# Preschoolers' Boolean Interpretation of Free Choice Disjunctions

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**Abstract**

This study investigates children's interpretation of free choice disjunctions like *"Larry is allowed to keep the book or the clock."* There has been some debate in the literature about whether these inferences are a type of quantity implicature or the result of the semantic composition of non-orthodox denotations of disjunction and permission modals, or different pragmatic enrichment mechanisms altogether. A study by Tieu et al. (2016) has shown that 4-year-olds give adult-like interpretations of free choice disjunctions, rejecting sentences like *"Larry is allowed to keep the book or the clock"* when only the book was allowed to be kept. This was notable given preschoolers' well-known difficulties generating scalar implicatures and has provided motivation for non-implicature-based accounts of free choice. In this paper, we argue that an aspect Tieu et al.'s study design meant that children in their study could have been generating free choice inferences as ad-hoc implicatures, which preschoolers are known to be able generate. In our study using a Truth Value Judgement Task design that avoids the problematic aspect, we found that 4- and 5-year-olds give free choice disjunctions a non-adult-like "Boolean" interpretation, accepting *"Larry is allowed to keep the book or the clock"* when only the book is allowed to be kept. This suggests that for children at least, free choice inferences underlyingly involve orthodox disjunction and permission operators and are a type of quantity implicature.

## 1. Introduction

Disjunctions in the scope of a permission modal like (1) typically have a "free choice" interpretation, i.e., that the options specified by the individual disjuncts are both permissible, although not necessarily at the same time:

1. Larry is allowed to eat cake or ice-cream.

   $\rightsquigarrow$ Larry is allowed to eat cake and Larry is allowed to eat ice-cream.

Sentences like (1) pose a puzzle for semantic theories that treat *or* as having a Boolean interpretation and *allow* as denoting existential quantification over deontically accessible worlds. Since $\Diamond(p \lor q)$ does not entail $\Diamond p \land \Diamond q$, if *or* is Boolean and *allow* existentially quantifies over deontic worlds, (1) should be compatible with Larry only being allowed cake. Yet (1) clearly has an interpretation that both cake and ice-cream are allowed options. This puzzle has motivated a variety of proposals about the character of natural language disjunction and permission modals, and the interface between semantics and pragmatics (e.g., Kamp 1973; Kratzer & Shimoyama 2002; Simons 2005; Fox 2007; Klinedinst 2007; Chemla 2009; Goldstein 2019; Aloni 2022, *inter alia*). One popular proposal characterizes free choice inferences as a type of quantity implicature, generated by enriching denotations of *or* and *allow* that are akin to their counterparts in classical logic (Kratzer & Shimoyama 2002, Alonso-Ovalle 2005; Fox 2007; Chemla 2009; Franke 2011; Bar-Lev & Fox 2020). This requires making use of "**disjunct alternatives,**" propositions corresponding to the individual disjuncts of the free choice disjunction that are generated by deleting elements of the original utterance (Katzir 2007; Fox & Katzir 2011). Other proposals revise the denotations of possibility and disjunction, and treat free choice inferences as a result semantic composition (Simons 2005, Goldstein 2019). A third, recent proposal has argued that free choice inferences are the result of non-truth-conditional pragmatic enrichment (Aloni 2022).

This report provides developmental evidence in favour of a quantity implicature characterization of free choice. We show that when the disjunct alternatives needed to generate the implicature cannot be derived from the immediate scenario context, children interpret (1) as being compatible with a scenario where only one disjunct is allowed. Our report is a response to a study by Tieu, Romoli, Zhou, & Crain (2016) showing that 4-year-old Mandarin children generate free choice inferences. Tieu et al.'s study is notable because even 5-year-olds are known to have difficulties generating scalar implicatures (Noveck 2001; Papafragou & Musolino 2003; Guasti, Chierchia, Crain, Foppolo, Gualmini & Meroni 2005; Katsos and Bishop 2011; Foppolo, Guasti & Chierchia 2012; Skordos and Papafragou 2016; Horowitz, Scheider & Frank 2018; *inter alia*). When children do successfully generate implicatures, this is often when the alternative needed to compute the implicature has been made salient in some way, for example, by contrasting underinformative and appropriately informative statements (e.g., Foppolo et al. 2012), by contrasting the scenes or referents that a statement is supposed to describe (e.g. Katsos and Bishop 2011; Stiller, Goodman & Frank 2015), or by initially training/priming children with the stronger alternative (e.g. Foppolo et al. 2012; Skordos and Papafragou 2016). Since Tieu et al.'s experimental design did not explicitly make the disjunct alternatives salient, children's behaviour in their study seems to suggest that free choice inferences do not pattern like scalar implicatures. Tieu et al.'s result has provided motivation for semantic (e.g., Goldstein 2019) and non-truth-conditional (e.g., Aloni 2022) accounts of free choice.

