Effects of Clear Speech on Silent Interval Duration in Speakers with Parkinson Disease

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Introduction

Previous authors have reported that speakers with Parkinson disease (PD) exhibit longer pause durations than control speakers. Studies of healthy talkers suggest that adopting a clear speech style typically results in a slowing of speech rate that lengthens speech segment durations, including silent interval durations. However, data suggest that speakers with PD may not exhibit changes in the relative proportion of pause between habitual and clear speech styles.

The purpose of the current study was to determine the extent to which clear speech affected the duration of silent intervals in the connected speech of participants with and without PD.

Method

Participants and Protocol:
Habitual and clear reading samples (The Caterpillar Passage; Patel et al., 2013) from 10 individuals with idiopathic PD (5 males, 5 females) and 10 older control speakers (CN group; 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 ranging in severity from mild to severe, with seven speakers falling in the mild to moderate range.

Acoustic analysis:
Analyses were completed using PRAAT (Boersma & Weenink, 2015). For this process, a spectrographic and waveform display were used to identify silent intervals that were at least 15 ms in duration. These intervals were identified and categorized for extraction and further processing.

Categorization:
The syntactic and phonemic context surrounding each silent interval was categorized relative to the syntax of the passage (Table 1). For each within- and between-word interval that was unrelated to the syntax of the passage, the preceding and subsequent phoneme manners surrounding the interval were characterized as either a stop, fricative, or sonorant. Phoneme manner categories are represented and defined in Table 2. Intervals associated with disfluencies or revisions were removed from the analysis. Additionally, inspiratory breaths that could be identified from the audio signal were noted.

Analysis:
The distribution of silent interval durations was examined for each participant. Because all distributions were negatively skewed, silent interval durations were log transformed, which yielded a bimodal distribution (Figure 1). The means of the first and second modes were identified using a Gaussian Mixture Model (GMM) analysis in MATLAB, which uses an Expectation-Maximization algorithm to estimate parameters of a Gaussian distribution with an expected number of modes (e.g., Rosen et al., 2010). To evaluate the fit of each GMM model, the percent root-mean-square (RMS) error was calculated for each fit by comparing the raw data to the predictions of the model.

Table 1. Description of Syntactic Boundaries

Boundary Type	Description
Major Boundary	A boundary coinciding with sentence-ending punctuation.
Minor Boundary	A clause or phrase boundary.
Between-Word Boundary	A between-word boundary occurring within a noun phrase, verb phrase, adjective phrase, adverbial phrase, or prepositional phrase.
Within-word Boundary	A silent interval occurring within a word.

Note: Descriptions from Goldman-Eisler (1968), Hawkins (1971), Huber et al. (2012), and Winkworth (1994).

Table 2. Preceding and Subsequent Phoneme Manner Categories

Phoneme Manner Category	Phonemes
Stops	/p/, /t/, /k/, /b/, /d/, /g/
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/, /ɑʊ/, /ɑɪ/, /ɑɚ/, /ɛɚ/

