***Maybe* now, *not* later: online processing of possibility and negation in adults and 2-year-olds**

Maxime Tulling (Université de Montréal), Vishal Arvindam (UC Santa Cruz) & Ailís Cournane (New York University)

Introduction. Ongoing debate questions whether the processing of negated utterances (e.g., *the door is not closed*) involves representing the situation in **one step** [1] (an open door) or whether it requires **two steps** [2,3], initially representing the mentioned situation (the closed door). Similarly, it is an open question whether the processing of possibility utterances (e.g., *maybe the door is closed*) involves simultaneous consideration of both possibilities [4] or only the mentioned one [5]. Moreover, it is unclear when these operations become available during development, even though 2-year-olds already produce *not* and *maybe* [6,7]. Our results are compatible with (i) a two-step model of negation processing in both adults and older 2-year-olds and (ii) early consideration of both alternatives in possibility processing in adults but not yet in 2-year-olds.

Methods. In a modified visual-world eye tracking task (sampled at 1000Hz), 24 adults (M= 25.4, SD= 8.99) and 21 2-year-olds (N = 21; M_{age} = 29.1 months; SD_{age}=4.35) participated in a guessing game. They watched videos displaying two animals sharing one common feature (e.g., identical legs) with a third partly obscured animal bearing this shared feature (Figure 1): ROIs (mentioned, unmentioned, or hidden). Once introduced to each animal, participants heard "Who's hiding?", followed by a target sentence: POSITIVE, POSSIBILITY or NEGATED (It's **also**/**maybe**/**not** a bee; Table 1) and a repetition of the prompt "Who is it?" 2500 ms after the noun onset. The experiment was within-subjects (Items: 4 POSITIVE, 8 POSSIBILITY, 4 NEGATED) and the 10 animal pairs used were pseudorandomized across subjects, controlling for screen position and introduction order. We predicted most looks to the unmentioned character in the NEGATED, fewest in the POSITIVE and intermediate looks in the POSSIBILITY condition.

Analysis. Gaze data falling within the three ROIs was analyzed post-target noun onset (250-2250ms) for adults and post-prompt repetition (2750-4750ms) for children. Children only looked towards target images in the post-prompt window, seemingly requiring their attention to be refocused on the identity-guessing task. We then divided these windows into **early** and **late** 1000ms segments to adjudicate between one and two-step models of negation processing [2] and probe the temporal dynamics of possibility processing. We fitted an LME model by subject and item for each time bin to predict the log ratio of proportion of looks to the mentioned over unmentioned ROI coupled with a permutation-cluster analysis to correct for multiple comparisons.

Results. While adults and children looked above chance at the mentioned ROI during both the early and late window in the POSITIVE condition, above-chance looks to the unmentioned ROI in the NEGATED condition only emerged in the late window for adults ($p<.001$) (Figure 2) and children above 30 months ($p=.044$) (post-hoc analysis, Figure 3). In contrast, adults (but not children) showed a significant decrease in the ratio of mentioned/unmentioned looks for the POSSIBILITY condition compared to the POSITIVE condition in the early window ($p=.045$), suggesting that the unmentioned option was considered early on in *maybe*-utterances.

Discussion. Our results are consistent with 2-step models of negation processing [2,3]: it takes 1000ms longer for adults and older 2-year-olds to identify the correct referent in the NEGATED compared to the POSITIVE condition (late window). We also found the unmentioned animal was actively considered in the POSSIBILITY condition more so than in the POSITIVE condition (early window), in line with theories positing simultaneous representation of multiple possibilities [4]. While not significant, children's time course results for POSSIBILITY overall resembles that of adults, reiterating the question whether children under 3 can hold two open possibilities in mind [8,9]. Moreover, this paradigm expands our toolkit for testing the processing of non-actual language.

References. [1] Tian et al. 2010, *QJEP* [2] Kaup et al. 2006, *JoP* [3] Kaup et al. 2007, *QJEP* [4] Phillips & Knobe 2018*, M&L* [5] Johnson-Laird & Ragni 2019, *Cognition* [6] Jasbi et al. 2021, *BU2020* [7] Cournane 2021, *LA* [8] Leahy & Carey 2020, *TCS*. [9] Grigoroglou & Ganea 2022

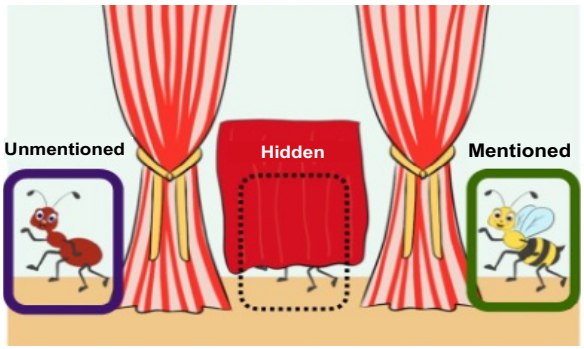

Figure 1. Example trials with regions of interest

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?
Target	POSITIVE	"It's *also a bee*"
	POSSIBILITY	"It's *maybe a bee*"
	NEGATIVE	"It's *not a bee*"
Prompt:		Who is it ?