However, as we will detail in section 3, an aspect of Tieu et al.'s design seems to indicate that the propositions equivalent to the disjunct alternatives were **contextually** salient in the experimental task, such that children in that study might have been, in effect, computing "ad-hoc" or contextual implicatures (Hirschberg 1985). Ad-hoc implicatures are easier for children to compute than scalar implicatures: children as young as 3-and-a-half can generate them (Stiller et al. 2015; Rees et al. 2023), arguably because unlike scalar implicatures, the alternatives used for ad-hoc implicature do not involve lexical replacement and are accessible from the task context. If children in Tieu et al's study were generating free choice inferences as ad-hoc implicatures, free choice may not be developmentally special and may not need special treatment in semantic/pragmatic theories.

In our experiment, we present 4- and 5-year-old English speakers with scenes described with sentences like (1), in a design where the disjunct alternatives must be derived for each scene and cannot be inferred from the task setup. In this configuration, children's interpretation of sentences like (1) are more revealing about their ability to generate free choice inferences and about the underlying nature of free choice disjunctions.

In the next section we outline how free choice inferences are generated as a quantity implicature using a recursive *exh* operator (Fox 2007). In section 3 we explain why propositions equivalent to the disjunct alternatives must have been contextually available for children in Tieu et al.'s (2016) experimental design. In section 4 we provide details of a Truth Value Judgement Task with 4- and 5-year-olds where we prevent the disjunct alternatives from being contextually available. Section 5 presents the results of this experiment, which we discuss in Section 6.

## 2. Free Choice as an Implicature

Generating free choice inferences as a quantity implicature requires making use of disjunct alternatives. If (2) is the basic denotation of a sentence like (1), its disjunct alternatives are (3) and (4) respectively:

2. $\Diamond(a \vee b)$
3. $\Diamond a$
4. $\Diamond b$

Deriving these inferences as implicatures also requires changes to the standard Gricean recipe for generating quantity implicatures, whereby stronger alternatives are simply treated as false and added to the original utterance. This is because adding the falsity of each disjunct alternative to the original disjunction yields a contradiction: if $\neg\Diamond a$ and $\neg\Diamond b$, then $\Diamond(a \vee b)$ cannot be true. There are a variety of proposals for how to change the Gricean recipe (e.g., Klinedinst 2007, Fox 2007, Chemla 2010, Franke 2011, Bar-Lev and Fox 2020, *inter alia*). For illustrative purposes, we will adopt Fox's (2007) recursive exhaustivity approach, although our argument extends to other approaches that make use of the disjunct alternatives.

We will focus on the operations involving the disjunct alternatives only and ignore the conjunctive alternative, $\Diamond(a \wedge b)$, since the conjunctive alternative does not play a role in free choice.[1]

Fox (2007) makes use of a covert operator, *exh,* which when applied to a sentence adds the negation of the sentence's "innocently excludable" alternatives to its meaning (defined below). The *exh* operator is defined by (5):

5. $[\![exh\, p]\!]^w = [\![exh]\!]^w(C)(p)$

$= p(w) \wedge \forall q\big(q \in IE(C)(p): \neg q(w)\big)$

where, $C$ is the set of alternatives to $p$, and $IE(C)(p) = \bigcap\{C' \subseteq C: C'$ is a maximal subset of $C$ such that $\{\neg q: q \in C'\} \cup \{p\}$ is consistent$\}$.

$IE(C)(p)$ defines the set of innocently excludable alternatives, the propositions that are in each of the maximal consistently excludable subsets of the set of alternatives. Informally, they are the set of alternatives that when treated as false and added to literal denotation of the utterance, are never the source of a contradiction.

