

PREDICTORS OF INTRA-WORD VARIABILITY IN TYPICALLY DEVELOPING PRESCHOOLERS

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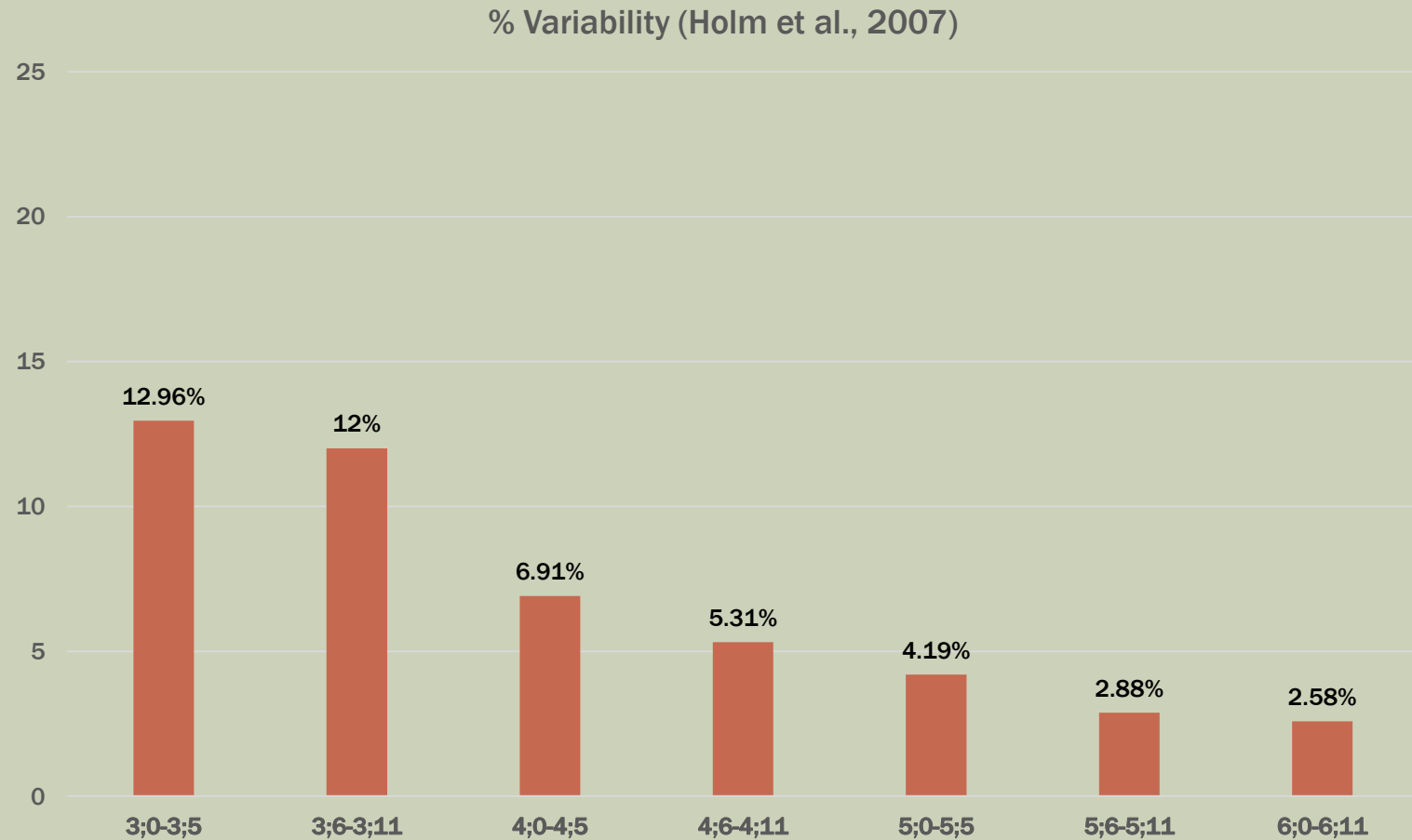
INTRA-WORD VARIABILITY

