

Phonatory tasks included three repetitions of maximum sustained vowel phonations, pitch glides, syllable repetition, short consonant-vowel-consonant (CVC) words and oral reading of a standardized passage. All recordings were analyzed using a Computerized Speech Lab (CSL) and Multi-Dimensional Voice Program (MDVP).

The most positive results occurred in the ON-stimulation, ON-medication condition across all speech parameters. The next most positive change occurred in the ON-stimulation, OFF-medication condition. The OFF-stimulation conditions produced the least amount of positive results. The results for standard deviation of VOT revealed the most dramatic change with an average standard deviation of 77ms for the /k/ phoneme in the OFF-stimulation, OFF-medication condition to an average standard deviation of 4ms in the ON-stimulation, ON-medication condition. The neurologists' clinical rating of motor disability for the ON-stimulation, ON-medication condition revealed only a mild speech impairment that resolved when the participant increased effort, and mild or no impairments in various motor symptoms.

Results of this study suggest that STN-DBS stimulation may be beneficial in reducing speech symptoms associated with PD, when combined with Parkinson medication. Pre-surgery motor and speech scores were not reported; therefore results cannot be compared to a baseline score. The results of this study need to be interpreted with caution, as they may only generalize to patients symptomatically similar to the one included in this study.

Experimental Design

Wang et al. (2003) investigated the effect of unilateral stimulation of the STN on respiratory and phonatory subsystems of speech production in six right-handed PD patients with mild to moderate dysarthria. Three patients received implantation of the STN-DBS stimulator in the right STN, and three in the left STN. Speech recordings were made in the OFF-medication state at baseline pre-surgery, and three months post-surgery with and without stimulation. Evaluators and patients were blinded to the stimulator conditions until after the data were analyzed. Tasks included six maximally sustained vowel phonations (MSVP), three diadokinetic rates, reading sentences with varying stress, and a structured monologue. Performance on non-speech motor tasks was rated by a movement disorder neurologist, using the motor section of the UPDRS-III.

A mixed two-factor analysis of variance with repeated measures was used to assess the significance of the changes in both, non-speech motor and speech tasks. The alpha level of 0.05 was used for all tests

except for the post-hoc tests. Group means were reported.

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compared to bilateral stimulation OFF, irrespective of the status of the left-sided stimulation. There were no significant differences in speech characteristics when comparing bilateral stimulation OFF with bilateral stimulation ON. Selective stimulation of the left STN had a significant negative effect, especially on prosody, when compared to bilctive oive

Discussion

The results of these studies need to be interpreted with caution as all deal with small sample sizes and many provide conflicting reports as to how effective the DBS-STN system is for speech in Parkinson's patients. While the motor benefit of the system is widely reported, the benefits on speech have yet to reach a consensus in the literature. Part of the discrepancy in the findings may be related to the patient selection criteria. Those studies demonstrating a positive effect of STN-DBS stimulation on speech often selected participants on the basis of a significant speech impairment (Gentil et al, 2003; Hoffman-Ruddy et al., 2001). Also, the fact that STN-DBS stimulation actually led to adverse effects on speech in some patients (Hamani et al., 2005; Dromey et al., 2000; Santens et al., 2003) is an important finding for SLPs working with this population. The study by Tornqvist et al. (2005) indicates the need for additional studies to investigate the precise stimulation parameters needed to optimize speech while still allowing for a substantial reduction of motor symptoms in PD.

The studies by Santens et al. (2003) and Wang et al., (2003) provide insight into the neural substrates modulating speech and language and how speech is differentially affected by left versus right stimulation of the STN. Indeed, most studies have suggested that bilateral stimulation of the STN is optimal for speech, but additional studies comparing unilateral and bilateral procedures are required.

The discrepancy in findings between speech and motor benefits has led some researchers to hypothesize that differently modulated pathways are involved in the regulation of speech and limb control (Santens et al., 2003). Further knowledge of the neural substrates that modulate speech should lead to an optimization of speech and limb treatment for deficits while minimizing adverse effects of stimulation.

Recommendations

Further well-controlled empirical studies examining the precise effects of STN-DBS on speech in a larger number of randomized Parkinson's patients using both quantitative and qualitative measurement tools are needed. More longitudinal studies are needed to investigate the long-term effects of STN-DBS in the later stages of the disease.

Future research should consider:

- different sites within the STN;
- evaluating the effect of STN-DBS on spontaneous conversational speech ;
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