EFFICACY OF LSVT LOUD IN A MULTILINGUAL CLIENT WITH HYPOKINETIC DYSARTHRIA AND PROGRESSIVE SUPRANUCLEAR PALSY

by

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ABSTRACT

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Efficacy of LSVT LOUD in a Multilingual Client with Hypokinetic Dysarthria and Progressive Supranuclear Palsy

Thesis directed by Associate Professor Allison Hilger

Purpose The purpose of this study was to determine whether LSVT LOUD (Lee Silverman Voice Treatment) would improve vocal features, communicative effectiveness, quality of life, and cognition for a multilingual participant with complex comorbidities seeking treatment for hypokinetic dysarthria.

Method This study used a case study design. The participant completed 16 one-hour sessions of LSVT LOUD treatment. Pre, post, and three-month maintenance data were collected.

Results This study found improvements in measures of vocal quality, vocal loudness, intelligibility, communicative effectiveness, quality of life, and increases in cognitive functioning immediately post treatment. Three months post treatment, improvements in vocal quality, intelligibility, and some measures of quality of life were maintained.

Conclusion The results indicate that LSVT LOUD was an appropriate treatment choice for the participant and resulted in some meaningful changes in vocal quality, intelligibility, and quality of life.

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CHAPTER I

INTRODUCTION

LSVT LOUD (Lee Silverman Voice Treatment) is an effective treatment for hypokinetic dysarthria secondary to Parkinson's Disease (Ramig et. al, 2001). While recent research suggests LSVT LOUD may also be effective in patients who experience dysarthria secondary to a variety of congenital and acquired conditions, the efficacy of LSVT LOUD in complex patients with a history of multilingualism and comorbid deficits is currently undefined. Speech-language pathologists are likely to encounter complex patients over the course of their career and have a dearth of evidence to support their clinical decisions. It is essential that the evidence base for well-known treatments such as LSVT LOUD be expanded to include complex cases and client profiles that do not fit the populations examined in current research so that clinicians have additional relevant evidence to inform their clinical decision making. The purpose of this study is to conduct a case study of a multilingual man with cognitive impairment and hypokinetic dysarthria due to suspected progressive supranuclear palsy.

CHAPTER II

REVIEW OF THE LITERATURE

LSVT LOUD was originally designed as a speech treatment for patients with hypokinetic dysarthria resulting from Parkinson's disease. According to Sapir and colleagues (2011), the neural mechanisms underlying the speech disorders associated with Parkinson's disease are complex and may include a range of factors including internal cueing deficits, scaling movement amplitude deficits, and sensory processing abnormalities in addition to muscle rigidity and hypokinesia secondary to dopamine deficiency. Bowed vocal folds (Blumin et al., 2004), decreased range of articulatory motion (Skodda et al., 2011), and a lack of respiratory support (D'Arrigo et al., 2020) frequently contribute to reduced intelligibility in Parkinson's Disease. The overarching goal of LSVT LOUD is to enhance intelligibility (Baumen et. al, 2018) by improving laryngeal closure, increasing articulatory range of motion, and increasing respiratory support (Ramig et al., 2004). LSVT LOUD achieves this goal by utilizing the principles of motor learning and neural plasticity.

LSVT LOUD follows a high dosage and high intensity standardized protocol. Clients complete 16 one-hour treatment sessions delivered across four consecutive days per week for four weeks. Each session consists of four daily exercises that remain the same throughout treatment (i.e., sustained phonation, pitch glides up, pitch glides down, functional phrases) and speech hierarchy exercises that progress from word level to conversational level over the course of treatment. Within each session, participants complete a minimum of 15 repetitions of each of the daily exercises, and patients are driven to produce high intensity effort throughout the entire session. Sensory calibration activities are embedded within sessions, and daily carryover and homework activities are provided to promote generalization of target voice outside of the therapy room.

In all LSVT LOUD treatment activities there is a single focus: "be loud." This focused, simple cue promotes changes across speech mechanism systems, and its simplicity is ideal for patients with cognitive deficits. LSVT LOUD further minimizes cognitive load during treatment through the use of modeling and shaping techniques. Clients are simply instructed by the clinician to "do what I do" and are provided with cuing for loudness rather than given lengthy explanations.

There is an increasing amount of evidence suggesting that LSVT LOUD is beneficial for populations outside of English-speaking patients with hypokinetic dysarthria resulting from Parkinson's Disease. Moya-Galé and colleagues (2018) demonstrated that LSVT LOUD improves speech in patients who do not speak English as their native language. Treatment improved intelligibility at the conversational level in a group of native Castilian Spanish speakers with hypokinetic dysarthria secondary to PD, and the authors theorize that treatment would likely produce similar results in patients who speak other dialects of Spanish.