- Characteristic of:
 - 1. Childhood apraxia of speech:** “inconsistent errors on consonants and vowels in repeated productions of syllables or words” (ASHA, 2007, p. 2)
 - 2. Phonological impairment:** “children producing 10 or more of the 25 words differently (> 40%), on at least two of the three occasions that they are elicited, should be classified as having inconsistent disorder” (Dodd & Crosbie, 2005, p. 152)
 - 3. Typical development:** McLeod and Hewett (2008); Macrae (2013); Sosa and Stoel-Gammon (2012)

RATES OF INTRA-WORD VARIABILITY

- 1. Childhood apraxia of speech:** very little published data; 56-88% variability in 3 children aged 4;6-7;7 (Marquardt et al., 2004); 100% variability in 16 Hebrew-speaking children aged 2;7-5;6 (Tubul-Lavy, 2012)
- 2. Phonological impairment:** 15-79% ($M = 41\%$) in children aged 3;6-5;5 (Macrae et al., 2014); 40% or higher reflects “inconsistent disorder” (Dodd & Crosbie, 2005)
- 3. What about typical development?**
 - 50-100% ($M = 78\%$) in children aged 1;9-3;1 (Macrae, 2013); 56-94% ($M = 76\%$) in children aged 2;0 (Sosa & Stoel-Gammon, 2012); 48-76% ($M = 67\%$) in children aged 2;5 (Sosa & Stoel-Gammon, 2012); 42-78% ($M = 53.7\%$) in children aged 2;0-3;4 McLeod & Hewett (2008)
 - However, Holm et al. (2007)...

RATES OF INTRA-WORD VARIABILITY



RATES OF INTRA-WORD VARIABILITY

- In addition to Holm et al. (2007), one study has documented rates of intra-word variability in children with typical development older than 3½
- deCastro & Wertzner (2011) found 9.8% intra-word variability in Brazilian Portuguese speaking children from 5;0-10;10 (*M* age not reported) (considerably higher than 2.95% for 6-year-olds in Holm et al., 2007)
- Has intra-word variability mostly resolved by 4 years old?
- Researchers must first document rates of intra-word variability in children with typical development before clinicians can use rates to diagnose SSDs and their subtypes

RESEARCH AIM #1

To document rates of overall intra-word variability and subtypes of variability in 2½- to 4-year-old children with typical speech and language development and to compare rates obtained from two different research sites

CONTRIBUTORS TO INTRA-WORD VARIABILITY

- **Word-specific factors:**

- 1. Phonological complexity (Macrae, 2013; Sosa & Stoel-Gammon, 2012)**
- 2. Word frequency (Sosa & Stoel-Gammon, 2012)**
- 3. Neighborhood density (Sosa & Stoel-Gammon, 2012)**

- **Child-specific factors:**

- 1. Age (Macrae, 2013)**
- 2. Expressive vocabulary (Macrae, 2013; Sosa & Stoel-Gammon, 2012)**

CONTRIBUTORS TO INTRA-WORD VARIABILITY

- Children in these studies were aged 3;1 or younger
- What about older children?
- Each of these studies had 15 participants
- What about a larger group of children?
- What about other child-specific factors, like speech sound production and receptive language abilities?

