Duration of Short Silent Intervals in the Connected Speech of Individuals with Parkinson Disease

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Background

A pause can be defined as a silent interval or temporary cessation in sounded speech and can result from motoric, prosodic, linguistic, and / or cognitive processes. As such, pause plays a critical role in examining respiration, articulation, and prosody of clinical populations. Previous work has used a number of different criteria for measuring pause. Past studies have defined pause as a silent interval in speech lasting at least 10 milliseconds (Skodda & Schlegel, 2008), at least 50 milliseconds (Goberman, Coelho, & Robb, 2005), or at least 200 milliseconds (Bunton & Keintz, 2008).

The purpose of the current study was to examine the duration of short silent intervals in the connected speech of individuals with and without PD that reflect articulatory processes.

Method

Participants and Protocol
Habitual reading samples (The Caterpillar Passage; Patel et al., 2013) from 10 individuals with idiopathic PD (5 males, 5 females) and 10 older control speakers (5 males, 5 females) were recorded onto a portable digital audio recorder using a table-top microphone. All speakers with PD presented with hypokinetic dysarthria as the primary type. Seven of the ten speakers fell in the mild to moderate range and three in the moderate-to-severe range. No between-group differences in speech rate, syllable number, or total speaking duration were observed, $p>0.05$ for all comparisons.

Acoustic analysis
Analyses were completed using PRAAT (Boersma & Weenink, 2015). For this process, spectrographic and waveform displays were used to identify silent intervals in the connected speech samples. These intervals were identified and categorized.

Categorization
Each pause was identified as being either between- or within-words. Silent intervals between-words were categorized as either related or unrelated to the syntax of the passage. Operational definitions are given in Table 1. Silent intervals within-words were categorized as unrelated to syntax. Silent intervals that coincided with a perceptually identifiable inspiratory breath were also identified. The phonetic context surrounding each silent interval was categorized by the preceding and subsequent phoneme manner. Phoneme manner categories are represented and defined in Table 2.

Analysis
Silent intervals that were categorized as syntactically unrelated, were not associated with a disfluency, and were not associated with inspiration were examined in the current study. Due to low number of occurrences in the passage, silent intervals associated with a preceding or subsequent affricate were excluded. Additionally, due to low number of observations for the subsequent phoneme manner category, the fricative and sonorant manner categories were combined to form a continuants category.

Table 1. Between-Word Boundaries

Boundary Type	Description
Syntactically Related [a]	A boundary coinciding with punctuation, between clauses, or between phrases.
Syntactically Unrelated [b]	Within-word boundary Between-word boundary occurring within a: noun phrase verb phrase adjective phrase adverbial phrase prepositional phrase

Note. a Descriptions from Goldman-Eisler (1968), Hawkins (1971), and Winkworth (1994). b This category includes silent intervals shorter than 150ms coinciding with stop gaps, glottal onsets, and articulatory hold gestures

Table 2. Preceding and Subsequent Phoneme Manner Categories

Phoneme Manner Category	Phonemes
Stops	/p/, /t/, /k/, /b/, /d/, /g/
Affricates	/tʃ/, /dʒ/
Fricatives	/f/, /v/, /θ/, /ð/, /s/, /z/, /ʃ/, /ʒ/, /h/
Sonorants	/m/, /n/, /ŋ/, /w/, /j/, /l/, /r/, /i/, /ɪ/, /e/, /ɛ/, /æ/, /ʌ/, /ə/, /ɝ/, /ɚ/, /u/, /ʊ/, /o/, /ɔ/, /ɑ/, /eɪ/, /ɔɪ/, /oʊ/, /aʊ/, /aɪ/, /ɑɚ/, /ɛɚ/

Note. The continuants category was used to characterize subsequent phoneme manner and includes the fricative and sonorant consonants listed.

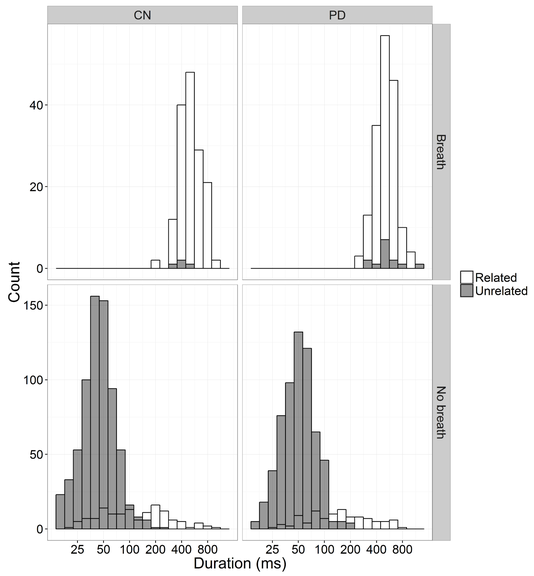

Figure 1. Histogram of silent intervals at boundaries both related and unrelated to syntax for the control (CN) and Parkinson Disease (PD) groups.

