Effect of Combined Modality Treatment on Phonation in Parkinson's Disease: Perceptual/Acoustic Analyses of Sustained Vowels

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Abstract

Objective: To determine whether Lee Silverman Voice Treatment (LSVT-LOUD) combined with Transcranial Magnetic Stimulation in individuals with Parkinson's Disease (PD) improves phonation to a greater extent than LSVT alone.

Background: Individuals with PD exhibit dysphonia. LSVT is a behavioral treatment for improving voice in PD. TMS is a noninvasive procedure for influencing brain activity hat enhances motor learning. LSVT is typically evaluated using voice intensity (dB) as the primary outcome measure. It is also of interest to examine the impact of LSVT+TMS on acoustic voice harmonic structure (cepstral peak prominence, CPP), perceived voice quality, and voice related quality of life.

Methods: Twenty-two participants with PD aged 50 – 78 years were randomized into 3 groups: Right (RTMS), Left (LTMS) and Sham (STMS). All participants exhibited hypophonia. More than mild depression or cognitive impairment were excluded. Medication schedules were maintained throughout the study. TMS was administered using 3000 pulses at the rate of 5 Hz with intensity of 80 V/m to the primary motor cortex (M1) larynx area in the LTMS and RTMS conditions, but at < 25 V/m in the STMS, determined via MRI/FMRI co-registration. STMS was applied with a plastic spacer, 30 mm thick placed between the TMS coil and subject's scalp. TMS was applied prior to LSVT. LSVT was administered by a LSVT certified SLP for 16 one-hour sessions. Patient were recorded on two different days at pre-treatment (tx), post-tx, and at FU in a sound treated booth for 3 trials of sustained vowel "ah". Intensity (dB) was measured using the LSVT Companion . CPP measures were obtained with Assessment of Dysphonia in Speech and Voice software. Participants rated their Voice Related Quality of Life. Vowels were rated by two experienced voice clinicians for overall severity, breathiness, and roughness.

Resutls: dB, CPP, voice quality and VRQOL increased significantly from pre-to-post treatment that was maintained at FU ($p < .01$). Actual and Sham TMS groups were not significantly different, indicating that improvements were due to LSVT alone.

Conclusions: LSVT significantly improved voice harmonic structure, perceived voice quality, and voice related quality of life to a similar degree with or without concurrent TMS.

Purpose

- **We questioned whether TMS plus LSVT administered to the cortical larynx area of the motor strip (M1) of the left hemisphere (LTMS) vs that of the right hemisphere (RTMS) would enhance the effect of LSVT on perceptual/acoustic measures of voice quality in sustained vowels in comparison with LSVT combined with a sham TMS condition (STMS), at Post-Tx and 3 month Follow UP (FU), in addition to increasing overall voice intensity.**
- **We also were interested in determining whether LSVT effects would be observed with some additional voice measures (CPP, CAPE-V ratings, and VRQOL) not previously reported.**

Methodology

Participants and Treatment:

- **22 PD participants (14 men, 8 women) age range: 50-78 yrs. (mean: 70 $\pm$ 7.9).**
- **Participants were randomly assigned to each TMS group.**
- **They maintained regular anti-Parkinson medications.**
- **No participants received additional therapy during the study and none received LSVT or TMS prior to this study.**
- **All participants exhibited hypophonia**
- **Those with more than mild depression or cognitive impairment were excluded.**
- **Each subject received LSVT for one hour per day, 4 x per week for 4 weeks.**
- **TMS was administered by a clinical neurophysiologist using the Nexstim Neuronavigation TMS system.**
- **LSVT was administered by an ASHA certified SLP also certified in LSVT.**
- **For TMS groups, the treatment consisted of a total of 3000 pulses delivered at the rate of 5 Hz with intensity of 80 V/m to the laryngeal primary motor cortex ($M1_{larynx}$) in the LTMS and RTMS conditions, but at < 25 V/m in the STMS.**
- **$M1_{larynx}$ locations were identified via a phonation and reading tasks using functional MRI that were co-registrated to the anatomical MRI.**

Recordings:

- **Recordings were obtained in a sound treated booth**
- **Each patient was recorded on two different days at each time Period: Pre-Tx, Post-Tx, and 3-month FU.**
- **Using a Countryman head-mounted microphone positioned 6 cm from the corner of the mouth, out of the breath stream.**
- **Tasks included production of 3 trials of sustained vowel /ɑ/.**
- **Signal were digitized directly to disc using the KayPENTAX CSL Model 4500 at 50 kHz sampling rate.**
- **Participants completed the VRQOL scale on each of the recording days.**

Materials and Measures:

