Developmental Changes in Phonological Representation: An investigation using the imitation paradigm

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Outline

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    - Development of gestural imitation
  - Imitation in speech communication
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Imitation

- Crucial role in the development of cognitive and social behavior of humans
- One of the basic mechanisms governing language acquisition
- Perception-Behavior Link (Chartrand & Bargh, 1999)

Imitation of physical gestures

- A.K.A: Chameleon effect, motor mimicry

- Facial expression (Dimberg, 1982; Bavelas et al. 1986)
  - Newborns (Meltzoff & Moore, 1977)
- Posture (Bernieri, 1988)
- Physical gestures/movements (Chartrand & Bargh, 1999)

Development of gestural imitation

- Imitation of physical gesture increases with age and developmental level

- Fouts & Liikanen (1975)
  - 5- and 8-year-olds in motor imitation (i.e., schemata used for playing with different sets of toys)
- Barr et al. (1996)
  - Deferred imitation of behaviors (e.g., shaking a mitten) by 6- to 24-month-old infants
- Anderson & Meno (2003)
  - Yawning was induced in children older than 5 (2-11)
- McGuigan et al. (2011)
  - 3- and 5-year-old children & adults in a puzzle-box task

Imitation in speech communication

- Syntactic structure (Bock, 1986; 1989; Pickering & Garrod, 2004)
- Word choice/description schemes (Garrod & Doherty, 1994)
- Paralinguistic features:
  - Speech rate (Webb 1970)
  - Pause and utterance duration (Gregory & Hoyt, 1982; Jaffe and Feldstein 1970)
  - Vocal intensity (Natale, 1975)

Imitation of phonetic features

- Phonetic imitation/convergence/ accommodation
  - Speakers become more similar to their interlocutor or model talker w.r.t. articulatory/ acoustic characteristics, as the result of brief exposure
- Coordination of speech gestures between speakers

Phonetic Imitation

- Phonetic features imitated:
  - Vowel formants (Babel, 2010, 2012; Pardo, 2010)
  - f0 (Babel & Bulatov, 2012; Pardo, 2010)
  - Segment durations (Delvaux & Soquet, 2007)
  - VOT (Shockley et al., 2004)
  - Spectral characteristics of /l/ (Honorof et al., 2011)
  - Lip aperture (Gentilucci & Bernardis, 2007)
  - Coarticulatory vowel nasality (Zellou, Scarborough, Nielsen, under review)

Phonetic Imitation

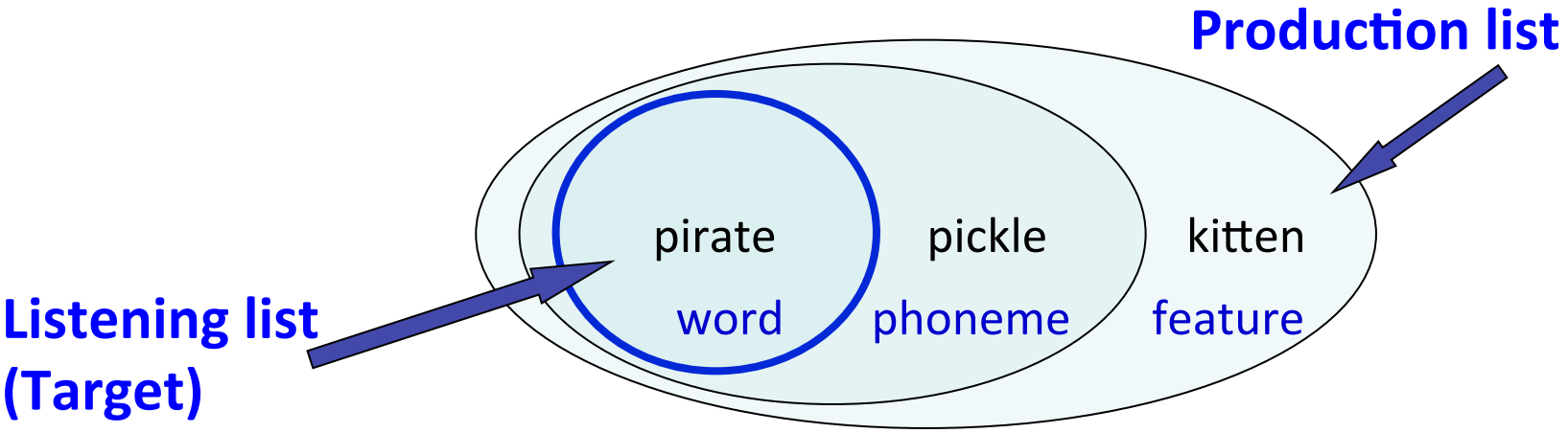
- Social factors
  - Gender (Namy et al., 2002; Pardo, 2006 & 2009; Babel, 2012)
  - Race of the model talker (Babel, 2012)
  - Rated attractiveness of the model talker (Babel, 2012)
  - Role in map-task (giver, receiver) (Pardo, 2006)
  - Speaker's attitude toward the model's social identificaiton (Babel, 2012; Yu et al. 2011)
  - Sexual orientation (Yu et al. 2011)
  - Interlocutor language distance (Kim et al., 2012)
  - Register (child-directed speech) (Ward, 2013)