Under Fox's (2007) proposal, *exh* applies recursively so that the enriched interpretations of (3) and (4) are treated as false, which results in a free choice interpretation of (2). Applying *exh* recursively to (2) yields (6):

6. $\big[\!\big[exh_2\,\big(exh_1\,\Diamond(a \vee b)\big)\big]\!\big]^w = [\![exh_2]\!]^w(C_2)([\![exh_1\,\Diamond(a \vee b)]\!]^w)$

$= [\![exh_2]\!]^w(C_2)\ (\underline{[\![exh_1]\!]^w(C_1)\big(\Diamond(a \vee b)\big)})$

Focusing on the first application of *exh,* underlined above, $C_1$ is the set containing the two disjunct alternatives, $\{\Diamond a, \Diamond b\}$. Since adding both the falsity of $\Diamond a$ and the falsity of $\Diamond b$ to (2) leads to a contradiction, and since these are the only alternatives in $C_1$, this means that $IE\big(C_1\big)(\Diamond(a \vee b)\big)$, the set of

[1]It does, however, play an important role in the inferences generated for basic disjunctions.

innocently excludable alternatives for the first application of *exh*, is empty.[2] Consequently, $[\![exh_1 \diamond (a \vee b)]\!]^w = \diamond (a \vee b)$.

Looking at the second application of *exh,* $C_2$ is the set of ***exhaustified*** disjunct alternatives, $\{exh_1 \diamond (a), exh_1 \diamond (b)\}$. Crucially, the application of $exh_1$ in these alternatives is with respect to $C_1$. Thus, $[\![exh_1 \diamond a]\!] = \diamond a \wedge \neg \diamond b$ and $[\![exh_1 \diamond b]\!] = \diamond b \wedge \neg \diamond a$, so $C_2 = \{\diamond a \wedge \neg \diamond b, \diamond b \wedge \neg \diamond a\}$.[3] Now, the meaning of $[\![exh_1 \diamond (a \vee b)]\!]^w$ is $\diamond (a \vee b)$. Adding to it the falsity of $exh_1 \diamond a$ and $exh_1 \diamond b$ gives (7):

7. $\diamond (a \vee b) \wedge \neg(\diamond a \wedge \neg \diamond b) \wedge \neg(\diamond b \wedge \neg \diamond a)$

   $\equiv \diamond (a \vee b) \wedge (\diamond a \rightarrow \diamond b) \wedge (\diamond b \rightarrow \diamond a)$

Since (7) is consistent, both elements of $C_2$ are innocently excludable and can be added to meaning of (6). (7) is equivalent to $\diamond a \wedge \diamond b$, the attested free choice interpretation of (2).

As we can see, free choice inferences can be generated as implicatures using the disjunct alternatives if *exh* can apply recursively such that enriched disjunct alternatives are treated as false.

## 3. Tieu et al. (2016)

Tieu et al. (2016) tested 4-year-old Mandarin speakers' interpretation of free choice disjunctions in a Truth Value Judgement Task (Crain and Thornton 1998). In the critical trials, children were presented with acted-out scenarios involving three characters and an observing puppet. For example, in one scenario, Kung Fu Panda and Batman were in a car-pushing competition, and were given instructions by the judge, Mr. Owl. Mr. Owl says (8) and (9) as the rules of the race:

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[2] To expand on this, adding the falsity of $\diamond a$ alone is consistent with (2), as is adding the falsity of $\diamond b$ alone to (2). Thus, the set of all maximal consistently excludable subsets of $C_1$ is $\{\{\diamond a\}, \{\diamond b\}\}$. The grand intersection of this set is empty, hence $IE(C_1)(\diamond(a \vee b))$ is empty.

[3] To see why, first consider $exh_1 \diamond a$. $[\![exh_1 \diamond a]\!] = [\![exh]\!]^w (C_1)(\diamond a)$, where $C_1 = \{\diamond a, \diamond b\}$. Obviously $\diamond a$ is not innocently excludable from itself. However, $\diamond a \wedge \neg \diamond b$ is consistent, so $\diamond b$ is innocently excludable. Thus, $[\![exh_1 \diamond a]\!] = \diamond a \wedge \neg \diamond b$, and for parallel reasons, $[\![exh_1 \diamond b]\!] = \diamond b \wedge \neg \diamond a$.

8. Kung Fu Panda is only allowed to push the green car

   = $\Diamond(\boldsymbol{push}(green)(KFP)) \wedge \neg\Diamond(\boldsymbol{push}(orange)(KFP))$

9. Batman is only allowed to push the orange car.

   = $\Diamond(\boldsymbol{push}(orange)(B)) \wedge \neg\Diamond(\boldsymbol{push}(green)(B))$

Before the competition began, Batman asked the puppet to remind him of the rules, which the puppet restates using a free choice disjunction like (10):

10. Batman is allowed to push the orange car or the green car.

A Boolean interpretation of the puppet's restatement, shown in (11), is compatible with the rule given by Mr. Owl, while a free choice interpretation of the puppet's statement, shown in (12) is not:

11. $\Diamond(\boldsymbol{push}(orange)(B)) \vee \Diamond(\boldsymbol{push}(green)(B))$
12. $\Diamond(\boldsymbol{push}(orange)(B)) \wedge \Diamond(\boldsymbol{push}(green)(B))$

If children generate free choice inferences, they should reject the puppet's restatement.

