Identification of subclasses of children with speech sound disorders using the PCC, PWP Intersect

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Children with speech sound disorders (SSD) have an impairment in acquiring and using the phonology of a language

- NOT due to lack of control of speech articulators
- 5-8% of all children
  - 80% require intervention
  - 99% of school SLP caseloads

(Bernthal et al., 2012; Gierut, 1998; NIDCD, 1994; Shriberg et al 1999; Smit et al., 1990)

2

Percent Consonants Correct (PCC) is a measure of consonant production accuracy

- Number of consonants produced correctly divided by the total number targeted

$$PCC = \frac{\text{Correct Consonants}}{\text{Total \# of Consonants}}$$

(Shriberg, 1993; Shriberg et al., 1997; Shriberg & Kwiatkowski, 1982)

3

The Proportion of Whole Word Proximity (PWP) is a measure of whole word accuracy

- Phonological Mean Length Utterance of target words (Target pMLU)
  - Consonants = 2 points
  - Vowels = 1 point

$$\text{Target pMLU} = \frac{\text{Consonants(2) + Vowels}}{\text{Total \# Words}}$$

(Ingram, 2002)

4

The Proportion of Whole Word Proximity (PWP) is a measure of whole word accuracy

- Phonological Mean Length Utterance of child's productions (Child pMLU)
  - Correct Consonants = 2 points
  - Substituted Consonants = 1 point
  - Vowels = 1 point

$$\text{Child pMLU} = \frac{\text{Correct Consonants(2) + Substituted Consonants + Vowels}}{\text{Total \# Words}}$$

(Ingram, 2002)

5

The Proportion of Whole Word Proximity (PWP) is a measure of whole word accuracy

$$PWP = \frac{\text{Child pMLU}}{\text{Target pMLU}}$$

(Ingram, 2002)

6

There tends to be a linear relationship between PCC and PWP scores

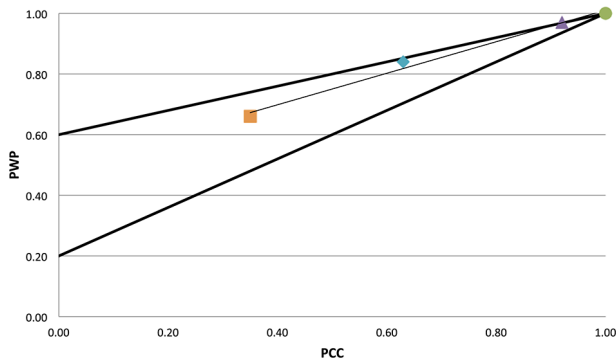|									PCC		PWP	
glasses	glæsɪz	g	l	æ	s	ɪ	z	4		10		
								0	0	5	50	
	dætɪd	d		æ	t	ɪ	d					
vacuum	vækjum	v	æ	k	j	u	m	4		10		
								1	25	5	50	
	fæku	f	ɑ	k		u						
knife	nɑɪf	n	ɑɪ	f				2		5		
								1	50	4	80	
	nɑs	n	ɑ	s								
pajamas	pədʒæməz	p	ə	dʒ	æ	m	ə	z	4	11		
									2	50	9	82
	pɪdæmɪd	p	ɪ	d	æ	m	ɪ	d				

PCC, PWP Intersect characterizes the interaction between consonant production accuracy and word complexity

- Assumption: higher accuracy for shorter, less complex words
  - Linear relationship between accuracy and complexity
- Categorize word complexity levels
  - Singletons, clusters, syllable length

(Babatsouli, Ingram, & Sotiropoulos, 2014; Knodel & Ingram, 2012; Purinton & Ingram, 2014)

PCC, PWP Intersect: Linear Pattern

PCC, PWP Intersect characterizes the interaction between consonant production accuracy and word complexity

- Assumption: higher accuracy for shorter, less complex words
  - Linear relationship between accuracy and complexity
- Categorize word complexity levels
  - Singletons, clusters, syllable length
- Children with SSD: Screening utility?
  - Linear PCC, PWP Intersect = Delay
  - Nonlinear PCC, PWP Intersect = Disorder

(Babatsouli, Ingram, & Sotiropoulos, 2014; Knodel & Ingram, 2012; Purinton & Ingram, 2014)

Study Question

- Can subgroups of children with SSD be identified based on their PCC, PWP Intersect patterns of words from the Nonword Repetition Task (NRT; Dollaghan & Campbell, 1998)?