RESEARCH AIM #2

Explore potential concurrent predictors of intra-word variability, including age, expressive and receptive vocabulary, and speech sound production abilities, in 2½- to 4-year-old children with typical speech and language development

PARTICIPANTS

- 43 children (19 male, 24 female) aged 2;6-4;2 ($M=3;3$) with typical speech and language development
- 34 children from Arizona; 9 from Florida
- All children administered Goldman-Fristoe Test of Articulation (GFTA-2), Expressive Vocabulary Test (EVT-2), Peabody Picture Vocabulary Test (PPVT-4), and Inconsistency Assessment (IA)
 - EVT mean standard score = 117 (s.d. = 12.7)
 - PPVT mean standard score = 114 (s.d. = 13.3)
 - GFTA mean standard score = 108 (s.d. = 10.4)

INCONSISTENCY ASSESSMENT

- 25 1-4 syllable words elicited 3 times each using pictures and objects within the same session (trials separated by another activity)
- Target words coded as variable if any differences in broad transcription (consonants and vowels) across 3 productions
- Percent variability calculated as # target words produced variably divided by total # target words (< 25 for some participants)
- Percentages also calculated for the following subcategories: consistent correct (CC), consistent incorrect (CI), variable with hits (VH), variable no hits (VN) (see Grunwell, 1992; Holm et al., 2007)

CONSENSUS TRANSCRIPTION

- IA transcribed using consensus transcription procedure similar to Shriberg et al. (1984) (majority of 17 consensus rules used)
 - Transcriptions for Arizona cohort were made from audio-video recordings
 - Transcriptions for Florida cohort were made from audio-only recordings
- Research assistants (RAs) were undergraduate or graduate majors in CSD with a particular strength in IPA transcription
- RAs received additional training in IPA transcription for the present study with first or second author

CONSENSUS TRANSCRIPTION

- Training involved transcribing IA responses from children not participating in the present study (Florida) or by transcribing responses from the GFTA (Arizona)
- Research assistants transcribed each production independently
- RAs then compared transcriptions and discussed disagreements
- In most cases, disagreements resolved
- In other cases, first or second author served as tie breaker

STATISTICAL ANALYSES

- **Research Aim #1** (rates of intra-word variability): descriptive statistics for overall variability and subcategories for all participants and Mann-Whitney U tests comparing rates across research sites (AZ and FL)
- **Research Aim #2** (predictors of intra-word variability): standard linear regression used to determine which child-specific factors, if any, among age (in months), speech sound production abilities (GFTA-2 raw score), expressive vocabulary (EVT-2 raw score), or receptive vocabulary (PPVT-4 raw score) predicted intra-word variability (% variability from IA)

