7081: Exploring lexical and phonological development in preschoolers: An eyetracking study

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Introduction and Rationale

- Vocabulary size in the toddler & preschool years is one of the best predictors of later language development and of academic success.
- Virtually all assessment of vocabulary is limited to asking young children to identify pictures (receptive vocabulary) or name pictures (expressive vocabulary).
- Recent research using the looking-while-listening paradigm (Fernald et al., 2006) has found that the speed at which children look to target objects when hearing the object-name at 18 months reliably predicts vocabulary size up to 8 years of age (Marchman et al., 2008).
- This work extends this finding in two respects:
  - We examined children's ability to identify unfamiliar objects when hearing a nonword.
  - We also examined children's ability to identify mispronunciations of familiar words.

Participants

- N = 31 children included (16 female, 15 male)
- 6 children excluded (3 had >50% missing data, 2 behavior issue, 1 computer error)
- Mean age: 37.4 months, range: 30-46 months)
- Mean standard score on EVT-2 (Williams, 2006): 127.9 (range: 106-149)
- Mean standard score on PPVT-4 (Dunn & Dunn, 2007): 130.2 (range: 96-159)

Methodology

- Looking-while-listening (Fernald, et al., 2008) mispronunciation (Swingley & Aslin, 2000; White & Morgan, 2008) paradigm.
- Experiment designed in E-Prime Professional 2.0, used to interface with Tobii T60 XL Eyetracker.
- Eyetracking task presented to children as "watching a movie."
- Images presented on screen, one familiar and one unfamiliar object .
- Position counterbalanced (Left-Right).
- Images normed for familiarity and unfamiliarity.

Three conditions

- Real words (RW)
- Mispronunciations of these real words, with a one-feature change of initial consonant (MP)
- Nonwords (NW)
- NW trials presented with familiar objects not used in RW trials.

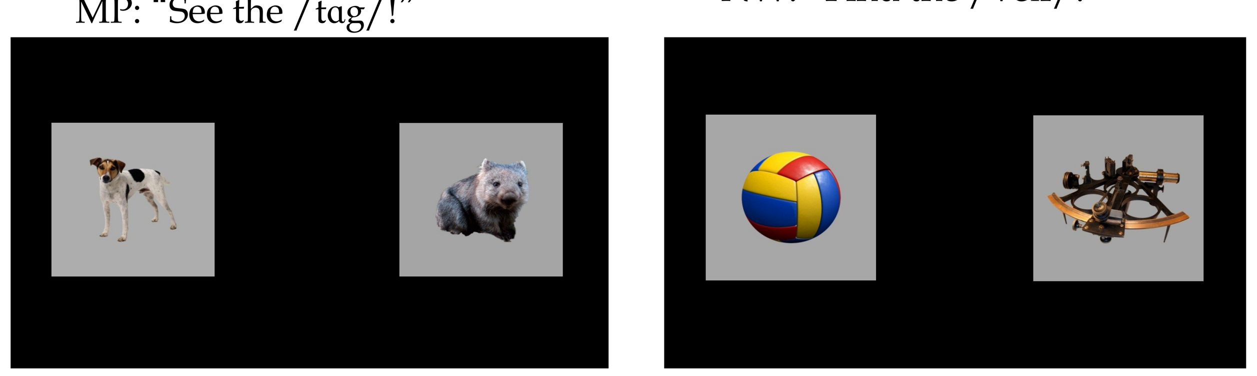
- Target words all CVC in carrier phrases "See the ___!" or "Find the ___!"
- Female speaker, child-directed speech register

- 6 RW + 6MP + 6NW * 2 repetitions + 2 RW familiarization trials = 38 trials
- 2 Blocks of 38 trials, Tobii calibrated before each block.
- Brief animation played ~every six trials to keep child engaged in task.

	Real words	Mispronunciation of real words	Nonsense words	Pictures matched with nonsense word
/s-ʃ/	soup	/ʃup/ bamboo steamer	/tʃim/ pastry mixer	bed
	shoes	/suz/ chemistry flasks	/giv/ golf club trolley	sock
/d-t/	dog	/tɑg/ wombat	/veɪf/ sextant	ball
	toes	/doz/ concertina	/fɪd/ horned melon	cake
/d-g/	duck	/gʌk/ junkocat (rubber animal toy)	/neɪdz/ universal work holder	car
	girl	/dɝl/ marmoset	/ʃæn/ bassoon reed	cup

RW: "Find the dog!"
MP: "See the /tɑg/!"

