"There's the ball *or* the car in this cup", but look, the ball is over there: Preverbal logical inferences scaffold early comprehension of verbal disjunction

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Abstract

The relation between logical reasoning and language development is debated. We addressed this issue by focusing on disjunctive reasoning (*A V B; exclude A; therefore, B*) and the acquisition of the connective "or" in 3-year-old children, comparing non-verbal and linguistic contexts. In Experiment 1, children completed first a non-verbal inferential task, and then succeeded in a linguistic inferential task, using "or" to define a set of alternatives (*A V B*) and visual information to exclude one and infer the other (*exclude A; therefore, B*). In Experiment 2, children instead completed a non-inferential control task followed by the same linguistic inferential task: although they succeeded in using visual information, they failed to use "or" to identify the relevant set of alternatives. Therefore, children who had previously engaged in non-verbal disjunctive reasoning showed a better comprehension of "or". These findings suggest that preverbal inferential abilities support the early acquisition of linguistic disjunction.

Keywords: disjunction; logical reasoning; logical language; preschoolers

Introduction

The relation between reasoning and language has long been a central topic in cognitive science. A core question concerns whether logical reasoning is fundamentally dependent on language, or whether it can emerge independently and only later become integrated with linguistic representations (Braine & O'Brien, 1998; Fedorenko, Piantadosi, & Gibson, 2024; Quilty-Dunn, Porot, & Mandelbaum, 2023). Developmental evidence has been particularly influential in this debate, as early-emerging logical abilities may reveal the extent to which reasoning precedes, depends on, or is shaped by linguistic knowledge.

One form of reasoning that has been broadly investigated is disjunctive inference, formalized as: *A V B; exclude A; therefore, B* [1]. This inference requires representing a set of two alternative possibilities and concluding that one must be true once the other is ruled out. This type of reasoning is not confined to abstract logic but is routinely applied in everyday situations. For example, consider a child searching for a missing toy: she knows that it could be either under the bed – where she usually leaves her toys – or in the toy box – where her father typically puts them away. If she looks under the bed and does not find it, she can then infer that the toy must be in the toy box. This simple scenario illustrates how people reason about events in the real world by entertaining multiple hypotheses, ruling out alternatives, and selecting the remaining plausible one.

At a conceptual level, the disjunctive inference draws on several logical ingredients. First, it requires representing a set of alternatives as linked by the logical relation of DISJUNCTION: the toy is in one of the two locations. Second, it involves EXCLUSION, insofar as one possibility must be ruled out: the toy is not under the bed. Third, it relies on the logical operation of deducing the remaining option, once the other is eliminated: therefore, the toy is in the box. In natural language, these concepts can be expressed by logical connectives such as "or" and "not". A central question is whether children can reason in these terms before they have mastered the corresponding linguistic labels – and, crucially, how these non-verbal abilities relate to the later acquisition of logical language.

From a linguistic perspective, the connective "or" poses well-known challenges for children. Some work suggests that this logical connective is acquired gradually, as part of a sequence of increasingly sophisticated competencies (Braine & Rumain, 1981). Research on language acquisition shows that preschoolers do not consistently assign adult-like interpretations to sentences containing "or" in truth-value judgment tasks (Chierchia et al., 2001, 2004; Singh et al., 2016; Tieu et al., 2017), or they do so only in certain contexts (Skordos et al., 2020). While adults typically interpret "A or B" as involving mutually exclusive alternatives, children are more likely to accept inclusive interpretations (Chierchia et al., 2001, 2004; Crain, 2008) or even conjunctive ones, under which the sentence is true only if both disjuncts hold (Singh et al., 2016; Tieu et al., 2017). Production data further indicate that "or" is also rare and much less frequent than other connectives like "and" in young children's spontaneous

[1] Disjunctive inference is a broad category of logical inferences that includes the disjunctive syllogism, a specific form of disjunctive inference that relies on propositional negation (¬A). In other words, the elimination of one disjunct can involve different representations than a propositional operator of negation (for a discussion of this point see Cesana-Arlotti & Halberda, 2024). Here, we remain neutral on whether children's disjunctive inferences involve propositional negation.

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speech and may be learned in a highly context-dependent manner (Jasbi et al., 2024; Morris, 2008). Thus, there is no clear consensus on when children acquire a full representation of "or". Here we adopt a different perspective, focusing on its inferential role: whereas prior work has examined truth-value judgments for sentences containing "or", no study to date has directly tested whether three-year-olds can use this connective to derive disjunctive inferences.

