



Acoustic variation during passage reading for speakers with dysarthria and healthy controls



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ABSTRACT

Purpose: Acoustic variation in a passage read by speakers with dysarthria and healthy speakers was examined.

Method: 15 speakers with Multiple Sclerosis (MS), 12 speakers with Parkinson's disease (PD), and 14 healthy speakers were studied. Acoustic variables included measures of global speech timing (e.g., articulation rate, pause characteristics), vocal intensity (e.g., mean sound pressure level and intensity modulation), and segmental articulation (i.e., utterance-level second formant interquartile range (F2 IQR)). Acoustic measures were obtained from three segments operationally defined to represent the beginning, middle, and end of a reading passage. Two speaking conditions associated with common treatment techniques for dysarthria were included for comparison to a habitual speaking condition. These conditions included a slower-than-habitual rate (Slow) and greater-than-habitual intensity (Loud).

Results: There was some degree of acoustic variation across the three operationally-defined segments of the reading passage. The Slow, Loud and Habitual conditions yielded comparable characteristics of variation. Patterns of acoustic variation across the three passage segments also were largely similar across speaker groups.

Conclusions: Within-task acoustic variation during passage reading should be considered when making decisions regarding speech sampling in clinical practice and research. The contributions of speech disorder severity and linguistic variables to within-task acoustic change warrant further investigation.

Learning outcomes: Readers will be able to (1) discuss the motivation for studying and understanding within-task variation in contextual speech, (2) describe patterns of acoustic variation for speakers with dysarthria and healthy speakers during passage reading, (3) discuss the relationship between non-habitual speaking conditions and within-task variation, (4) understand the need to consider within-speaker, within-task variation in speech sampling.

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1. Introduction

Passage reading is widely used in dysarthria research and clinical practice. Commonly used passages include “The Grandfather Passage” (Darley, Aronson, & Brown, 1969a; Darley, Aronson, & Brown, 1969b; Reilly & Fisher, 2012), the

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“Rainbow Passage” (Fairbanks, 1960), “The Farm script,” (Crystal & House, 1982), the “Hunter script,” (Crystal & House, 1982), “The John Passage,” (Tjaden & Wilding, 2004), and “The Caterpillar” (Patel et al., 2013). Compared to other structured speech tasks such as sentence production, passage reading is suggested to better approximate the requirements for spontaneous speech (Duffy, 2013; Patel et al., 2013). Unlike spontaneous speech, however, passage reading offers structure and control over the content produced, which is helpful for clinicians and researchers to document and describe behaviors, particularly when characterizing dysarthria (Patel et al., 2013). In addition, linguistic and prosodic aspects of speech can be considered within a controlled context (see also Patel et al., 2013).

Passage reading further allows for an examination of speech production over a longer span of time when compared to structured tasks like sentence production. For example, Yunusova, Weismer, Kent, and Rusche (2005) examined the acoustic basis of intelligibility variation over the course of a passage read by persons with Parkinson’s disease (PD) or Amyotrophic Lateral Sclerosis (ALS) and by healthy controls. Results indicated that length of grammatical units and second formant interquartile range (F2 IQR), a global index of segmental integrity for vocalics, were related to intelligibility variation over the course of passage reading. Additionally, speakers with PD and ALS whose intelligibility was poorer produced more variable breath group durations over the course of the reading passage compared to speakers with relatively better intelligibility. In another study, Skodda and Schlegel (2008) examined speech timing and pause variables at the beginning and end of a passage read by speakers with Parkinson’s disease (PD) and healthy controls. Results indicated an increase in speech rate at the end of the passage for both groups, but speakers with PD increased rate more relative to healthy controls. As suggested by the studies reviewed here, within-task change or variation in dysarthric speech production has received limited research attention in. However, as discussed in the following sections, this type of within-task speech production variability has methodological and theoretical implications for researchers studying dysarthria.

1.1. Passage reading as a methodological issue

Studies of neurologically normal speech suggest the presence of within-task changes in speech produced during passage reading, which has important implications for speech sampling. For example, declination, in the form of fundamental frequency (F0) declination (e.g., Ladd, 1988; Pierrehumbert, 1979) and the analogous articulatory declination (e.g., Vayra & Fowler, 1993), would seem to predict a decrease in F0 and articulatory integrity over time. Physiological fatigue may also affect speech produced over an extended period of time. Solomon (2000), for example, demonstrated that exercise-induced tongue fatigue contributed to a decrease in second formant (F2) frequency for the vowels /i/ and /u/. Tongue fatigue was also associated with reduced slope of F2 transition for consonant-vowel /tɑ/ and diphthong /ɔɪ/. Similarly, higher lung volume has been reported toward the beginning relative to the end of a reading passage (Winkworth, Davis, Ellis, & Adams, 1994). Thus, in addition to linguistic variation, a variety of sources point to the potential for inherent variation in speech production over the course of passage reading.

Furthermore, it is unclear whether within-task variation could influence stimulated non-habitual speech characteristics, which is a subject of interest in dysarthria. Many management techniques for dysarthria require speakers to voluntarily alter rate, loudness, clarity, or other speech characteristics to facilitate intelligibility, and stimulability testing in which a speaker is instructed to modify speech output is often used to evaluate the potential value of an intervention technique (Yorkston, Beukelman, Strand, & Hakel, 2010). For healthy speakers, Smiljanić and Bradlow (2008) demonstrated that acoustic characteristics of clear speech were comparable over the course of an extended speech task. This finding indicates that healthy speakers were able to maintain a clear speech style over time. However, it is unknown whether speakers with dysarthria are able to maintain stimulated changes in speech style for a period of time. This knowledge is of clinical importance and may help inform decisions concerning candidacy for progressing to a treatment approach or training program.

1.2. Theoretical relevance of within-task variation

Within-task variation in passage reading is one form of within-speaker variability. Theories and models of healthy speech production have explained variations in production as the manifestation of adaptive behaviors. For example, Lindblom’s (1990) H & H theory suggests that changing communicative demands dictate variations in phonetic distinctiveness along a continuum ranging from Hypo- to Hyper-speech. Within the H & H framework, speech tasks are not categorically different. Instead, task differences are always relative on the H & H continuum. Consistent with this concept that speech behaviors operate along a continuum, it has also been hypothesized that the end goals of speech production as motor events are dynamic rather than singular in nature (e.g., target region, Guenther, Hampson, & Johnson, 1998). Moreover, the neural substrates of variations in speech have received attention (e.g., Houde & Nagarajan, 2011; Niziolek, Nagarajan, & Houde, 2013; Sidtis, 2015). Advances have been made in understanding the impact of dysarthria on speech production characteristics and variables that may facilitate intelligibility. However, an account of speech production variability in dysarthria remains elusive (Perkell, 2013; Weismer et al., 2008). Therefore, a systematic examination of within-task variations under different speaking conditions for healthy speakers and speakers with dysarthria may further the understanding of variability in dysarthria (Kent, Kent, Weismer, & Duffy, 2000; Weismer, Tjaden, & Kent, 1995).

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