Characteristics of TD Children and Children with SSD

	TD (n=24)	SSD (n=24)
Assessment Age: Mean (SD)	5.11 (1.18)	4.87 (1.15)
	t(46)=-0.735, p > .46	
GFTA-2 Standard Score	106.00 (6.83)	69.17 (11.93)
	t(46)=-13.125, p < .0001	
GFTA-2 Percentile Score	54.54 (18.49)	6.83 (4.99)
	t(46)=-12.202, p < .0001	
GFTA-2 Raw Score (i.e., number of errors)	8.67 (8.71)	38.21 (13.87)
	t(46)=8.838, p < .0001	
Leiter-R Standard Score	117.18 (11.91)	109.39 (14.83)
	t(32)=-1.520, p > .11	
TELD-3 SLQ Standard Score	110.94 (12.06)	101.29 (14.14)
	t(38)=-2.237, p < .04	
PPVT-IV Standard Score	113.13 (12.48)	106.21 (9.31)
	t(46)=-2.176, p < .04	
Hearing	Within normal limits	Within normal limits

The NRT words were divided into 4 categories based on word length

Easiest

- One syllable: 4
  - nɑɪb, voʊp, tɑʊʤ, dɔɪf
- Two syllable: 4
  - teɪvak, tʃoʊvæg, vætʃɑɪp, nɔɪtɑʊf
- Three syllable: 4
  - tʃinɔɪtɑʊb, nɑɪʃoʊveɪb, dɔɪtɑʊvæb, teɪvɔɪtʃɑɪg
- Four syllable: 4
  - veɪtɑtʃɑɪdɔɪp, dævoʊnɔɪtʃig, nɑɪʃɔɪtɑʊvub, tævɑtʃinɑɪg

Hardest

(Dollaghan & Campbell, 1998)

13

Procedure

- NRT words pre-recorded on computer
- Children asked to listen and repeat what the "alien" said
- Children's productions were recorded
- NRT words narrowly transcribed off-line
  - 94% reliability
- PCC and PWP values were calculated

14

Subgroups of children were created based on their PCC, PWP Intersect patterns

- Linear
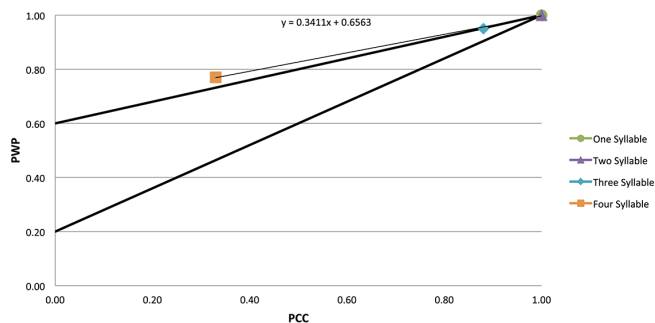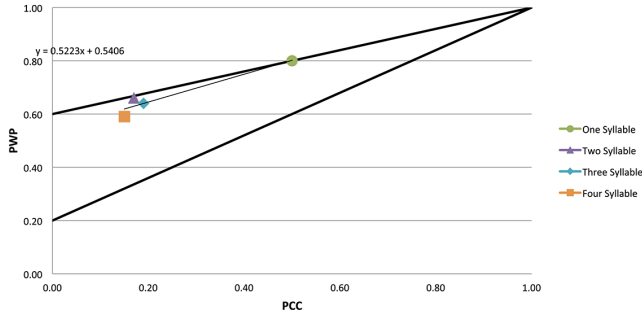 - 1 syll $\geq$ 2 syll $\geq$ 3 syll $\geq$ 4 syll

