Effects of contextual constraint on word recognition in adults and 4–5 year-old children

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An important question for psycholinguists is how bottom-up and top-down pathways interact during language comprehension. For instance, as an individual hears a sentence, does bottom-up processing occur first, with integration of higher-level representations only occurring after words have been identified from the speech stream? Or do listeners continuously construct and integrate higher-level representations into processing of bottom-up input? Prior research with adults suggests that top-down semantic information is integrated early in lexical processing, allowing adults to rule out semantically incongruent candidates [1]. The present study explores the degree to which semantic context constrains early lexical processing in 4–5 year-old children. Developmental studies like this are crucial for constructing a theory of comprehension that is compatible with all life stages. Critically, top-down processing is challenging for young children in some domains; for instance, visual world studies of syntactic ambiguity resolution find that children show reduced or no integration of top-down information [2–6]. Such reduced top-down influence could indicate that top-down and bottom-up language comprehension pathways develop separately and that information only moves through these pathways rapidly enough to interact once an individual has sufficient experience or processing efficiency (indeed, such factors influence contextual effects in adults; e.g., [7–9]). Understanding the early stages of language comprehension can thus provide insight into the system's architecture.

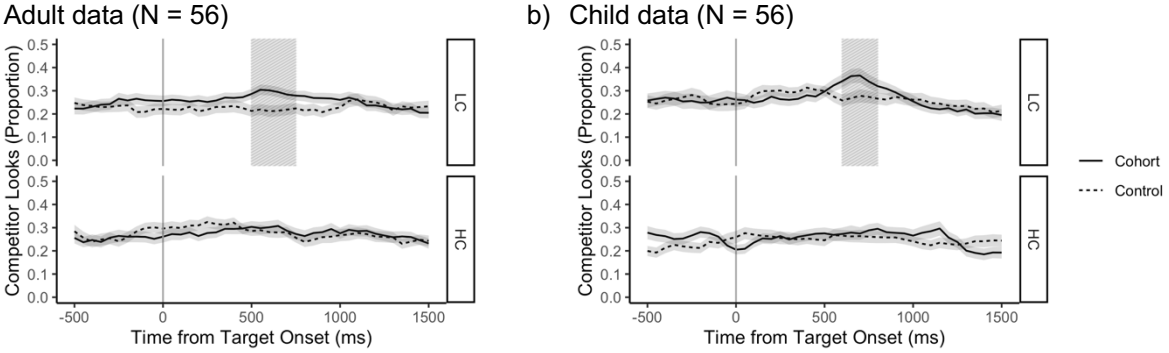
Method. We conducted a visual world eye-tracking experiment (in American English) with adults (N = 56) and 4–5 year-olds (N = 56). In each trial, participants saw four images and heard a sentence; they were tasked with selecting the image that matched a word from the sentence. Each sentence contained a target word and a task word (corresponding to the selected image). We manipulated the predictability of the target word to create low and high constraint conditions (Figure 1). The displays contained a competitor image, an image of the task word, and two unrelated distractors. We manipulated whether the competitor image name shared onset phonemes with the target word (the cohort condition) or whether it appeared with an alternative target (the control condition). The experiment thus had a 2 x 2 within-subject manipulation of contextual constraint (low, high) and competitor condition (cohort, control). If top-down cues influence word recognition, we would expect the phonemic cohort effect (the difference in competitor image looks between the cohort and control conditions) to be substantially larger in neutral, low constraint contexts and small or absent in high-constraint contexts. Our study is conceptually similar to [1], however our displays do not include an image of the target word, meaning that a reduced/absent cohort effect in the high constraint condition cannot result from anticipatory target image looks (e.g., [10]) drawing looks away from the cohort competitor.