NW: "Find the /veɪf/!"



- Images matched for height (333 px.), animacy, complexity/interestingness.
- Placed on 600 x 600 px. gray box.
- Centered on vertical axis, 100 px. from screen edge, 520 px. from each other.

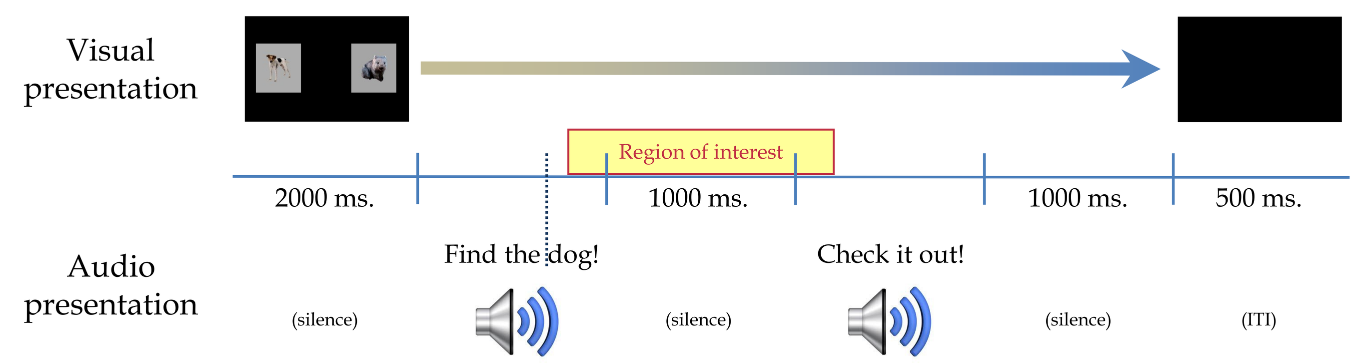


Figure 1. Timeline of a single trial.

Data Reduction: Area of Interest (AOI)

- Defined by gray box surrounding object.
- Eyetracks within AOI of familiar object: coded as 1, within AOI of unfamiliar object: coded as 0.
- Used to calculate log-odds of looking to familiar object.
- Time period of interest 200 – 1700 ms. after target word onset.

Research Questions

Based on previous research, we expected that the growth curve of looking to RW's over time would be predicted by vocabulary size. We were particularly interested in the following two questions:

- Is the growth curve of looking to MP's (relative to looking to RW's) predicted by vocabulary size or age?
- Is the growth curve of looking to NW's (relative to looking to RW's) predicted by vocabulary size or age?