From a cognitive point of view, a growing body of literature suggests that some components of disjunctive reasoning emerge very early in development. Strikingly, preverbal infants as young as one year of age have been shown to draw disjunctive inferences from purely visual events and to detect outcomes that violate such inferences (Cesana-Arlotti et al., 2018; Cesana-Arlotti, Kovács, & Téglás, 2020). These findings suggest that the capacity to represent alternatives and to reason deductively may be available before children acquire verbal disjunction.

How these early successes should be interpreted, however, remains a matter of debate. Some accounts argue that infants and young children rely on non-logical strategies that do not require representing disjunctions over alternatives, such as minimal representation of possibilities (Leahy & Carey, 2020). On this latter view, genuine reasoning over alternatives would emerge only later, alongside the acquisition of logical words such as "or", "can", or "have to" (Leahy, et al., 2022; Mody & Carey, 2016). Other accounts, by contrast, provide additional evidence that infants and young children can truly recruit logical inferences over alternatives (Bohus et al., 2023; Cesana-Arlotti et al., 2022; Cesana-Arlotti & Halberda, 2024; Wang & Cesana-Arlotti, 2025). This interpretation is further supported by recent work on disjunctive and modal reasoning, which shows that preschoolers succeed in reasoning over alternatives under supportive task conditions (Alderete & Fei Xu; Baumann et al., 2024; Cesana-Arlotti et al., 2025; Gautam, Suddendorf, & Redshaw, 2021; Turan-Küçük & Kibbe, 2025; see Esmer & Cesana-Arlotti 2025, for findings with infants).

In sum, these results suggest that children's ability to reason over alternatives and draw disjunctive inferences may emerge well before their reliable understanding and use of the connective "or", whose developmental trajectory remains debated. This dissociation raises a key open question about how these two competencies are related: if children can reason over alternatives before mastering verbal disjunction, what role does early, non-verbal disjunctive reasoning play in the acquisition of "or"?

The current study

The current study investigates whether young preschoolers understand the meaning of "or", and how linguistic and non-verbal reasoning abilities relate to one another early in development. Specifically, we address two research questions. First, can 3-year-old children use the connective "or" to derive disjunctive inferences? Second, can non-verbal disjunctive inferences scaffold children's comprehension of this logical connective?

We examined these questions in two preregistered experiments with 3-year-old English-speaking preschoolers. In Experiment 1, children first completed an *inferential cognitive task* adapted from Cesana-Arlotti et al. (2018). They observed two objects that were hidden behind an occluder. A cup scooped one of the two; then, the object left behind the occluder briefly appeared, and finally children had to identify the object in the cup. To correctly do so, they had to infer that since one object was not in the cup but behind the occluder, then the other was in the cup. Crucially, no linguistic disjunction was provided, and success required drawing a non-verbal disjunctive inference based solely on visual information. We expect children to succeed in this task, as previous work shows that even infants as young as one year of age are capable of similar non-verbal reasoning.

Children were then tested on an *inferential linguistic task* requiring similar reasoning but involving an additional linguistic disjunction. Three objects were hidden by an occluder, a cup scooped one of them, and children heard a disjunctive statement (e.g., "What's in the cup? The car *or* the ball"). One of the remaining objects was then shown behind the occluder. To respond correctly, children had to (i) use "or" to include the relevant set of disjuncts and (ii) use visual information to exclude one of them. This task addresses our first research question: whether 3-year-olds' comprehension of "or" supports disjunctive inferences.

To examine our second research question concerning the relation between non-verbal and linguistic disjunctive reasoning, we designed Experiment 2, in which a new group of preschoolers was tested on the same linguistic task used in Experiment 1. However, instead of first completing the inferential cognitive task, these children were initially tested on a *non-inferential control task*. This task was visually similar to the inferential cognitive task but did not require children to reason inferentially, as the target object was visibly shown being placed into the cup. After establishing that children could successfully perform this control task, we assessed their performance on the linguistic inferential task.

By comparing children's performance on the linguistic task across experiments, we examined whether prior engagement in non-verbal disjunctive reasoning facilitates linguistic disjunctive inference. Higher performance in Experiment 1 would indicate that activating non-verbal disjunctive inferences in the *inferential cognitive task* supports children's subsequent logical comprehension of "or" in the *inferential linguistic task.* This result would support the view that non-verbal inferential abilities may serve as developmental precursors to the meaning of linguistic disjunction.

Experiment 1

In this experiment, a group of 3-year-old preschoolers performed first an *inferential cognitive task* and then an *inferential linguistic task.*

Method

The experimental methodology, sample size, exclusion criteria, and analyses were preregistered on AsPredicted.