RESULTS

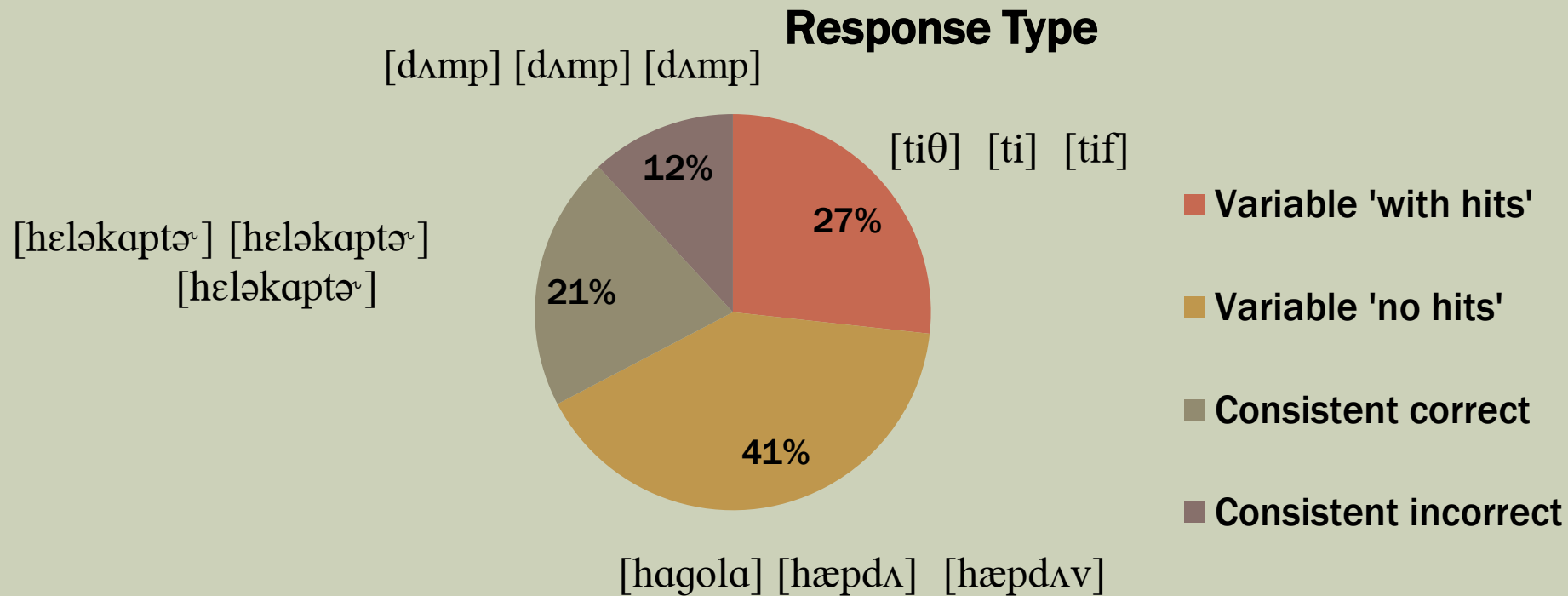
COMPARING THE TWO COHORTS

- Independent samples Mann-Whitney U Test
 - Mean age of the groups does not differ (Florida $M = 42$ months; Arizona $M = 38$ months)
 - Groups do not differ on vocabulary or articulation test STANDARD scores
 - Groups do not differ on proportion of words produced variably on the IA
 - Florida cohort has higher EVT raw scores than Arizona cohort ($p=.01$)
 - Florida cohort has lower GFTA raw scores than Arizona cohort ($p=.04$) (i.e., Florida cohort had fewer errors on target consonants)

RESULTS

RESEARCH AIM #1: RATES OF INTRA-WORD VARIABILITY AND RESPONSE TYPE

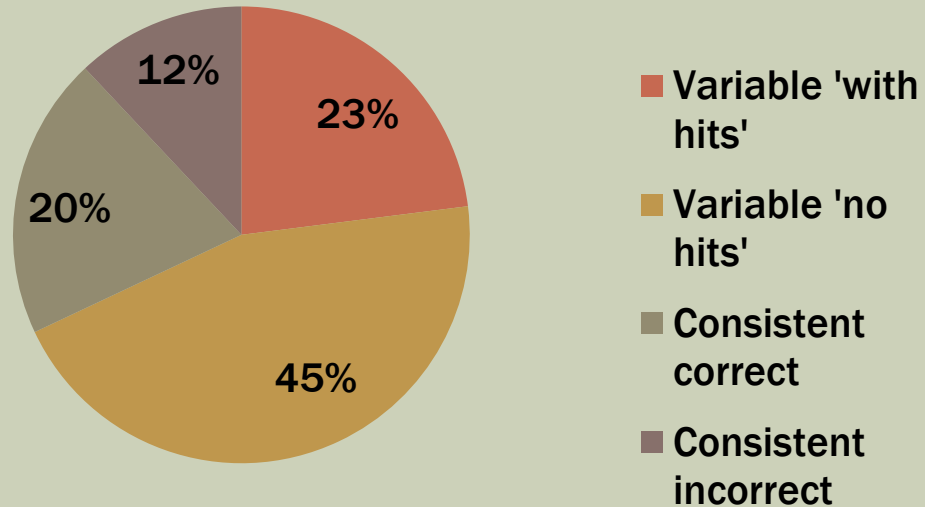
- For all children, mean proportion of words produced variably was 68% (s.d. = 16.5; range = 32%-100%)
 - Florida cohort = 70%; Arizona cohort = 68%



