APPLICATION OF THE LEE SILVERMAN VOICE TREATMENT (LSVT®) TO INDIVIDUALS WITH MULTIPLE SCLEROSIS, ATAXIC DYSARTHRIA, AND STROKE

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ABSTRACT
Reduced speech intelligibility has been observed in Parkinson’s disease (PD), ataxic dysarthria, multiple sclerosis (MS) and in individuals who have suffered a cerebral vascular accident (CVA). Data support the effectiveness of the Lee Silverman Voice Treatment (LSVT) on the improvement of vocal function and speech intelligibility in PD. Today, only a small percentage of patients with chronic neurologic disease receive treatment to improve speech and voice. This paper will report improvement in case studies of individuals with MS, ataxic dysarthria and CVA and suggest that the effects of LSVT may not be restricted to the dysarthria associated with PD.

1. INTRODUCTION
Neurologic disorders can result in reduced speech intelligibility. A recent goal of speech therapy for these individuals is to improve speech intelligibility by addressing the underlying laryngeal pathology [1]. Laryngeal dysfunction in individuals with neurologic disorders can include decreased or increased adduction of the vocal folds (hypoadduction or hyperadduction), difficulty in producing a stable voice (phonatory instability), and impaired coordination of movements (phonatory incoordination). These dysfunctions may reduce speech intelligibility by affecting the perceptual characteristics of pitch, loudness, quality, intonation, and voiced-voiceless contrasts [2].

Developed in the late 1980’s, the Lee Silverman Voice Treatment® (LSVT) was designed to use a direct phonatory approach to improve vocal fold adduction characteristics in Parkinson’s disease, a neurological disorder affecting the basal ganglia. Because the voices of individuals with PD are characteristically weak and breathy, effortful and intensive phonatory exercises became the focus of treatment. Data gathered since 1995 support the effectiveness of the LSVT on the improvement of both vocal function and speech intelligibility in PD [3]. More recent studies suggest that the effects of LSVT extend beyond phonation and include improved voice quality, prosody, articulation, speech intelligibility and swallowing [4]. Ramig et al. speculate that these effects are related to increased motor drive as well as improvement in self-monitoring skills.

While the LSVT was designed specifically to treat vocal weakness in PD, the more global impact of this treatment on general communicative behaviors suggests that it may tap into deeper motor control systems, and be an appropriate approach for a variety of neurologic conditions. The purpose of this paper is to review findings from three studies applying LSVT to individuals with the neurological conditions of Multiple Sclerosis (MS), ataxic dysarthria and stroke (CVA).

2. STUDY #1: LSVT AND MULTIPLE SCLEROSIS

2.1. Background
Approximately 40-45% of individuals with MS suffer from reduced speech intelligibility [5]. The specific characteristics will depend upon the location of the lesions in the central nervous system, the severity of the neurologic involvement and the fluctuating nature of the disease. Petajan et al. [6] have discussed the interaction between fatigue, disuse atrophy and depression in individuals with MS. They argued that exercising the system that is prone to fatigue could minimize these three factors. They demonstrated that individuals with MS who had received intensive aerobic training improved significantly in fitness and quality of life, whereas those who did not receive such training did not improve. Given these findings, LSVT was administered to two individuals with MS to determine if a treatment approach using high effort vocal exercise would improve speech intelligibility [7].

2.2. Subjects and Treatment
Two women with MS took part in this study. Subject 1 (S1) was 47 years old and had been diagnosed with MS 12 years earlier. Subject 2 (S2) was 48 and had had MS for 15 years. Both subjects were stable on their medications, and both were in remission at the time of the study. Voice characteristics included reduced loudness and fatigue. Subjects reported intelligibility as a significant communication problem.

The LSVT was administered as described elsewhere [8]. Briefly, patients are led through a repeated series of simple, high-effort exercises designed to maximize phonatory efficiency and improve phonatory-respiratory coordination.
through increasing vocal loudness. Exercises are carried over into hierarchical speech tasks for generalization. Therapy is administered four times a week for four weeks, each session lasting one hour.