Tieu and colleagues found that in these scenarios, children in the study rejected the puppet's restatements 91% of the time. In control trials testing the exclusivity inference of basic disjunctions, those same children accepted the puppet's underinformative statements 82% of the time. If free choice inferences are quantity implicatures, the children in this study computed them much more easily than they computed scalar implicatures. Since the experiment's design did not explicitly highlight the disjunct alternatives by contrast or priming, these results seem to indicate that something is developmentally special about free choice.

Note, however, that the rejection of the puppet's statement requires children to also correctly interpret *only* in the initial rule. If children treat *only* as vacuous, then the denotation of the rule for Batman is simply $\Diamond(\boldsymbol{push}(orange)(B))$, which is compatible with both a free choice interpretation and a Boolean interpretation. This means that if children treated *only* as vacuous, they would have accepted the puppet's rule restatement regardless of whether or not they generated free choice inferences. Children's rejection of the puppet's statements tells us that they correctly interpreted "*Batman is only allowed to push the orange car"* in addition to giving (9) a free choice interpretation.

Under standard semantic analyses, the denotation of *only* adds the falsity of its prejacent's alternatives to the prejacent's denotation.[4] For (8), the prejacent of *only* and its focus alternative are shown by (13) and (14) respectively:

13. $\Diamond(\boldsymbol{push}(orange)(B))$.
14. $\Diamond(\boldsymbol{push}(green)(B))$.

Crucially, both (13) and (14) are equivalent to the disjunct alternatives of the puppets restatement: simplifying *Batman is allowed to push the orange car or the green car* yields the alternatives, *Batman is allowed to push the orange car* and *Batman is allowed to push the green car.* This means that independent of the puppet's disjunctive restatement, the alternatives needed to generate free choice inferences had to have been contextually accessible for participants, in order for them to interpret *only* non-vacuously in the original rule.

This may have been due to the characters and objects in the scenarios being visually present before the initial rule was said, which may have motivated children to construct a common ground for the task that contained the disjunct alternatives. Prior to the rule being spoken, children were presented with two characters (e.g., Kung Fu Panda, Batman) who they were told would be racing cars, and three options for the races (e.g., green car, orange car, purple car). At this point, children may have initially constructed a common ground like (15):

15. $\{\Diamond(\boldsymbol{push}(orange)(KFP)),$

    $\Diamond(\boldsymbol{push}(green)(KFP)),$

[4] Something like, $[\![\text{only}]\!](C)(p)(w) = p(w). \forall q(q \in IE(C) \rightarrow \neg q(w))$, where $IE(C)$ is the set of innocently excludable alternatives.

$\Diamond(\boldsymbol{push}(purple)(KFP))$,

$\Diamond(\boldsymbol{push}(orange)(B))$,

$\Diamond(\boldsymbol{push}(green)(B))$,

$\Diamond(\boldsymbol{push}(purple)(B))\}$

Since (15) contains both $\Diamond(\boldsymbol{push}(orange)(B))$and $\Diamond(\boldsymbol{push}(green)(B))$, the propositions needed to correctly interpret both the initial rule and the puppet's restatement are contextually available for both semantic enrichment and implicature computation. The use of *only* in the initial rule might also have functioned a literal signal to recruit alternatives for semantic enrichment.

Given the above, the free choice interpretations in Tieu et al.'s study might be better thought of as ad-hoc implicatures using contextually provided alternatives that just happened to have been equivalent to the disjunct alternatives. Children may underlying represent free choice disjunctions using a Boolean disjunction operator and an existential deontic modal, and they may have difficulty generating the free choice implicature when the scenario is such that the disjunct alternatives are not contextually available. In the following experiment we investigate how preschoolers interpret free choice disjunctions when the disjunct alternatives cannot be derived from the broader scenario.

