

Abnormal Volume-Duration Relationship in Parkinsonian Speech

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ABSTRACT

Past studies on Parkinsonian speech have generally examined the parameters of speech separately. Thus volume and suprasegmental duration have largely been described independently of each other on the assumption that two measures are not related. This assumption was tested by manipulating intensity and examining the corresponding effect on duration. Twelve Parkinson's disease (PD) patients and twelve normal healthy controls read according to three conditions; as softly as possible, as loudly as possible, and with no volume instruction (at normal volume). Total Duration of reading (with pauses), and Net Duration (without pauses) were examined. For Net Duration, both groups were similar, and did not vary across volume conditions. PD patients, however, demonstrated decreased Total Duration as speech volume was increased. The abnormal Parkinsonian relationship is suggestive of a trade-off between the two parameters in order to achieve adequately loud reading, and may be explained by increased attention associated with increased effort when speaking louder.

1. INTRODUCTION

Past acoustic studies on Parkinsonian speech have generally focused on building a descriptive inventory of speech parameters such as pitch, voice onset time, segmental duration, suprasegmental (overall) duration and speech volume, relative to geriatric controls. Thus volume and duration have been largely described as independent of each other with the exception of recent investigations into the effect of the Lee Silverman Voice Treatment (LSVT) on measures of segmental duration such as word, vowel and rise-time (rate of friction onset) duration³. The effect of volume changes on suprasegmental duration has not been investigated, presumably because of the high variability^{1,9,12} and the conflicting findings of descriptive studies^{7,8}, or perhaps due to an implicit assumption that suprasegmental indices of speech duration (e.g. reading time) are not systematically related to speech intensity.

Although some studies have speculated a relationship between suprasegmental duration and articulatory precision^{2,6,13}, the possibility of a relationship between suprasegmental duration and speech volume remains unexplored. The present study investigated the relationship between these two measures of speech motor control by manipulating speech intensity and

examining the corresponding effect on two temporal measures of overall (suprasegmental) speech duration.

2. METHOD

2.1 Participants

Twelve idiopathic PD patients (mean age = 75;3, standard deviation = 5;11) with hypophonic dysarthria and twelve controls (mean age = 76;3, standard deviation = 3;3) with no neurological complications participated in this study. There were ten males and two females in each group. Patients were stabilised on anti-Parkinson medication and remained on their usual medication regime when participating in the experiment, and were tested between one and three hours of receiving medication.

2.2 Apparatus

The reading stimuli consisted of Fairbank's Rainbow passage⁴ in large print. A Marantz tape recorder (PMD222) and microphone (David Clark) were used to record reading in a sound attenuated room. Data on duration were obtained using the KAY Elemetrics CSL 5.05 system.

2.3 Procedure

Participants were allowed practice trials to familiarise themselves with the Rainbow passage and were then asked to read according to three instruction conditions. The first condition was the Normal condition where participants were simply told to read the passage; no instruction on volume was given and participants read at their automatic self-selected default volume. The second condition was the Soft condition where they were told to read as softly as possible (but without whispering), as if there was a baby sleeping in the same room. In the third condition i.e. the Loud condition, participants were instructed to read as loudly as possible (but without shouting), as if they were at a very noisy place such as a sporting event. The mouth-to-microphone distance was kept at a constant of 20cm.

The readings were then analysed to obtain two measures of duration. In all cases, the very first sentence was discarded to allow participants to settle into an appropriate set. Total Duration was measured from the second sentence till the end of

the paragraph, including pauses. Pauses were later edited out and Net duration was obtained.

3. RESULTS

Although patients' reading was generally softer than controls', both groups did in fact read at different volumes corresponding with the manipulation of reading instruction type. Figure 1 shows the volume data for patients and controls in response to the three reading instructions. A two-way repeated measures ANOVA with factors of Group (patients, controls) and Instruction (soft, normal, loud) showed a significant main effect of Group ($F(1,22) = 18.49, p < .001$) and Instruction ($F(2,44) = 86.21, p < .001$), and a just significant Group x Instruction interaction ($F(2,44) = 3.22, p = .05$), indicating that both groups varied volume in response to reading instructions to similar extents, although patients had a tendency to be slightly softer in the loud condition.

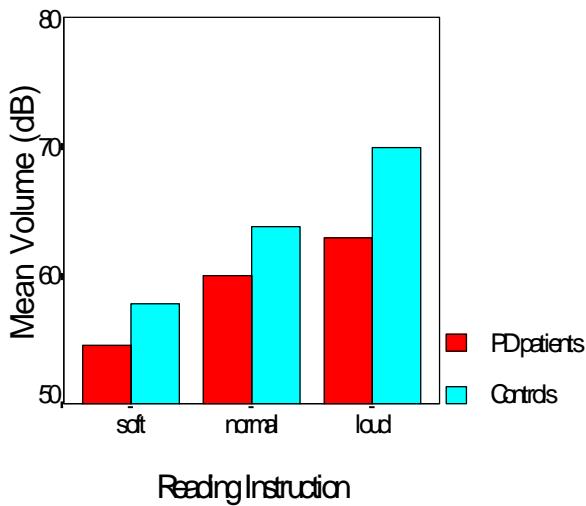


Figure 1. PD patients' and Controls' mean reading volume according to instruction condition (soft, normal, loud).

