

Phonological complexity and language skills in disfluent speakers

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Introduction

- ▶ We now know that approximately one third of children who stutter also exhibit a concomitant phonological disorder (Nippold, 1990; Wolk, Conture, & Edwards, 1993), and approximately 10 percent exhibit a concomitant language disorder (Blood & Seider, 1981; Arndt & Healey, 2001; Boscolo, Bernstein Ratner & Rescorla, 2002). Continued research explores this notion of sub-grouping.
- ▶ Many researchers have discussed a connection between phonological factors and stuttering, and between language demand and fluency behavior (e.g., Bloodstein & Bernstein Ratner, 2008; Guitar, 2006).
- ▶ However, the specific aspects of phonological, lexical, and/or semantic encoding are not yet fully understood.

- ▶ Various measures of phonological complexity have been studied in individuals who stutter, e.g.:
 - ▶ Anderson, 2007; Anderson & Byrd, 2008; Bernstein Ratner, Newman & Strekas, 2009; Dworzynski & Howell, 2004; Gregg & Yairi, 2007; Howell, 2004; Howell, Au-Yeung, Yaruss, & Eldridge, 2006; Howell & Au-Yeung, 2007; Sasisekaran, DeNil, Smyth & Johnson, 2006
- ▶ Theories such as the Covert Repair Hypothesis (Postma & Kolk, 1993) and Execution and Planning (EXPLAN) model (Howell, 2004) may help us explain the triad of factors of language, phonology and fluency, which are quite complex.
- ▶ For example, according to EXPLAN, word planning (PLAN) occurs independently, but *in parallel*, with word execution (EX) organized by the motor system. Stuttering may occur when the plan of the word about to be produced is not ready at the time that the execution of the previous word has been concluded.

- ▶ Anderson (2007) investigated the phonological complexity of stuttered words in preschool-aged children who stutter. Measures included word frequency, as well as:
 - ▶ **Phonological Neighborhood “Density”**: The number of words that differ due to an added/deleted/substituted phoneme. So a word like “cat” is in a relatively dense neighborhood with “cats” “bat,” “kit,” “cap” etc...35 different words); whereas “wolf” is in a relatively sparse neighborhood, with only 3 words as neighbors: “woof”, “wooly” & “wool”
 - ▶ **Neighborhood frequency**: The average word frequency per million of all of the word’s phonological neighbors, divided by the number of its neighbors. E.g., “wolf” has a neighborhood frequency of 4.0:
 - ▶ “woof” = 1 “wooly” = 1 & “wool” = 10, $sum = 12 / 3 = 4.0$
- ▶ She found that stuttered words were lower in word frequency and neighborhood frequency than fluent words. No difference in density was found, however, perhaps due to the preponderance of function words (71%) that these young children stuttered upon.

- ▶ To date, there are little to no published studies of phonological neighborhood density and neighborhood frequency in older children and adolescents who stutter, and yet this is a population who stutters more on content words than function words (e.g., Howell, Au-Yeung & Sackin, 1999)
- ▶ Dworzynski and Howell (2004) and Howell and Au-Yeung (2007) used an Index of Phonological Complexity (IPC) to assess the stuttered words of children older than 6 years of age up to adults.
- ▶ As one might expect, Content words tend to be longer in phonemes, higher in IPC and lower in word frequency than Function words.

Rationale and Research Question

- ▶ If we knew more about the link between language disorder, phonological complexity, and disfluent behavior across the lifespan, we would be better able to draw theoretical and clinical implications.
- ▶ Therefore, our research question was:
 - ▶ On phonological complexity measures (e.g., IPC; density), do 7- to 18-year-olds who only stutter differ from their stuttering peers who have a concomitant language disorder?

Methods

- ▶ Of the 138 monolingual British English stutterers' samples from the UCLASS database ("Release 1"; Howell, Davis & Bartrip, 2009), eight (6%) were identified as +Language disorder, consistent with ~ 10% S+LD reported by Blood & Seider (1981).
- ▶ Samples for a group of stuttering-only speakers (S-only) were located from the database to be the same gender and +/- 10 months difference in age.
- ▶ Between-group differences in terms of handedness, gender and median age of stuttering onset reflect general findings about S+LD individuals (Bloodstein & Bernstein Ratner, 2008, pp. 213-220).
- ▶ Table 1 shows these talker group comparisons.