Table 1. Trial structure with example stimuli

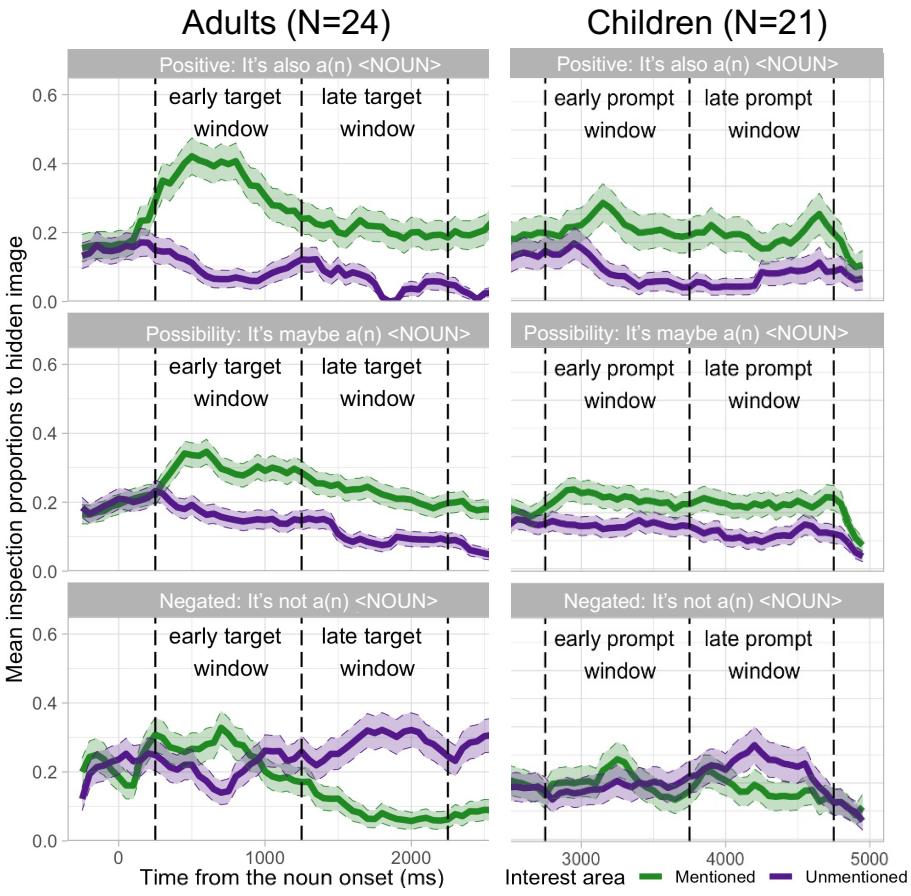

Figure 2. (on the left) Mean proportion of looks to mentioned (in green) and unmentioned (purple) image after target noun for adults (left) and after repeated prompt for children (right). 0 on the x-axis indicates noun onset.

Cluster-permutation tests show that adults and children look above chance at target image in positive condition (early and late window). Adults also look above chance to target in late window negative condition and the (log) proportion of mentioned / unmentioned is significantly higher in the early target window of *also*-utterances than for maybe-utterances. For children we observed no differences between also and maybe condition.

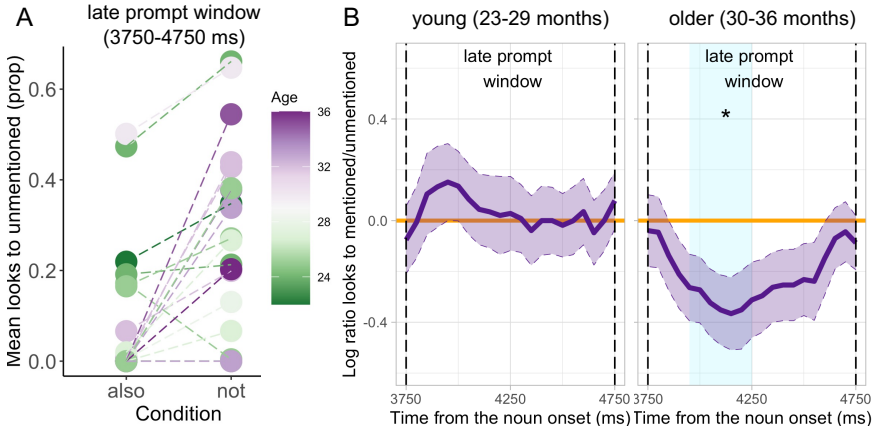

Figure 3. (on the right) Effect of children's age on the processing of negation in late prompt window A) Individual means for proportion of looks to unmentioned image in the positive (also) and negated (not) condition by age (in months). B) Above-chance looks at unmentioned ROI detected in older (N=10) but not in younger (N=11) two-year-olds (post-hoc analysis)