Phonetic Complexity and Phonotactic Probability of Stuttered Utterances

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Introduction

- Linguistic planning and motor execution variables have been shown to contribute to stuttered speech. For example:
  - Increased phonetic complexity of words has been reported to increase the likelihood of stuttering (Dworzynski & Howell, 2004; cf. Eldridge, 2006).
  - Increased or decreased phonotactic probability of words have been reported to have no influence on stuttering, possibly due to lack of sensitivity to segmental detail (Anderson & Byrd, 2008; Byrd, Conture & Ohde, 2007).
- The influence of planning and execution is typically examined in isolation without consideration of the interplay between these two dynamic variables.
- It has been suggested that stuttering is the result of temporal asynchronies between planned and executed segments of speech (Howell, 2010).
- Perhaps, these asynchronies are more evident at the utterance level, rather than the word level, as connected speech requires more precise timing mechanisms.
- To date, the research that has examined phonotactic probability effects on stuttering has controlled for some (e.g., word frequency, neighborhood density, neighborhood frequency), but not all (e.g., length and complexity) variables that potentially impact speech output and fluency (Anderson & Byrd, 2008).
- Further, the published reports of the impact of phonetic complexity on stuttering have not yet controlled for any of the aforementioned variables on the speech fluency (see Ratner, 2005 for review).

Research Questions

Thus, the four main *purposes* of this study were as follows:

PURPOSE I: To examine whether **phonetic complexity** *uniquely* predicts disfluencies at the utterance level during spontaneous speech.*

PURPOSE II: To examine whether **phonotactic probability** *uniquely* predicts disfluencies at the utterance level during spontaneous speech.*

PURPOSE III: To examine whether the **interaction of phonetic complexity and phonotactic probability** contributes to predictability of disfluencies during spontaneous speech.*

*Purpose I-III were completed while controlling for the effects of syntactic complexity, length of utterance, word frequency, neighborhood frequency and neighborhood density.

PURPOSE IV: To determine whether **syntactic complexity, length of utterance, word frequency, neighborhood density,** or **neighborhood frequency** (while controlling for phonotactic probability and phonetic complexity) uniquely contribute to the predictability of disfluencies during spontaneous speech.

Method

- ***Participants***
  - 14 children who stutter (CWS)
    - 8 males, 6 females (M = 44 mos; *SD* = 11 mos).
    - No other speech and/or language disorder.
- ***Data Collection***
  - CWS conversed with parents for ~20 min.
  - Play-based setting with age-appropriate toys.
  - Video recordings were made for all samples.
- ***Data Analysis***

Transcript Preparation

- The authors and trained undergraduate research assistants prepared initial transcriptions of the conversations on an utterance-by-utterance basis.
- These transcriptions were reviewed for reliability of transcription of the utterances and for coding of instances of stuttering, phonetic complexity, phonotactic probability, length, complexity, word frequency, neighborhood density, and neighborhood frequency of each word within each utterance.
- Any discrepancies at the level of the utterance or relative to variables of interest and controlled variables were resolved through review and discussion by the three authors.

Variables

Variables of Interest

Stuttered Utterance

- This analysis was completed by comparing utterances that contained one or more instances of stuttered speech (N = 171) to utterances that contained no instances of stuttered speech (N = 159) (Byrd, Coalson & Bush, in press).

Phonetic Complexity

- This analysis was completed using the Index of Phonetic Complexity (IPC: Jakielski, 1998).

Phonotactic Probability

- This analysis was completed using the Child Mental Lexicon (CML: Storkel & Hoover, 2010). Both segmental and biphone probabilities were coded.

Controlled Variables

Length of Utterance

- This analysis was completed by counting the number of syllables per utterance (Logan & LaSalle, 1999).

Syntactic Complexity

- This analysis was completed by counting the number of clauses (predicate + noun) per utterance (Logan, 2003).

Word Frequency, Neighborhood Density and Neighborhood Frequency

- These analyses were completed using the Child Mental Lexicon (CML: Storkel & Hoover, 2010).