Phonetic Imitation

- Cognitive factors
  - Attended aspects of speech (Goldinger, 2013)
  - Presentation modality (audio vs. audiovisual) (Miller et al. 2010; Dias & Rosenblum, 2011)
  - Lexical frequency (Goldinger, 1998)
  - Autistic traits (Mielke et al, 2013; Ward, 2013)
  - Phonological representations (Nielsen, 2011)

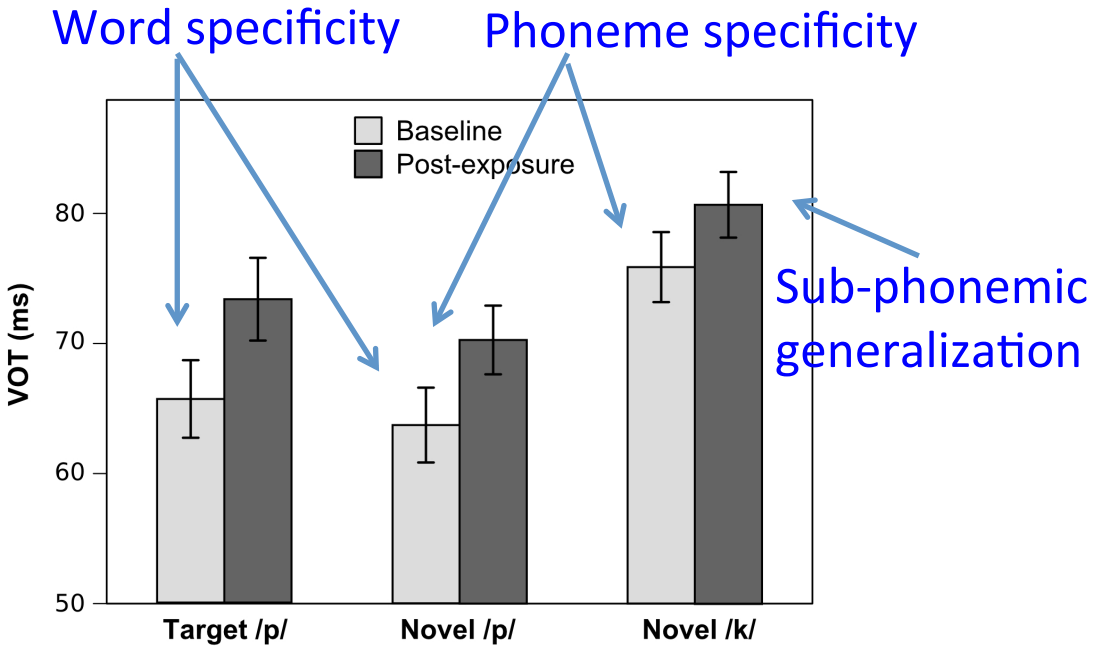
Phonetic imitation and Phonological representations

- Nielsen (2011):
- Examined how VOT imitation can be generalized
  - Baseline Production > Target Exposure > Test Production
  - Target (listening) stimuli = Subset of production list



Phonetic imitation and Phonological representations

- Extended VOT in the Target stimuli was imitated, and the change was generalized to words which participants did not listen to (Novel /p/ and /k/)



- Three levels of phonological representations (i.e., word, phoneme, and sub-phonemic gesture/feature) contribute to the patterns of phonetic imitation

