

# Voice Onset Time and Vowel Duration Across Multiple Speech Rates in Normal and Parkinsonian Speakers

by

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Individuals with Parkinson's disease (PD) present with motor control deficits evident in decreased speech intelligibility<sup>1</sup>. Additionally, poor control of speech rate has been implicated in the speech deficits of PD<sup>2,3</sup>. Subsequently, rate manipulation has been used extensively as a clinical treatment of choice with this population<sup>4</sup>. However, it remains to be determined whether the disordered speech of PD speakers is a consequence of impaired speech motor control or of the abnormal speech rates they produce. That is, are slow speech rates inherently different from normal rates? This question holds for both neurogenically normal and disordered speakers.

Studies employing speech rate manipulation allow examination of speakers' motor control systems under varying conditions. These studies offer unique opportunities for drawing conclusions about the organization of speech motor control. Studies have revealed differences between the speech of fast and slow talkers. For example, Crystal and House<sup>6</sup> reported that there was greater variability for their three slow speakers than for their three fast speakers suggesting there are differences in motor control at various speech rates.

This paper reports initial analysis of speech at six self-selected speech rates, by neurologically normal and PD speakers. The questions addressed include: (1) Are there essential differences between the speech of normal and PD speakers at different speech rates? and, (2) Do normal and PD speakers vary segment durations differently at different speech rates?

## METHODS

**Subjects:** Four PD and five neurologically normal speakers between 50 and 78 years old served as subjects.

**Stimuli:** Subjects produced three different utterances, 15 times each, at six different speech rates. The six rates and three utterances were elicited in random order. Data were audio recorded and later digitized and analyzed using the Kay Elemetrics Computerized Speech Lab. For the present study analysis was conducted on one of the three stimuli, the utterance "Buy Bobby a poppy." The following measures are presented: total utterance duration, voice onset time (VOT) of the initial /p/ in poppy, and vowel duration of the /a/ in poppy.

**Magnitude Production:** Eliciting speech at different rates has been accomplished through a variety of procedures such as modelling and pacing. However, these rigid techniques do not easily allow the elicitation of a wide range of rates within a subject, and they force the speaker to attempt motoric adjustments that may not be natural for that speaker. Therefore, this investigation used a magnitude production task to elicit speech at six different rates. This procedure involved asking subjects to produce an utterance at their normal speech rate. Following practice subjects were told to think of this rate, their normal rate, as being equal to the number '10'. They were then asked to speak twice as fast as their normal rate. Subjects were given the opportunity to practice and the number '20' was then assigned to this rate. Similarly the number '40', was assigned to a rate four times as fast as their normal rate, '5' to half their normal rate, and '2.5' to one-quarter their normal rate. Finally, subjects were asked to speak as fast as they could, this rate was termed 'MAX'. The numbers and the word MAX were always present in front of the subjects when they were speaking. Before each rate condition subjects were reminded of what the number meant (e.g., 20 = 2xs as fast as normal). Subjects were instructed to produce each repetition on a single breath and to not use increased interword pause time to lengthen their total utterance durations. This was practised and monitored on-line, and when it occurred that token

was repeated. Thus subjects autophonically scaled the six different rates at which they spoke.

## RESULTS

**Total Utterance Duration:** All subjects, both neurologically normal and PD, were able to produce speech at six different rates. Within subjects, the means of adjacent rates (e.g., MAX vs 40 or 10 vs 20) often did not differ greatly. However, total utterance duration differences were present both within and across all subjects across the six target rates. In general, the total utterance durations produced by PD speakers were slower than the normal speakers at each rate. Furthermore, the quantity of rate change, relative to the self-selected normal rate, was less for the PD than for the normal speakers. This was true for both faster and slower rates (see Table 1).