LSVT LOUD is also beneficial for use in individuals with congenital and acquired neurological conditions. In a case study following two adult participants with intellectual and language impairments resulting from Down's Syndrome, a positive treatment effect was observed for acoustic measure of loudness and phonatory stability following LSVT LOUD treatment (M"ah"ler & Jones, 2012). Two women with Multiple Sclerosis (MS) demonstrated improved vocal loudness, decreased vocal fatigue, increased perceived communicative effectiveness, and improved confidence following LSVT LOUD treatment (Sapir et al., 1999). Similarly, Baldanzi and colleagues (2020) found LSVT LOUD increased vocal loudness, decreased vocal fatigue, and improved self-perception of voice in individuals with MS. A study by Mahler & Ramig (2012) found that adults with dysarthria secondary to stroke showed improved phonatory stability, vowel space area and listener preference in addition to increased dB SPL. In a separate study following patients with dysarthria secondary to TBI and stroke, Wenke et. al (2009) found improvements in both acoustic measures (i.e., vocal frequency range and improved word and sentence intelligibility) and measures of communicative effectiveness and quality of life (i.e. improved ratings of communication initiation and participation and well-being). Sale et al. (2015) found LSVT LOUD to be efficacious in a group of 16 patients with Progressive Supranuclear Palsy, noting cross-system effects on laryngeal and respiratory functions, as well as improved speech intelligibility. These studies support the hypothesis that LSVT LOUD encourages cross-system improvements that positively impact speech and increases neural plasticity. The intensity and simple, focused cuing found in LSVT LOUD appears to be beneficial for patients with cognitive deficits resulting from congenital or acquired conditions.

The participant in this study is a multilingual 69-year-old male with suspected Progressive Supranuclear Palsy. He demonstrates mild-moderate hypokinetic dysarthria characterized by reduced intelligibility (estimated at 80% at the conversational level), monoloudness, monopitch, and occasional rushes of accelerated speech. Vocal quality is rough with occasional pitch breaks. The participant is a native French speaker who learned Spanish as a second language in high school and English as a third language at age 23. At present, he primarily speaks English for daily communication and uses both French and English at home. Given the participant's known hypokinetic dysarthria, cognitive deficits, and multilingualism, it is likely that he will benefit from the intensity, structure, and simple cuing of LSVT LOUD.

CHAPTER III

DESIGN AND METHOD

Design

This study was a case study to determine whether LSVT LOUD would improve vocal features, communicative effectiveness, quality of life, and cognition for a multilingual participant with complex comorbidities seeking treatment for hypokinetic dysarthria. A case study is an intensive investigation of an individual in which the researcher identifies key variables of interest for which to collect and analyze data. Case studies can offer additional information that may fill in knowledge gaps that exist in the current literature.

In this study, pre-treatment measures of speech acoustics, participant perception of speech and communication, spouse perception of speech and communication, quality of life, and cognition were taken prior to beginning treatment. The participant then completed 16 sessions of LSVT LOUD. Post-treatment data were collected immediately following treatment and three months post treatment.

Research questions

This study aimed to determine whether LSVT LOUD is an effective treatment for improving the following in a multilingual participant with complex comorbidities: (1) speech intelligibility, (2) vocal quality, (3) prosodic variation, (4) loudness, (5) communicative effectiveness, (6) participant and caregiver perception of voice, (7) quality of life, and (8) cognitive function.

Participant

The participant in this study is a 69-year-old man recruited from the University of Colorado Speech, Language, and Hearing Clinic (CU SLHC). The participant was born in France and learned French as his first language. In high school, he learned Spanish as a second language, and reported he no longer considers himself fluent and speaks it only casually at present. He learned English at age 23, and it has been his dominant language since moving to the United States. Presently, he primarily speaks English for daily communication at home with occasional use of French. The participant reported being born left-handed but uses his right hand to write. The participant reported a history of head injuries from skiing, and believes he may have dyslexia, although it was never formally diagnosed. The participant reported diplopia and had not yet received updated lenses at the time of the study. Memory and executive functioning deficits were first noted in 2016. In 2018, symptoms reported by the participant included word finding impairment and difficulty “speaking fluently,” and family members noted the participant was “less talkative, less motivated and outgoing.”