15

Linear PCC, PWP Intersect

$y = 0.3665x + 0.634$
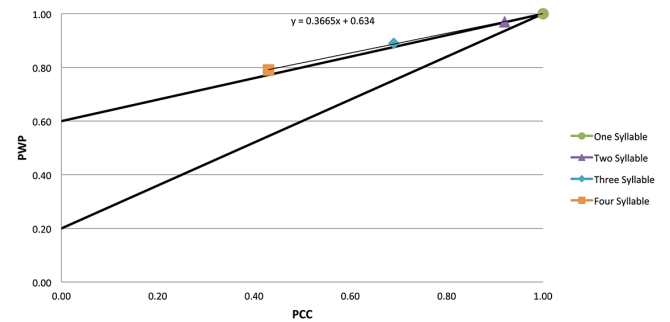
16

Linear PCC, PWP Intersect

$y = 0.3411x + 0.6563$

17

Subgroups of children were created based on their PCC, PWP Intersect patterns

- Linear
  - 1 syll $\geq$ 2 syll $\geq$ 3 syll $\geq$ 4 syll
- Nonlinear
  - Any longer word category more accurate than a shorter word category
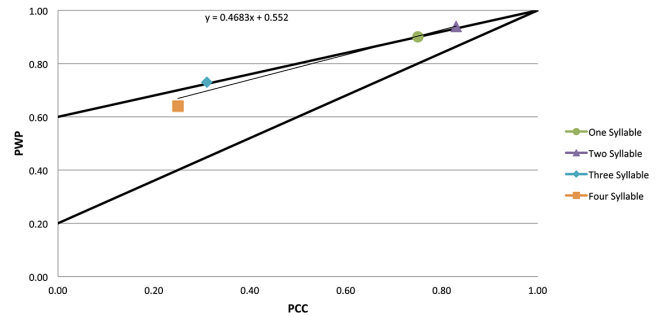   - 2 syll > 1 syll
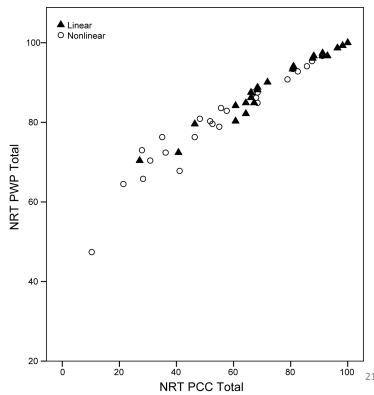   - 3 syll > 2 syll

18

Nonlinear PCC, PWP Intersect

$y = 0.5223x + 0.5406$

PWP vs PCC

- One Syllable
- Two Syllable
- Three Syllable
- Four Syllable

19

Nonlinear PCC, PWP Intersect

$y = 0.4683x + 0.552$

PWP vs PCC

- One Syllable
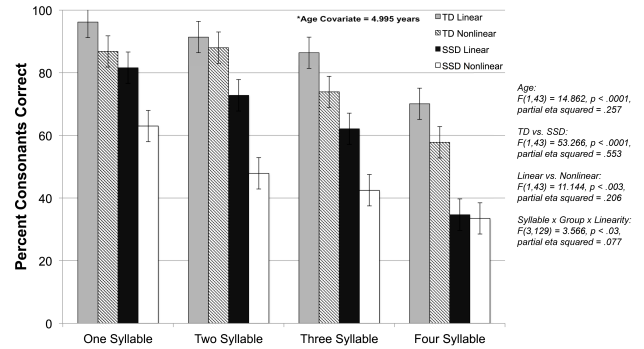- Two Syllable
- Three Syllable
- Four Syllable

20

Children with Linear Intersect patterns tended to produce nonwords more accurately