Table 1. Total Utterance Duration (ms): Buy Bobby a poppy

RATE	NORMAL	PD
Maximum	820	730
40 = 4 x Normal	872	759
20 = 2 x Normal	1007	823
10 = Normal	1193	982
5 = x Normal	1483	1212
2.5 = x Normal	2399	1493

**Voice Onset Time:** Both subject groups generally increased VOT as the target speech rate decreased. However, when looking at the individual data it appears as if two distinct patterns of speech production were present (see Figure 1). For four of the normal subjects and one of the PD subjects VOT increased rapidly as total utterance duration increased. The remaining subjects presented with minimal changes in VOT across speech rate changes. R<sup>2</sup> values ranged from 3.5 to 70.6 and 4.0 to 32.3 for the normal and PD subjects, respectively. Three of the normal and one of the PD subjects had R<sup>2</sup> values over 30%. Additionally, the overall quantity of VOT change accompanying changes in total utterance duration was less for the PD speakers than the normal speakers.

**Vowel Duration:** Inspection of Figure 2 reveals that all normal and two PD subjects greatly increased mean vowel duration as they increased total utterance duration. The remaining two PD subjects produced relatively stable mean vowel durations as they increased total utterance duration. R<sup>2</sup> values ranged between 20.3 and 88.5 and 0.1 and 71.9 for the normal and PD subjects, respectively. However, R<sup>2</sup> values for four normal but only one PD subject were over 30%.

## CONCLUSIONS

Across the different rates PD speakers produced shorter durations than did the normal speakers; they spoke faster. More importantly, they did not vary their speech rate, relative to their self-selected normal rate, as much as the normal subjects. This may be related to reduced range-of-motion reported in PD. It also appears that some PD subjects varied their segment durations

systematically in manners similar to most normal speakers, while others did not. Analysis of additional subjects will reveal whether these are truly patterns of motor control or simply artifactual. Finally, low  $R^2$  values for both VOT and vowel duration for the PD subjects indicates that their speech was highly variable. It may be that it is this high degree of within speaker variability that contributes to reduced speech intelligibility in PD speakers.