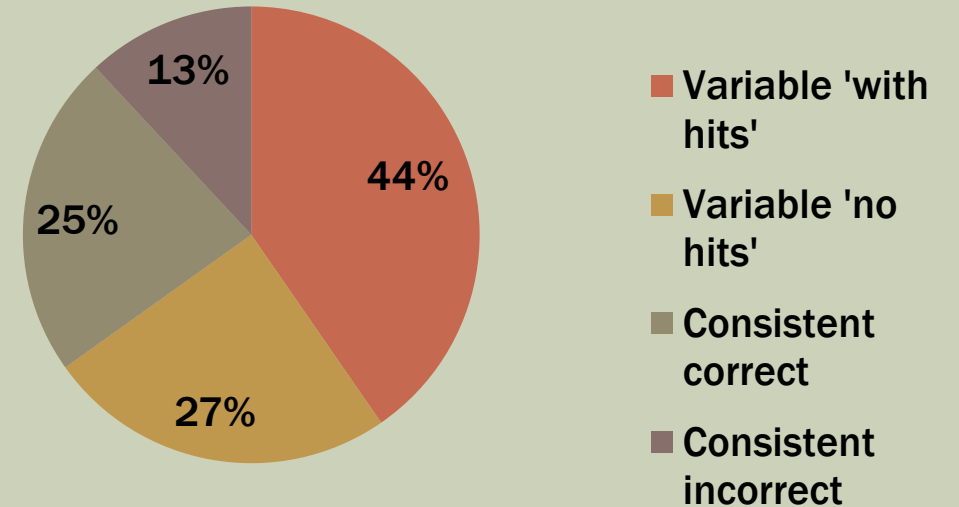
RESULTS

RESEARCH AIM #1: RESPONSE TYPE FOR EACH COHORT

Arizona cohort (n=34)



Florida cohort (n=9)



RESULTS

RESEARCH AIM #2: PREDICTORS OF VARIABILITY

- Standard multiple regression with proportion of words produced variably (IA) as outcome measure
 - Predictor variables include:
 - Age (in months)
 - EVT raw
 - PPVT raw
 - GFTA raw

Correlations between variability and all predictor variables

	Age	EVT	PPVT	GFTA
Variability	-.458**	-.610**	-.493**	.442**

**p<.01

RESULTS

RESEARCH AIM #2: PREDICTORS OF VARIABILITY

Model summary: $R^2=.436$, $R^2_{adj}=.375$, $F(4,37)=7.16$, $p<.001$

Coefficients

	<i>B</i>	β	<i>t</i>	<i>p</i>
Age (in months)	-.001	-.022	-.131	.897
EVT	-.006	-.628	-2.739	.009*
PPVT	.000	.049	.246	.807
GFTA	.001	.090	.579	.566

RESULTS

SUMMARY

- 68% of words produced with some variability (similar rates obtained at both research sites)
- Variable 'no hits' was the most frequent response type (41%); followed by variable 'with hits' (27%), consistent correct (21%), and consistent incorrect (12%)
- Variability is significantly correlated with age, expressive vocabulary, receptive vocabulary, and articulation ability
- When all variables are entered into a regression model, **expressive vocabulary is the only significant predictor of variability, accounting for 38% of the variance**

RESULTS

ADDITIONAL ANALYSIS

- Correlations among child factors and different response types

	Age	EVT	PPVT	GFTA
V 'with hits'	.163	.260	.267	-.628**
V 'no hits'	-.475**	-.663**	-.562**	.797**
C Correct	.489**	.621**	.588**	-.669**
C Incorrect	.233	.229	.172	.038

- In a regression model, EVT and GFTA are both significant predictors of rate of Variable 'no hits', accounting for 70% of the variance
- Only GFTA predicts rate of Variable 'with hits' responses (42% of variance accounted for)

DISCUSSION

- Results are consistent with previous work (Macrae, 2013; McLeod & Hewett, 2008; Sosa & Stoel-Gammon, 2012), but very different from Holm et al., 2007

Why?