The participant’s most recent videostroboscopy vocal fold exam completed by an otolaryngologist in 2020 indicated vocal fold bowing but no other laryngeal pathology. Results from a videofluoroscopic swallowing study completed in 2021 noted transient penetration with large amounts of thin liquids and no evidence of aspiration. Magnetic Resonance Imaging results from 2019 demonstrated age advanced cerebral atrophy involving the frontal, parietal, and temporal lobes, and midbrain atrophy. The participant's most recent neurology report stated that the overall impression is consistent with "Progressive Supranuclear Palsy, though a somewhat atypical presentation." The participant's symptoms of note include a wide-based gait, difficulty moving eyes upward, early/progressive falls (often backwards), and imaging report of midbrain atrophy. The participant was first seen by a neurologist in 2019 following complaints of progressive decline in memory and executive functioning, followed by changes in language and voice. Initially, the nonfluent variant of Primary Progressive Aphasia was suspected but was subsequently ruled out when the participant's language skills remained relatively stable over time.

The participant completed a formal speech and language evaluation in French and English at the University of Colorado Speech Language and Hearing Clinic in 2020. He was given the diagnosis of mild-moderate aphasia, mild-moderate cognitive communication deficit, and mild-moderate hypokinetic dysarthria. His cognitive communication deficit was characterized by deficits in memory, visuospatial skills, and executive functions. At the time of evaluation, his dysarthria was characterized by imprecise articulation, reduced loudness, monoloudness, monopitch, a breathy vocal quality, an occasional rapid rate of speech with short rushes of speech, palilalia, and fatigue with longer periods of speech production. Prior to the start of the study, his intelligibility was estimated to be approximately 80% at the conversational level by an unfamiliar listener (i.e., clinician who was not providing treatment to the participant in this study).

The participant received individual speech-language therapy outside of the university clinic from 2019-2020, and both individual and group therapy at the CU SLHC beginning in the fall of 2020. Previous treatment targeted inspiratory and expiratory muscle strength training, use of attention and memory strategies, use of compensatory strategies to address word finding difficulties, improving sleep and exercise, engaging in daily activities that promote cognitive and language stimulation, independently asking follow-up questions during conversation, and independently expanding and elaborating on responses to questions during conversation.

Baseline measures

Hearing was assessed using a standard hearing screening procedure. Octave intervals between 500 and 6000 Hz were presented at 25 dB HL in a sound booth via supra-aural headphones. The participant responded to all tones at 25dB with the exception of 500 Hz in the right ear, for which the participant responded at 30dB.

An oral peripheral exam was conducted to assess the oral mechanism and cranial nerve functioning. Twitching of the right corner of the mouth when at rest and mild left-sided weakness of the tongue was noted when resisting lateral pressure from the clinician. Diadokinetic rate was calculated for /pʌ/, /tʌ/, /kʌ/, and /pʌtəkə/ to assess articulatory agility and coordination. Intermittent incoordination and short bursts of speech followed by inhalation were noted.

Table 1. Baseline: Diadochokinetic Rate

Baseline- Diadochokinetic Rate			
	Participant syllables produced per second	Norms- Median (SD)	Range

/pʌ/	4.2	6.9 (0.81)	5.3-7.8
/tʌ/	5	6.8 (0.43)	5.7-7.3
/kʌ/	4.2	6.3 (0.75)	5.0-8.1
/pʌtəkə/	1.4	6.1 (1.41)	3.0-8.0
Norms for males 69-74 years of age (Pierce et al., 2013)			

The participant completed the Patient Health Questionnaire-9 to screen for depression. The patient's responses indicated a moderate depression severity. The participant indicated that functionally, he is "somewhat" having difficulty with life tasks due to his symptoms.

Table 2. Baseline: Patient Health Questionnaire-9

Baseline- Patient Health Questionnaire-9	
Scale: 0= not at all, 1= several days, 2= more than half the days, 3= nearly every day	
1. Little interest in pleasure or doing things	2
2. Feeling down, depressed or helpless	1
3. Trouble falling or staying asleep, or sleeping too much	3
4. Feeling tired or having little energy	1
5. Poor appetite or overeating	0
6. Feeling bad about yourself- or that you are a failure of have let your family down	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	2
8. Moving or speaking so slowly that other people have noticed. Or the opposite- being so fidgety or restless you have been moving around a lot more than usual	1
9. Thoughts that you would be better off dead or hurting yourself in some way	0
Total:	**13**
PHQ-9 Score and Depression Severity: 1-4 none, 5-9 mild, 10-14 moderate, 15-19 moderately severe, 20-27 severe	

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) and the Behavior Rating Inventory of Executive Function–Adult Version, Self-Report Form (BRIEF-A) were used to assess the participant's cognitive functioning. To assess communication effectiveness, the Communicative Effectiveness Survey (CES) was used. Forms were completed by both the participant and his spouse. Participant perception of voice was measured using the Voice Handicap Index (VHI), and the LSVT Perceptual Rating Form was completed by both the participant and his spouse to collect information about their perceptions of the participant's speech. As an additional perceptual measure of vocal quality, the clinician rated the participant's voice using the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V). Speech intelligibility was assessed by asking an unfamiliar listener (i.e., the clinician) to estimate the percent intelligibility of a connected speech sample (i.e., conversation and reading).