Participants Twenty-four 3-year-old preschoolers (*M*age = 39 months 10 days; range = 36m12d – 42m22d; 14 boys) were included. As preregistered, we excluded children with certified language or hearing impairments; those who failed to correctly label each object at least once during a 9-trial familiarization phase (*N*=9); those who did not complete the study (*N*=5); those who perseverated by giving the same response throughout; those who made more than one error in a 3-trial post-test (*N*=6), or those who provided fewer than two responses per task. Three other participants were excluded because of equipment failure. All children were typically developing and were recruited through emails to caregivers listed in the laboratory's database (who joined it via Facebook advertisement and flyers). All children were either English-speaking monolinguals or, if bilinguals, they were exposed to English at least 70% of the time, as assessed through a language questionnaire. Participants' caregivers provided informed consent. Families received a $5 Amazon gift card and a certificate of participation after the study.

We used a sequential Bayesian sampling procedure to determine sample size (Mani et al., 2021). We calculated the Bayes Factor (*BF*) in JASP (JASP Team, 2025). The study began with an initial sample of $N = 24$ 3-year-old preschoolers, with a plan to stop data collection until one of the following pre-registered criteria was met: $BF_{10} > 5$ (interpreted as moderate evidence in favor of the hypothesis H1), or $BF_{10} < 1/3$ (interpreted as moderate evidence in favor of the null H0), or reaching a max number of 48 participants.

Stimuli and Materials The stimuli consisted of animated PowerPoint videos, including introductory, familiarization, inferential cognitive, inferential linguistic, post-test, and feedback videos. Across all movies, the same materials were used: a cartoon penguin character named Gigi, a set of three toys (i.e., a car, a ball, and an umbrella), an orange cup, and a dark gray occluder. The three toys differed in shape but shared an identical red top, which was the critical visual cue throughout the task.

In the introductory videos, Gigi was presented together with her toys, which were shown and labelled one at a time. These videos served to introduce the character and materials used in the experiment.

In the familiarization videos, a single toy appeared in the center of the screen and was named by a prerecorded voice (e.g., "There's the car!"). An occluder then rose from the bottom of the screen, first partially occluding the object (leaving only the red top visible) and then fully hiding it. A cup subsequently appeared from above, moved behind the occluder, and re-emerged on one side of the screen containing the object, with only its red top visible. Finally, the occluder disappeared and Gigi appeared on the screen.

The inferential cognitive videos (see Figure 1A) followed the same general structure as the familiarization videos but presented two objects simultaneously (e.g., the car and the umbrella). The objects were introduced by a prerecorded voice (e.g., "Look at Gigi's toys! There's the car, there's the umbrella"). After both objects were fully occluded, the cup reappeared containing one of the objects, again showing only the red top, accompanied by a prerecorded prompt (i.e., "What's in the cup? Let's keep looking!"). One of the objects then briefly emerged from behind the occluder before disappearing again. The occluder and the object were removed, and Gigi appeared on the screen.

The inferential linguistic videos (see Figure 1C) were structurally identical to the inferential cognitive videos, with two key differences. First, rather than two objects, three objects (i.e., car, ball, and umbrella) were initially introduced (e.g., "Look at Gigi's toys! There's the car, there's the umbrella, there's the ball!"). Second, when the cup reappeared from behind the occluder, a prerecorded verbal statement of a linguistic disjunction was played (e.g., "What's in the cup? The car or the ball!"). As in the inferential cognitive videos, one of the two objects mentioned in the linguistic disjunction then briefly emerged before the scene ended, and Gigi appeared again next to the cup.

The post-test videos were similar to the familiarization ones but did not include any prerecorded speech.

Feedback videos showed Gigi in the center of the screen. In three videos, one object emerged bouncing from the cup next to Gigi (one video per object). In the fourth feedback video, Gigi celebrated with stars around her.

Multiple versions of each video were created for counterbalancing reasons, resulting in 16 experimental conditions. We fully counterbalanced the target object in the cup, the order of linguistic disjuncts in the inferential linguistic videos, the left-right position of the objects on the screen, and the order of trials.

Procedure Participants were tested online via the Zoom platform. Children were seated either independently in front of a laptop or on their caregiver's lap. Caregivers were instructed not to assist the child by naming objects or repeating disjunctive statements; they were allowed only to repeat the prompt "What's in the cup?" if needed, which was the question the experimenter asked throughout the study.