Preceding Phoneme Manner

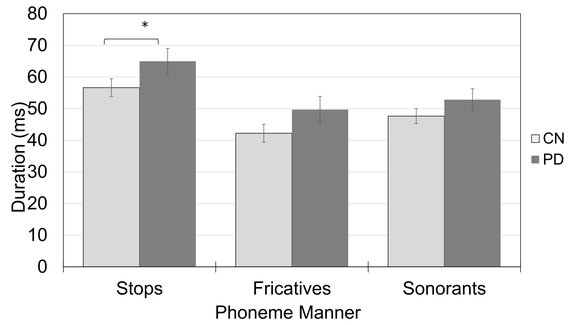

Figure 2. Fixed effect estimates and standard error for the duration of short silent intervals that were preceded by stops, fricatives, and sonorants for the control (CN; light gray) and Parkinson Disease groups (PD; dark gray). Note: * denotes $p<0.05$.

Subsequent Phoneme Manner

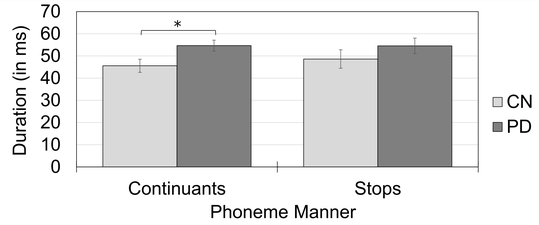

Figure 3. Fixed effect estimates and standard error for the duration of short silent intervals that were followed by continuant and stop consonants for the control (CN; light gray) and Parkinson Disease groups (PD; dark gray). Note: * denotes $p<0.05$.

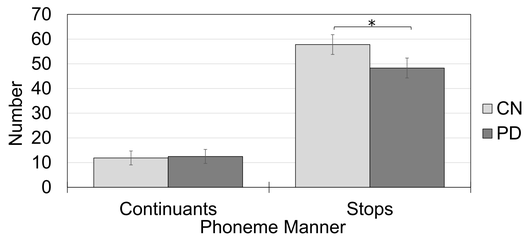

Figure 4. Fixed effect estimates and standard error for the number of short silent intervals that were followed by continuant and stop consonants for the control (CN; light gray) and the Parkinson Disease groups (PD; dark gray). Note: * denotes $p<0.05$.

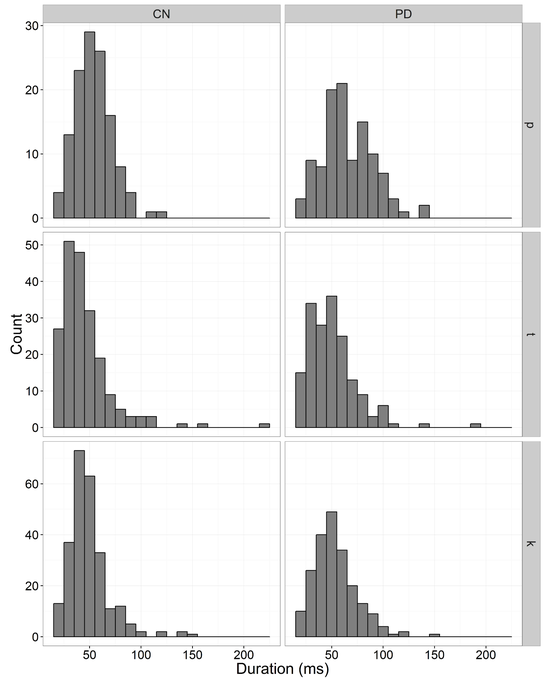

Figure 5. Histogram of voiceless stop gap interval duration by stop consonant for the control (CN; left panes) Parkinson Disease (PD; right panes) and Control (CN; left panes) groups.

Results and Discussion

The individuals with PD exhibited an overall longer duration of short silent intervals compared to control participants (Figures 2 & 3). Additionally, the participants in the PD group produced fewer silent intervals that coincided with a subsequent stop consonant than control speakers (Figures 4 & 5).

Results suggest short silent intervals that are unrelated to syntactic boundaries, prosodic emphasis, or an inspiratory breath are slightly longer for speakers with PD than healthy controls. This may result from speech timing deficits associated with basal ganglia dysfunction secondary to PD, reflecting a subtle disruption in speech fluency or articulation.

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