- TD children
  - 12 Linear
  - 12 Nonlinear
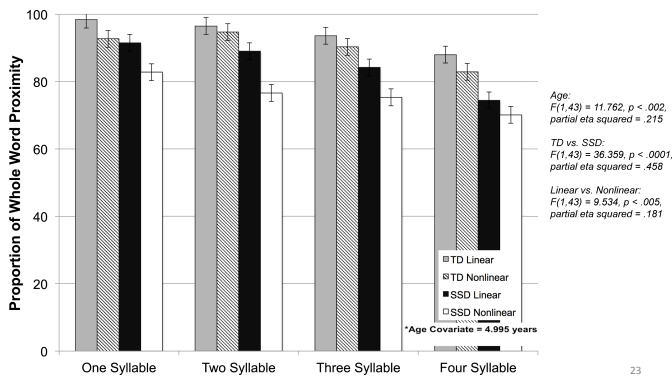- Children with SSD
  - 11 Linear
  - 13 Nonlinear

Linear
Nonlinear

NRT PWP Total vs NRT PCC Total

21

Children with Linear Intersect patterns had significantly higher nonword PCC scores

*Age Covariate = 4.995 years

TD Linear
TD Nonlinear
SSD Linear
SSD Nonlinear

Percent Consonants Correct — One Syllable, Two Syllable, Three Syllable, Four Syllable

Age:
$F(1,43) = 14.862, p < .0001,$
partial eta squared = .257

TD vs. SSD:
$F(1,43) = 53.266, p < .0001,$
partial eta squared = .553

Linear vs. Nonlinear:
$F(1,43) = 11.144, p < .003,$
partial eta squared = .206

Syllable x Group x Linearity:
$F(3,129) = 3.566, p < .03,$
partial eta squared = .077

Children with Linear Intersect patterns had significantly higher PWP scores

Proportion of Whole Word Proximity — One Syllable, Two Syllable, Three Syllable, Four Syllable

TD Linear
TD Nonlinear
SSD Linear
SSD Nonlinear

*Age Covariate = 4.995 years

Age:
$F(1,43) = 11.762, p < .002,$
partial eta squared = .215

TD vs. SSD:
$F(1,43) = 36.359, p < .0001,$
partial eta squared = .458

Linear vs. Nonlinear:
$F(1,43) = 9.534, p < .005,$
partial eta squared = .181
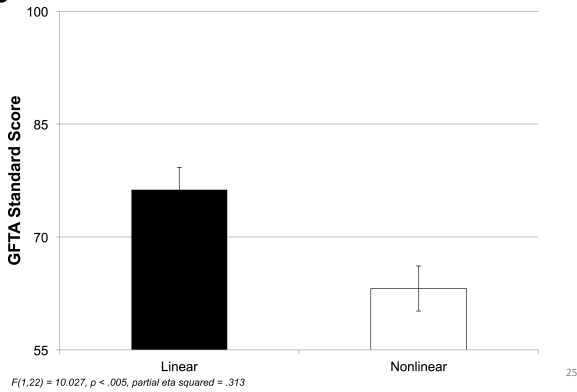
23

Across both TD and SSD groups, children with Linear Intersect patterns had slightly higher GFTA Standard Scores