## 4. Experiment

We assessed preschool-aged English-speaking children's interpretation of free choice disjunctions using a Truth Value Judgement Task (Crain and Thornton 1998). We prevented the disjunct alternatives from being contextually implied by telling children a rule that applies generally to any item and by presenting that rule without any referents of the rule present. Our scenario involved a soft-toy, Larry, whose mum is throwing out some of his things. Children heard a rule indicating Larry is allowed to keep items with reds stars on them. The rule came in two variations. In the basic rule, children heard (16a), which has a denotation like (16b):

16. a. Larry's mum put a red star on all the things Larry is allowed to keep

    b. $\forall x(\Diamond keep(x)(Larry) \rightarrow put(red\_star)(x)(Larry's\ Mum)$

In the exhaustified rule, children heard an additional sentence using *only* that reinforces the rule:

17. a. Larry's mum put a red star on all the things he's allowed to keep. <u>So, he's only allowed to keep things with a red star on them.</u>

The first sentence of (17a) has the denotation shown in (16b). The second sentence adds something like (17b) to its meaning:

b. $\Diamond keep(things\_with\_red\_star))(Larry) \wedge$

$\neg\Diamond keep(things\_without\_red\_star))(Larry)$

Importantly, neither rule explicitly names the particular items – e.g., teddy, train, ball, etc. – that Larry is allowed to keep. Children also heard the rule prior to viewing any scenes, to prevent them from constructing a common ground like (15).

In the critical trials, children viewed scenes with three items (e.g., a train, a teddy, and ball), one with a red star under it (e.g. the teddy), and heard Larry say something like (18):

18. I'm allowed to keep the train or the teddy.

If children reject Larry's statement, we can be confident that they have done so without the disjunct alternatives being contextually available.

### ***4.1. Methods***

#### *4.1.1. Participants*

We recruited 78 typically developing English-speaking 4- to 5-year-olds (M= 5.05, min = 4.02, max = 5.99) and 75 monolingual or English-dominant adults (min = 22, max = 63). The children had already participated in a previous experiment looking at their interpretation of *some* and *all,* which is not reported here. Children were recruited from around the United States and Australia through advertising and word-of-mouth (U.S. English N= 76; Australian English N = 2). Adults were recruited using Prolific and self-reported as not having any language, speech or cognitive impairments. We used a pre-determined criterion to exclude participants from analysis who failed more than two out of eight control trials. This led to two children and three adults being excluded from analysis.

*4.1.2. Design and Materials*

Participants were randomly assigned to one of three conditions that varied the type of rule the participants heard and whether the critical trials involved a disjunction or conjunction (Table 1). In the **disjunction** condition (N children = 27, N adults = 23), participants heard the basic rule (16a), and the critical trials used a disjunctive statement like *"I'm allowed to take the X or the Y."* In the **disjunction+only** condition (N children = 26, N adults = 27), participants heard the exhaustified rule (17a), and the critical trials sued a disjunctive statement like *"I'm allowed to take the X or the Y."* In the **conjunctive** condition (N children = 23, N adults = 22), the participants heard the basic rule (16a), and the critical trials used a conjunctive statement like *"I'm allowed to take the X and the Y."* The conjunction condition was included to ensure that an interpretation that Larry was claiming both items were allowed was possible in the task.

Stimuli consisted of visual scenes containing three everyday objects, only one of which had a red star underneath it. Scenes were paired with pre-recorded assertions made by a male voice, that contained a permission modal and came in three flavours: single constructions as in, *"I'm allowed to keep the X";* disjunctive constructions, as in *"I'm allowed to keep the X or the Y";* and conjunctive constructions as in *"I'm allowed to keep the X and the Y."*

Participants saw 16 trials, eight critical and eight control, presented in pseudo-randomized order. In critical trials, Larry produced a disjunctive sentence or a conjunctive sentence in a scene where the star was under only one of the mentioned items (Figure 1a). Participants heard a disjunctive or conjunctive sentence depending on their assigned condition. Whether the item with the star was mentioned in the first or second disjunct/conjunct was balanced across trials. For the eight control trials, four used a single construction that was unambiguously true (two) or unambiguously false (two) (Figure 1b/c). The other four used a disjunctive/conjunctive sentence that was false because the item with the star was the third, unmentioned item (Figure 1d).

## 5. Results

Figure 2 shows the mean proportion of responses that accepted the puppet's statement in the critical trials, by each individual and by group. Children generally accepted the puppet's statement in the disjunction condition (*M* = 64%*, SD* = 38%) and in the disjunction only condition (*M* = 59%*, SD* = 48%), and generally rejected the statement in the conjunction condition (*M* = 9.7%*, SD* = 14%). Adults in all three conditions rejected the puppet's statements (disjunction: *M* = 17%*, SD* = 35%; disjunction+only: *M* = 27%*, SD* = 45%; conjunction: *M* = 0%*, SD* = 0%).