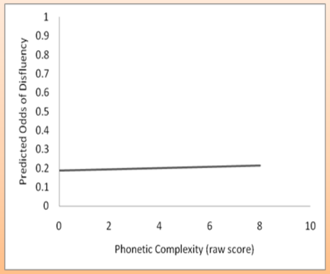
Results

PURPOSE I

Question 1: Does **phonetic complexity** uniquely predict disfluencies at the utterance level during spontaneous speech?

Analysis: Logistic regression analysis with phonetic complexity as the predictor variable of interest and fluency of utterance as the dependent measure. All other predictor variables were controlled (i.e., phonotactic probability, syntactic complexity, length of utterance, word frequency, neighborhood frequency and neighborhood density).

Results: Phonetic complexity was not a significant predictor of greater odds of stuttering *(OR = 1.021, p = 0.817)*. That is, increased phonetic complexity of the words in an utterance did not uniquely increase the likelihood that the utterance would be stuttered.

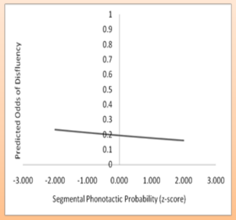


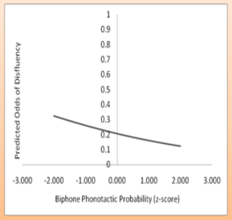
PURPOSE II

Question 2: Does **phonotactic probability** uniquely predict disfluencies at the utterance level during spontaneous speech?

Analysis: Logistic regression analysis with phonotactic probability as the predictor variable of interest and fluency of utterance as the dependent measure. All other predictor variables were controlled (i.e., phonetic complexity, syntactic complexity, length of utterance, word frequency, neighborhood frequency and neighborhood density).

Results: Neither segmental phonotactic probability *(OR = 0.893, p = 0.531)* or biphone phonotactic probability *(OR = 0.737, p = 0.129)* were significant predictors of greater odds of stuttering. That is, increased or decreased phonotactic probability of the words in an utterance did not uniquely increase the likelihood that the utterance would be stuttered.





PURPOSE III

Question 3: Does the **interaction of phonetic complexity and phonotactic probability** contribute to the predictability of disfluencies during spontaneous speech?

Analysis: Two 2-way interactions (phonetic complexity x segmental phonotactic probability, phonetic complexity x biphone phonotactic probability) with fluency of utterance as the dependent measure.

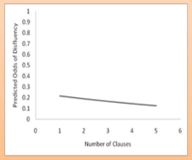
Results: Interactive effects of phonetic complexity and segmental phonotactic probability revealed no significant prediction of greater odds of stuttering *(OR = 1.156, p = 0.499)*. Similarly, interactive effects of phonetic complexity and biphone phonotactic probability was not a significant predictor of stuttering *(OR = 0.831, p = 0.251)*. That is, interactions between these two planning and execution variables do not appear to affect the likelihood that the utterance will be stuttered.

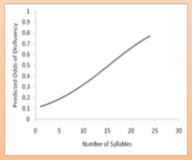
PURPOSE IV

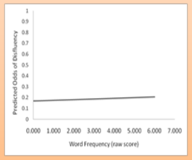
Question 4: Do **syntactic complexity, length of utterance, word frequency, neighborhood density, or neighborhood frequency** uniquely contribute to the predictability of disfluencies during spontaneous speech?

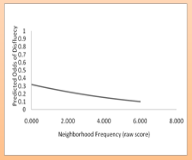
Analysis: Logistic regression analysis with syntactic complexity, length of utterance, word frequency, neighborhood frequency and neighborhood density as predictor variables of interest and fluency of utterance as the dependent measure. Phonetic complexity and phonotactic probability were controlled.

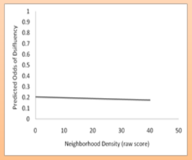
Results: Only length of utterance was a significant predictor of increased likelihood that the utterance would be stuttered *(OR = 1.152, p = 0.000)*. That is, of all variables considered, only increased utterance length significantly increased the likelihood that an utterance would be stuttered.