- Data collection site
- Transcription procedures
- Need to rethink the idea that intra-word variability is not a characteristic of typical speech development (even in children as old as 4 years)
- Given high rates of variability in typically developing young children, caution should be used in assuming that segmental variability necessarily indicates motor planning/programming deficits in children with speech sound disorder (see Goffman, Gerken, & Lucchesi, 2007)
- Variable 'no hits' responses is common in children with typical speech development and does not necessarily reflect speech disorder, as has been suggested (Holm et al., 2005)

DISCUSSION

- Further study is needed to describe the characteristics of intra-word variability in different populations and different age groups (e.g., typical development, phonological disorder, CAS)
 - By different research teams
 - Using different transcription methods
 - Using different variability metrics

DISCUSSION

- What does the intra-word variability observed here reflect?
 - **Lack of stable, segmental, phonological representations**
 - Particularly Variable 'no hits' responses
 - **Phonological working memory**
 - Similar to Non-word repetition
 - **Strategies used by children to get closer to the adult target**
- **Clinical applications of intra-word variability in the assessment of language and pre-reading development**

CONCLUSION

- Work by a variety of different researchers at different data collection sites and often with different methods is arriving at the consensus that intra-word variability is prevalent in typically developing children as old as 4-years
- Variable 'with hits' vs. variable 'no hits' does not appear to differentiate typical from atypical intra-word variability
- Clinicians should use caution in using intra-word variability in the differential diagnosis of speech sound disorder with young children until we know more about the characteristics of variability in different clinical populations

REFERENCES

- American Speech-Language-Hearing Association. (2007). Childhood apraxia of speech [Positionstatement]. Available from www.asha.org/policy.
- de Castro, M. & Wertzner, H. (2011). Speech inconsistency index in Brazilian Portuguese-speaking children. *Folia Phoniatica et Logopaedica*, 63, 237-241.
- Dodd, B., & Crosbie, S. (2005). A procedure for classification of speech disorders. In B. Dodd(Ed.), *Differential diagnosis and treatment of children with speech disorder* (2nded.). London, United Kingdom: Whurr.
- Grunwell, P. (1992). Assessment of child phonology in the clinical context. In C. A. Ferguson, L. Menn, & C. Stoel-Gammon (Eds.), *Phonological development: Models, research, implications*. Baltimore, MD: York Press.
- Holm, A., Crosbie, S., & Dodd, B. (2005). Treating inconsistent speech disorders. In B.Dodd(Ed.) *Differential Diagnosis and Treatment of Children with Speech Disorder* (pp.182-201). London: Whurr.

REFERENCES

- Macrae, T. (2013). Lexical and child-related factors in word variability and accuracy in infants. *Clinical Linguistics & Phonetics*, 27(6-7), 497-507.
- Marquardt, T. P., Jacks, A., & Davis, B. L. (2004). Token-to-token variability in developmental apraxia of speech: Three longitudinal case studies. *Clinical Linguistics & Phonetics*, 18, 127-144.
- McLeod, S., & Hewett, S. R. (2008). Variability in the production of words containing consonant clusters by typical 2- and 3-year-old children. *Folia Phoniatica et Logopaedica*, 60, 163-172.
- Sosa, A. V., & Stoel-Gammon, C. (2012). Lexical and phonological effects in early word production. *Journal of Speech, Language, and Hearing Research*, 55, 596-608.
- Tubul-Lavy, G. (2012). Intra-word inconsistency in apraxic Hebrew-speaking children. *Clinical Linguistics & Phonetics*, 26, 502-517.
- Holm, A., Crosbie, S., & Dodd, B. (2007). Differentiating normal variability from inconsistency in children's speech: Normative data. *International Journal of Language and Communication Disorders*, 42(4), 467-486.