2.3. Procedures

Audio recordings were made in a sound treated booth using a head-mounted microphone (AKG-C410) at 8 cm and a sound level meter (Bruel and Kjaer 2230) at 30 cm from the lips. Subjects were instructed to perform the following tasks: 1) sustain “ah” for as long as possible, six times; 2) read the “Rainbow Passage”; 3) describe a picture; and 4) speak freely on a topic of their choice for 30 seconds. Sound pressure level (SLP), duration of sustained phonation, and perceptual ratings of vocal loudness were made. Recordings were made several times immediately prior to treatment, immediately following treatment, and at 6 months follow up.

2.4. Results

The authors found that both individuals showed significant improvement in SPL across all tasks (see figure 1 below for S1 data), which were maintained out to 6 months after treatment terminated.

![Figure 1](sound-pressure-level-subject-1.png)

Duration of sustained phonation and perceptual ratings of vocal loudness were also significantly improved for both subjects. Table 1 below presents perceptual ratings of loudness for subject 1, made by naïve listeners.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>SEM</th>
<th>F (1,10)</th>
<th>P &lt;</th>
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<tbody>
<tr>
<td>Rainbow</td>
<td>35</td>
<td>2.65</td>
<td>2.06</td>
<td>41.74</td>
<td>0.001</td>
</tr>
<tr>
<td>Picture</td>
<td>46.5</td>
<td>1.68</td>
<td>2.41</td>
<td>65.06</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 1: Perceptual rating of loudness by naïve listeners (0 = normal; 100 = too soft)

3. STUDY #2: LSVT AND ATAXIC DYSARHTIRA

3.1. Background

Ataxic dysarthria is a motor speech disorder associated with cerebellar dysfunction. Past studies of the treatment of ataxic dysarthria have reported only modest or limited improvement in speech intelligibility or naturalness following treatment geared toward teaching the patient to change and monitor articulatory precision, rate, stress patterning or pitch inflection [9]. Studies of healthy speakers and those with PD have provided positive evidence for the effects of loud phonation on speech production [4]. It has been suggested that loud phonation may serve as a global variable, affecting multiple systems and upscaling the output of these systems. Sapir et al. [10] examined changes in acoustic and perceptual measures of speech, as well as functional outcomes and overall communicative ability in an individual with ataxic dysarthria treated with LSVT.

3.2. Subject and Treatment

The subject involved in the study was a 48-year-old female with a 16-year history of iatrogenically-induced thiamine deficiency encephalopathy, resulting in cerebellar dysfunction. She was described as having a weak, breathy and hoarse voice, with low pitch and reduced pitch variability. Articulatory movement was reduced in coordination. Independent evaluation by a speech pathologist with experience in motor speech disorders led to a diagnosis of ataxic dysarthria.

The LSVT was administered as described above.

3.3. Procedures

Data were collected from the subject 3 times during the week prior to therapy, twice immediately following therapy, and once 9 months after therapy terminated. Audio recordings were made in a sound treated booth using the same procedures for study #1 above, except the microphone was placed at a distance of 6 cm from the lips. In addition to the sustained phonation, reading and spontaneous speech tasks, the subject was also asked to read a set of sentences used for articulatory acoustic analysis. Measurements included sound pressure level (SPL), fundamental frequency (F0) mean and variability, formant frequencies for vowels, perceptual ratings of speech, and an employment satisfaction scale. Select measurements will be discussed below.

3.4. Results

3.4.1. Acoustic Analysis

All acoustic measurements (SPL, F0, F1 and F2) exhibited significant changes pre-post and pre-fu LSVT indicating improvement.

Of particular interest may be the articulatory dynamics of vowel production, suggesting a more coordinated speech production following therapy and the likelihood of improved intelligibility. Figure 2 below illustrated changes in format frequencies of the vowels produced in the sentence “the potato stew is in the pot”, before and after treatment. Panel b illustrates increases in the excursion of the second formant frequency, suggestive of greater articulatory movements and more precise achievement of target sounds. Increases in format dynamics – expressed as standard deviations for F1 and F2 traces for vowel sequences within sentences (see figure below) – were found to be significant for all three sentences and all conditions (pre-post and pre-fu) except for F1 in the sentence: “the potato stew is in the pot”.

![Figure 2](articulatory-acoustic-analysis.png)
Figure 2: Spectrographic display with F1 and F2 traces for vowels in *The potato stew is in the pot*, before treatment (panel a) and after (panel b). X axis indicated frequency (Hz); Y axis is time. Note greater excursion of vowel formants after treatment.

