Effects of age, hearing loss, and phonological neighborhood density on children's perceptual confusions

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Main research questions

1. Does accuracy of repetition of distinctive features vary as a function of natural class for children with and without hearing loss?

2. How do children with and without hearing loss perform on a standardized speech production measure (the GFTA-II)?

3. Which subject attributes are the strongest predictors of performance on linguistic features?

Background

Lexical status Lexical neighborhood relationships differ between real words and non-words.

Age An older child's lexicon may be different in a number of respects that have been shown to affect accuracy (e.g., robustness of representations, fluency, number of lexical items and associated neighborhoods; Storkel, 2002; Edwards, Beckman, & Munson, 2004; Munson, Edwards, & Beckman, 2005).

Distinctive features (natural classes) known to improve with age.

Hearing loss (i.e., audibility) affects the lexicon:

► The lexicon may develop slower in children with HL (Davis, Morrison, von Hapsburg, & Warner-Czyz, 2005; Ertmer & Stark, 1995).
► Lexical competition may reduce lexical access ability (Jerger, Lai, & Marchman, 2002)
► Nonword repetition and phonological awareness performance may be decreased (Briscoe, Bishop, & Norbury, 2001; Moeller, Tomblin, Yoshinaga-Itano, Connor & Jerger, 2007)
► Manner characteristics associated with fricatives and affricates (noise > 3-4 kHz) may be inconsistently audible to children with HL (Stelmachowicz, Pittman, Hoover, Lewis, & Moeller, 2004; Pittman & Stelmachowicz, 2000)
► Children who are better able to see speech production characteristics tend to produce better speech segments, as evidenced in children with CIs and in deaf children (Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000; Levitt, McGarr, & Geffner, 1987). Thus, labial place phones may be reproduced with greater accuracy.

♦ **Little direct evidence bears on how childhood hearing loss affects the the reproduction of phonemes from various natural classes, or how phoneme reproduction varies for words versus nonwords.**

Method

Participants

		N	PTA dB HL (*M*, *SD*)	GFTA-II SS (*M*, *SD*)
Hearing Impaired (*N* = 31)	**4 year olds**	17	43 (14)	106 (8)
	7 year olds	14	42 (18)	94 (18)
Normal Hearing (*N* = 30)	**4 year olds**	15	screened at 15	109 (10)
	7 year olds	15	screened at 15	102 (10)
	all pooled	61	—	103 (11)

► Children with HL all wore amplification during testing.

Materials

► 100 monosyllabic word forms (68 words, 32 non-words)
► stimuli = citation-style, natural production, adult female voice
► to confirm naturalness of stimuli, open-set identification task (*N*=7 adult judges): 98.7% accuracy
► stimuli do not vary by overall size (n-phones) or lexical usage frequency

Phones in stimulus words (raw *N*)

		words	non-words	total
Voicing	voiced	37	88	125
	voiceless	17	29	46
Manner	fricative/affricate	31	22	53
	stop	23	95	118
Place	labial	16	30	46
	alveolar	30	51	81
	velar	8	36	44

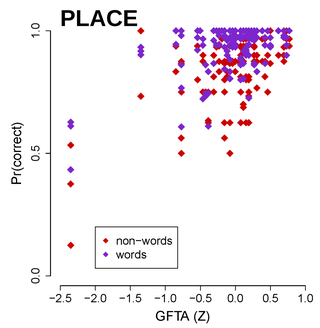
Procedure

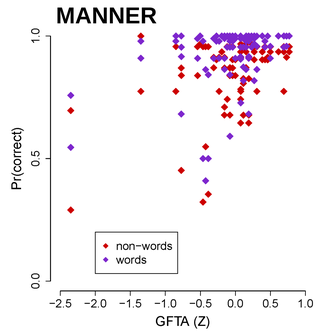
► All stimuli randomized as part of computer game with participants
► Listen-and-repeat **task:** "say what the lady on the computer says"
► Stimuli played in open-field at about 68dB SPL
► Speech production was assessed via Goldman Fristoe-II
► Lexical access abilities were assessed via Expressive Vocabulary Test-II

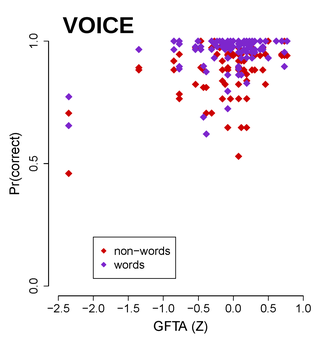
Data analysis, Bayesian logistic regression model