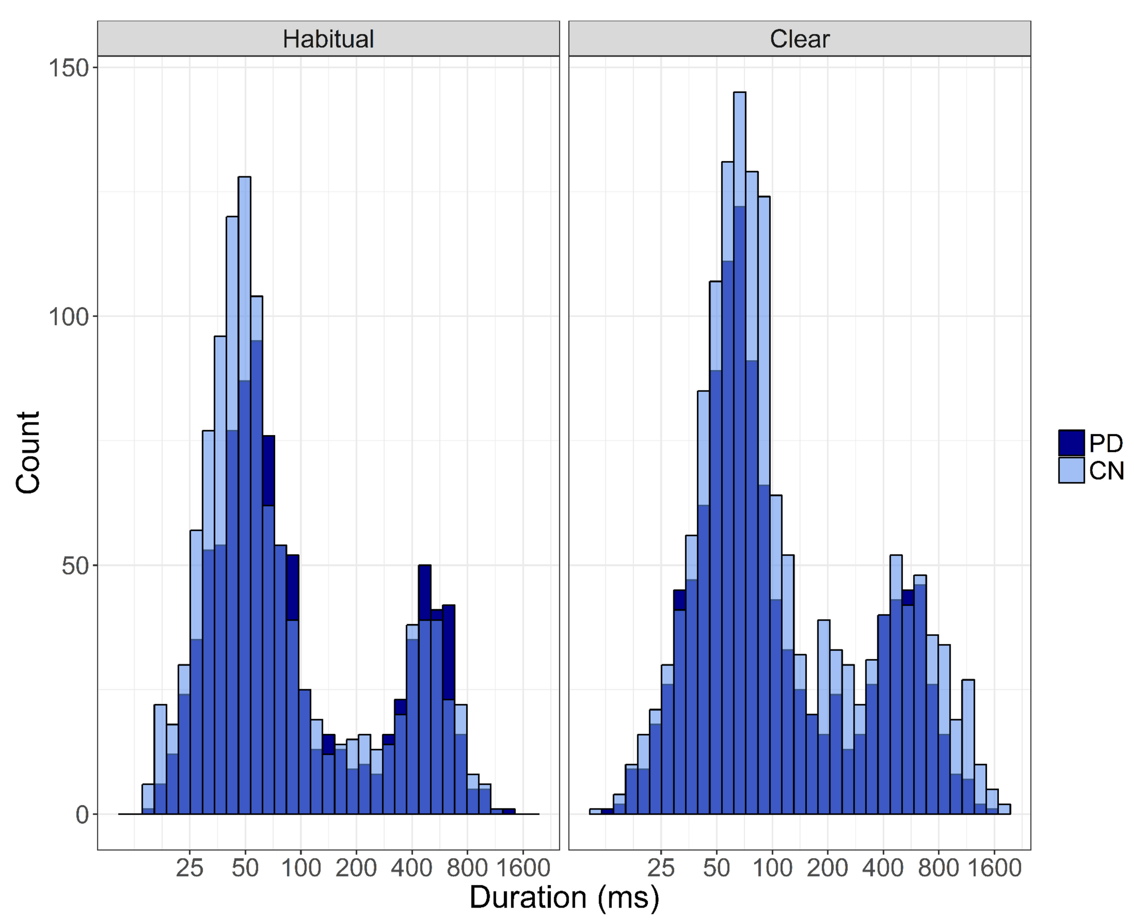

Figure 1. Distribution of silent intervals in habitual (left) and clear speech (right) conditions for control speakers (CN) and speakers with Parkinson disease (PD).

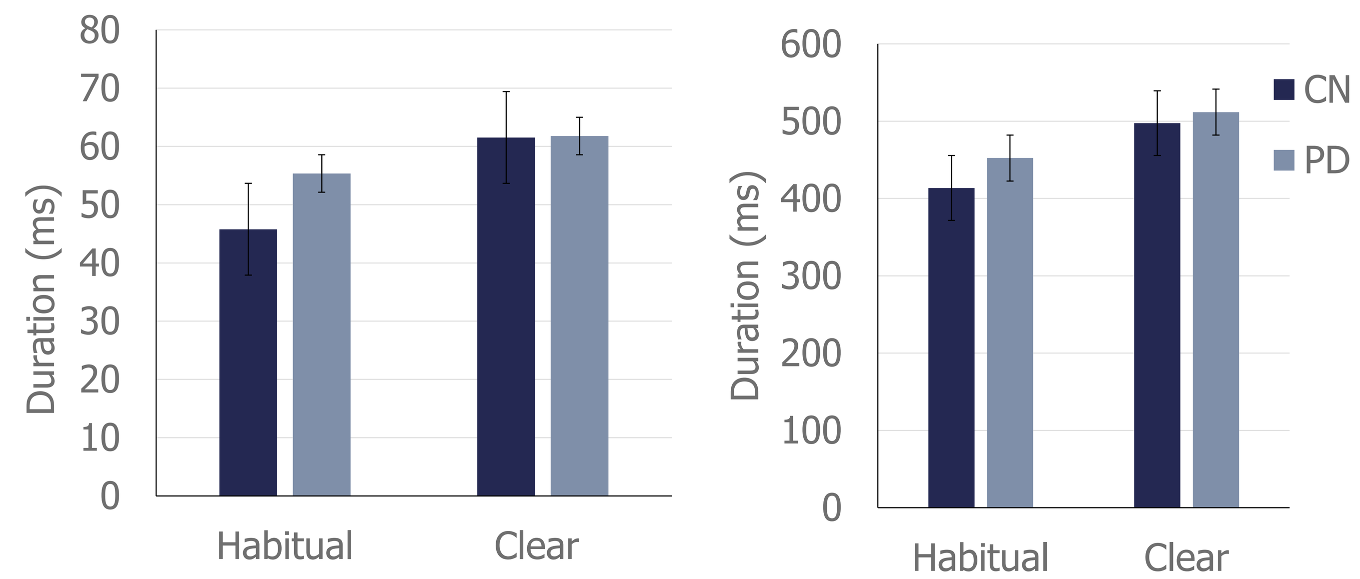

Figure 2. Duration of Mode 1 (Left Pane) and Mode 2 (Right Pane) silent intervals in habitual and clear conditions for control speakers and speakers with PD.