Figure 2 shows Total Duration data for the three reading instructions. A two-way repeated measures ANOVA with factors of Group (patients, controls) and Instruction (soft, normal, loud) showed a significant main effect of Instruction ($F(2,44) = 3.83, p < .05$), and a just significant Group x Instruction interaction ($F(2,44) = 3.21, p = .05$). The interaction effect was due to the differential change between patients' and controls' Total Duration for soft, normal and loud reading. Controls' Total Duration was relatively steady regardless of reading volume. PD patients, however, were maximally slow for the soft condition and demonstrated decreased Total Duration as speech volume was increased, approximating control performance for the loud condition.

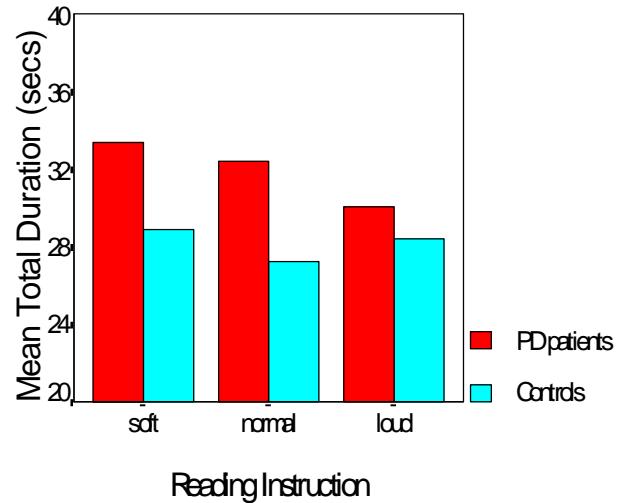


Figure 2. PD patients' and Controls' Total Duration of reading according to instruction condition (soft, normal, loud).

Patients and controls performed similarly on the index of Net Duration, showing no variation across volume conditions. A two-way repeated measures ANOVA with factors of Group (patients, controls) and Instruction (soft, normal, loud) showed no significant main effect of Group ($F(1,22) = .01, p = .94$) or Instruction ($F(2,44) = .17, p = .85$), and no significant Group x Instruction interaction ($F(2,44) = 1.63, p = .21$).

4. DISCUSSION

This study found that PD patients took progressively less time overall (Total Duration) to read at increasingly louder levels. This inverse relationship was unique to patients as controls took the same time (Total Duration) to read at any volume. Thus, patients appeared to rely on this volume-Total Duration trade-off to achieve adequately loud reading whereas controls did not. The Net Duration index, however, was similar for both groups, consistent with past research suggesting increased pause time in Parkinsonian speech^{1,7}, and remained steady across the different volume conditions. Because the trade-off occurred only for Total Duration and not for Net Duration (without pauses), patients therefore seemed to have spent progressively less time on increasingly infrequent pauses, as volume of reading instruction increased. Shorter breaths may seem to indicate decreased inspiration, and/or less frequent breaths may conversely suggest insufficient respiration, but may not necessarily be true since Parkinsonian volume was still increased by nearly the same ratio as that of controls for the normal condition, and (to a slightly lesser extent) for the loud condition. It is more likely that patients simply hastened the duration and reduced the frequency of breath intake while maintaining adequate respiratory support via sufficiently deep inhalations, thus more closely approximating the performance of controls.

The normalisation of Total Duration under the loud instruction is consistent with the findings of improvement on other non-targeted supraglottal parameters when therapy is exclusively targeted at increasing volume, according to the Lee Silverman Voice Treatment (LSVT) model³. This can be interpreted as the result of increased physiological effort resulting in increased respiratory support. However, a preliminary study demonstrated the successful reduction of rate in a PD patient with high speech rate when instructed to speak at a level two times louder than normal¹¹. It seems then that the direction of temporal change upon volume modification may be dependent on the nature of the presenting deficit in speech rate. Hence rather than a simple and indiscriminate increase in physiological effort upon instructions to consciously increased speech volume, the normalisation of speech tempo towards normal (from opposite extremes common in PD) may be explained by the modulatory effect of artificially directing attentional resources to the movement production aspect (i.e. articulatory process as opposed to articulatory content) to comply with the task demands imposed by instructions regarding volume of speech. The role of directed attention in improving Parkinsonian upper⁵ and lower¹⁰ limb motor control is well known and would seem to be a parsimonious explanation of defective speech motor control given the common fronto-striatal circuit mediating complex well-learned (automatic) movement sequences.

5. REFERENCES

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