After the initial setup, the experimenter introduced Gigi, explaining that she needed help finding her toys. Children then watched the introductory video, followed by the familiarization phase. At the end of each familiarization video, the experimenter asked "What's in the cup?", and the child responded verbally. Each child completed between three and nine familiarization trials and advanced to the test phase only after correctly naming each object (i.e., car, ball, and umbrella) at least once; otherwise, the study was discontinued. After each response, the experimenter played a feedback video and provided content-specific verbal feedback (e.g., "Good job, you found it! Let's keep going!" or "Nice try, but that's the car! Let's try again!").

Children then moved on to the inferential cognitive task. Each child completed four trials. As in the familiarization phase, after each video the experimenter asked "What's in the

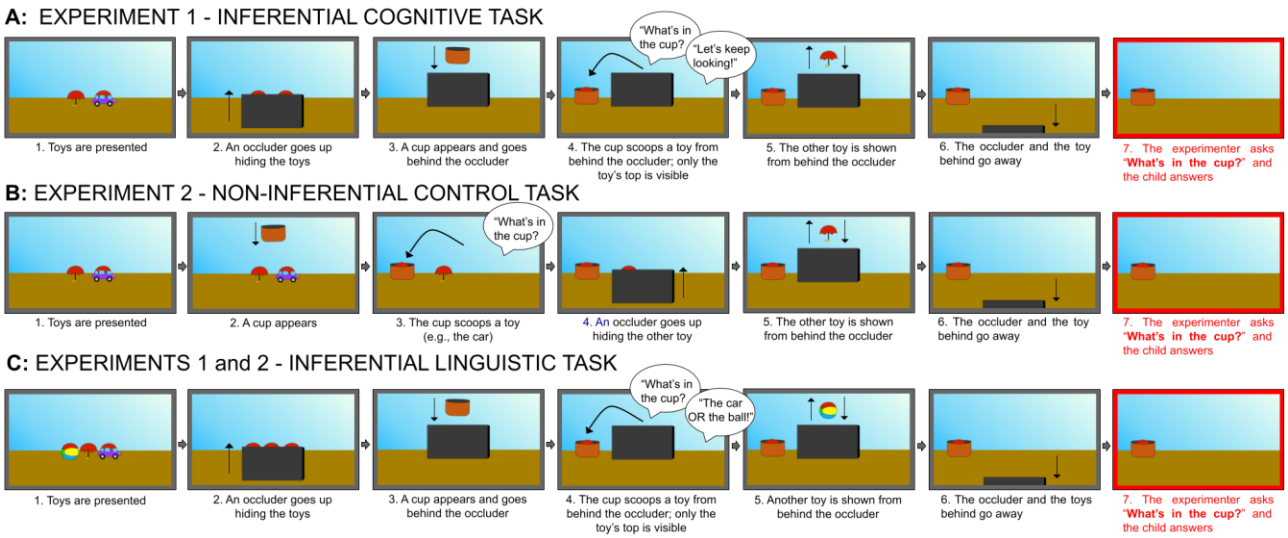

Figure 1: Example stimuli and procedure for Experiment 1 and 2. Speech balloons show the prerecorded sentences heard by the child. **A:** Inferential cognitive task (Exp1): children infer the hidden object from visual information alone. **B:** Non-inferential control task (Exp2): no inference is needed, as the scooped object is visible. **C:** Inferential linguistic task (Exp 1-2): children infer the hidden object by integrating visual and linguistic information.

cup?"; the child responded verbally and content-specific feedback was provided.

After a short break, in which the experimenter encouraged children to continue paying attention (i.e., "Thanks for playing with Gigi! She really needs your help. Now there's more toys, we have to listen carefully. Let's continue to play!"), children completed the inferential linguistic task. This task also consisted of four trials per child. All children were presented with the three objects, and each video included a disjunctive linguistic prompt.

Finally, children completed the post-test phase, which included three trials, one per object, presented in the same order as in the familiarization phase. As before, the experimenter asked "What's in the cup?" at the end of each video, and the child responded verbally. Feedback in this phase was always positive and non-informative, consisting of the celebratory Gigi video, regardless of the child's response. To be included in the final sample, children were required to respond correctly in at least two of the three post-test trials.

Analysis, Results and Discussion

In each trial, we transcribed the object named by children in response to "What's in the cup?". Trials in which children gave no response or named an object absent in the trial were excluded. The same transcribed responses were then coded as 1 or 0 separately for each analysis according to its specific criteria, and an average accuracy score was computed per child for each analysis. As Shapiro-Wilk tests indicated non-normal distributions, all analyses used Bayesian one-sample Wilcoxon signed-rank tests.