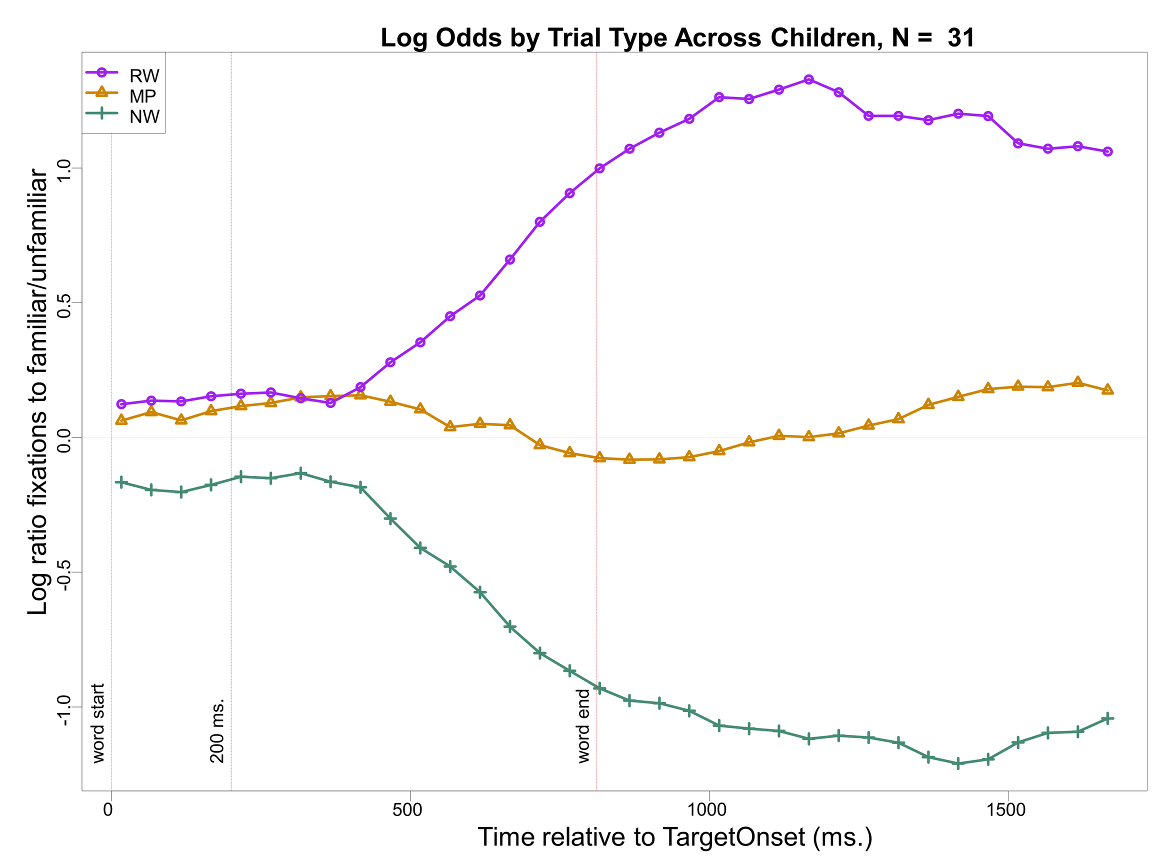


Figure 2. Mean log-odds for looking to familiar object for all three conditions

- As expected, children generally looked at the familiar object on RW trials.
- Children looked at the unfamiliar object on NW trials.
- Although not evident on the group mean plot, there was considerably more variability on the MP trials, relative to either the RW or NW trials.