Development of speech imitation

- Not fully understood
- Imitation increases with age?
- Kuhl & Meltzoff (1996): 12-, 16-, and 20 wo infants
  - Older infants produced vowels that were closer to the model stimuli
- Loeb & Allen (1993): 3 yo and 5 yo
  - Older children imitated modeled intonation contours more
- Welcowitz et al. (1976): 6½-7 yo and 5½-6 yo
  - Older children showed greater accommodation of pause duration

Development of speech imitation

- No age affect?
- Street & Cappella (1989):3-6 yo
  - Children imitate turn-taking pauses & speaking rate, but no effect of age or sex once verbal ability was taken into account (linguistically more developed children showed stronger convergence)
- Eaton & Ratner (2013): 3 & 4 yo
  - Children imitated consonant reduction (e.g., final stop deletion) and speech rate with no effect of age

Development of speech imitation

- Decreases with age?
- Ryalls & Pisoni (1997): 4 & 5 yo
  - Younger children imitated/matched stimulus word duration more than older children and adults
  - Imitation decreased with age, while talker normalization progressed with age

Phonetic imitation by children

- Most studies examine paralinguistic features, and little is known about phonetic imitation produced by children, and its developmental course
- Ward (2013)
  - Children (4-6 yo) imitated only the phonetic measures (formant values); no imitation of "global" measures (i.e., f0 & vowel duration)
  - Stronger imitation in the audiovisual modality and in the child-directed register

Development of phonetic imitation

- We don't know how phonetic imitation develops
- Understanding its developmental course will help us understand the mechanism of phonetic imitation
  - Accounts proposed:
    - Exemplar (Goldinger, 1998): imitation decreases with age
    - Communication Accommodation Theory (Giles et al. 1991)
    - Direct realist view (Fowler, 1989)
  - Comparison with development of gestural imitation

Development of phonological representations

- Further, investigating the developmental course of phonetic imitation might provide new insight of phonological representations in children
- Phonological representations develop throughout childhood (e.g., Edwards et al., 2004; Hazan and Barrett, 2000)
- By examining the patterns of phonetic imitation produced by children (and adults), we hope to learn about phonological representations at different developmental stages

Research questions

- Do children imitate fine phonetic detail?
- Does age of participant influence the degree and patterns of phonetic imitation?
- Does their imitation show evidence for word-, phoneme-, and sub-phonemic level of representation?

Current Study: VOT imitation by children

"Phonetic imitation by young children and its developmental changes"
To appear in JSLHR

- Goal
  - Examine the developmental changes in the degree and patterns of phonetic imitation
- Participants
  - 16 preschoolers (10M & 6F, Age: 4;5-5;4, Mean = 4;11)
  - 15 3rd graders (7M & 8F, Age: 8;6-9;1, Mean = 8;9)
  - 18 college students (3M & 15F, Age: 18-26, Mean =21:02)

Stimuli Selection

- Listening list (for listening block): 12 "Target" words (initial /p/)
- Production list (for baseline and test block): 56 words
  - 12 Target words with initial /p/ *'pizza', 'pen'*
  - 24 Novel (non-target) words
    - 12 words with initial /p/ *'popcorn', 'pig'*
    - 12 words with initial /k/ *'cake', 'car'*
  - 20 filler words *'frog', 'scooter'*

Stimuli Selection

- Target vs. Novel words were balanced in lexical frequency
  - CML (The Child Mental Lexicon) [Moe et al. (1982)]
  - CDS (Child-Directed Speech frequency count by Ping Li, CHILDES)

[As in Nielsen, 2011]

- Target /p/ vs. Novel /p/ comparison for testing word specificity
- Novel /p/ vs. Novel /k/ comparison for testing phoneme specificity
- Novel /k/ for testing sub-phonemic generalization

Stimuli Construction

- A phonetically trained American English speaker (female) recorded the 12 Target words (= listening list)
- Child directed speech

- The VOT of initial /p/ was extended by 50ms by copying medial portions of the aspiration (cf. Shockley et al. 2004)
  - Original VOT = 57.2 ms (SD=12.64ms);
  - Extended VOT =107.5 ms (SD=16.12ms)
  - Word duration = 668.6 ms