Acoustic measures were used to assess vocal quality, prosodic variation, and loudness control. Audio files were recorded in Audacity on a Dell laptop (XPS 15) with an AKG head-worn condenser microphone (C520) digitized through a MOTU UltraLite-mk3 Hybrid Audio Interface. The head-worn microphone was positioned 1cm from the participant's mouth. The audio files were then analyzed using Praat to obtain data for fundamental frequency in Hz (mean, minimum, maximum), intensity in dB SPL (mean, minimum, maximum), harmonics-to-noise ratio, smooth cepstral peak prominence, jitter, shimmer, and segment duration. Acoustic measures were taken for the following tasks: (1) maximum duration for sustained "ah", (2) maximum fundamental frequency range, (3) reading of the "Grandfather passage," (4) generative naming, (5) conversation, (6) dual motor and speech task during conversation (i.e., zipping and unzipping a bag while speaking), and (7) picture description using the "Cookie Theft" image. Acoustic measures were analyzed for the entire audio sample for maximum duration for sustained "ah" and sentence repetition, and for three randomly selected five second samples each from passage reading, conversation, and picture description.

IRB

The University of Colorado Boulder's Institutional Review Board (IRB) determined that approval for this case study was not required. Their review indicated that a case study based on an adult participant who was treated in the University clinic was already protected under HIPAA. No additional review or approval was deemed necessary given all procedures and methods adhered to HIPAA regulations.

Treatment Method

LSVT LOUD is a standardized, intensive voice treatment designed to improve speech intelligibility in patients with hypokinetic dysarthria due to Parkinson's Disease. LSVT LOUD targets the underlying components of hypokinetic dysarthria and seeks to improve respiratory support and laryngeal closure, as well as encourage increased range of motion in articulation (Ramig et al., 2004). LSVT accomplishes these goals by focusing on a single target: loudness. "Loud" is a simple cue which triggers cross-system effects (Fox et al., 2006). Loudness is targeted with intensive and high effort practice and calibration activities to promote generalization to daily speaking. The treatment utilizes clinician cues for loudness, modeling, and positive feedback to shape a loud voice with good vocal quality that the client uses consistently outside of sessions.

Treatment is provided over the course of 16 one-hour sessions conducted four days per week over the course of four consecutive weeks. Each one-hour session consists of daily activities, which include high intensity repetitions through a sustained vowel task, pitch glides up and down, production of a set of ten functional phrases, speech hierarchy tasks and spontaneous speech. The speech hierarchy tasks utilize materials and topics that are salient to the client, and gradually build from the word/phrase level in week one, to the sentence level in week two, to the paragraph level in week three, and finally the conversational level in week four. Calibration is addressed throughout each session and seeks to build the clients' ability to self-cue use of adequate effort when producing loud speech, which in turn results in more intelligible speech.

Additionally, clients are given daily calibration assignments and homework assignments. Homework consists of six repetitions each of the daily exercises (i.e., sustained phonation, pitch glides up, pitch glides down), repetition of functional phrases, and speech hierarchy practice. Homework is completed once per day on days the client receives treatment, and twice per day on days the client does not receive treatment. Clients are expected to continue the daily practice routine following the completion of treatment to promote maintenance of treatment effects.

The participant completed 16 LSVT LOUD treatment sessions between June 7 - July 1, 2021.

Table 3. Treatment Timeline

Treatment Timeline	
Date	**Activity**
6/2/2021	Baseline measures taken
6/7-6/11/2021	Week 1 LSVT LOUD Administered
6/14-6/17/2021	Week 2 LSVT LOUD Administered
6/21-6/25/2021	Week 3 LSVT LOUD Administered
6/28-7/1/2021	Week 4 LSVT LOUD Administered
7/1/2021	Immediate post data taken for acoustic measures, VHI, CES, LSVT Perceptual Scale, CAPE-V
7/7/2021	Post data taken for RBANS, BRIEF-A
10/5/2021	3 month post data taken for for acoustic measures, VHI, CES, LSVT Perceptual Scale, CAPE-V

Statistical Analysis

Statistical analyses were conducted with R version 4.0.5 (R Core Team, 2021) using RStudio version 1.4.1103 (RStudio Team, 2021). Five Bayesian unequal variances models were run using Stan modeling language (Carpenter et al., 2017) and the R package brms (Burkner, 2018). Bayesian modeling was chosen in contrast with frequentist modeling because of the robust ability to model unequal variances. Considering that standard deviation is rarely equal between two groups, building a model with unequal variances was more appropriate for this dataset. For all models, default priors were specified.