In the inferential cognitive task, children were required to identify the object in the cup by excluding the object that was shown outside the cup. Responses naming the target object were coded as correct (1), and responses naming the competing object were coded as incorrect (0). Children performed above chance in selecting the correct answer (M = 88.19%, SD = 24.32; BF_{10} = 8171; chance level = 0.5) (see Figure 2), providing strong evidence for successful non-verbal disjunctive reasoning, as predicted by the proposal that infants and preschoolers can reason logically before the age of four years, and prior to the full mastery of verbal disjunction (Cesana-Arlotti et al., 2018, 2020).

In the inferential linguistic task, children were asked to identify the object with an inference based on the experimenter's verbal prompt and visual information. Thus, responses naming the target object were coded as 1, and responses naming one of the two other objects were coded as 0. Children performed above chance in selecting the correct answer (M = 78.82%, SD = 23.05; BF_{10} > 10,000; chance level = 0.33) (Figure 2). Crucially, success required children to (i) include the relevant set of disjuncts based on "or" comprehension (e.g., "The car OR the ball"), and (ii) exclude the object shown outside the cup. Since the two components of the inference required different abilities – namely, "or" comprehension and excluding one disjunct based on visual information – we examined these competencies separately.

First, we tested children's comprehension of "or". Thus, responses naming either disjunct (i.e., ball or car) were coded as correct (1); responses naming the unmentioned object (i.e., umbrella) as incorrect (0). Children reliably named a disjunct above chance (M = 88.54%, SD = 22.1; BF_{10} = 48.92; chance level = 0.66).

Second, we tested children's exclusion of the object seen behind the occluder. Responses naming not-shown objects were coded as correct (1); naming the shown object as incorrect (0). Again, accuracy exceeded chance (M = 82.64%, SD = 18.04; BF_{10} = 264.0; chance level = 0.66).

Taken together, these results suggest that by age 3 children understand the inclusive meaning of the connective "or", and use visual information to exclude one of disjunct and derive

a deductive inference. Importantly, children in Experiment 1 completed the inferential linguistic task after having first engaged in non-verbal disjunctive reasoning in the inferential cognitive task. This raises the question of whether their success in the linguistic task was facilitated by this prior non-verbal experience – in other words, whether activating disjunctive reasoning in a non-linguistic context may have primed or scaffolded children's subsequent use of "or" to guide inference. To address this question, we conducted Experiment 2, and compared the two experiments.

Experiment 2

In Experiment 2, a new group of 3-year-old preschoolers performed first a *non-inferential control task* and then the *inferential linguistic task*.

Method

The experimental methodology, sample size, exclusion criteria, and analyses were preregistered on AsPredicted.

Participants Twenty-four 3-year-old preschoolers (*M*age = 38 months 19 days; range = 36m9d – 42m17d; 11 boys) were included. Nineteen additional participants were tested but not included in the analysis due to failure in the familiarization phase (*N*=10), failure in the post-test phase (*N*=7), or because they did not complete the study (*N*=2). The recruitment procedures, inclusion criteria, and ethical protocols for Experiment 2 were identical to those used in Experiment 1.

Stimuli and Materials The stimuli and materials used in Experiment 2 were identical to those used in Experiment 1, with one crucial exception: the inferential cognitive videos were replaced by non-inferential control videos. As in Experiment 1, all stimuli were animated videos created in PowerPoint.

The non-inferential control videos (see Figure 1B) were visually similar and matched in structure and timing with the inferential cognitive ones but did not require children to draw a disjunctive inference to identify the object in the cup. In each control video, two toys with identical red tops were presented on the screen (e.g., "Look at Gigi's toys! There's the car, there's the umbrella"). One object was then visibly scooped up by the cup (e.g., the car), and a prerecorded voice asked "What's in the cup?". Subsequently, an occluder rose to hide the remaining object (e.g., the umbrella), which later reappeared briefly from behind the occluder. The occluder and objects were then removed, and Gigi appeared on the screen next to the cup.

As in Experiment 1, we fully counterbalanced the target object in the cup, the order of linguistic disjuncts in the inferential linguistic videos, the left-right position of the objects on the screen, and the order of trials.

Procedure The procedure in Experiment 2 was identical to that of Experiment 1, except for the replacement of the inferential cognitive task with the non-inferential control task. This task also consisted of four trials. After each video, the experimenter asked "What's in the cup?", and the child responded verbally.

Analysis, Results and Discussion

Coding and analyses followed the same criteria adopted in Experiment 1. Children's verbal responses were transcribed, trials with no response or irrelevant answers were excluded, and averaged accuracy scores were computed at the child level. As in Experiment 1, all analyses were conducted using Bayesian one-sample Wilcoxon signed-rank tests.