Procedure

- Picture naming task
- All children were tested at their school (in a quiet room)
  - Adults: Sound attenuated room
- Words in the production list were presented as a picture slide show (1 picture at a time, self-paced)
  - Images pre-tested by a preschooler for possible ambiguity
- The participants were asked to name each picture
  - "Can you please tell me what the picture is?"
- Wore headphone/microphone (Logitech A-0365A)

Procedure

1. Baseline Block 
   - Participants named each picture in the slide show (= production list); their speech was recorded
2. Listening Block 
   - Participants listened to the recording of target words with extended VOT (3 repetitions, 3 s /word, images also presented)
3. Test (Post-listening) Block 
   - Same as the Baseline Block (their speech was recorded)

- VOTs and word durations were measured using Praat

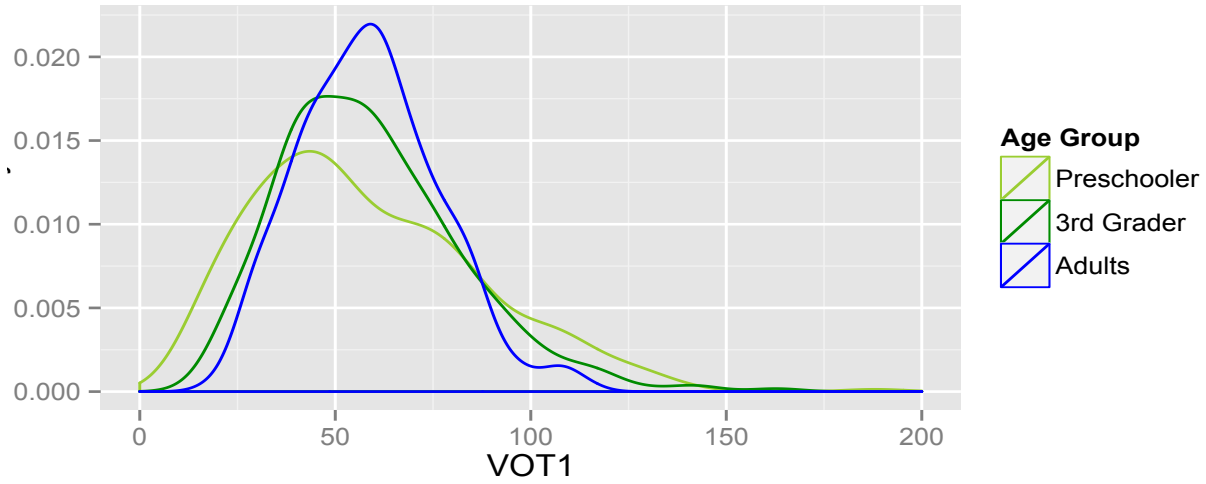
Results: Extended VOT was imitated by children and adults

	VOT (ms) (SD)		Word Duration (ms) (SD)	
Age Group	Baseline	Test	Baseline	Test
Preschooler	62.44 (29.3)	77.79 (34.9)	586 (191)	598 (189)
3rd grader	64.78 (24.6)	76.53 (27.8)	551 (157)	582 (164)
Adult	64.34 (19.2)	71.23 (19.7)	488 (114)	517 (120)