Results/Discussion. Across the two age groups, we observed evidence of phonemic cohort competition in the low constraint condition but not in the high constraint condition (Figures 2–3), suggesting that participants used top-down semantic cues to inhibit activation of incongruent lexical candidates. The analyses did not identify a difference in the modulation of the cohort effect between populations. These results demonstrate that by 4–5 years of age, children are able to use contextual information to constrain word recognition to approximately the same degree as adults, providing evidence that top-down language comprehension pathways are robust and active prior to formal schooling and literacy. This finding contrasts with prior child studies focused on syntactic ambiguity resolution [2–6], though it aligns with more recent child EEG work showing evidence of top-down lexical prediction in naturalistic contexts [11–12]. This contrast could suggest either that top-down information is easier for children to integrate with fewer task demands (e.g., no ambiguity) or that top-down integration depends on the type of processing (e.g., syntactic vs. lexical) or cue strength. Curiously, the present findings also diverge from a similar experiment [13] that found that adults do not use *syntactic* context during word recognition to eliminate mismatching lexical candidates. This finding could suggest that both adults and children are more apt to use top-down information when it is highly constraining.

Figure 1. Example item (target word in bold, task word underlined). The competitor image *mitten* appeared with target *leash* (from target–cohort pair *leash–leaf*) in the control condition.

Low Constraint (LC) sentence: *The child took the **milk** […] and then played with his toy <u>spaceship</u>* High Constraint (HC) sentence: *The baby drank the **milk** […] and then played with his toy <u>spacehip</u>*
Cohort competitor: *mitten*, Control competitor: *ice*
Image display: *mitten/ice* (competitor), *spaceship* (task), *jellyfish* (distractor), *tunnel* (distractor)

Figure 2. Grand average competitor image looks over time (ribbons indicate standard error).

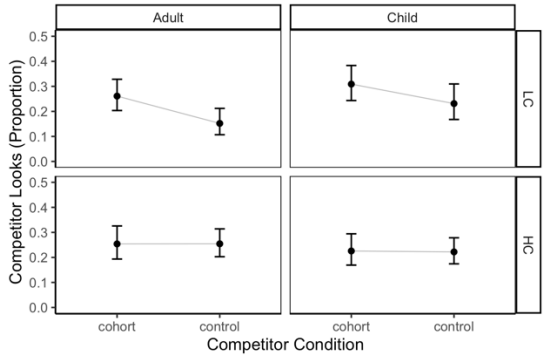


A cluster permutation analysis (e.g., [6]) did not identify any clusters with a three-way interaction between competitor condition (cohort, control), constraint (low, high), and age group (adult, child). We similarly did not observe any competitor condition x age group interaction clusters in separate analyses of the LC and HC data.

In the adult data, a reliable cluster for the effect of competitor condition (i.e., phonemic cohort effect) emerged 500–749 ms after target onset in the LC condition (summed z-score = 13.19, p = 0.03). In the child data, a trending cluster emerged 600–799 ms after target onset in the LC condition (summed z-score = 8.92, p = 0.07).

No cohort effect clusters emerged in the HC condition in either the adult or child data.

Figure 3. Competitor condition x constraint x age group effect plot (error bars indicate 95% confidence intervals).



There was a significant competitor condition x constraint interaction (β = -0.13, z = -2.13, p = 0.03) such that the phonemic cohort effect was larger in the LC condition than the HC condition.

The competitor condition x constraint x age group interaction was not reliable (β = -0.04, z = -0.81, p = 0.42), suggesting that the modulation of the phonemic cohort effect by constraint did not differ across age groups.

The analysis time window (preregistered) was determined by the earliest onset of a cohort effect in the LC condition in either population and the offset of the LC cohort effect in adults (as child cohort effects can perseverate; [14]).

References. [1] Dahan & Tanenhaus (2007), [2] Snedeker & Trueswell (2004), [3] Snedeker et al. (2009), [4] Snedeker & Yuan (2008), [5] Trueswell et al. (1999), [6] Yacovone et al. (2021), [7] Huettig & Janse (2015), [8] Ito et al. (2018), [9] Mani & Huettig (2012), [10] Altmann & Kamide (1999), [11] Levari & Snedeker (in prep), [12] Yacovone et al. (in prep), [13] Gaston (2020), [14] Sekerina & Brooks, 2007