In the non-inferential control task, children were asked to identify the object in the cup after directly observing it being scooped up, with no inference required. As expected, they named the target object above chance (M = 95.49%, SD = 10.42; BF_{10} > 10,000; chance level = 0.5) (see Figure 2).

In the inferential linguistic task, which was identical to Experiment1, children succeeded in selecting the correct object (M = 65.97%, SD = 21.56; BF_{10} > 10,000; chance level = 0.33) (Figure 2). Then, we examined the two inference components separately.

This time, in the "Inclusion by OR" test, children did not reliably name a disjunct above chance (M = 75.69%, SD = 23.94; BF_{10} = 0.725; chance level = 0.66), providing no clear evidence of understanding the meaning of "or". Instead, as in Experiment 1, they used visual information to exclude one disjunct (M = 86.11%, SD = 16.79; BF_{10} = 1285; chance level = 0.66).

Taken together, these results reveal a dissociation in Experiment 2: while children were able to exclude the object revealed behind the occluder, they did not reliably use "or" to restrict the space of alternatives.

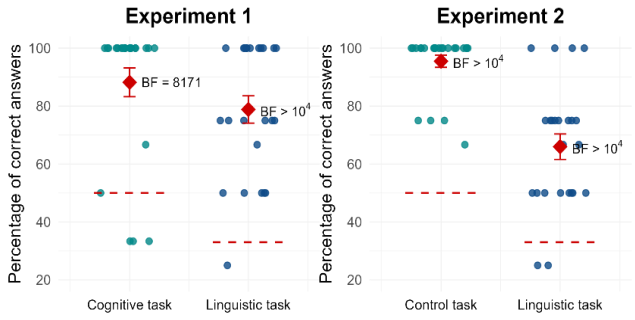

Figure 2: Percentage of target answers in the two tasks for Experiment 1 (left) and 2 (right). Dots show participants' scores, red rhombuses the group means, error bars the standard errors, and dashed red lines the chance level.

Comparison Experiments 1 and 2

To examine whether non-verbal disjunctive inferences can scaffold children's comprehension of "or", we compared performance in the inferential linguistic task across experiments.

A Bayesian Mann-Whitney test showed that children in Experiment 1 outperformed those in Experiment 2 in naming the target object (BF_{10} = 168.91, ω = 0.696, 95% HDI [0.553, 0.833]). Follow-up preregistered analyses examined which

component of the inference drove this difference. The two groups did not differ in their ability to exclude the visually available object (BF_{10} = 0.185, ω = 0.418, 95% HDI [0.264, 0.575]), suggesting that both groups were equally capable of using visual information to rule out one disjunct. By contrast, children in Experiment 1 were clearly better at including only the named disjuncts (BF_{10} = 941.214, ω = 0.735, 95% HDI [0.599, 0.865]), indicating greater comprehension of the meaning of "or" (Figure 3). The overall performance advantage in Experiment 1 was therefore specifically driven by better "or" comprehension, rather than by differences in the exclusion component. Since the only difference between experiments was whether children had previously completed an inferential or non-inferential cognitive task, our data suggests that children in Experiment 1 benefitted from a priming effect of non-verbal inference to "or" comprehension. We leave to the General Discussion the interpretation of this finding.

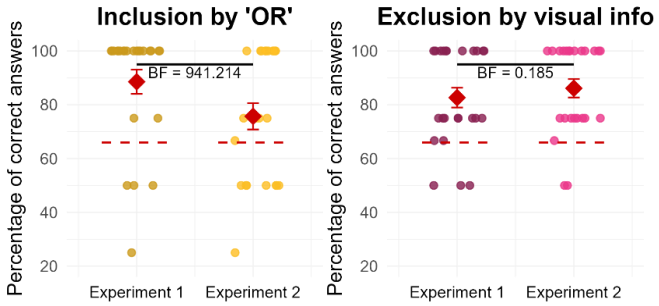

Figure 3: Percentage of correct answers in the inferential linguistic task for Experiment 1 and 2. Left: *Inclusion by "OR"* (selection of a named disjunct). Right: *Exclusion by visual information* (exclusion of the visible object). Dots show participants' scores, red rhombuses the group means, error bars the standard errors, dashed red lines the chance level, and black lines with text the Bayes Factor for the between-experiment comparison.

General Discussion

The present study investigated the relationship between logical reasoning and language, focusing on the role of preverbal deductive inferences (Cesana-Arlotti et al., 2018) in the acquisition of the linguistic connective "or".