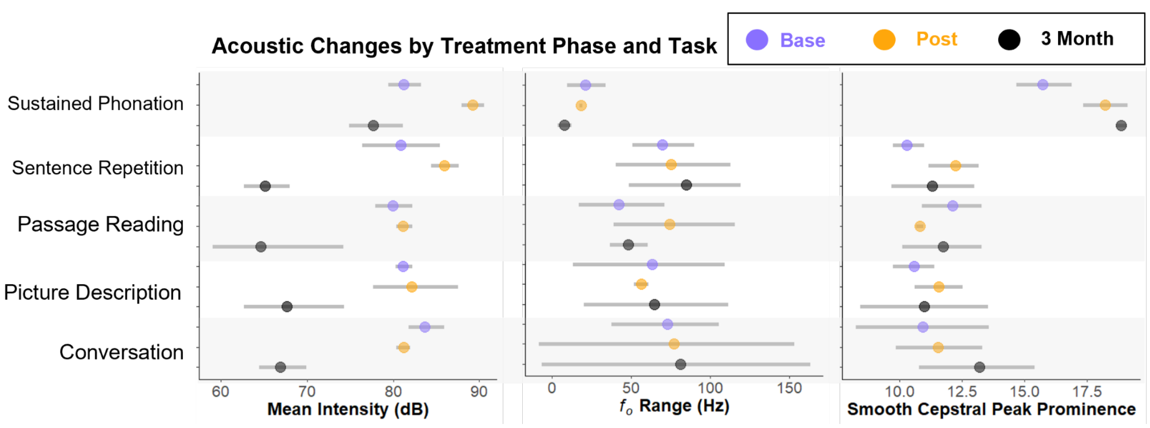
Each model assessed the production of mean intensity, f_o range, and smooth cepstral peak prominence by treatment phase (baseline, post-treatment, and three-month) separately for each speaking task (sustained phonation, sentence repetition, passage reading, picture description, and conversation). To model unequal variances, the models included separate sigma parameters for the baseline phase vs. post-treatment phase. Four sampling chains with 2,000 iterations were run for each model with a warm-up period of 1,000 iterations. 95% credible intervals (CI's) and probability of direction for each effect are reported. Probability of direction (*pd*) is the probability that a parameter is positive or negative (Makowski et al., 2019). Given that a value of zero indicates no effect, a high *pd* value indicates a greater probability that the effect is greater than zero. The 95% CI means that we are 95% certain that the true value lies within a specified interval.

CHAPTER IV

RESULTS

Acoustic Measures

Figure 1. Acoustic Changes by Treatment Phase and Task



Note. Mean estimate and 95% credible interval for mean intensity (left), f_o range (middle), and smooth cepstral peak prominence (right) by treatment phase and speaking task. Treatment phase is indicated for each speaking task by baseline testing (purple), post-treatment testing (orange), and three-month post-treatment maintenance testing (gray).