Individual Differences in Looking to MP's

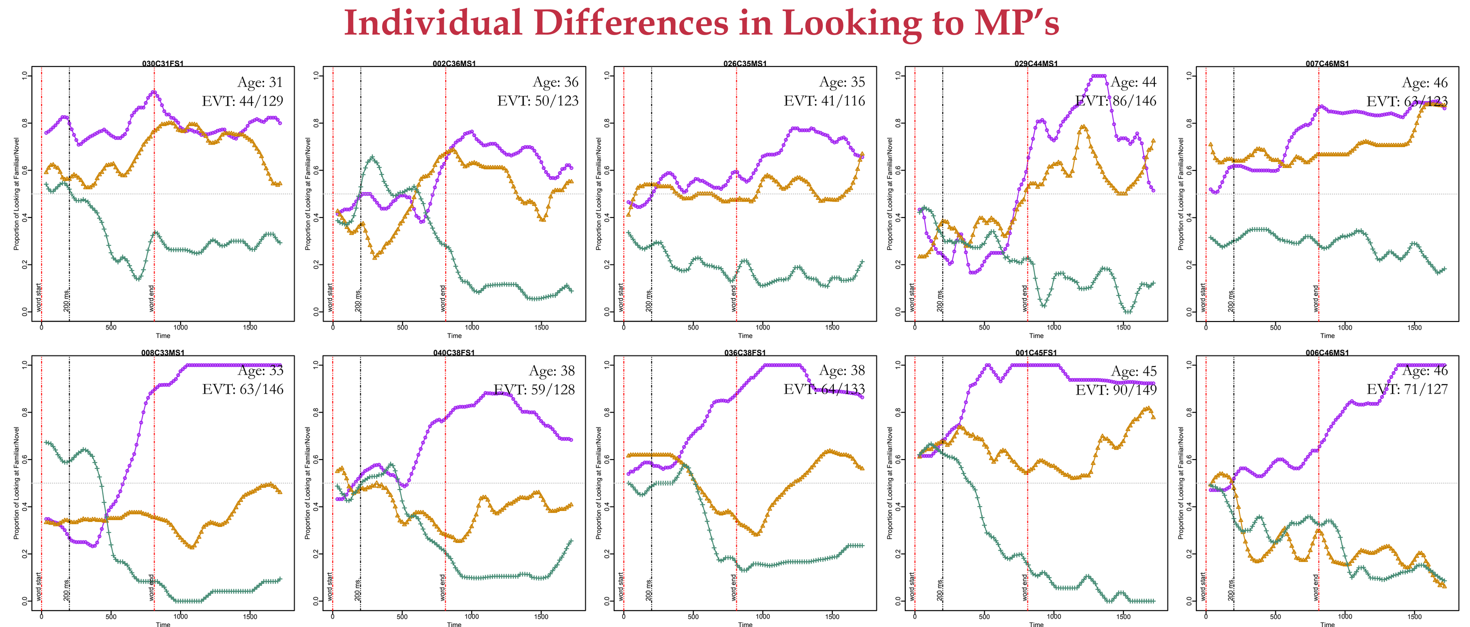


Figure 3. Individual subject data of ten subjects for proportion of looking to familiar object in all three conditions.

- The top pattern suggests less mature perceptual ability. These children are not very sensitive to the mispronunciation and show little differentiation between the RW and MP trials.
- The bottom pattern suggests more mature perceptual ability. These children clearly differentiate between the RW and the MP trials.

Analysis : Growth Curve Modeling using a Hierarchical Linear Model (HLM)

- Most analyses of eye-tracking data have examined latency of first look to target and/or relative looking time to target.
- Instead, a growth curve analysis was used to measure differences over time for different conditions (Barr ,2008; Mirman, et al., 2008).
- Looking patterns for each condition were calculated using the log-odds of looking to the familiar object over time.
- 0.5 was added to all values as a continuity factor to adjust for extreme log-odds.
- Missing data due to blinks were interpolated.
- Growth curve analysis is a more sensitive measure of online perceptual processing than simply looking at latency or relative looking time; we are able to model perception over time.

Analysis and Results: 2-level growth curve analysis

- Intercept and slope allowed to be random.

Level 1: binned across three consecutive points of 24 trials per condition to calculate log odds of looking to familiar object per bin 200-1700 ms. after stimulus.

- Each bin represents approx. 50 ms.
- Predictors: Orthogonal Polynomial Time (linear and quadratic).
- Conditions: RW, MP, NW
  - RW was the reference condition.
  - MP and NW conditions were compared to the RW condition.

Level 2: Child

- Predictors: mean-centered EVT raw scores, mean-centered child age in months.
- Note: PPVT-4 raw scores were not included because EVT scores were a better predictor.

Results

Significant Main Effects

- Significant effect of EVT raw score: As expressive vocabulary increased, the intercept of the RW curve increased.

- Significant effect of condition:
  - The intercept for the MP curve was significantly lower than for the RW curve.
  - The intercept for the NW curve was significantly different from the RW curve and even lower than the one for the MP curve.

- Significant effect of linear and quadratic time on RW curve.
  - Increased speed and acceleration in log-odds of looking to familiar object.

- Note: The main effect of age was not significant.

Significant Interactions

- EVT x Condition
  - For both MP and NW curves, higher EVT scores were associated with more negative slopes
  - Children with higher EVT scores were less likely to look to familiar object for MP and NW trials, compared to RW trials.

- Condition x Time (linear and quadratic)
  - The slope was negative for the MP (and NW) conditions relative to the RW condition.
  - The acceleration curve for looking to familiar object was more flat over time for the MP (and NW) conditions relative to RW.

- EVT x NW Condition x Time (linear)
  - The two-way interaction was increased as a function of EVT.
  - HIgher EVT score was associated with more negative slope with flatter acceleration curve, relative to RW.