Across two experiments, we contributed to this debate with three main findings. First, we found that 3-year-old children are highly proficient in non-verbal disjunctive inferences. In Experiment 1, they demonstrated great accuracy in the inferential cognitive task, successfully identifying a hidden object by excluding the other alternative based on visual information alone. This result is in line with previous findings from infancy and early childhood showing that children can reason deductively (Bohus et al, 2023; Cesana-Arlotti et al., 2018, 2020; Cesana-Arlotti & Halberda, 2024; Gautam, Suddendorf, & Redshaw, 2021; Grigoroglou, Chan & Ganea, 2019).

Second, we showed that 3-year-old children's comprehension of "or" can already support disjunctive inferences, corroborating the view that such inferential competence may be constitutive of the core meaning of this connective (Braine & Rumain, 1981).

Our third and most critical finding is that making disjunctive inferences in a non-verbal task improved children's understanding of the logical meaning of "or" in a subsequent linguistic comprehension task, even after just four trials. This priming effect – observed in Experiment 1 but absent in Experiment 2, where the linguistic task followed a non-inferential control task – provides experimental evidence that non-verbal deductive competencies are linked to logical language comprehension at age 3. At least two accounts can explain this link.

On a *semantic* account, the non-verbal disjunctive inference and the early comprehension of the meaning of "or" tap into shared mental logical operations (Braine & Rumain, 1981). In this view, the core meaning of "or" would connect to a mental inferential schema (Braine & O'Brien, 1998). That is, both ambiguous visual events in the inferential cognitive task and the meaning of "or" in the inferential linguistic task set up the premise – i.e., *car V ball* – of a disjunctive inference. Thus, the priming effect would reflect a direct link between children's non-verbal disjunctive inferences and the logical meaning of "or".

On a *pragmatic* account, instead, non-verbal disjunctive inferences would be linked more directly to an exhaustivity implicature produced by children in the linguistic task (Gotzner, Barner, & Crain, 2020). Since they heard "car or ball", but the umbrella was not mentioned, it is implied that the umbrella was not inside the cup, thus the object inside the cup could only be the car or the ball. In other words, in the inferential linguistic task, children may set up the premise of the disjunctive inference not directly via comprehension of the meaning of "or", but by way of an exhaustivity implicature. In this case, the priming effect would reflect a connection between non-verbal disjunctive inferences and the mental computations underlying exhaustivity implicatures.

While both these proposals are compatible with our results, parsimony may favor the semantic account, since exhaustivity implicatures may also require processing the logical meaning of connectives. In line with this consideration, 4-year-old children's exhaustivity implicatures have been shown to be modulated by the logical strength of "or" and "and" (Gotzner, Barner, & Crain, 2020). Furthermore, a broader developmental pattern suggests that semantic meaning precedes pragmatic enrichment (Noveck, 2001).

To conclude, these findings suggest that preverbal disjunctive reasoning can facilitate children's emerging comprehension of verbal disjunction. More broadly, our results point to an early developmental link between reasoning and language, opening new avenues for research on how the two domains constrain each other across development.

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References

Alderete, S., & Xu, F. (2023). Three-year-old children's reasoning about possibilities. *Cognition*, *237*, 105472.

Baumann, L., Schidelko, L. P., Proft, M., & Rakoczy, H. (2024). Even 3-and 4-year-olds master some modal reasoning tasks-if they have a more agentive structure. [Preprint].

Bohus, K. A., Cesana-Arlotti, N., Martín-Salguero, A., & Bonatti, L. L. (2023). The scope and role of deduction in infant cognition. *Current Biology, 33*(18), 4014-4020.

Braine, M. D. S., & O'Brien, D. P. (Eds.). (1998). *Mental logic*. Psychology Press.

Braine, M. D. S., & Rumain, B. (1981). Development of comprehension of "or": Evidence for a sequence of competencies. *Journal of Experimental Child Psychology, 31*(1), 46-70.

Cesana-Arlotti, N., Martín, A., Téglás, E., Vorobyova, L., Cetnarski, R., & Bonatti, L. L. (2018). Precursors of logical reasoning in preverbal human infants. *Science, 359*(6381), 1263-1266.

Cesana-Arlotti, N., Kovács, Á. M., & Téglás, E. (2020). Infants recruit logic to learn about the social world. *Nature Communications, 11*, 5999.

Cesana-Arlotti, N., Varga, B., & Téglás, E. (2022). The pupillometry of the possible: an investigation of infants' representation of alternative possibilities. *Philosophical Transactions of the Royal Society B, 377*(1866), 20210343.

Cesana-Arlotti, N., & Halberda, J. (2024). A continuity in logical development: Domain-general disjunctive inference by toddlers. *Open Mind, 8*, 809–825.