3.4.2. Perceptual Ratings

Perceptual ratings of both speech articulation and vocal intonation indicate improvements. For articulation ratings, it was found that both the post and follow-up samples were significantly more likely to be rated as having better articulatory precision than the pre LSVT samples, supporting the acoustic evidence above (table 2).

<table>
<thead>
<tr>
<th>Treatment condition</th>
<th>N =</th>
<th>Pre</th>
<th>Post</th>
<th>Fu</th>
<th>Same</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre vs. post</td>
<td>285</td>
<td>30</td>
<td>205</td>
<td>--</td>
<td>50</td>
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<tr>
<td>Pre vs. fu</td>
<td>234</td>
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<td>--</td>
<td>165</td>
<td>45</td>
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<tr>
<td>Post vs. fu</td>
<td>312</td>
<td>--</td>
<td>36</td>
<td>103</td>
<td>173</td>
</tr>
</tbody>
</table>

Table 2: Listener ratings of articulatory precision comparing pairs of multiple repetitions of three sentences (“The blue spot is on the key,” “When sunlight strikes raindrops in the air,” and “The potato stew is in the pot”). Listeners were asked to choose the sentence with “better articulatory precision”, or indicate whether the two sentences sounded the same.

Intonation was also found to improve significantly from pre-to-post, but this improvement was not maintained at follow up (table 3).

<table>
<thead>
<tr>
<th>Treatment condition</th>
<th>Pre</th>
<th>Post</th>
<th>Fu</th>
<th>Same</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre vs. post</td>
<td>1</td>
<td>25</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Pre vs. fu</td>
<td>3</td>
<td>--</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Post vs. fu</td>
<td>--</td>
<td>25</td>
<td>1</td>
<td>--</td>
</tr>
</tbody>
</table>

Table 3: Listener ratings of intonation for pre vs. post-, pre vs. fu- and post vs. fu-treatment pairs of the “Rainbow Passage.” Listeners were asked to choose the passage with “better or more normal intonation”, or indicate whether the two passages sounded the same.

4. LSVT AND STROKE

Changes in intelligibility have also been reported in individuals following cerebral vascular accident (CVA), together with changes in vocal functioning [9]. Given similarities in some perceptual characteristics of speech and voice among individuals with PD and stroke, it is reasonable to consider using LSVT for individuals with stroke.

Recently, Will et al. (2002) conducted two case studies to obtain preliminary data regarding changes in voice and speech after LSVT in two subjects who had stroke (CVAs). The results documented improvements in vocal SPL, perceptual ratings of speech and voice and improved articulatory acoustics. Increases in SPL ranged from 6.0-12.8dB (at 30cm) and continued to be above pre-treatment levels at 4 months post for one subject. The second subject increased vocal SPL from .2 to 6.8dB (at 30cm) and maintained these changes 4 months post-treatment.

Both subjects reported increased confidence in their ability to communicate and positive changes in their daily functional communication following treatment. Results from these cases suggest that LSVT improved vocal SPL and articulatory characteristics of speech in individuals with stroke.

5. DISCUSSION

We do not have a complete understanding of the underlying physiologic mechanisms that allow improved voice and speech in individuals with these neurological conditions following LSVT. Studies in animals suggest that the limbic system, anterior cingulate cortex, thalamus and basal ganglia are involved in the regulation of vocal intensity associated with emotive vocalization [11]. Brain stimulation and cell recordings in animals indicate that emotive vocalization is associated with co-activation of the respiratory, phonatory and oral facial muscles [11]. The periaqueductal gray, which receives input from most of the areas of vocalization and sensory input from the vocal periphery, is also involved in the regulation of vocal intensity [11]. Taken together, these findings suggest that the global effects of loud phonation may be mediated via common neural mechanisms [10].

The neural mechanisms that regulate ‘loud phonation’ appear to have a role in cognitive and executive functions such as drive, goal directed activity, attention to action, self-regulation, internal cueing and motor learning. Therefore the
use of loud vocalization to improve voice and speech production may also result in improved learning and maintenance of learned vocal behaviors through stimulation of these central mechanisms [10].

Today, only a small percentage of patients with chronic neurologic disease receive treatment to improve speech and voice. The improvement measured in the case studies reviewed here suggest that the effects of LSVT may not be restricted to the dysarthria associated with idiopathic PD.

6. REFERENCES