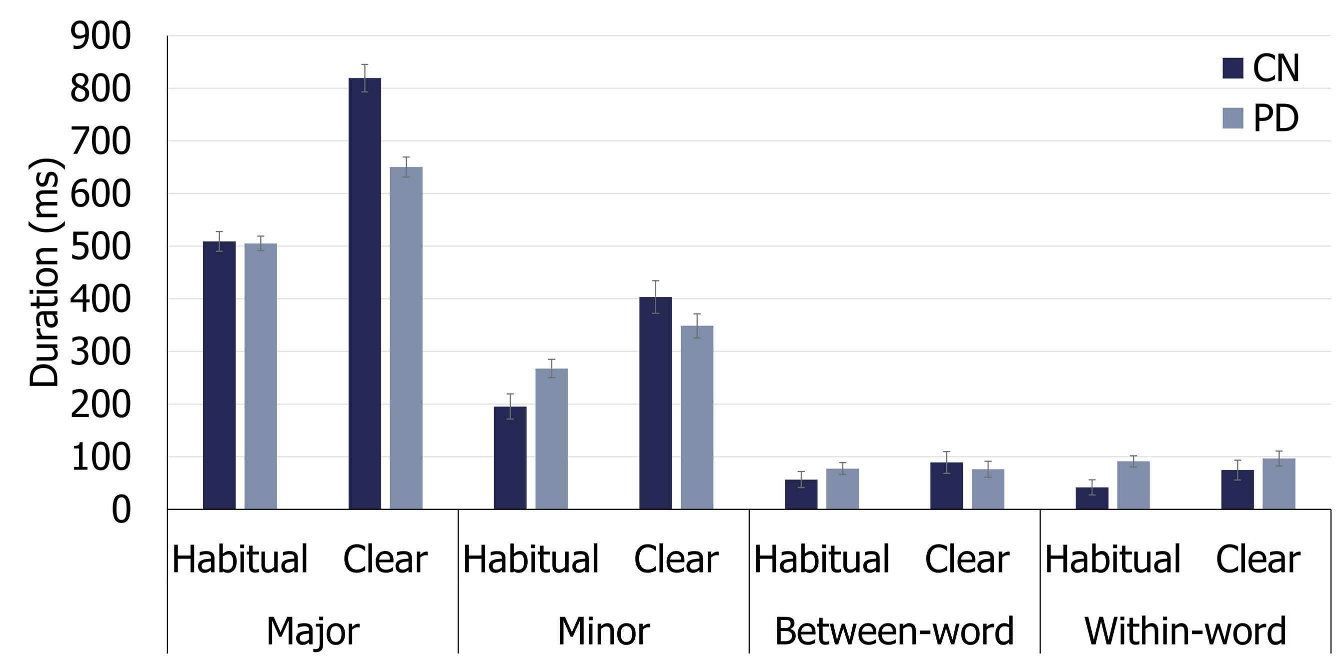

Figure 3. Duration of silent intervals at each syntactic boundary by for speakers in the Parkinson disease (PD) and control (CN) groups in both the habitual and clear speech styles.