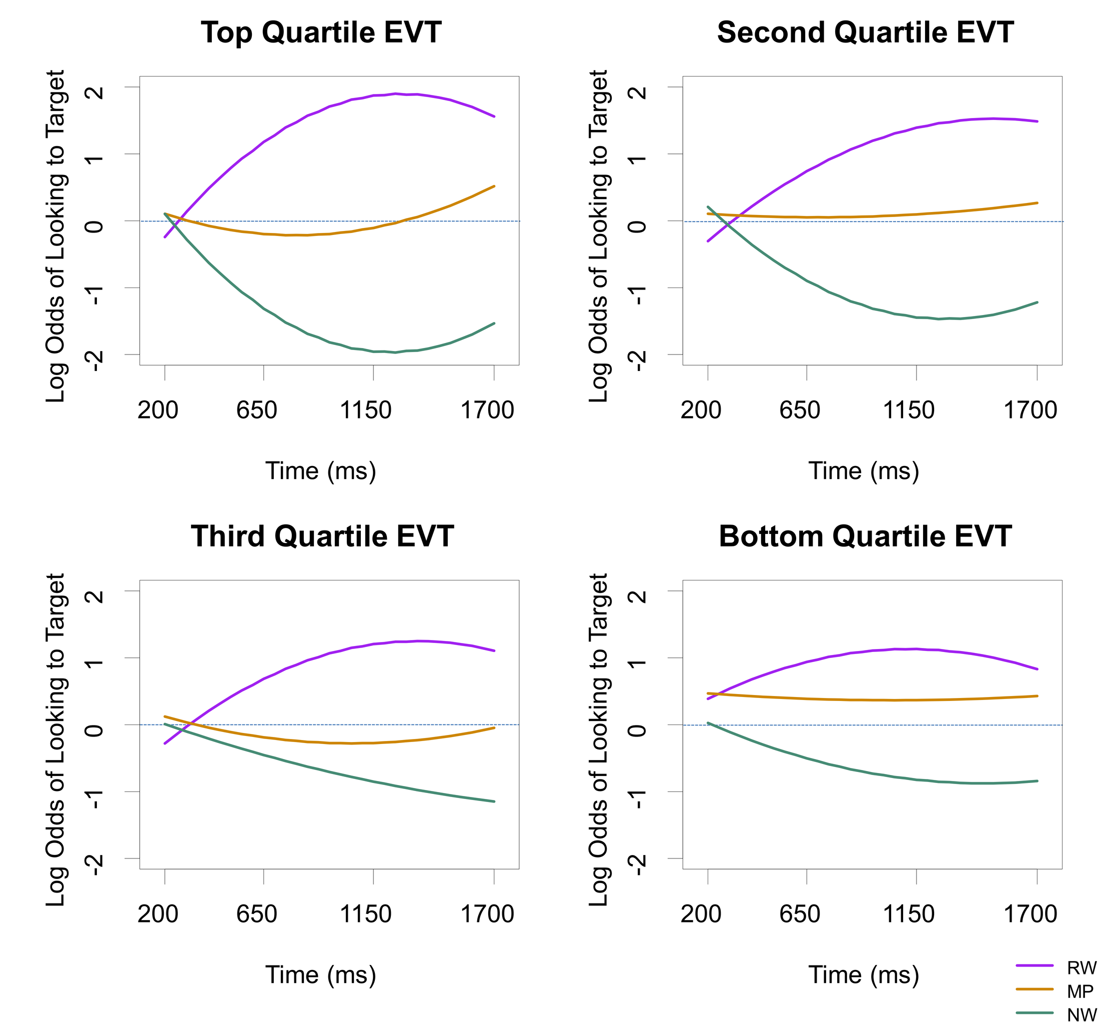


Figure 4. Model fits for the three conditions and for four ranges of expressive vocabulary.

Discussion

These results suggest that young children with large vocabularies don't simply understand and produce more words than their peers with smaller vocabularies; they begin to explain the relatonship between vocabulary size and rate of vocabulary growth.

- We found that children with larger expressive vocabularies:
  - Looked at unfamiliar objects more consistently when presented with a novel word. That is, children with larger vocabularies had better *mutual exclusivity* than children with smaller vocabularies.
  - Looked less at familiar objects when presented with a one-feature mispronunciations of the object-names. That is, children with larger vocabularies were more sensitive to small phonetic differences.
- Growth curve data (i.e., performance) was better predicted by expressive vocabulary size than age.

Future Directions

- Recruit children with a larger range of EVT scores and SES backgrounds.
- Design a longitudinal study using this experimental paradigm.
  - Does performance on this task predict vocabulary growth?
  - Is performance on this task related to an independent measure of speech perception?
- Include additional predictors in the model (e.g., GFTA score, SES, a measure of executive function).

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