Examining individual differences using the mispronunciation paradigm

Franzo Law II, Jianshen Chen, & Jan Edwards

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

WAISMAN CENTER

Overview

Many eye-tracking studies with young children focus on group differences. We are interested in developing measures of individual differences of aspects of phonological knowledge to use in a longitudinal study of interactions between phonological development and vocabulary growth. This study was designed to develop an individual measure of the robustness of speech perception.

Participants

- ❑N = 26 children included, (14 female, 12 male)
- ❑9 children excluded
- ❑Age mean: 37 months, range: (30-46)
- ❑Standardized Expressive Vocabulary Test (EVT) mean: 129 range: 106-149

Methodology

- ❑Looking-while-listening (Fernald, et al., 2008) mispronunciation (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 known object one unfamiliar object .
- ❑Position counterbalanced (L-R).
- ❑Images normed for familiarity.

Three conditions

Real words (RW)
Mispronunciations of these real words (MP)
- ❑Phonetic feature change of first consonant.

Nonsense words (NW)

NW trials presented with familiar objects not used in RW trials.

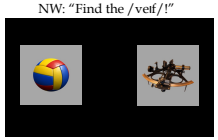
Target words all CVC in carrier phrases "See the ___!" or "Find the ___!"
Female speaker, child-directed speech register

6 RW + 6MP + 6NW * 2 repetitions = 36 trials (+ 2 familiarization trials).
2 Blocks of 38 trials, Tobii calibrated before each block.
Brief animation played ~every six trials to keep child engaged in task.

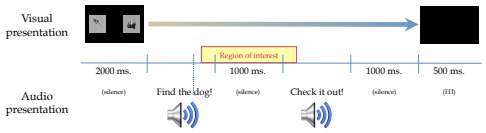
	Real words	Mispronunciation of Real words	Nonsense words	Pictures matched with nonsense word
/s-ʃ/	soup	/ʃup/	/ʧim/	
		bamboo steamer	pastry mixer	bed
	shoes	/suz/	/ʤiv/	
		chemistry flasks	golf club trolley	sock
/d-ʧ/	dog	/ʧag/	/veɪtʃ/	
		wombat	sextant	ball
	toes	/doz/	/ʧd/	
		concertina	horned melon	cake
/d-ʤ/	duck	/ʤʌk/	/neɪdz/	
		junkoat (rubber animal toy)	universal work holder	car
	girl	/dɵl/	/ʃæn/	
		marmoset	bassoon reed	cup

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

NW: "Find the /veɪtʃ/!"



- ❑ 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.



Research Questions

Children are expected to look to familiar object for RW trials, to novel object for NW.
What is the looking pattern for MP trials?
- ❑Are they treated similarly to RW, NW, or in between?
- ❑What are possible child-specific measures of perceptual performance?

Area of Interest (AOI)

- ❑Defined by gray box surrounding object.
- ❑Eyetracks within AOI of familiar object: coded as 1, unfamiliar object: coded as 0.
- ❑Used to calculate proportion and log-odds of looking to familiar object.
- ❑Time period of interest 300 – 1800 ms. after target word onset.

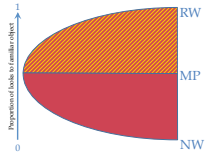
Analysis 1: Area Under the Curve

Area under the curve (AUC) was calculated for each child using the *proportion* of looking to the familiar object over time.

❑Curve smoothing: moving average of proportion looks to target across 5 time points.

❑AUC-ratio used as a dependent measure, combining all three trial types into a single score for each child.

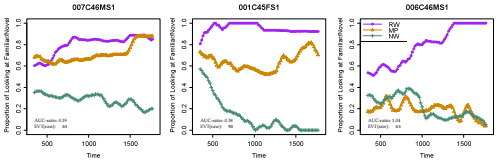
❑However, does not directly account for changes in eyegaze patterns as they unfold over time.



numerator = AUC for RW relative to MP
Larger numerator indicates child treated MP more like a NW.

denominator = AUC for RW relative to NW
Larger denominator indicates child reliably treated RW and NW as predicted.

Three different patterns are expected, based on this proposed measure: All except three of the children showed one of these three patterns.



AUC-ratio close to 0
The child does not differentiate between MP and RW. Suggests less-mature (robust) perceptual ability.

AUC-ratio close to 0.5
The child treats MP as different from both RW and NW. Suggests checking between two images.