Figure 1a. VOT vs Total Utterance Duration, Normal Ss

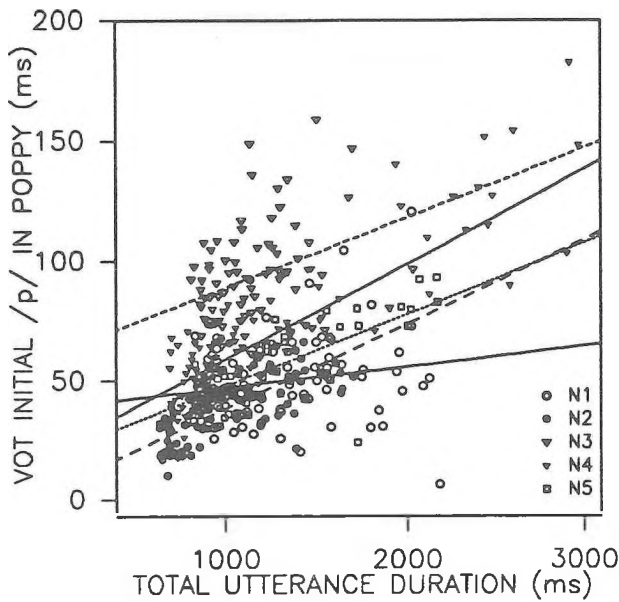


Figure 1b. VOT vs Total Utterance Duration, PD Subjects

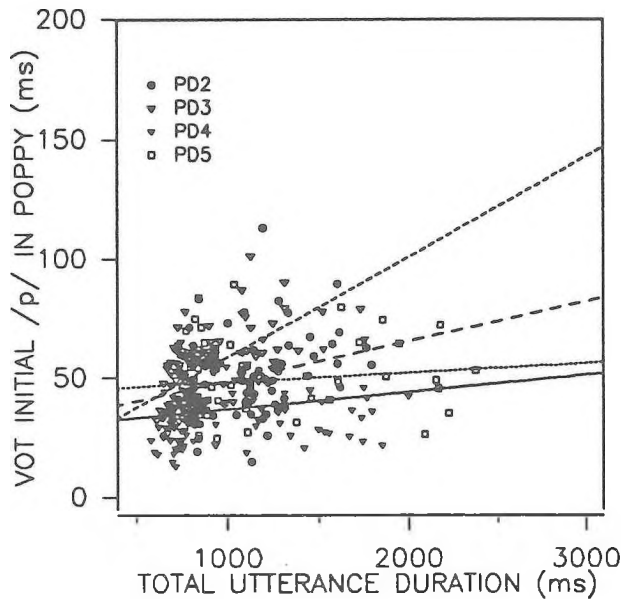


Figure 2a. Vowel vs Total Utterance Duration, Normal Ss

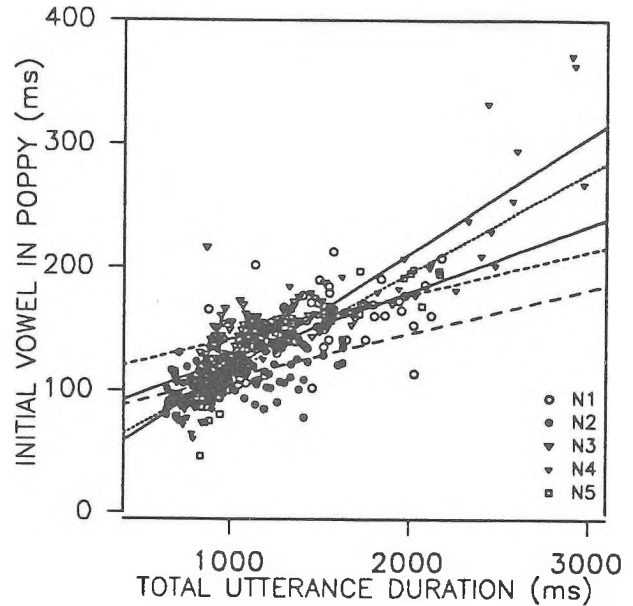
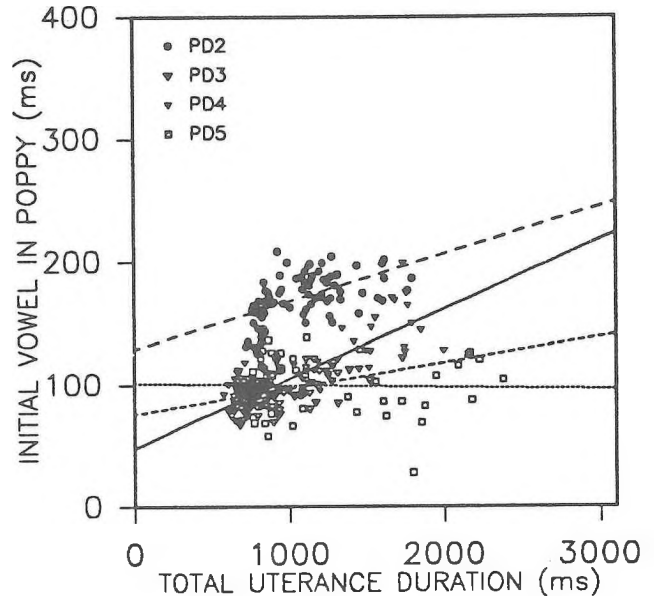


Figure 2b. Vowel vs Total Utterance Duration, PD Ss



#### REFERENCES

- <sup>1</sup>Darley, F.L., Aronson, A.E., & Brown, J. (1975). *Motor Speech Disorders*. Toronto: W. B. Saunders Company.
- <sup>2</sup>Forest, K., Weismer, G. & Turner, G.S. (1989). Kinematic, acoustic, and perceptual analyses of connected speech produced by Parkinsonian and normal geriatric adults. *Journal of the Acoustical Society of America*, *85*, 2608-22.
- <sup>3</sup>Caligiuri, M.P. (1987). Labial kinematics during speech in patients with Parkinsonian rigidity. *Brain*, *110*, 1033-1044.
- <sup>4</sup>Yorkston, K., Beukelman, D. & Bell, K. (1988). *Clinical Management of Dysarthric Speakers*. Boston: Little, Brown & Co.
- <sup>5</sup>Crystal, T. & House, A. (1990). Articulation rate and the duration of syllables and stress groups in connected speech. *Journal of the Acoustical Society of America*, *88*, 101-112.