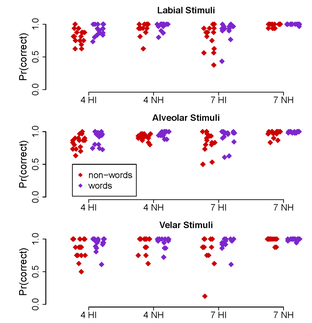
► **Dependent variable**
1. distinctive feature reproduction accuracy
► Independent variables in the model
1. Lexical status (word vs. non-word)
2. Age (4 yrs, 7 yrs)
3. Hearing status (HI, NH)
4. Productive phonology (GFTA standard score)
5. Expressive vocabulary (EVT standard score)
6. Stimulus feature value
- Voice (voiced, voiceless)
- Manner (stop, fricative/affricate)
- Place (labial, alveolar, velar)

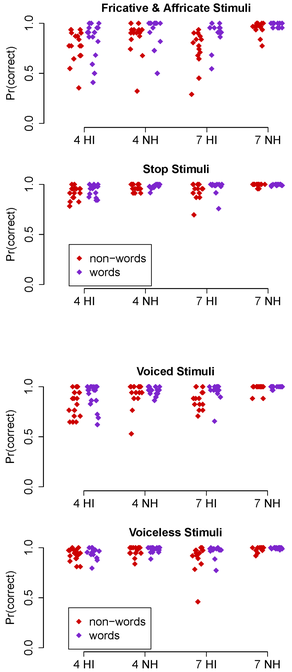
Rev. Bayes











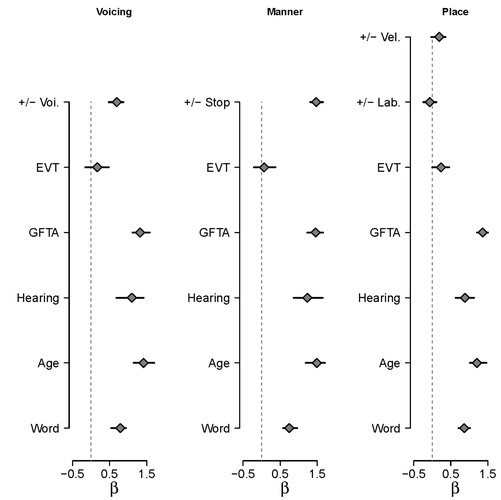


Figure. Parameter estimates (beta) for the natural classes voicing, manner, and place as they interact with the variables of interest. A larger absolute beta value indicates that parameter is a stronger independent predictor.

Results

1. **There is a bias toward voiceless responses. Voiced stimuli are more likely to be produced as voiceless than vice versa.**
2. **There is a bias toward stop responses. Fricatives/affricates are more likely to be produced as stops than vice versa.**
3. **There is no bias with respect to place.**
4. **The manner bias is larger than the voicing bias, as reflected in the relative magnitudes of the +/- stop and +/- voiced parameters.**
5. **The fricative/affricate manner class is more variable and inaccurate, perhaps reflecting HH kids' perceptual difficulties, but may also be in production.**
6. **Age, lexical status, & GFTA are consistent predictors of feature accuracy for both HH and NH kids (not too surprising).**

Conclusions

1. **Voice and manner accuracy varies for both children with and without HL. Place accuracy does not appear to similarly vary. This is surprising because place distinctions may be especially perceptually challenging for HH children.**
2. **The GFTA was a consistent and strong predictor for all DF reproduction accuracies; HH children had poorer performance overall.**
3. **Manner DFs appeared to be the strongest predictors of performance. In particular, fricatives/affricates tended to be stopped, especially for children with HL. This is well known in the literature.**

Future directions

1. **Look at additional dependent variables (RTs, acoustic characteristics). RTs may shed light on lexical access (e.g., longer RTs in response to *harder* words or phones), and acoustic similarity to the stimulus may shed light on phonetic convergence and imitation skills in children with and without HL.**
2. **Look at characteristics of vowel production accuracy. Perception of vowel height, backness, and rounding may be differentially affected by hearing loss.**
3. **Investigate results with respect to lexical processing models such as NAM, TRACE, PARSYN, Shortlist, MERGE).**