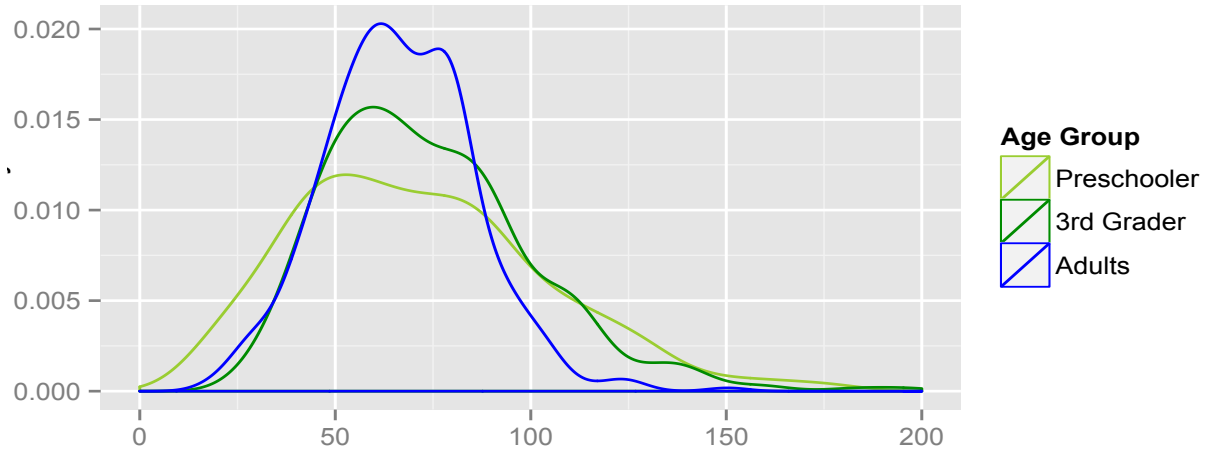
Target: (VOT) 107.5 ms; (Word) 668.6 ms

Results: Distribution of VOT Baseline vs. Test

Baseline VOT



Test VOT



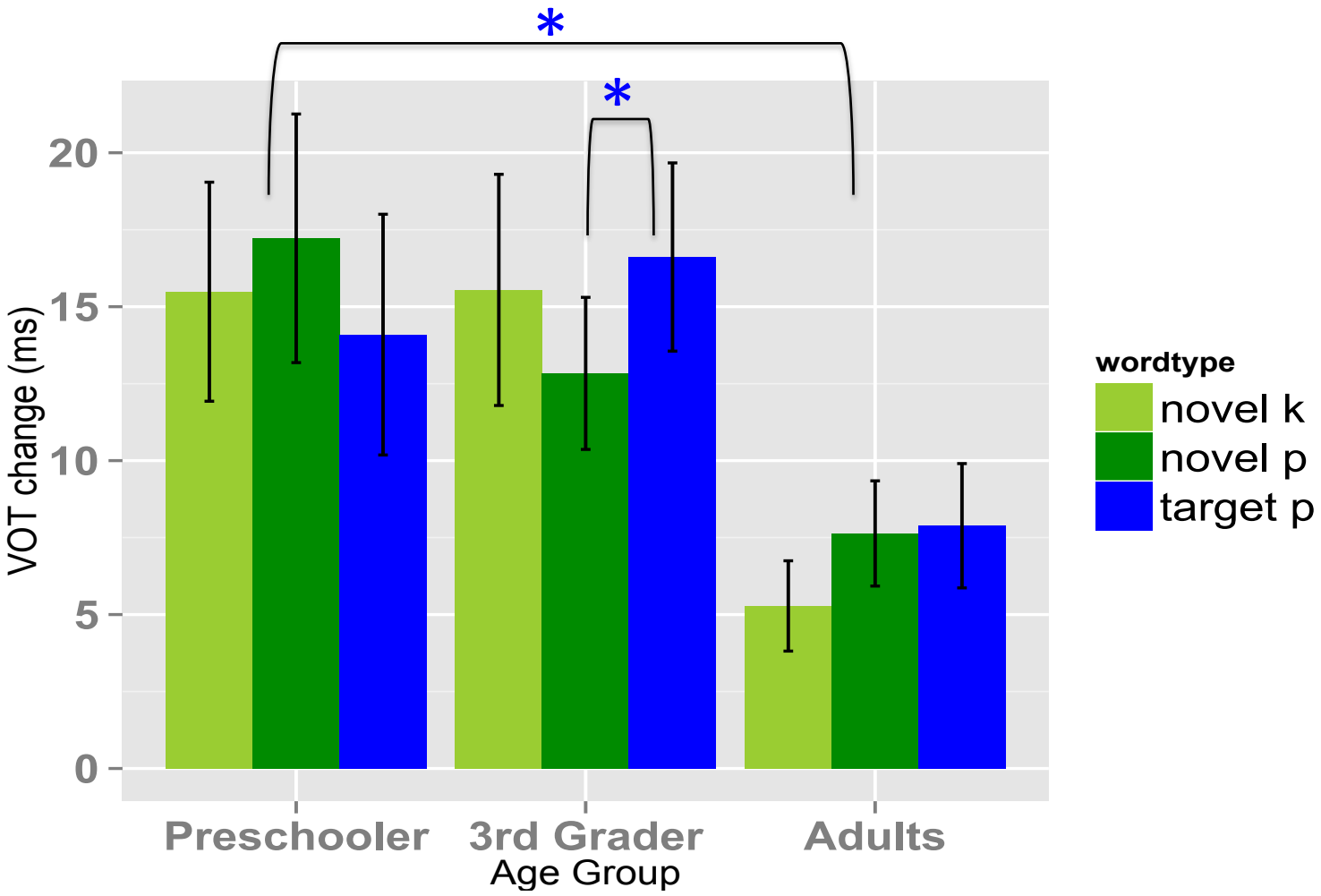
Analysis: Linear mixed-effects modeling

- Dependent variable = Change in VOT (ms)
- Fixed effects
  - Phoneme: /p/ vs. /k/
  - Age: preschooler vs. 3rd grader vs. adults
  - Exposure: Target (=heard) vs. Novel (=unheard)
  - Gender
  - Word-change: change in word duration (from baseline to test)
  - Baseline VOT
- Random effects
  - Participant, Word
  - Random intercepts: Word & Participant
  - Random slopes: Baseline VOT, Phoneme, Word-change by Participant; Baseline VOTWord-change by Word

Modeling Results

- Significant main effects:
  - Phoneme (/p/ vs. /k/) [t=3.69] (/p/ changed more)
  - Age (Preschooler vs. Adult) [t=-2.22] (less change for adult)
  - Baseline VOT [t=-19.7]
- Significant interactions:
  - Age x Word-change (Preschooler vs. 3rd grader) [t=-2.03] (Preschoolers did not change word duration compared to 3rd grader)
  - Phoneme x Word-change [t=2.91] (more change for /p/ word duration)
- No significant effects:
  - Age (Preschooler vs. 3rd grader) [t=0.43]
  - Word-change [t=1.02]
  - Exposure, Gender [t<1]