Table 4. Acoustic Changes by Treatment Phase and Task

		Mean Intensity (dB)	*fo* Range (Hertz)	Smooth Cepstral Peak Prominence

Task	*Phase*	*Estimates*	*CI (95%)*	*pd*	*Estimates*	*CI (95%)*	*pd*	*Estimates*	*CI (95%)*	*pd*
Sustained Phonation	Base	81.24	(79.63, 82.64)		21.03	(5.33, 9.78)		15.61	(14.63, 16.42)	
	Post - Base	**7.93**	**(5.90, 9.97)**	**100.00 %**	1.28	(-24.40, 24.53)	57.03%	**2.64**	**(1.50, 3.92)**	**99.67%**
	3-Month - Post	**-11.59**	**(-16.41, - 7.58)**	**99.35%**	-15.7	(-45.15, 14.85)	89.10%	**0.6**	**(-0.29, 1.49)**	**94.75%**
	3-Month - Base	**-3.76**	**(-9.22, 0.30)**	**96.92%**	**-13.88**	**(-27.33, 0.19)**	**97.55%**	**3.21**	**(2.14, 4.19)**	**99.92%**
Sentence Repetition	Base	80.98	(77.41, 84.53)		69.46	(50.48, 88.99)		10.33	(9.76, 10.91)	
	Post - Base	**5.01**	**(1.02, 8.96)**	**98.92%**	5.66	(-36.87, 51.98)	62.50%	**1.93**	**(0.73, 3.14)**	**99.30%**
	3-Month-Post	**-20.95**	**(-25.20, - 17.68)**	**100.00 %**	6.39	(-44.25, 53.93)	63.28%	-0.91	(-3.08, 1.14)	84.72%
	3-Month - Base	**-15.89**	**(-21.99, - 10.13)**	**99.95%**	12.96	(-25.34, 49.79)	80.00%	1	(-0.78, 2.79)	89.40%
Passage Reading	Base	79.64	(78.31, 81.06)		41.51	(17.85, 62.00)		12.1	(10.34, 13.47)	
	Post - Base	1.42	(-0.34, 3.23)	57.15%	32.47	(-10.95, 76.85)	76.17%	**-1.28**	**(-2.68, 0.46)**	**93.47%**
	3-Month - Post	**-16.39**	**(-21.61, - 5.87)**	**99.38%**	-24.5	(-66.51, 15.64)	65.53%	0.84	(-0.97, 2.20)	72.67%
	3-Month - Base	**-15.05**	**(-20.69, - 4.28)**	**99.35%**	6.82	(-20.53, 35.51)	50.75%	-0.51	(-2.96, 1.30)	62.12%
Picture Description	Base	81.11	(80.16, 81.95)		64.42	(44.22, 88.31)		10.64	(9.73, 11.54)	
	Post - Base	0.16	(-3.37, 3.13)	57.15%	-7.71	(-33.26, 13.06)	76.17%	**0.92**	**(-0.57, 2.24)**	**93.47%**
	3-Month - Post	**-14.27**	**(-24.13, - 4.85)**	**99.38%**	7.45	(-42.33, 52.29)	65.73%	-0.66	(-3.78, 2.34)	72.67%
	3-Month	**-13.57**	**(-18.92, -**	**99.35%**	-0.25	(-89.89,	50.75%	0.35	(-2.71,	62.12%

	- Base		**4.80)**			83.97)			3.32)	
Conversation	Base	83.48	(81.62, 85.23)		73.04	(36.58, 104.81)		10.84	(8.12, 13.37)	
	Post - Base	**-2.34**	**(-4.23, -0.17)**	**97.92%**	8.54	(-76.64, 85.17)	61.38%	0.69	(-2.45, 4.10)	71.38%
	3-Month - Post	**-14.36**	**(-17.18, -11.50)**	**100.00%**	10.68	(-119.09, 149.26)	56.47%	1.49	(-1.68, 4.47)	88.33%
	3-Month - Base	**-16.78**	**(-20.14, -13.32)**	**100.00%**	10.97	(-83.00, 97.86)	60.50%	**2.13**	**(-1.77, 5.53)**	**90.33%**

Note. Median estimate and 95% credible interval for the Bayesian unequal variances model on the effect of task and treatment phase on the production of mean intensity, f_o range, and smooth cepstral peak prominence. The phase column indicates the parameter estimates for the baseline testing phase as well as the estimates for the difference between the post-treatment testing phase and the baseline testing phase. Probability of direction (pd) indicates the probability that the difference between testing phases is strictly positive or negative. Bolded parameters indicate compelling evidence for the effect.

Figure 1 and Table 4 display the parameter estimates and 95% credible interval for mean intensity, f_o range, and smooth cepstral peak prominence by treatment phase and speaking task. Contingent on the data and model, there is compelling evidence that mean intensity increased in the post-treatment phase for sustained phonation (β = 7.93 dB, 95%CI = [5.90, 9.97]) and sentence repetition (β = 5.01 dB, 95%CI = [1.02, 8.96]) but decreased in the post-treatment phase for conversation (β = -2.34 dB, 95%CI = [-4.23, -0.17]). For three-month maintenance data, mean intensity decreased compared to post-treatment and baseline phases for all tasks: sustained phonation ($\beta_{3\text{-month - post-treatment}}$= -11.59 dB, 95%CI = [-16.41, -7.48]; $\beta_{3\text{-month - baseline}}$ = -3.76 dB, 95%CI = [-9.22, 0.30]), sentence repetition ($\beta_{3\text{-month - post-treatment}}$= -20.95 dB, 95%CI = [-25.20, -17.68]; $\beta_{3\text{-month - baseline}}$ = -15.89 dB, 95%CI = [-21.99, -10.13]), passage reading ($\beta_{3\text{-month - post-treatment}}$= -16.39 dB, 95%CI = [-21.61, -5.87]; $\beta_{3\text{-month - baseline}}$ = -15.05 dB, 95%CI = [-20.69, -5.87]), picture description ($\beta_{3\text{-month - post-treatment}}$= -14.27 dB, 95%CI = [-24.13, -4.85]; $\beta_{3\text{-month -}}$