Table 1:

	Stuttering (S)-Only	S + Lang.Disorder (LD)
Gender	5 males; 3 females	5 males; 3 females
Age (Yrs;Mos)	13;1 (7;8- 17;10)	12;8 (7;7 - 18;1)
Family Hx Positive ST	1 Yes; 3 No; 4 unknown	7 No; 2 unknown
Handedness	7 Right-h.; 1 unknown	2 Right h.; 5 Left-h., 1 unknown
Time Since ST Onset	68 mos (43-145 mos)	97 mos (45-141)
Prior Tx	3 None; 5 (10-58 mos)	2 None; 5 (2-56 mos)

- ▶ Average number of words per Communication Unit (CU) and Average number of dependent clauses (dc) Per CU (Loban, 1976) were significantly ($p=0.02$) different between groups:
 - ▶ **S-Only:** words/CU = 11.20 (8.11-14.6); dc/CU = 0.35 (0.16-0.62)
 - ▶ **S+LD:** words/CU = 8.87 (6.56-11.7); dc/CU = 0.16 (0-0.36)
- ▶ From transcripts of all 16 samples, stuttered words were identified, and nearest fluent words were selected to match on grammatical type (Content v. Function), and word familiarity.
- ▶ Stuttered / fluent matches: 70% = Content; 30% = Function
- ▶ The Speech & Hearing Lab Neighborhood Database at Washington University in St. Louis (Method A) was used to derive all measures except for IPC, j which was derived per word by assigning 1 point if the following were present:
 - ▶ Velar, fricative, affricate, and liquid; Vowel+/r/; Coda = Consonant; Syllable length > 3; Singleton phonemes that are place-variegated; Consonant clusters; Place-variegated Consonant clusters (Jakielski, 1998)

- 20% of all transcripts were re-coded for words, clauses & CUs, consensus was reached, and questionable utterances and fragments excluded prior to Loban (1976) analysis.
- Only words judged as each Stuttered and Fluent by an expert and a trained judge were submitted for statistical analysis. See **Table 2** below.

	IPC	Phonemes	Density	Neighborhood Frequency
Stuttered words of S vs. S+DL	Mann-Whitney U test for independent samples (overall $p = 0.05 / 4 = 0.0125$)			
Stuttered vs. Fluent words Within S	Wilcoxon Signed Ranks Test for related samples (overall $p = 0.05 / 8 = 0.006$)			
Stuttered vs. Fluent words Within S+DL				

Results

- ▶ **Table 3** below shows no significant differences ($p > 0.0125$) between the Stuttered words of the S-only group ($N = 54$) and those of the S+LD group ($N = 47$) on:
 - ▶ Index of Phonological Complexity (IPC); Phoneme length
 - ▶ Phonological neighborhood density (“Density”)
 - ▶ Neighborhood frequency (“NeighFreq”)

	IPC	Phoneme length	Density	NeighFreq
S-Only ($n = 8$; $N = 54$)	4 (0-9)	4 (2-10)	4 (0-27)	29.5 (0-2,704)
S+LD ($n = 8$; $N = 47$)	4 (0-8)	4 (2-7)	6.8 (0-28)	28.2 (0-1,726)

- ▶ However, when the two groups were combined as related samples and when Stuttered ($N = 101$) words were compared to. Fluent words ($N = 101$), three significant differences were found:
 - ▶ Fig. 1: Phonological length & complexity
 - ▶ Fig. 2: Phonological neighborhood “Density”
 - ▶ Fig. 3: Neighborhood frequency