VOT change by Word Type and Age Group

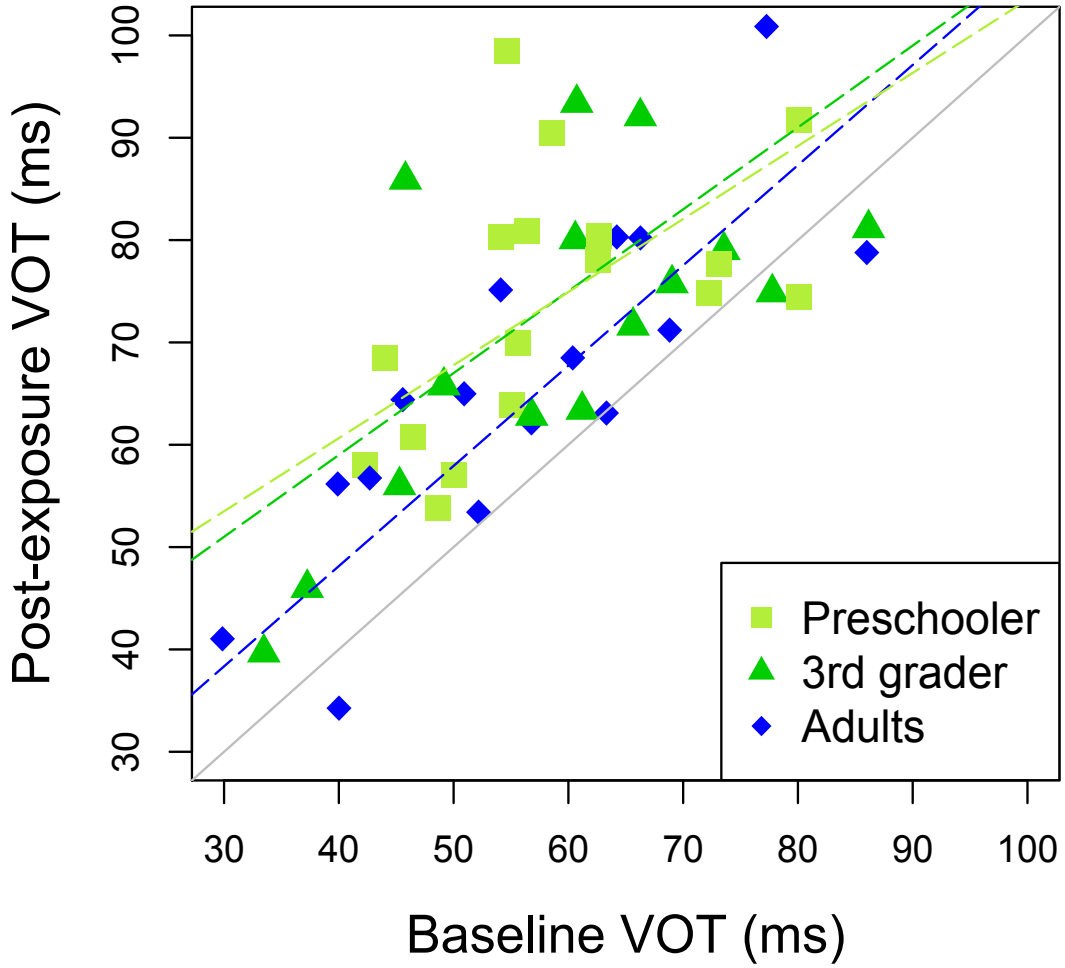


Final Model

Parameter	Estimate	Std. Error	t-value
(Intercept)	61.96	3.26	18.98
Phoneme = /p/	9.79	2.66	3.69
Age = 8	1.30	3.02	0.43
Age = 20	-6.51	2.94	-2.22
Wordchange	0.02	0.02	1.02
Baseline VOT	-0.68	0.03	-19.71
Wordchange: Baseline VOT	0.00	0.00	1.95
Age = 8: Wordchange	-0.03	0.02	-2.03
Age = 20: Wordchange	-0.01	0.02	-0.64
Phoneme = /p/: Wordchange	0.04	0.02	2.91

* Variable selection by stepAIC( ): Gender and Exposure excluded in the final model

Imitation was greater for children



Results Summary

- Extended VOT was imitated by children and adults
- Imitation was greater for children

- Sub-phonemic generalization
  - VOT in Novel /k/
- Phoneme specificity
  - More increase in /p/
- No word specificity
  - No effect of Exposure

- When analyzed separately, 3rd graders' imitation was greater for Target /p/ words than Novel /p/ words => word specific imitation [t=3.314]