- **Sustained vowels were selected from the recorded sound files, down sampled to 25kHZ, trimmed and edited to remove background noise if needed.**
- **KayPentax *Analysis of Dysphonia in Speech and Voice (ADSV™)* (Awan, 2011) was used to obtain cepstral/spectral analyses of each signal which included the Cepstral Peak Prominence (CPP) as output. CPP is an acoustic index of the strength of harmonic energy present in the voice that is not based on automated pitch tracking, therefore more appropriate for analyzing dysphonic voices.**
- **dB levels for sustained vowels were obtained using the LSVT Companion which also functions as a virtual sound level meter with mic positioned 30 cm from the speaker's lips.**
- **Voice Quality ratings were accomplished by 2 experienced SLPs using ASHA's CAPE-V Scale for Overall Severity, Breathiness, Roughness. After consensus training, Cronbach's Alpha coefficients exceeded the consistency criterion of .70, enabling averaging of ratings across raters.**
- **Resultant data were submitted to between groups x repeated measures ANOVAs (TMS groups = 3, treatment periods = 3, recording sessions = 6) at alpha level = .05. Data were the averages of 3 vowel tokens from each recoding day. Post hoc comparisons were Bonferroni adjusted Fisher's tests.**

Results

- **A statistically significant main effect of treatment time (pre, post, FU) was obtained for each of 6 measures ($p < .01$) for all participants combined. Post hoc comparisons (Bonferroni) demonstrated significant improvement from pre-to-post treatment that was maintained at FU ($p < .05$, adjusted).**
  No other effect or interactions attained statistical significance.
- **Large treatment effect sizes ranged from $\eta^2 = 0.319 – 0.446$.**
- **Pearson Correlations demonstrated significant moderate relationships among the voice quality ratings and the acoustic measures ($p < .001$). Notably, CPP was negatively correlated with Overall Voice Quality ($r = -.59$), Breathiness ($r = -.63$) , and Roughness ($r = -.48$). Harmonic structure increased as perceived dysphonia decreased.**

Figure 1: Spectral/Cepstral analysis of sustained /ɑ/ showing harmonic structure (A panels) and CPP (B panels). Note increased harmonic energy & CPP at Post & FU.

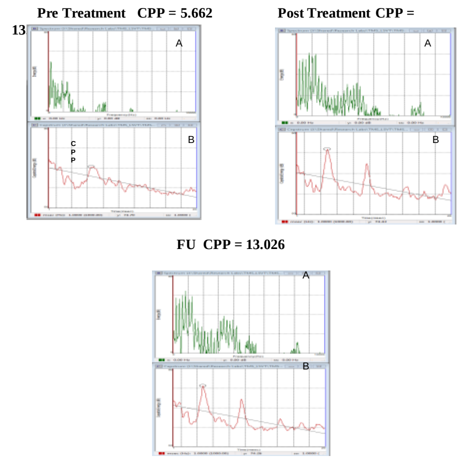
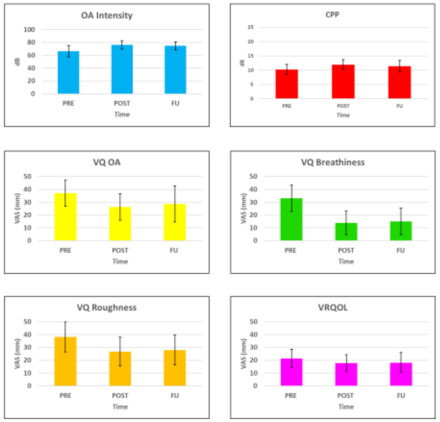


Figure 2. Means and Standard Deviations (Error Bars) for Six Voice Measures at Pre-Tx, Post-Tx and FU evaluations.



Discussion & Conclusions

- **Voice intensity (dBspl) increased significantly from pre-to-post Tx for all participants in keeping with expectations of the LSVT program. See Figure 2.**
- **CPP also increased after Tx as anticipated, reflecting increased dominance of harmonics and greater periodicity in the post treatment voice spectra. CPP findings agree with a recent report by Alharbi et al (2019). This is evident from the height of the CPP and inspection of harmonic spectra at Post and FU periods compared with the Pre-treatment values. See Figure 1.**
- **However, the absence of a significant TMS Group x Time interaction for each acoustic variable indicates that effects of treatment must be attributed to LSVT-LOUD.**
- **CAPE-V Voice Quality ratings and VRQOL also improved from Pre-to-Post Tx for sustained vowels. Both clinicians and patients perceived reduced dysphonia following Tx. See Figure 2.**
- **Post treatment improvements observed for all participants combined were maintained at FU for both acoustic and perceptual variables. See Figure 2.**
- **There was clearly a voice treatment effect for LSVT with voice improvement from pre-to-post treatment that was maintained at FU, irrespective of TMS conditions.**
- **There was also no Treatment Group x Time interaction for the voice quality ratings (CAPE-V & VRQOL). Therefore these effects also were dominated by behavioral LSVT.**

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