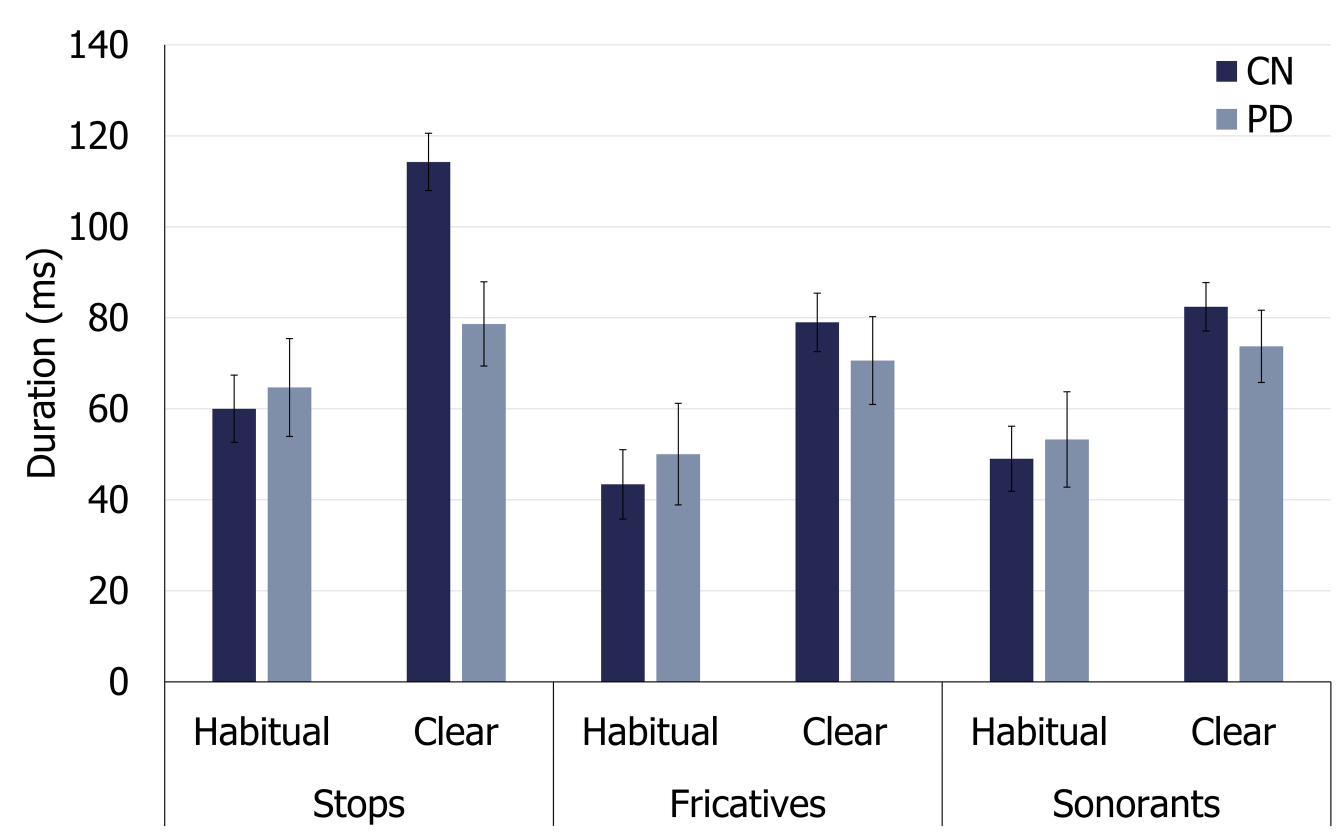

Figure 4. Duration of short silent intervals for the control group (CN) and Parkinson disease group (PD) for each style. In the clear style, control speakers increase the duration of silent intervals that were preceded by a stop consonant. This clarity-related change was significantly less for speakers with PD.

Results and Discussion

Comparison of the observed values to the predicted values from the Gaussian models suggested good fits for all participants, RMS Range: 0.3-3.5%. On average, the first mode (M1) corresponded to short silent intervals, around 1.75 log ms (56.23 ms), and the second mode (M2) corresponded to longer silent intervals, around 2.67 log ms (467.19 ms).

Effects of Clear Speech on Pause Distribution:
Results revealed a significant group by style interaction for the M1 intervals, p=0.008. Post-hoc comparisons revealed that speakers in the control group exhibited a significant increase in M1 silent interval duration, p<0.001, from the habitual to clear style, whereas participants in the PD group did not, p=0.05. For M2, results revealed a main effect of group that suggested all M2 silent intervals were significantly longer in the clear compared to habitual condition, p=0.004.

Syntactic Boundary Category:
As expected, silent intervals at Major and Minor boundaries were significantly longer than between- and within-word boundaries, p<0.001. Both groups exhibited clarity-related increases for silent intervals that coincided with Major and Minor boundaries, p<0.001. However, speakers with PD exhibited significantly less clarity-related increase in silent interval durations at the Major and Minor boundaries than controls, p<0.001.

Preceding & Subsequent Phoneme Manner:
For the control group, the clarity-related increase in silent interval duration was significantly greater for intervals that were preceded by a final stop consonant, p<0.001. The clarity-related increase in the duration of silent interval that were preceded by a stop was significantly less for speakers with PD than controls, p<0.001. Relative to the effect of subsequent phoneme manner, speakers with PD exhibited significantly less clarity-related increase in silent interval duration than controls, especially when the interval was followed by a continuant, p=0.002.

These findings suggest that both prosodic and articulatory changes associated with clear speech are less robust for speakers with PD than controls.

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