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Discussion and Conclusions

PURPOSE I

Question 1: Does **phonetic complexity** uniquely predict disfluencies at the utterance level during spontaneous speech?

- Utterances containing words considered difficult to execute, as measured by the IPC, did not appear to influence the likelihood of disfluency. These findings are contrary to Dworzynski and Howell (2004). Perhaps the IPC is not an appropriate tool to use as it is based on the speech output of infants and is not sensitive to difficult phonetic constructs common to older children.

PURPOSE II

Question 2: Does **phonotactic probability** uniquely predict disfluencies at the utterance level during spontaneous speech?

- Utterances were not more or less likely to be disfluent based on the phonotactic probability of component words. These findings support Anderson and Byrd (2008) and Byrd et al. (2007), suggesting that the lexical representations of children who stutter may be less specified.

PURPOSE III

Question 3: Does the **interaction of phonetic complexity and phonotactic probability** contribute to the predictability of disfluencies during spontaneous speech?

- Temporal mismatches between planning and execution units were not supported (Howell, 2010). That is, greater disfluencies were not observed in utterances containing high phonotactic probability (and phonetically difficult speech segments or vice versa.

PURPOSE IV

Question 4: What degree of influence do controlled variables exhibit on predictability of disfluencies during spontaneous speech?

- As reported in previous studies, length of utterance was a significant predictor of utterance disfluency. Thus, findings of previous studies of phonetic complexity (in particular) using isolating words from connected speech may be compromised by the apparent lack of control for utterance length.

- ***In summary***, findings indicate that when controlling for factors known to influence the motoric and linguistic complexity of utterances, neither phonotactic probability or phonetic complexity significantly predict speech fluency. In addition, findings further confirm that the length of utterances significantly impacts fluency.

- ***Future research*** should consider examining segmental influences on words or syllables adjacent to moments of stuttering while again controlling for the same factors as in the present study.

References

Anderson, J. D. & Byrd, C. T. (2008). Phonotactic probability effects in children who stutter. *Journal of Speech, Language, and Hearing Research, 51,* 851-866.

Byrd, C.T ., Coalson, G. A. & Bush, C. A. (in press). The communicative intent of stuttered utterances. *Journal of Interactional Research in Communication Disorders.*

Byrd, C. T., Conture, E. G., & Ohde, R. O. (2007). Phonological priming in young children who stutter: Holistic versus incremental processing. *American Journal of Speech-Language Pathology, 16,* 43-53.

Dworzynski, K. & Howell, P. (2004). Predicting stuttering from phonetic complexity in German. *Journal of Fluency Disorders, 29,* 149-173.

Eldridge, K. (2006). *Phonological complexity and speech disfluency in young children.* (Unpublished dissertation/PhD thesis) University of Pittsburgh, Pittsburgh, PA.

Howell, P. (2010). Language-speech processing in developmental fluency disorders. In J. Guendouzi, F. Loncke & M. Williams (Eds.) *The handbook of psycholinguistic and cognitive processes: Perspectives in communication disorders.* London: Taylor & Francis.

Jakielski, K. J. (1998). *Motor organization in the acquisition of consonant clusters.* (Unpublished dissertation/PhD thesis) University of Texas at Austin, Austin, TX.

Logan, K. (2003). Language and fluency characteristics of preschoolers' multiple-utterance conversational turns. *Journal of Speech, Language, and Hearing Research, 46,* 178-188.

Logan, K., & LaSalle, L. (1999). Grammatical characteristics of children's conversational utterances that contain disfluency clusters. *Journal of Speech, Language, and Hearing Research, 42,* 80-91.

Ratner, N. B. (2005). Is phonetic complexity a useful construct in understanding stuttering? *Journal of Fluency Disorders, 30,* 337-354.

Storkel, H. L. & Hoover, J. R. (2010). An online calculator to compute phonotactic probability and neighborhood density on the basis of child corpora of spoken American English. *Behavior Research Methods, 42,* 497-506.