Cesana-Arlotti, N., Jáuregui, S., Mazalik, P., Nichols, S., & Halberda, J. (2025). Logical Concepts of (Im)possibility Guide Young Children's Decision-Making. *Developmental science, 28*(5), e70044.

Chierchia, G., Crain, S., Guasti, M. T., Gualmini, A., & Meroni, L. (2001). The acquisition of disjunction: Evidence for a grammatical view of scalar implicatures. In *Proceedings of the 25th Boston University Conference on Language Development* (Vol. 25, pp. 157-168). Cascadilla Press.

Chierchia, G., Guasti, M. T., Gualmini, A., Meroni, L., Crain, S., & Foppolo, F. (2004). Semantic and pragmatic competence in children's and adults' comprehension of "or." In I. Noveck & D. Sperber (Eds.), *Experimental pragmatics* (pp. 283–300). Palgrave Macmillan.

Crain, S. (2008). The interpretation of disjunction in universal grammar. *Language and Speech, 51*(1–2), 151–169.

Esmer, Å., & Cesana-Arlotti, N. (2025). The origin of the possible: 12-month-olds' understanding of certain, likely, and unlikely events. In *Proceedings of the Annual Meeting of the Cognitive Science Society* (Vol. 47).

Fedorenko, E., Piantadosi, S. T., & Gibson, E. (2024). Language is primarily a tool for communication rather than thought. *Nature, 630*(8017), 575-586.

Gautam, S., Suddendorf, T., & Redshaw, J. (2021). When can young children reason about an exclusive disjunction? *Cognition, 207*, 104507.

Gotzner, N., Barner, D., & Crain, S. (2020). Disjunction triggers exhaustivity implicatures in 4-to 5-year-olds: Investigating the role of access to alternatives. *Journal of Semantics, 37*(2), 219-245.

Grigoroglou, M., Chan, S., & Ganea, P. A. (2019). Toddlers' understanding and use of verbal negation in inferential reasoning search tasks. *Journal of Experimental Child Psychology, 183*, 222-241.

Jasbi, M., Jaggi, A., Clark, E. V., & Frank, M. C. (2024). Context-dependent learning of linguistic disjunction. *Journal of Child Language, 51*(1), 1-26.

JASP Team (2025). JASP (Version 0.95.3) [Computer software].

Leahy, B. P., & Carey, S. E. (2020). The acquisition of modal concepts. *Trends in Cognitive Sciences, 24*(1), 65-78.

Mani, N., Schreiner, M. S., Brase, J., Köhler, K., Strassen, K., Postin, D., & Schultze, T. (2021). Sequential bayes factor designs in developmental research: Studies on early word learning. *Developmental science, 24*(4), e13097.

Mody, S., & Carey, S. (2016). The emergence of reasoning by the disjunctive syllogism in early childhood. *Cognition, 154*, 40-48.

Morris, B. J. (2008). Logically speaking: Evidence for item-based acquisition of the connectives AND & OR. *Journal of Cognition and Development, 9*(1), 67-88.

Noveck, I. A. (2001). When children are more logical than adults: Experimental investigations of scalar implicature. *Cognition, 78*(2), 165-188.

Quilty-Dunn, J., Porot, N., & Mandelbaum, E. (2023). The best game in town: The reemergence of the language-of-thought hypothesis across the cognitive sciences. *Behavioral and Brain Sciences, 46*, e256.

Singh, R., Wexler, K., Astle-Rahim, A., Kamawar, D., & Fox, D. (2016). Children interpret disjunction as conjunction: Consequences for theories of implicature and child development. *Natural Language Semantics, 24*(4), 305-352.

Skordos, D., Feiman, R., Bale, A., & Barner, D. (2020). Do children interpret 'or' conjunctively?. *Journal of Semantics, 37*(2), 247-267.

Tieu, L., Yatsushiro, K., Cremers, A., Romoli, J., Sauerland, U., & Chemla, E. (2017). On the Role of Alternatives in the Acquisition of Simple and Complex Disjunctions in

French and Japanese. *Journal of Semantics, 34*(1), 127–152.

Turan-Küçük, E. N., & Kibbe, M. M. (2025). Three- and four-year-old children represent mutually exclusive possible identities. *Journal of Experimental Child Psychology, 249*, 106078.

Wang, Z., & Cesana-Arlotti, N. (2025). Core Logic: Fourteen-month-olds exclude physical possibilities that would make an agent irrational. In *Proceedings of the Annual Meeting of the Cognitive Science Society* (Vol. 47).