baseline = -13.57 dB, 95%CI = [-18.92, -4.80]), and conversation ($\beta_{3\text{-month - post-treatment}}$= -14.36 dB, 95%CI = [-17.18, -11.50]; $\beta_{3\text{-month - baseline}}$ = -16.78 dB, 95%CI = [-20.14, -13.32]). Smooth cepstral peak prominence increased post-treatment for sustained phonation (β = 2.64, 95%CI = [1.50, 3.92]), sentence repetition (β = 1.93, 95%CI = [0.73, 3.14]), and picture description (β = 0.92, 95%CI = [-0.57, 2.24]). Smooth cepstral peak prominence decreased post-treatment for passage reading (β = -1.28, 95%CI = [-2.68, 0.46]). For three-month maintenance data, smooth cepstral peak robustly increased for sustained phonation ($\beta_{3\text{-month - post-treatment}}$= -20.95, 95%CI = [-25.20, -17.68]; $\beta_{3\text{-month - baseline}}$ = -15.89, 95%CI = [-21.99, -10.13]). No robust changes were measured post-treatment for f_o range, however there was a robust decrease in f_o range for the 3-month post-treatment testing compared to baseline (β3-month - baseline = -13.88, 95%CI = [-27.33, 0.19]).

Perceptual and Quality of Life Measures

Figure 2. The Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) Perceived Deviance by Vocal Parameter

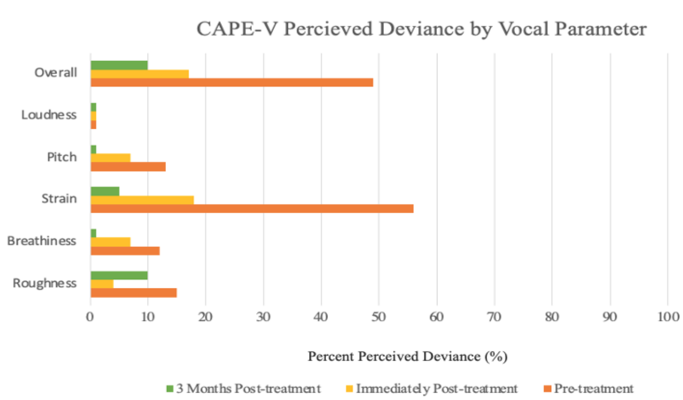


Figure 2 displays CAPE-V measures obtained prior to, immediately post treatment, and three months post treatment. The CAPE-V is a tool for auditory-perceptual analysis of the voice in which the clinician places a tic mark on a 100cm line to indicate perceived severity of each parameter. The line is measured in cm from the left side to give a score out of 100. A score of 0 indicates no deviant vocal quality, while a score of 100 indicates severe vocal quality. "Intermittent" and "Consistent" are descriptors used to qualify whether a parameter is perceived consistently within and across speaking tasks. Immediately post-treatment, improvement was noted in all parameters, but the greatest improvement was observed for strain and overall severity. These improvements were maintained and slightly improved three months post-treatment. The results indicate that perceptual measures of voice (i.e., roughness, breathiness, strain, pitch, loudness, overall severity) improved post-treatment, and were maintained three months post-treatment.

