1. INTRODUCTION

Goal of the Study
The adult parser makes structural commitments prior to clear bottom-up evidence. The development of these predictive mechanisms, however, has not been investigated. This study asks whether children make the same structural predictions as adults by examining 5-year-olds’ real time processing of "wh"-questions.

Filler-gap dependency processing:
(1) What did John paint the door with ___?
   - Upon processing a filler, the adult parser actively completes filler-gap dependencies by predicting a gap in the first possible syntactic position, i.e., the direct object of paint in (1), in advance of bottom-up evidence [1-4]. Do children also utilize the active gap filling strategy?

Child predictions in the visual world:
- Both adults and children as young as 2½ make anticipatory fixations on an appropriate object based on verb information [5-7]. However, these fixations could be driven by the conceptual association between a verb and object and not a prediction of the direct object position.
  - Comparison of fixations on cake in…
  - The boy will eat the cake. vs. The boy will move the cake.

The present visual world study:
- Given that children acquire requisite grammatical knowledge of filler-gap dependencies (e.g., [8]) & make adult-like predictions in verb-based visual world studies, it is plausible that they would be able to actively complete filler-gap dependencies.
- Previous studies have argued that children utilize an active gap filling strategy [9,10], but did not provide time course evidence. The present study aims to fill this gap in the literature.

2. EYE-TRACKING STUDY

Design
Participants were told a story with an accompanying display and then asked a question about that story.

Participants
Children: 12 5-year-olds, mean age = 5.5, range 4.8 - 5.2
Adults: 27 Johns Hopkins University undergraduates

Stories (n = 20)
- Animated stories with 2 events each with an associated verb, direct object, & instrument. 2 events are critical to prevent participants from determining the content of the question before processing the verb (see [3] & [4]'s revisions).

Event 1: eat cake with fork
Event 2: wash dishes with sponge

Target Questions (n = 10; 5 wh, 5 yes-no)
Can you tell me…
  - what Emily was eating the cake with ___? (wh)
  - if Emily was eating the cake with the fork? (yes-no)

The wh-question contains a filler-gap dependency, while the yes-no question does not. The yes-no condition serves as a control for the verb-based fixations found in [5-7].

Filler Questions (n = 10; 5 wh, 5 yes-no)
Can you tell me…
  - what Emily was eating ___ with the fork? (wh)
  - if Emily was eating the dishes with the fork? (yes-no)

Eye-tracking
EyeLink 1000 Remote eye-tracker (SR Research, Toronto, ON)

Predictions
- Active gap filling – Because 2 objects are displayed, the verb must be processed before the object associated with what can be determined. A greater proportion of fixations on the target object during the verb region (mean duration = 450ms) in the wh-condition indicates active gap filling.

3. RESULTS

Accuracy: Adults were 99% accurate (1 adult missed 1 filler question). 5-year-olds were 95% accurate; no child had an accuracy < 85%.

4. DISCUSSION & CONCLUSION

Main Findings: This is the 1st study to examine real time filler-gap dependency processing in children, and found that 5-year-olds are not actively predicting a gap location in this task.

Remaining Issues:
- Vocabulary size: Other studies [6,7] found an effect of vocabulary size on the timing of anticipatory fixations. We are currently re-running the present study & collecting vocabulary data (PPVT™-4) for a new set of 5-year-olds to address this issue.
- Indirect questions: Active gap filling may not be triggered in indirect questions due to larger processing demands.
  - [10,11] provide offline evidence for active gap filling in globally ambiguous direct wh-questions like Where did Emily tell someone that she will catch a butterfly? They found that 1) children associate the gap with the 1st verb in English, French & Japanese despite differing word orders, and b) this association bias persists even when this interpretation is blocked by a filled gap (Where did Emily tell someone at the pool…).  
  - Currently testing the direct question version: What was Emily eating the cake with?

Development of Predictions:
- The above results suggest that active gap filling must be learned. Thus, models of the parser must be able to explain the fact that 5-year-olds are not utilizing an active gap filling strategy.
- These results are compatible with models that include a probabilistic component such that predictions are learned via exposure to distributional information, e.g., [13].
- However, the preliminary distribution analysis of wh-questions with what indicates that there may be reliable distributional information to expect a direct gap filling. Further distributional analyses are underway.

4. CONCLUSION

Statistical Analysis
- Logit mixed models [12] on 30ms bins in the verb region, i.e., 200-650ms after verb onset
  - Fixed effects: age group, question type
  - Random intercepts: participants, items
- For bins 380 - 650ms, significant interaction between age group & question type (all p < 0.03, shaded on Age Comparison figure)
- Pairwise – Adults: More fixations on target in wh-condition (all p < 0.001, shaded on Adult figure)
- Pairwise – 5-year-olds: No reliable effect of question type (all p > 0.2)

References

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