Effect of deep brain stimulation on acoustic speech parameters in patients with Parkinson's disease

Papathanasiou I.[1], Protopapas A.[2], Deligiorgi G.[1], Lolakidi A.[1], Kasselimis D.[3], Themistocleous M.[4], Boviatsis E.[4], Sakkas D.[4]

[1]Department of Speech & Language Therapy, TEI Patras Greece
[2] Institute for Language & Speech Processing, Maroussi, Greece
[3] Department of Psychology, University of Crete, Greece
[4] Department of Neurosurgery, Medical School, University of Athens, Greece

Introduction

Impairment of speech can affect almost 89% of patients with Parkinson's disease (PD) (Logeman et al., 1989). The speech of PD patients is described as hypokinetic dysarthria and has been analyzed in an extensive range of perceptual acoustic and physiological studies.

Today, bilateral subthalamic nucleus deep brain stimulation (STN-DBS) is considered as the main surgical management approach for patients with PD. Tripoliti et al. (2006) compared the effects of STN-DBS with medical (drug) treatment versus medical (drug) treatment alone over one year. They reported that the STN –DBS group improved the intensity of sustained phonation and the mean of long-term average spectrum of the monologue and reading sentences over one year whereas the drug-only group did not. Neither group showed improvement of sentence intelligibility scores.

Introduction

This study was among the first to report changes in acoustic properties of speech, but the detailed nature of these changes relative to articulatory and cognitive executive functions has not been investigated.

Here we report preliminary results of seven patients with PD before and six months after surgical STN-DBS treatment, where we study in detail the acoustic properties of their speech in relation to articulatory and other cognitive motor executive tasks.

Method

Seven patients with PD (mean age 68.3 years), part of a larger trial, were recruited in the Department of Neurosurgery, Medical School, University of Athens, Greece. During the surgical procedure patients were implanted bilaterally with quadripolar electrodes model 3389 Medtronic. The postoperative neurological management involved progressive adjustment of the stimulation parameters and a parallel decrease of medication. The aim was to provide maximum overall therapeutic effect with minimum side effects.

Method

Data analysis:

Acoustic analysis of the recorded data were conducted using the Praat software. For the statistical analysis the Wilcoxon Signed Ranks Test was used.

Patient assessment:

Patients were assessed 3 days before the surgical procedure "on medication" state and six months post operation (when their stimulator was fully regulated) "on stimulation" state. The assessment protocol consisted of several tests. Cognitive and executive measures included a simple motor reaction task (button press in response to a light), a speech reaction task (respond to light by saying /a/), and a cognitive executive function construction task. For articulatory functioning, the Greek version of Frenchay Dysarthria Assessment (FDA) was used.

Method

Patient assessment: (cont)

For acoustic measures and rate of speech we used the following tasks: sustained phonation, word list reading, text reading, and one minute monologue describing the cookie theft picture of BDAE. The word list included 40 words. Ten were chosen to contain the five Greek vowels /a, i, o, u, e/ stressed and unstressed between plosive sounds in open and closed syllables. So for each vowel, data were collected in all combinations of stress and open/closed syllable. The remaining 30 words were chosen to start with the plosive consonants /p, b, t, d, k, g, c, / followed by a vowels, to measure voice onset time (VOT). All patients gave informed consent to participate in the study.

Results

Articulatory and speech functions: There were no significant differences in articulatory functioning as assessed in the FDA tasks and in speech rate during reading or speaking. However, post operatively a great variability between the patients was observed compared to the pre-operative condition (greater standard deviations).

Results

Acoustic measures: There were no significant differences in any of the acoustic measures evaluated with our protocol including: vowel duration in stressed and unstressed syllables, vowel pitch, vowel formants F1-F2-F3, voice onset time, jitter, shimmer, and mean fundamental frequency in citation or spontaneous speech. Unlike articulatory functioning, no substantial increase in variability was observed in these acoustic measures.

Results

Cognitive and executive functions: There was a significant increase in speech reaction time in the post-operation condition compared to pre-operation ($z = -2.366$, exact $p = .016$, two-tailed). There were no significant differences in motor reaction time or in the executive task. Great between-patient variability was observed in these tasks as well.

Discussion

Our data from 7 patients showed no significant changes in the articulatory and acoustic properties of speech in PD patients who have undergone STN-DBS treatment to improve their motor function. However, cognitive tasks related to speech appear to have deteriorated post-operatively, suggesting that the changes in speech reported elsewhere may be related not to acoustic properties of speech itself but to the cognitive functions related to speech-specific motor planning. Importantly, there was no evidence of deteriorated coordination among speech motor components that are required for complex articulation, such as for stop consonants, as evidenced by unaffected VOT measures.

Discussion

The discrepancy between the acoustic properties of speech and the cognitive speech-related task remains unclear. It may be related to changes induced by the STN-DBS in neural pathways underlying speech mechanisms. Further studies are needed to investigate this issue in the future.

References

Logeman et al. (1978). Frequency and co-occurrence of vocal tract dysfunction in the speech of a large sample of Parkinson patients. *Journal of Speech & Hearing Disorders*, *43*, 47–57.

Tripoliti et al. (2006). Speech in Parkinson's disease following subthalamic nucleus deep brain stimulation: Preliminary results. *Journal of Medical Speech-Language Pathology*, *14*, 309–315.

Effect of deep brain stimulation on acoustic speech parameters in patients with Parkinson's disease

Papathanasiou I.[1], Protopapas A.[2], Deligiorgi G.[1], Lolakidi A.[1], Kasselimis D.[3], Themistocleous M.[4], Boviatsis E.[4], Sakkas D.[4]

[1]Department of Speech & Language Therapy, TEI Patras Greece
[2] Institute for Language & Speech Processing, Maroussi, Greece
[3] Department of Psychology, University of Crete, Greece
[4] Department of Neurosurgery, Medical School, University of Athens, Greece