Fig. 1: Phonological length & complexity

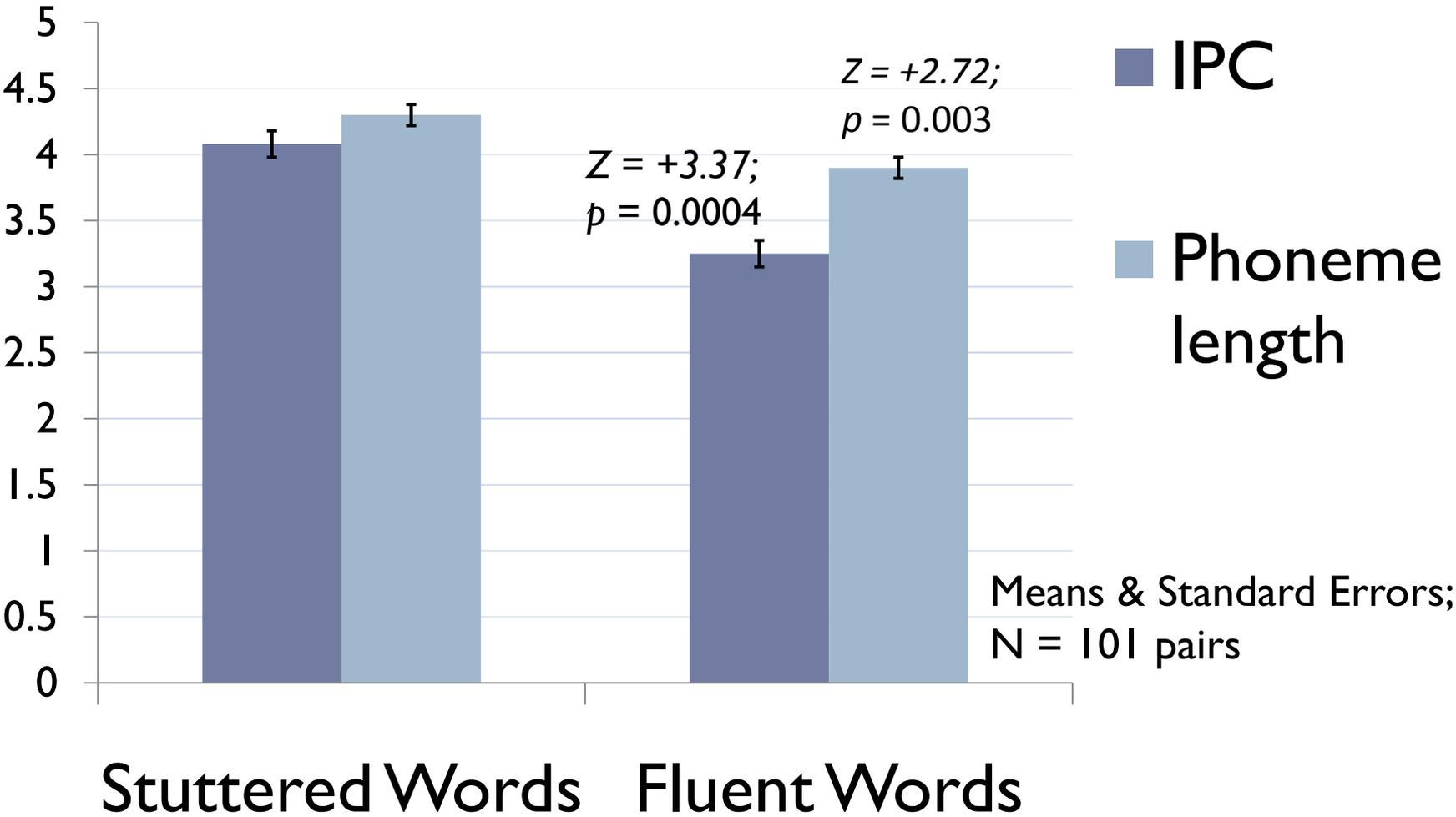


Fig. 2: Phonological neighborhood density

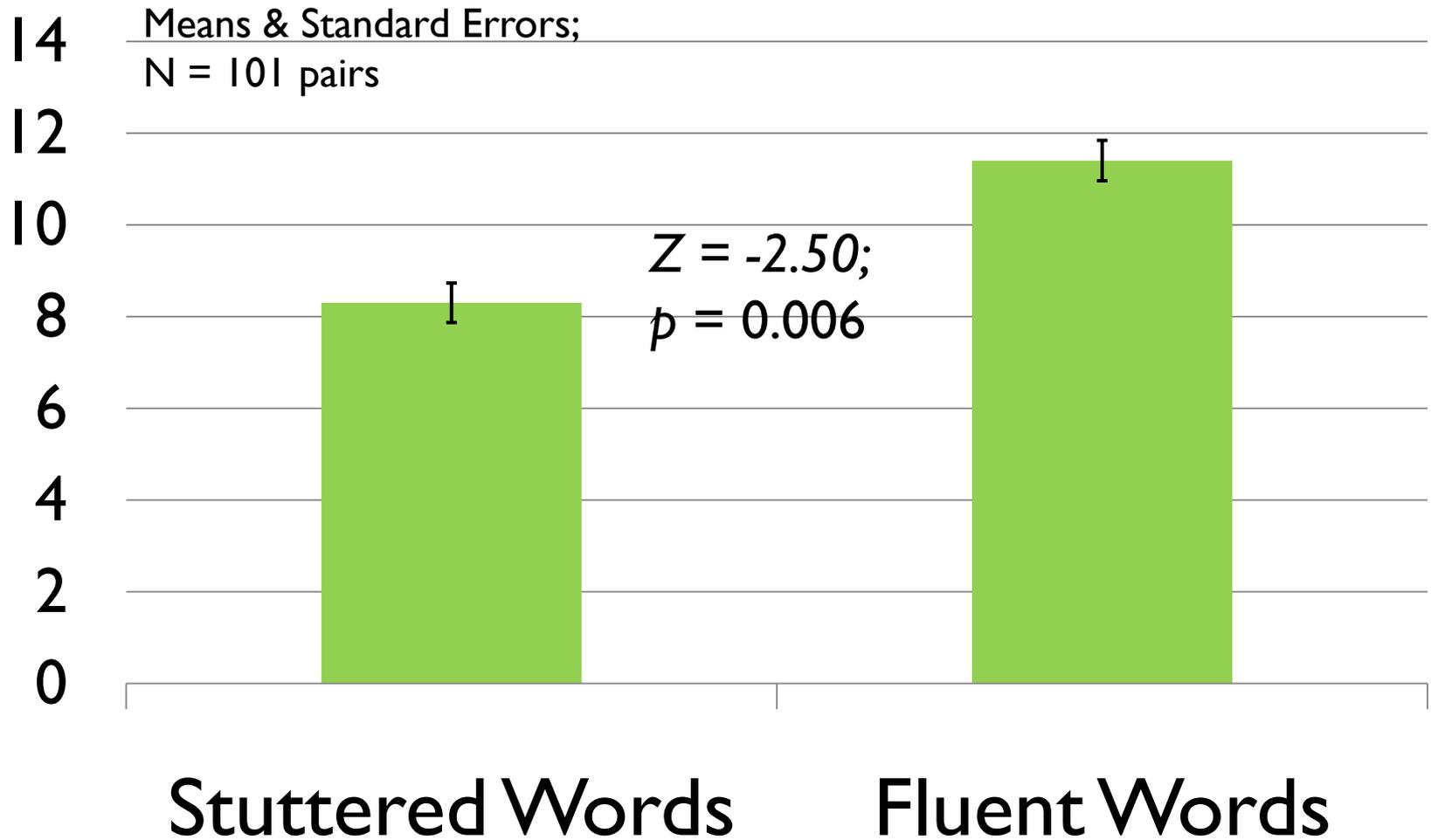


Fig. 3: Neighborhood frequency

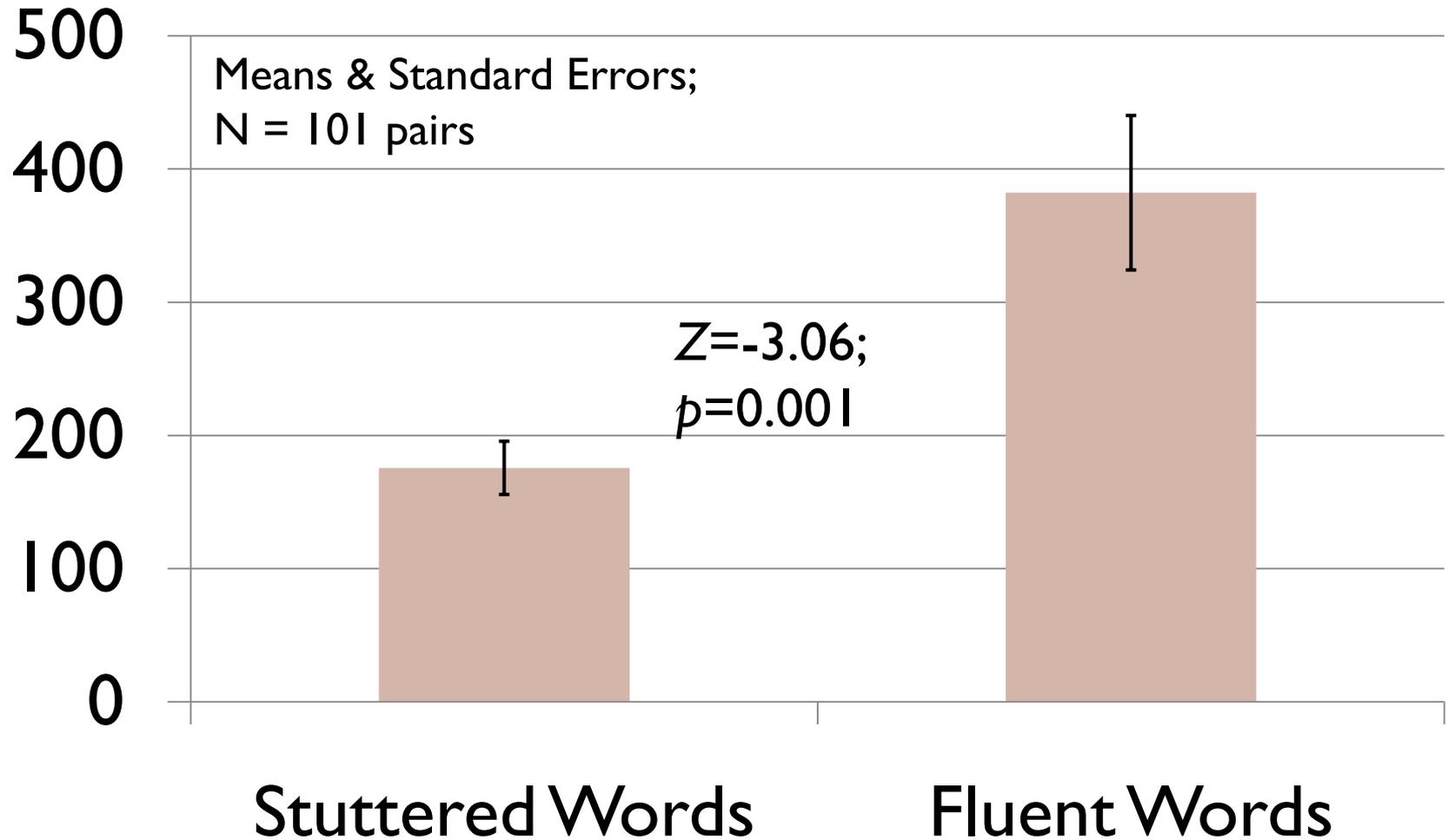


Table 4: S+LD contributed to IPC & phoneme length differences between stuttered and fluent words, whereas the S-Only group contributed to Neighborhood Frequency differences.

Wilcoxon Signed Ranks ($Z = 3.30; 2.60; -2.5$, respectively; $p \leq 0.006$)

Medians and ranges

	IPC		Phoneme length		Density		Neigh. Freq.	
	ST	FL	ST	FL	ST	FL	ST	FL
S-Only ($n = 8$; $N = 54$)	4 (0-9)	3.5 (0-10)	4 (2-10)	3 (2-10)	4 (0-27)	10.5 (0-28)	29.5 (0-2,704)	57.5 (0-10,066)
S+LD ($n = 8$; $N = 47$)	4 (0-8)	3 (0-5)	4 (2-7)	3 (2-8)	6.8 (0-28)	13 (0-30)	28.2 (0-1,726)	72.5 (0-1,870)

Discussion

- ▶ Our findings showed that stuttered words were lower in neighborhood frequency than fluent words. This corroborates findings in preschoolers (Anderson, 2007).
- ▶ Findings also showed in our subjects (7- to 18-yr-olds) 70% of stuttered words were Content words and 30% were Function words. This contrasts with Anderson's (2007) findings that preschoolers produced the opposite proportion – that is, stutterings on 30% Content; 70% Function words.