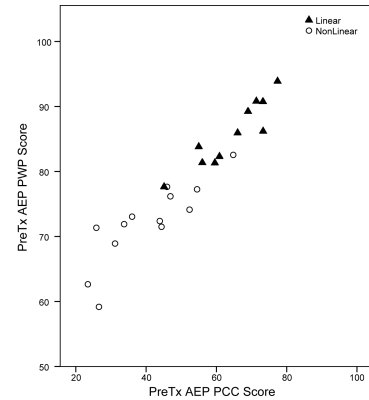GFTA Standard Score — Linear, Nonlinear
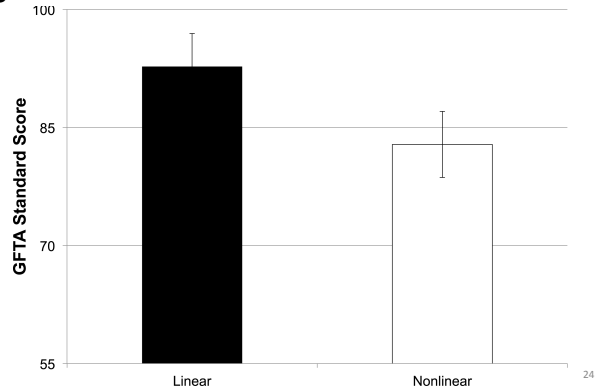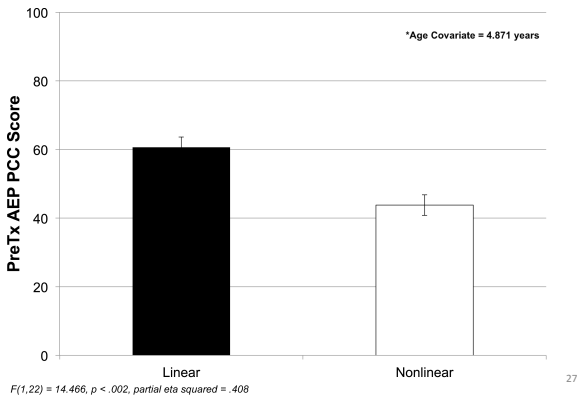
24

Children with SSD with Linear PCC, PWP Intersect patterns had higher GFTA Standard Scores

GFTA Standard Score (y-axis: 55, 70, 85, 100)
Linear, Nonlinear

F(1,22) = 10.027, p < .005, partial eta squared = .313

25

Children with SSD with Linear NRT Intersect patterns had higher production accuracy on the AEP speech probe

▲ Linear
○ NonLinear

PreTx AEP PWP Score (y-axis: 50, 60, 70, 80, 90, 100)
PreTx AEP PCC Score (x-axis: 20, 40, 60, 80, 100)

26

Children with SSD with Linear Intersect patterns had significantly higher AEP PCC scores

*Age Covariate = 4.871 years

PreTx AEP PCC Score (y-axis: 0, 20, 40, 60, 80, 100)
Linear, Nonlinear

F(1,22) = 14.466, p < .002, partial eta squared = .408

27

Functional extension of NRT PCC, PWP Intercept analysis: Prediction of GFTA Standard Scores for all children

- One Syllable PCC
- Two Syllable PCC
- Three Syllable PCC

- Further assessment needed
- Possible SSD?

▲ Linear
○ Nonlinear
R^2 = .489

GFTA Standard Scores (y-axis: 40, 60, 80, 100, 120)
NRT Two-Syllable PCC Scores (x-axis: 0, 20, 40, 60, 80, 100)
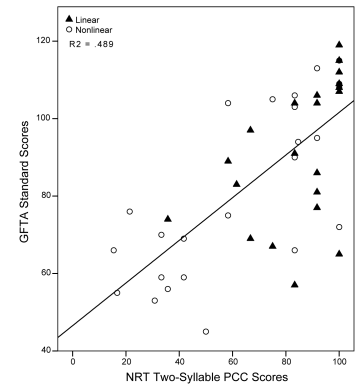
Summary

- Can subgroups of children with SSD be identified based on their PCC, PWP Intersect patterns of words from the Nonword Repetition Task (NRT; Dollaghan & Campbell, 1998)?
  - Yes!
  - Children with linear patterns had higher production accuracy
    - GFTA & AEP
  - Two-syllable NRTs predict GFTA performance
  - Clinical potential of PCC, PWP Intersect and NRT?

29

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30
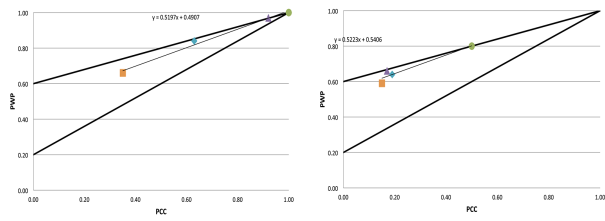
Questions?

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