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The effect of phonetic complexity on the speed of single-word productions in adults who do and do not stutter

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ABSTRACT

Purpose: The purpose of this study was to investigate the influence of phonetic complexity as measured by the Word Complexity Measure (WCM) on the speed of single-word production in adults who do (AWS, $n = 15$) and do not stutter (AWNS, $n = 15$).
Method: Participants were required to name pictures of high versus low phonetic complexity and balanced for lexical properties. Speech reaction time was recorded from initial presentation of the picture to verbal response of participant for each word type. Accuracy and fluency were manually coded for each production.
Results: AWS named pictures significantly slower than AWNS, but there were no significant differences observed in response latency when producing word of high versus low phonetic complexity as measured by the WCM.
Conclusion: Findings corroborate past research of overall slowed picture naming latencies in AWS, compared to AWNS. Findings conflict with data that suggest that the phonetic complexity of words uniquely compromises the speed of production in AWS. The potential interaction between lexical and phonetic factors on single-word production within each group are discussed.

1. Introduction

The EXPLAN model of stuttering (EX: execution, PLAN: planning; Howell, 2011, pp. 2267–2273) argues that moments of stuttered speech occur due to insufficient time to plan speech prior to production. Phonetic complexity, as described by the EXPLAN model, refers to the complexity of movement required to execute articulatory sequences. According to the EXPLAN model, complex motor sequences require additional time to formulate, and stuttered speech occurs when verbal execution is initiated prior to the completion of the more complex speech plan (e.g., Howell, 2004, 2011). To date, the influence of increased phonetic complexity on stuttered speech has been debated (Bernstein Ratner, 2005; cf. Howell & Dworzynski, 2005). Research has demonstrated a relationship for older children and adults who stutter (e.g., Al-Timimi, Khamaiseh, & Howell, 2013; Dworzynski & Howell, 2004; Howell & Au-Yeung, 2007; Howell et al., 2006) but not younger children who stutter (e.g., Coalson & Byrd, 2016; Coalson et al., 2012; Dworzynski & Howell, 2004; Howell & Au-Yeung, 1995; Logan & Conture, 1997; Throneburg et al., 1994). Bernstein Ratner (2005) has suggested that past findings of phonetic complexity as a significant contributor to stuttered speech, in the manner predicted by the EXPLAN model, is difficult to determine due to a number of confounding methodological and theoretical concerns.

One fundamental concern noted by Bernstein Ratner (2005) is the lack of experimental data that links phonetic complexity to the

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Table 1
Word-level factors considered within studies of phonetic complexity in children and adults who stutter.

Phonetic Categories	Throneburg et al.[†]	Logan & Conture[††]	IPC	WCM
Dorsals	N/A	N/A	1	1
Fricatives	1	N/A	1	1
Voiced fricatives		N/A	N/A	1
Affricates		N/A	1	1
Voiced affricates		N/A	N/A	1
Liquids/Syllabic liquids		N/A	1	1
Rhotics		N/A	1	1
Place variegation of single consonants	N/A	N/A	1	N/A
Word-final consonants	N/A	1	1	1
Word-initial consonants	N/A	1	N/A	N/A
> 2 syllables	1	N/A	1	1
> 1 syllables		N/A	N/A	N/A
Consonant clusters (intra-syllabic, onset or coda)	1	N/A	1	1
Consonant clusters (inter-syllabic)		N/A	1	N/A
Consonant clusters (intra-syllabic, onset)	N/A	1	N/A	N/A
Consonant clusters (intra-syllabic, coda)	N/A	1	N/A	N/A
Place variegations within clusters	N/A	N/A	1	N/A
Non-initial stress	N/A	N/A	N/A	1
Number of studies applied to children who stutter < 6 years of age	2	1	1	2
Number of studies applied to older children and adults who stutter	1	0	7	1

Note. IPC – Index of Phonetic Complexity (Jakielski, 1998); WCM – Word Complexity Measure (Stoel-Gammon, 2010).
[†] Categories from Throneburg et al. (1994).
[††] Categories from Logan and Conture (1997).

ease of speech planning and production in typically fluent adults, and whether these effects are independent from the well-documented influence of co-occurring lexical and linguistic properties (e.g., word frequency: Newman & German, 2005; neighborhood density: Luce & Pisoni, 1998; Vitevitch, 2002; neighborhood frequency: Vitevitch & Sommers, 2003). Further, if a distinct relationship between phonetic complexity and speech planning does exist in adults who do not stutter (AWNS), no research is available that indicates that planning complex sequences is delayed to a greater extent in adults who stutter (AWS). Thus, the primary motivation for the present study was to provide these data for AWNS and AWS using an experimental paradigm in which the phonetic complexity of stimuli is manipulated, and the lexical factors of the stimuli are carefully controlled.

1.1. Phonetic complexity and fluency in persons who stutter: spontaneous speech data

A notable challenge to previous studies that have examined phonetic complexity and stuttered speech is the inconsistency of measurement tools used to determine what is and is not considered a complex phonetic sequence (see Table 1 for comparative rubric). Until recently, Jakielski's (1998) Index of Phonetic Complexity (IPC) has been the primary metric that was used (and available) to researchers. The IPC is an eight-factor index derived from pre-linguistic speech output of infants (n = 5; 7–36 months) which provides an aggregated complexity score for individual words based on specific phonetic properties such as consonant type, vowel type, number of syllables, consonant variegation, consonant clusters, and consonant variegation within clusters. There are unpublished data to support the IPC scoring method as a reasonable metric for verbal output of children between 1 and 3 years of age (e.g., Jakielski, 2002; Jakielski, Maytasse, & Doyle, 2006). Despite the correspondence between phonetic complexity and speech development at younger ages in typically developing children, Dworzynski and Howell (2004) found that increased IPC values do not predict stuttered speech in children under 6 years of age. Instead, IPC values are only associated with moments of stuttered speech for speakers 6 years of age and older (e.g., Howell & Au-Yeung, 2007; Howell et al., 2006; LaSalle & Wolk, 2011; Wolk & LaSalle, 2015). That is, the effects of phonetic complexity on stuttering appear to emerge only *after* speech production systems have matured based on data from spontaneous speech production. These findings conflict with the perspective that younger children with developing speech production systems would be more vulnerable to increased articulatory demand. The observed influence of phonetic complexity in AWS also conflicts with previous data that indicate motor-speech plans of fluent and stuttered words in AWS are intact prior to production (Sussman, Byrd, & Guitar, 2011). Additionally, although increased phonetic complexity may decrease articulatory coordination in AWS, this instability does not necessarily result in overt disfluencies (Smith, Sadagopan, Walsh, & Weber-Fox, 2010). The unexpected influence of phonetic complexity (as measured by the IPC) on stuttered speech observed in AWS, but not in children who stutter, raises questions of whether additional methodological factors may have contributed to previous reports.

Bernstein Ratner (2005) argues that findings from previous studies are compromised by one or more confounding factors. First, the appropriateness of the IPC as an adequate measure of phonetic complexity in AWS has been challenged given that many of the phonetic constructs are based on pre-linguistic verbal output. Second, lexical factors such as word frequency and phonological neighborhood properties were not accounted for in previous investigations of phonetic complexity measured by the IPC. Third, previous studies extracted individual words from connected speech and did not consider utterance position, utterance length, or the syntactic complexity of utterances – factors known to influence the fluency of production in individuals who stutter – during analyses. Fourth and finally, the presumption that phonetic complexity impedes speech planning in individuals who stutter may be premature,