To analyze this data, we fitted a logistic mixed effects regression model using the *glmer* function in R's *lme4* package (Bates, Mächler, Bolker, & Walker, 2015), using backwards elimination to select the best model, and compared the marginal means derived from the best model to chance. The initial model predicted participant response (accept, reject) as a function of experimental condition (disjunction, disjunction+only, conjunction), age group (adult, child), disjunct position of the item with the star (first, second), and the interaction between age group and condition, with participants and items as random intercepts.[5] The best included only condition and age group as predictors. This model's parameters are shown in Table 2. We used the *emmeans* package in R (Lenth, 2017) to compute the model's estimated marginal means and test whether they fell significantly below or above chance. Children in the two disjunction conditions were significantly above chance in **accepting** the puppet's statement (

Of the children, only those in the conjunction condition rejected the critical trials at a rate significantly below chance ($p < 0.0001$). Adults rejected the critical trials significantly below chance in all

[5] response ~ condition * age.group + disjunct.position + (1|PID) + (1|item.number)

three conditions. This suggests that children did not robustly generate free choice inferences in either the disjunction and disjunction+only conditions.

## 6. Discussion

Children in our study failed to generate free choice inferences, accepting sentences like *"I'm allowed to keep the train or the teddy"* in a scenario where the speaker was only allowed to keep the one item (e.g. the teddy). This is consistent with children interpreting these sentences as involving a Boolean disjunction operator is in the scope of an existential quantifier that ranges over deontic worlds. Mentioning *only* in the rule did not facilitate free choice interpretations.

In so far as language development is revealing about the mechanisms and representations that underly adult linguistic competence, our results point to free choice inferences being underlyingly a type of quantity implicature, generated by using disjunct alternative to enrich an utterance whose literal denotation has a disjunction and a permission operator that are akin to their counterparts in classical logic. 4- and 5-yearolds are known to have difficulty generating implicatures when the alternatives needed to do so are not contextually accessible (Guasti et al. 2005; Katsos and Bishop 2011; Foppolo, et al. 2012; Skordos and Papafragou 2016; *inter alia*). In our study, we blocked the contextual accessibility of the disjunct alternatives by telling children a rule that applied generally to any item, not the specific items that were referenced in the critical trials, and by making sure children never heard a proposition that was equivalent to any disjunct alternative until they assessed the critical trial. That children failed to generate free choice inferences is consistent with their inability to generate implicatures in the absence of contextual support. Free choices inferences do not appear to be developmentally special, and pattern like quantity implicatures more broadly.

Children in the *disjunction* and *disjunction-only* were not above chance in their acceptance of the free choice disjunction (although for children in the *disjunction-only,* this difference was marginal). We also do not show a condition where children successfully generate free choice. This could suggest that free choice inferences were available at all in the task design, or that the task was confusing for children.

However, children in the conjunctive condition rejected sentences like *"I'm allowed to keep the cup and the chair,"* which in the task context is equivalent to free choice. This is evidence that the free choice interpretation was available in the task context. Furthermore, very few individual children were at chance in *disjunction* and *disjunction+only* conditions; the distribution of children's individual responses looks bimodal, with the responses clustered towards full acceptance and full rejection. Individual children were not confused. This is notable, given the characterization of free choice inferences as easier to derive based on Tieu et al.'s (2016) results.

Our findings pose a challenge for accounts of free choice under which Boolean interpretations are more complex or more costly to process than free choice interpretations. Goldstein (2019), for example, derives free choice inferences using non-classical disjunction and permission operators, such that a Boolean interpretation of a free choice sentence requires an additional "flattening" operator that intervenes between the permission modal and the disjunction operator. Under this account, the behaviour of children in our study implies that they preferred a more complex representation that included the flattening operator over a representation without it. Aloni's (2022) proposal revises the underlying modal system and argues for a new mechanism of pragmatic enrichment. Aloni argues that processing utterances where one structure has an empty state – like a disjunction which is true by virtue of one disjunct being true – is cognitively costly enough such that speakers apply this new pragmatic enrichment to remove empty states from the representation. Under this system, free choice inferences are the result of this kind of pragmatic enrichment. Again, the implication of this proposal is that the children in our study preferred the more costly empty state Boolean disjunction over applying the pragmatic enrichment mechanism. Aloni (2022) partially motivates her proposals by appealing to the early acquisition of free choice inferences. Children's behaviour in our study suggests this appeal is not warranted.

