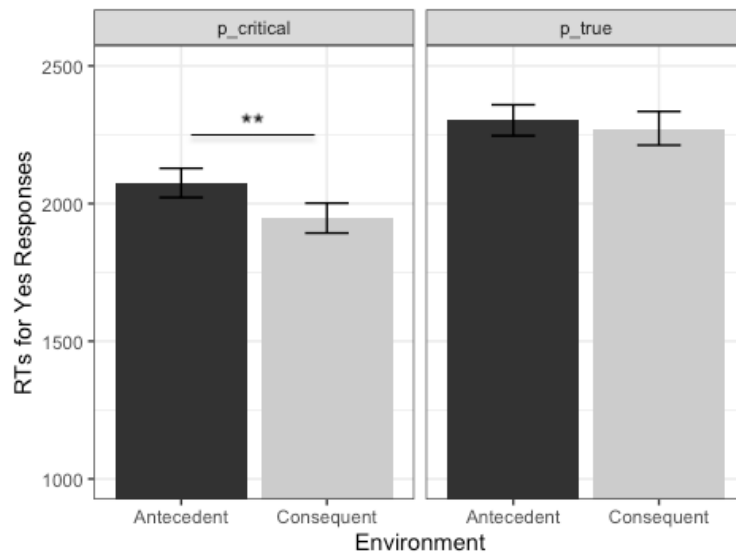
Figure 4: RTs for Yes responses

A generalized mixed-effect model with a log distribution, with Environment and Condition as predictors, revealed a significant interaction (t = 2.845, p < .01), driven by the difference between Antecedent and Consequent environments in the p_critical condition. In other words, in the p_critical condition, we indeed observed response time latencies associated with the endorsement of the Antecedent condition, compared to the Consequent condition. This is in line with the idea that local accommodation is applied in this particular environment as a "last resort" process to rescue an unfulfilled presupposition from leading to presupposition failure.

4. General Discussion

Taken together, our results suggest that children from age 4 to 6 may be at different developmental stages with respect to their ability to deal with presuppositional *if*-conditionals. Starting with the oldest group, our results for the 6-year-olds, on first look, seemed to indicate that this population did not understand how presuppositions project from conditionals. They reached high Yes-response rates in both the Antecedent and the Consequent environments, with no asymmetry between them. Whereas the high Yes-response rates in the Consequent environment is predicted, the high Yes-response rates in the Antecedent environment was not.

However, as we discovered in Experiment 2, 6-year-olds' behavior was in fact consistent with the adults' response pattern, where we also found at-ceiling Yes-response rates in both environments in the critical condition. To explain the

response pattern of adults and 6-year-olds, we appealed to the local accommodation mechanism (Heim 1983): while presuppositions embedded in the antecedent of an *if*-conditional project wholesale and would thus lead to a presupposition failure in our critical condition, adults and 6-year-olds are able to avoid this via application local accommodation. This process generated a reading of the instruction sentence that could be considered fulfilled in the outcome. This, however, comes at a cost: results from Experiment 2 revealed that when adult participants do apply local accommodation and respond Yes in the Antecedent environment, this additional process incurs response time latencies in the Antecedent environment compared to the Consequent environment. This finding is very much in line with existing psycholinguistic work suggesting that local accommodation is costly during online comprehension (Chemla & Bott 2013; Romoli & Schwarz 2015; Zehr & Schwarz 2016). The response patterns of 6-year-olds then suggests that at this developmental stage, not only do children have adult-like understanding of the presupposition projection patterns of *if*-conditionals, but that they can recruit local accommodation, possibly as a last resort mechanism, so as to avoid presupposition failure.

Unlike the 6-year-olds, the response pattern of 5-year-olds revealed an environment-based asymmetry, with fewer Yes responses in the Antecedent environment than the Consequent environment. We take this pattern to be the result of the following factors combined: First, 5-year-old children are able to distinguish the projection patterns in *if*-conditionals. In other words, they treat the antecedent as presupposition projection "hole", an environment from which presuppositions project wholesale, and the consequent as a "filtering" environment, from which a weaker, conditionalized presupposition projects. Second, unlike older children, at least some 5-year-olds are still at a stage where they have not yet mastered local accommodation, consistent with previous literature (Zehr et al. 2016; Tieu et al. 2018). As such, 5-year-olds who do not have adult-like command of local accommodation will respond No in the Antecedent environment where the embedded presupposition is projected fully.

Finally, the 4-year-old group were neither adult-like in their response patterns, nor did they show an asymmetry, making it difficult to interpret their results. Future work will need to establish, using adequate controls, whether 4-year-olds have full command of *if*-conditionals.

To sum up, our findings suggest that the non-uniform presupposition projection patterns of *if*-conditionals are in place by at least age 5. The differences in behavior between 5- and 6-year-olds result not from divergent semantic competence, but from differences in the ability to recruit additional mechanisms such as local accommodation.

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