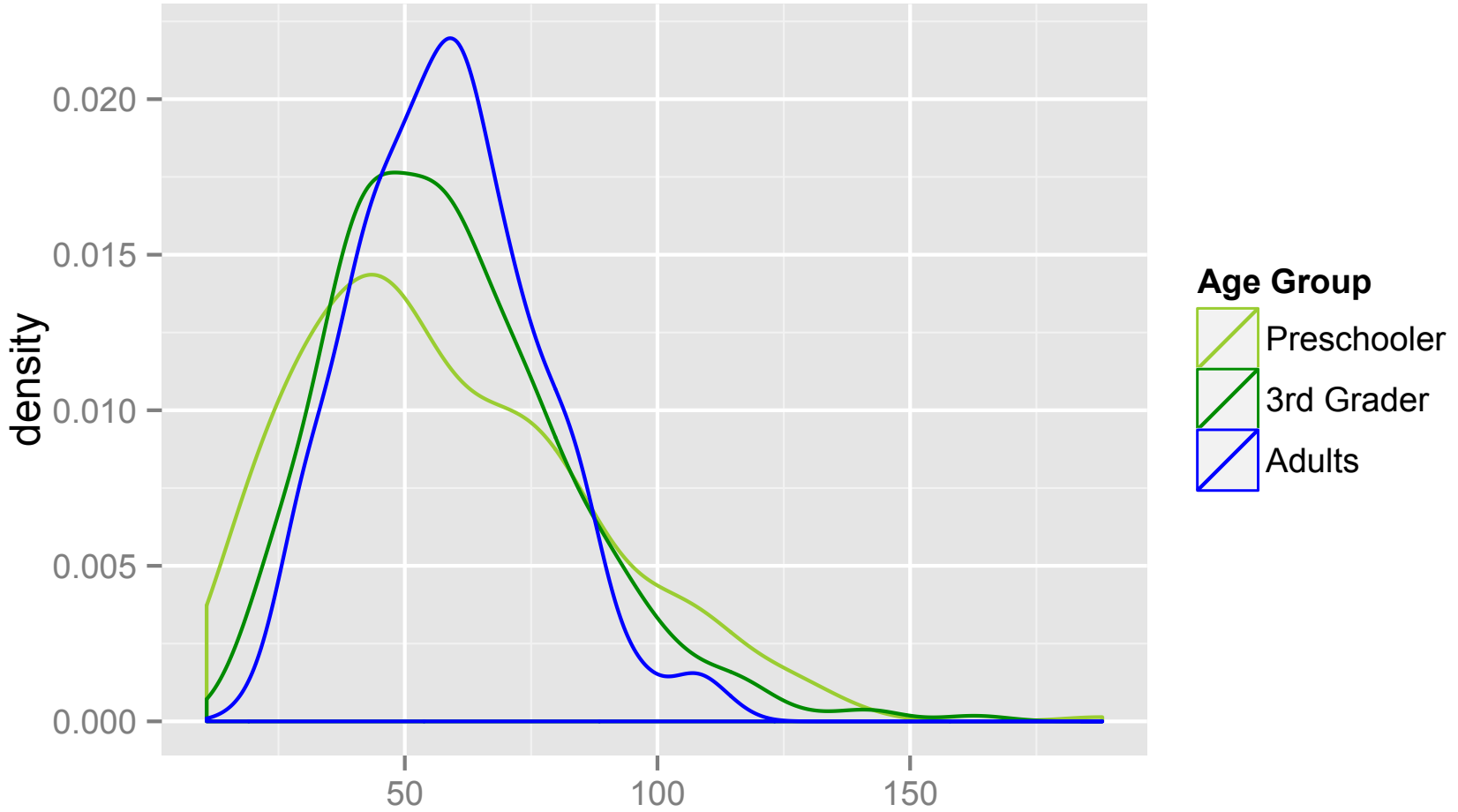
Research questions

- Do children imitate extended VOT?
  - Yes, both groups of children imitated extended VOT
- Does participant age influence the degree and patterns of phonetic imitation?
  - Yes, children showed stronger imitation than adults, and the effect of exposure was significant only in 3rd graders
- Does their imitation show evidence for word-, phoneme-, and sub-phonemic level of representation?
  - All age groups showed phoneme-level specificity and sub-phonemic generalization; Only 3rd graders showed word-level specificity

Development of phonetic imitation

- Children showed greater imitation than adults
- More developed phonological categories do not lead to greater imitation
  - Trade-off between phonological development and phonetic imitation?
  - cf. Ryalls & Pisoni (1997): 4 & 5 yo
    - Imitation decreased with age, while talker normalization progressed with age

Phonological Development: VOT (baseline /p/) distribution by Age



Development of phonetic imitation

- As speakers' phonological representations develop with age, their categorical perception becomes more efficient (e.g., Hazan and Barrett, 2000)
- Retain less unprocessed information in memory >> less imitation?
- However, non-significant age difference among children (contrary to prediction by the exemplar view)
- Neural plasticity/critical period?
- …or simply effect of Child Directed Speech? (cf. Ward, 2013)

Discussion

- No age effect on phonetic imitation among children
  - Older children did not show greater imitation, contrary to studies in gestural imitation
    - ➢ Suggests possibly different mechanisms for gestural vs. phonetic imitation
    - ➢ Speech >> phonemic categories
    - ➢ Phonetic vs. paralinguistic features?

Discussion

- Robust effect of sub-phonemic generalization for all age groups
  - Sub-phonemic representation -> available at age 4-5
  - Target of phonetic imitation = sub-phonemic >> articulatory gestures? features?

- Word-level specificity was observed only among 3rd graders
  - Suggests more developed lexical representation for older children
  - Lexical representation -> likely more subtle than sub-phonemic gesture/feature

To tie together the two themes of today's workshop…

- Between-speaker gestural coordination (=imitation)
  - Crucial for initial stage of phonological acquisition
  - As children's phonological categories develop, it becomes less vital
- Within-speaker gestural coordination
  - As children's phonological categories develop, it becomes more stable
  - Possibly attenuates imitation

Implications for models of phonetic imitation

- Exemplar-based theories (e.g., Goldinger, 1998) readily predict the observed age effect
- Successful model of phonetic imitation may include:
  - Exemplar-based categories/representations including sub-phonemic unit
  - Sensitivity to social/cognitive factors

Conclusion

- Stage of phonological development affects degree of imitation
- Sub-phonemic representations are present in early childhood, and phonological categories become more stable over the course of development
- Possibly different mechanisms for gestural vs. phonetic imitation

- Next step:
- Adolescent >> exemplar vs. neural plasticity
- Children with SLD >> phonological development vs. social factors (Child Directed Speech)