While free choice inferences may not be developmentally special, this doesn't imply that they do not form a distinct class of quantity implicature in adult language. In adults, free choice inferences have been shown to be less costly to generate than standard scalar implicatures (Chemla and Bott 2014), and in ternary judgement tasks, to be less acceptable than basic disjunctions when only one disjunct is true (Tieu, Bill, & Romoli 2019). It may be that simplification of the original disjunction (Katzir 2007, Fox & Katzir 2011) provides a less-costly source of alternatives for mature speakers, but not for preschool-aged children. This may be due to the unavailability of simplification at younger ages, or because knowing that the asserted utterance can itself be a source of alternatives requires a form of metalinguistic awareness that preschoolers do not possess. Further research is needed to understand why free choice has these signatures in adult language and the time course of their development.

## 7. Conclusion

In this report, we provided developmental evidence from 4- and 5-year-olds that suggest free choice disjunctions underlyingly involve a disjunction and permission operator akin to those found in classical logic. Free choice inferences do not appear to be developmentally special, but rather pattern like quantity implicatures more broadly. These results add to the evidence that that free choice inferences are a type of quantity implicature (Kratzer & Shimoyama 2002, Alonso-Ovalle 2005; Fox 2007; Chemla 2009; Franke 2011; Bar-Lev & Fox 2020), and not the result of non-classical denotations of disjunction, permission, and pragmatic enrichment (Simons 2005, Goldstein 2019, Aloni 2022).

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## 9. Appendix

### *9.1. Tables*

*Table 1: Experiment Conditions*

| ***Condition*** | ***Rule*** | ***Critical Sentence*** | ***N children*** | ***N adults*** |
|---|---|---|---|---|
| disjunction | Larry's mum put a red star on all the things Larry is allowed to keep | I'm allowed to keep the train or the teddy | 27 | 23 |
| disjunction+only | Larry's mum put a red star on all the things Larry is allowed to keep. So, he's only allowed to keep things with a red star on them. | I'm allowed to keep the train or the teddy | 26 | 27 |
| conjunction | Larry's mum put a red star on all the things Larry is allowed to keep | I'm allowed to keep the train and the teddy | 23 | 22 |

*Table 2: Parameters of best logistic regressions model*

| ***Parameter*** | ***B*** | ***Std β*** | ***95 % CI*** | ***p*** |
|---|---|---|---|---|
| Intercept (condition = disjunction, group = Child) | 1.84 | – | [–0.53, 4.22] | 0.129 |
| Condition: disjunction + only | 0.56 | 0.56 | [–1.78, 2.89] | 0.640 |
| Condition: conjunction | –8.36 | –8.36 | [–12.21, –4.51] | < 0.001 |
| Group: Adult | –8.44 | –8.44 | [–11.92, –4.96] | < 0.001 |

*Table 1: Test of Estimated Marginal Means against Chance (two-tailed)*

| ***Group*** | ***Condition*** | ***Estimate (log-odds)*** | ***SE*** | ***z*** | ***p*** |
|---|---|---|---|---|---|
| Child | disjunction | 1.84 | 1.21 | 1.52 | 0.128 |
| Child | disjunction+only | 2.40 | 1.26 | 1.904 | 0.068 |
| *Child* | *conjunction* | *-6.52* | *1.32* | *-4.928* | *<0.0001* |
| *Adult* | *disjunction* | *-6.60* | *1.26* | *-5.229* | *<0.0001* |
| *Adult* | *disjunction+only* | *-6.04* | *1.26* | *-4.785* | *<0.0001* |
| *Adult* | *conjunction* | *-14.96* | *2.60* | *-5.760* | *<0.0001* |