- ▶ A very interesting finding was that stuttered words tended to be: (a) more phonologically complex (i.e., higher IPC) and (b) sparser than fluent words. This also corroborates findings from school-age and older speakers who stutter (Dworzynski & Howell, 2004; Howell & Au-Yeung, 2007). In particular, our earlier work on single cases who stutter and/or clutter, also showed a tendency for stuttered words to be sparser (LaSalle & Wolk, 2009).

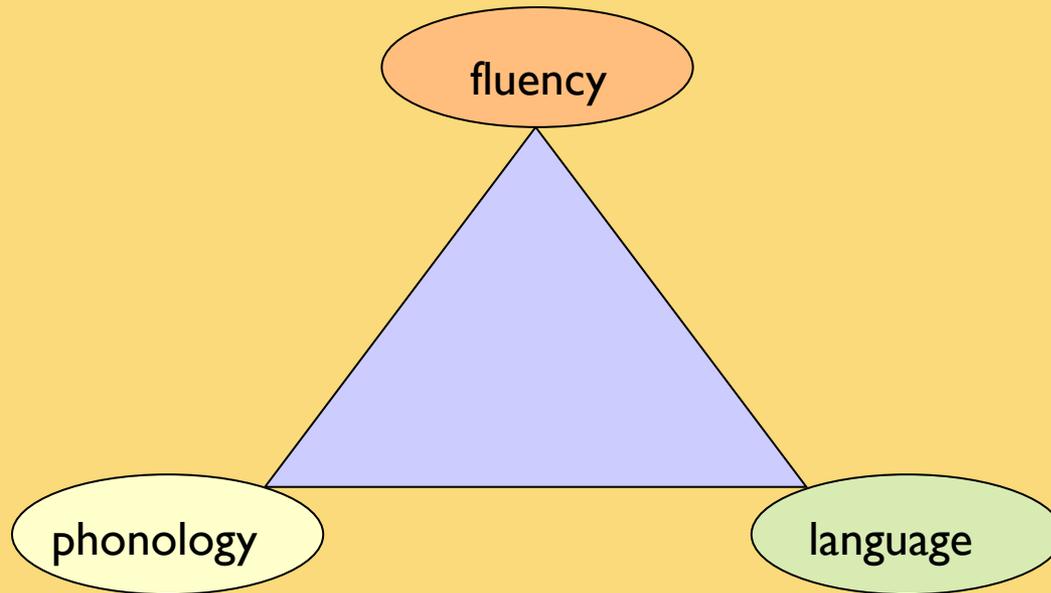
- ▶ In a study of German speakers, 6 yo to adults, Dworzynski & Howell (2004) found a larger difference in IPC scores between stuttered and fluent words in German than in English; they also found that IPC significantly correlated with stuttering on content words.
- ▶ Howell and Au-Yeung (2007) found that in 6- to 11-year-olds and adult Spanish speakers, stuttering on function words did not correlate with IPC, but stuttering on content words did correlate positively with IPC.
- ▶ Our findings provide additional support for their conclusions that linguistic factors in general, and phonetic factors specifically, affect stuttering rate.

- ▶ Finally, phonological monitoring difficulties may explain why stuttered words are phonologically longer and more complex than fluent words :
 - ▶ Sasisekaran, DeNil, Smyth and Johnson (2006) in their study of phonological encoding in the silent speech of persons who do and do not stutter, found that PWS were significantly slower in phoneme monitoring, rather than general monitoring, reaction times, or auditory monitoring deficits.
- ▶ Our preliminary findings suggest that the two talker groups of those who only stutter vs. those with a concomitant language disorder are more alike than different on phonological measures.

Implications for future research

- ▶ Larger samples of stuttered words and/or larger samples of subjects are needed to confirm the notion that stutters are more likely to occur on words that are phonologically complex. Cross-linguistic studies are also indicated.
- ▶ One methodological issue to be considered for future studies is method of elicitation, such as connected speech vs. one-word tasks.
- ▶ In a study on preschoolers, sparser words were produced more accurately and quickly than dense words in a one-word task (Arnold, Conture & Ohde, 2005). However, in the present study, connected speech was used. Connected speech provides more opportunities for varied phonological contexts as well as more rapid sequencing of simultaneous planning and execution (e.g., EXPLAN, Howell, 2004).

Further investigation of the triad of factors of language, phonology and fluency, especially within connected speech samples, is key towards advancing our knowledge of stuttering subgroups.



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