2-year-olds process negation online: Evidence from eye-tracking

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Offline tasks have shown that 18-to-27-month-olds grasp the truth-functional meaning of "not" [1,2]. Attempts to confirm these findings in online processing initially failed [3], possibly due to a lack of discourse context to license negation. A recent eye-tracking study showed that slightly older 35-month-olds can overcome the processing costs associated with negation when provided with such a supportive discourse context and a salient question under discussion (QUD) [4]. In contrast, 30-months-olds only succeeded with an additional block of affirmative contrasts before the negated sentences. However, [4] probed negation with an object relative clause (e.g., *show me the one DW didn't eat*), which independently burdens the parser [8]. In the current study, we employ eye-tracking with simple declarative sentences (as in [1,2]) to assess whether 28-month-olds (i) process the truth-functional meaning of "not" online, and if so, (ii) do so in a *one-step* [3,5] or *two-step* [6,9] manner.

Methods. We adapted the preferential looking paradigm [7], effective with young children, to visual world eye-tracking to allow for greater spatiotemporal resolution. Our novel application takes the form of a guessing game. 2-year-olds (N = 15; M_{age} = 28-months; SD_{age}=0;04; 5 excluded; Projected N=25[1]) watched videos displaying two animals sharing one common feature (e.g., identical legs) and a third partly-obscured animal bearing this shared feature (Figure 1). Once introduced to each animal, they are prompted with "Who's hiding?", before hearing the test sentence, either: POSITIVE, NEGATIVE (It's **also/not** a bee; Table 1). They were then probed again with the question "Who is it?" before the animal was revealed. This design allowed us to provide an overt QUD, a syntactically simple test sentence, and a salient alternative to the negated proposition. The experiment was within-subjects (4 POSITIVE, 4 NEGATIVE). We also included a MODAL condition with the modal adverb *maybe,* but focus only on the NEGATIVE vs POSITIVE contrast for the present purpose. We used 10 animal pairs pseudorandomized across subjects and each child saw at most two of each pair (e.g., bee mentioned once, ant mentioned once), controlled for screen position and introduction order.

Predictions. The 3000 ms from the onset of the noun until the second question served as the coarse window of interest and the proportion of looks to the *unmentioned* vs. *mentioned animal* (bee vs. ant; Figure 1) served as the dependent measure. For descriptive purposes, we also present the 3000-6000 ms window from the second question until the animal reveal. For the 3000 ms interest period, we predicted that children would look more to the *unmentioned* than *mentioned* animal in the NEGATIVE condition if they understood its truth functional meaning. Further, we divided the window into an *early* (0-1500 ms) and *late* (1500-3000 ms) window to probe the time course of processing [3]. We reasoned that more looks to the *unmentioned* vs. *mentioned* animal in the early window in the NEGATIVE condition would suggest a one-step mode of processing [6,9], while more initial looks to the *mentioned* vs *unmentioned* animal suggests two-step processing [3,5].

Results. Preliminary time course analysis suggests that children look more at the *unmentioned* vs. *mentioned* animal in the NEGATIVE condition in the *early* window and again in the later 3000-6000 ms window (Figure 2; right), thus corroborating the finding that 28-month-olds understand the truth-functional meaning of "not" [1,2]. Even when the *early window* is split by participant and age (Figure 3), children across the age range look more to the *unmentioned* animal in the NEGATIVE condition. Although there is more variation in looks to the *mentioned* animal in the early window (Figure 3, right) and outliers that look more at the *unmentioned* animal in the POSITIVE condition, the effect of negation remains robust across the age range (Figure 3, left). We thus

provide preliminary evidence that 2-year-olds not only understand the truth functional meaning of "not" but immediately engage in this computation in a manner compatible with one-step models [6,9].
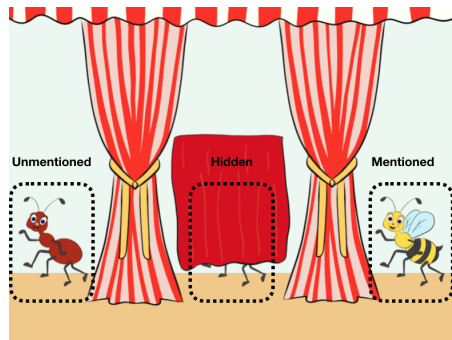

Figure 1: *Sample visual trial (ant-bee) with areas of interest highlighted.*

Sample trial (bee and ant)	
Trial set-up	Look, this is a bee! [bee bounces]
	Look, this is an ant! [ant bounces]
	Who's hiding?
Conditions Positive	It's <u>also</u> a bee!
Conditions Negative	It's <u>not</u> a bee!