### *9.2. Figures*

*Figure 1*

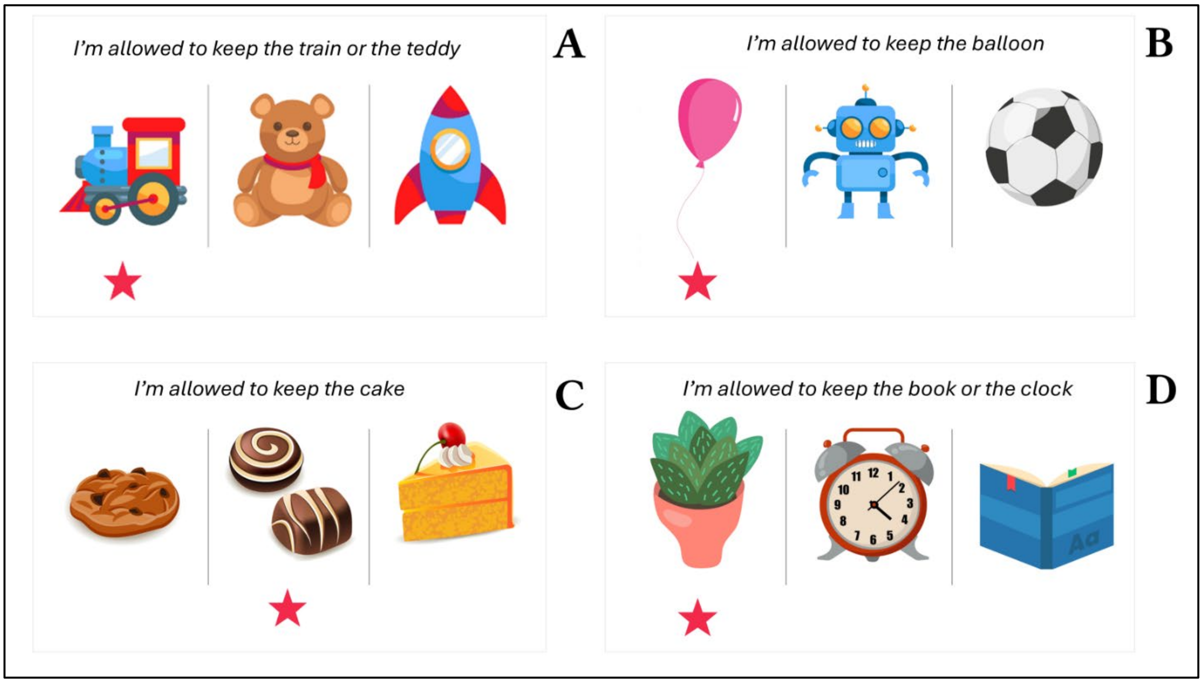
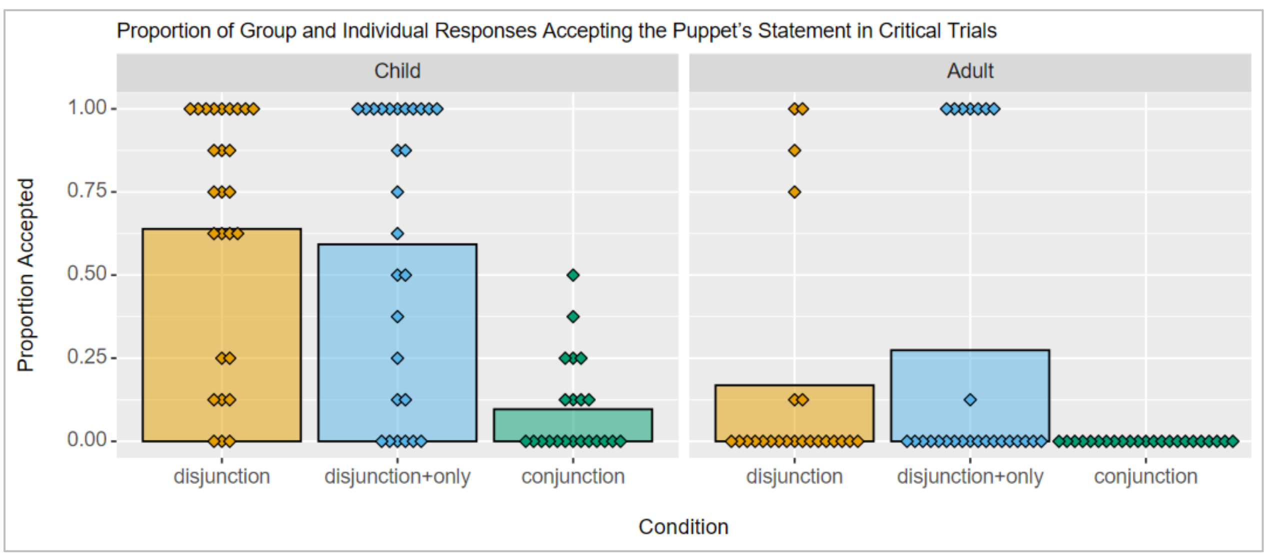



*Figure 2*



### *9.3. Figure Captions*

*Figure 1:*

Examples of the critical and control trials. (a) shows a critical trial, which is true under a Boolean interpretation, but false under a free choice interpretation. (b) shows a true control, (c) shows a false control, and (d) show a false disjunction control. Participants in the conjunctive condition heard the sentences in (a) and (d), but with “and” as the connective instead of “or.”

*Figure 2:*

Proportion of group and individual responses accept puppet's statement in critical trial. Each diamond represents an individual’s response profile. E.g. there are two children in the disjunction condition who accepted the puppet’s statement 25% of the time. The bar plots represent mean proportion accepted for each group.