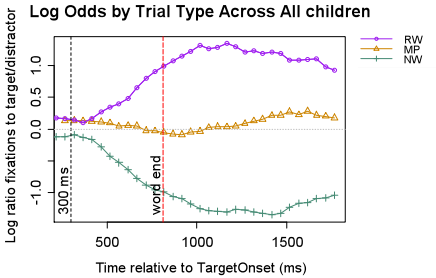
AUC-ratio close to 1
The child treats MP as similar to NW, ignoring the phonetic similarity to the RW.

- ❑ Middle pattern may be reflective of more fine-grained speech perception, but right-most pattern may be reflective of more efficient word learning.
- ❑ Independent measures of speech perception and word learning may be needed to interpret these patterns.

Preliminary analysis : Linear Regression

- ❑ AUC for RW relative to NW is positively related to expressive vocabulary size (p = 0.005) but not age (p = 0.22).
- ❑ A larger difference in area implies that the child consistently looks to familiar target for RW, non-familiar for NW, as predicted.
- ❑ This pattern indicates good word learning skills and hence a larger vocabulary.
- ❑ This result is consistent with work on younger children (Fernald et al., 2006), showing that children with larger vocabularies have shorter latencies and longer looking times to familiar words.
- ❑ AUC-ratio was not correlated with expressive vocabulary (p = 0.63) or age (p = 0.24).

Analysis 2: Growth Curve Modeling using a Hierarchical Linear Model (HLM)



- ❑Takes into account differences that may unfold over time we also propose a growth curve analysis using HLM to measure time-varying differences of log-odds among different word types (Barr, 2008; Mirman et al., 2008).
- ❑Looking patterns for each word type were calculated using the log-odds of looking to the familiar object over time.
- ❑Extreme log-odd calculations were adjusted by adding 0.5 to all values.
- ❑Pros: more sensitive measure of online perceptual processing; able to model perception over time.
- ❑Cons: difficult to combine all trial types in a meaningful way.

2-level HLM looking at log-odds of looking to familiar object for RW trials only

- ❑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 300-1800 ms. after stimulus.
- ❑Each bin represents approx. 50 ms.
- ❑Predictors: Time (liner and quadratic) centered such that the intercept of the model represents the log odds of looking to the familiar object 1500 ms. after stimulus onset.

Level 2: Child
- ❑Predictors: mean-centered EVT raw score, mean-centered child age.

Results

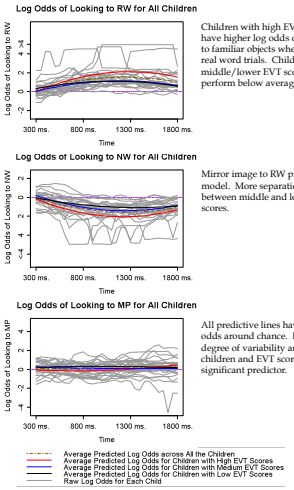
Random Intercept
Controlling for age, EVT score has a significantly positive relationship with intercept (i.e., higher EVT -> higher log-odds of looking to familiar object at 1500 ms.)
[$t(23) = 2.495$, $p = 0.02$]

Random Linear Slope (Growth Rate)
Controlling for age, children with higher EVT scores had a faster growth curve (i.e., higher EVT -> steeper slope across time)
[$t(23) = 1.735$, $p = 0.096$]

Random Quadratic Slope (Acceleration Rate)
Controlling for age, children with higher EVT scores had a lower acceleration rate across time (i.e., higher EVT -> the log-odds of looking to familiar object reach asymptote faster)
[$t(23) = -1.799$, $p = 0.085$]

Growth Curve modeling using NW log-odds mirrored results described above, as expected.

No relationship was found in model between vocabulary and log-odds of looks to familiar object for MP (note variability in MP trials in figure).



Children with high EVT scores have higher log odds of looking to familiar objects when hearing real word trials. Children with middle/lower EVT scores perform below average

Mirror image to RW predicted model. More separation between middle and lower EVT scores.

All predictive lines have log-odds around chance. Large degree of variability among children and EVT score not a significant predictor.

Summary

We offered two proposals to use eye tracking data gathered using Tobii to explore the relationship between perceptual performance and expressive vocabulary size.

Perceptual performance on RW and NW trials are as predicted:
- ❑ Children looked to familiar object in RW trials and to novel objects in NW trials
- ❑ This study is most interested in performance on MP trials, but performance on MP trials was most variable.

Future Directions

- ❑ Recruiting children with a larger range of EVT scores and SES background.
- ❑ Designing a longitudinal study using this experimental paradigm.
- ❑ Inclusion of additional predictors of language development (e.g., receptive vocabulary, language production).
- ❑ Exploring the possibility of using information about pupil dilation as a measure of cognitive effort.
- ❑ Participant exclusion criteria.

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