Table 1: *Sample audio stimuli (ant-bee) corresponding to Figure 1.*
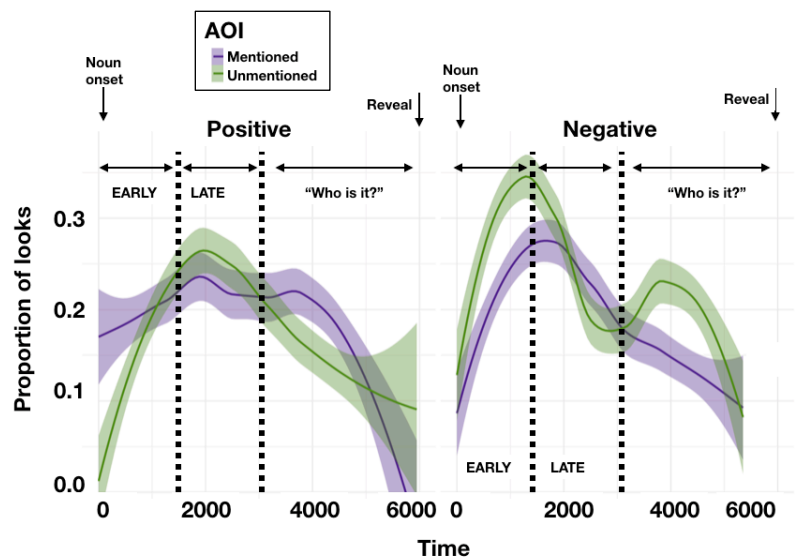

Figure 2: *Proportion of looks to either the <u>mentioned</u> or <u>unmentioned</u> animal on the Y-axis by condition) as a function of time on the X-axis. The 3000ms time-window from noun onset to the second question ("Who is it?") is divided into the early window (0-1500 ms) and late window (1500-3000 ms).*
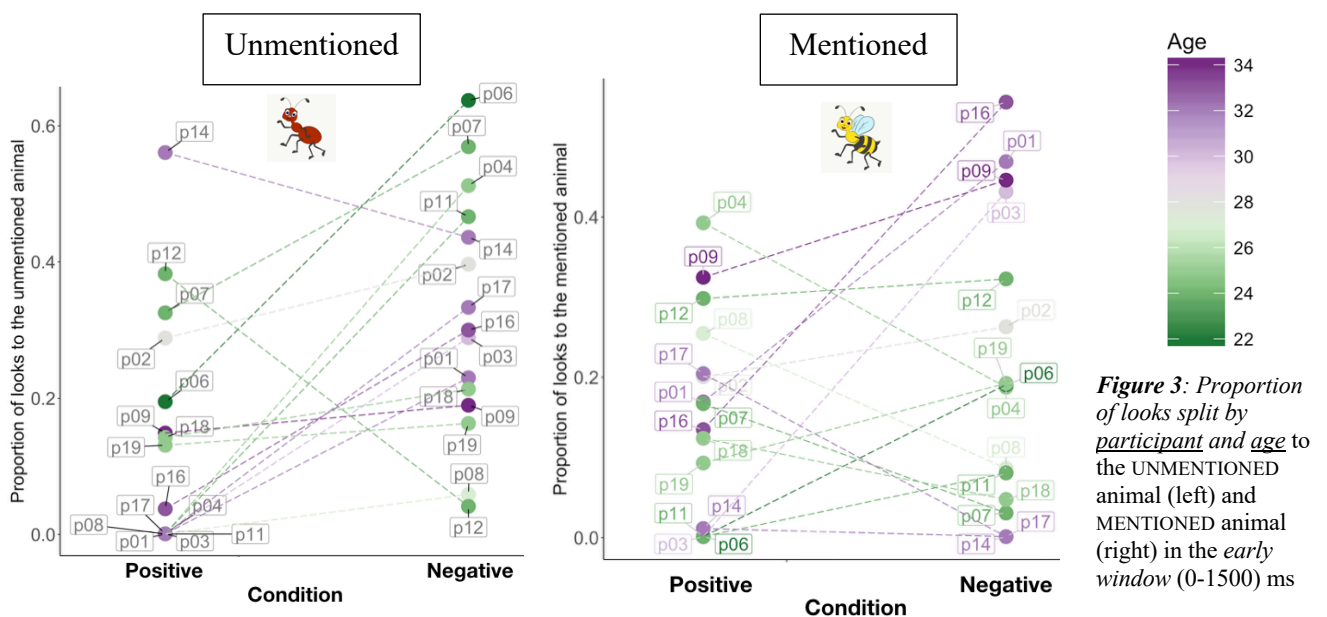

Figure 3: *Proportion of looks split by <u>participant</u> and <u>age</u> to the UNMENTIONED animal (left) and MENTIONED animal (right) in the early window (0-1500) ms*

References. [1] Austin et al. (2014). *Dev psych*. [2] de Carvalho et al. (2019). *Accepted.* [3] Nordmeyer & Frank. (2014). *JML.* [4] Reuter et al. (2018). *Child Development.* [5] Kaup et al. (2006). *Journal of Pragmatics.* [6] Tian et al. (2010). *QJEP.* [7] Golinkoff et al. (1987). *Journal of Child language.* [8] Friedmann & Novogrodsky. (2004). *Journal of Child language.* [9] Burnsky et al. (2017). *CUNY talk.*

[1]COVID DISCLAIMER: Data collection has been disrupted by COVID 19 restrictions on human subject research. Research will be resumed once these restrictions are lifted.