Figure 3. Participant Responses to the LSVT Perceptual Rating Form

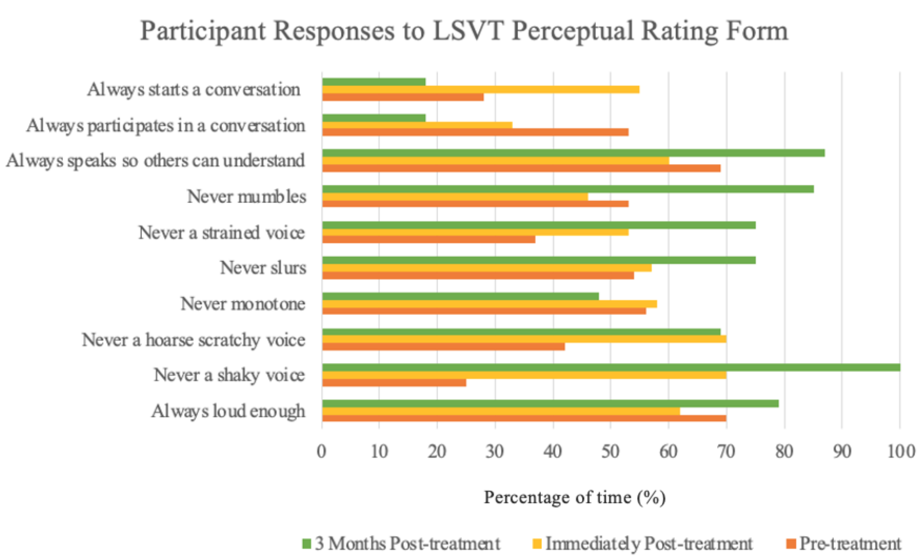


Figure 4. Spouse Responses to the LSVT Perceptual Rating Form

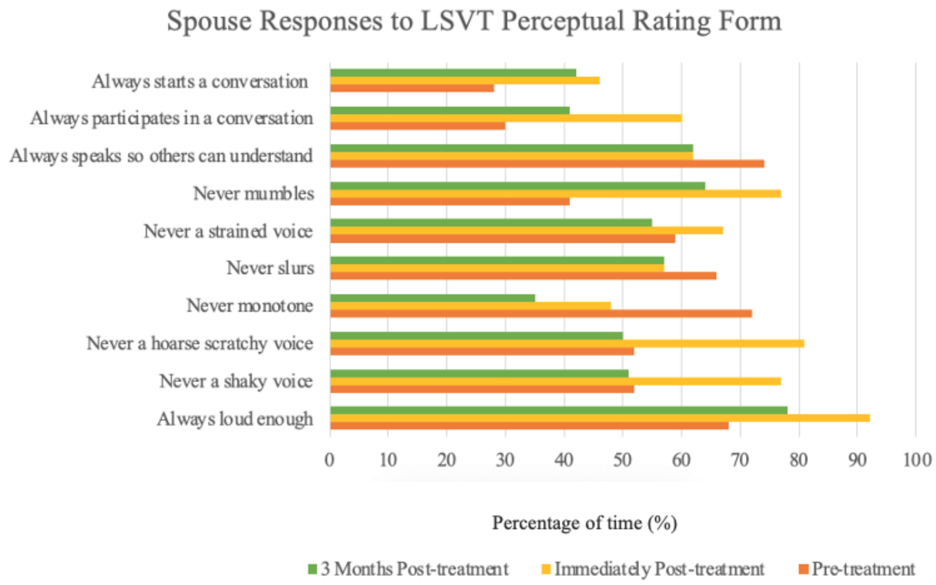


Figure 3 and Figure 4 display participant and spouse responses to the LSVT Perceptual Rating Form prior to treatment, immediately post-treatment, and three months post-treatment. To complete the form, the respondee marks a tic mark on a continuum from "never" to "always." The distance of the tic mark on the line is converted to a percentage of the time for interpretation. Immediately post treatment, both the participant and spouse responses indicated a louder, less shaky, less scratchy and less strained voice and increased participation and initiation in conversations. Three months post-treatment, the participant's responses indicated maintained or improved levels of perception of voice and decrease in conversational participation and initiation that fell below pre-treatment levels. The spouse rated "always loud enough," "always participates in a conversation," and "always starts a conversation" above baseline levels, but below immediate post-treatment levels.

Table 5. Participant and Spouse Responses to The Communicative Effectiveness Survey (CES)

Participant and Spouse Responses to The Communicative Effectiveness Survey (CES)

Key: 1= not at all effective, 4= very effective

Item	Baseline		Immediately Post-treatment		3 Months Post-treatment	
	Participant Response	Spouse Response	Participant Response	Spouse Response	Participant Response	Spouse Response
1. Having a conversation with a family member or friends at home.	2	3	3	3	3	3
2. Participating in conversation with strangers in a quiet place.	2	2	2	3	2	2
3. Conversing with a familiar person over the telephone.	3	3	3	3	3	3
4. Conversing with a stranger over the telephone.	1	1	3	2	2	2
5. Being part of a conversation in a noisy environment (social gathering).	1	2	3	2	2	1
6. Speaking to a friend when you are emotionally upset or angry.	4	2	3	3	3	2
7. Having a conversation while travelling in a car.	2	3	3	4	4	3
8. Having a conversation with someone at a distance (across a room).	2	1	3	2	2	2
Total	**17**	**17**	**23**	**22**	**17**	**18**

Table 5 displays the baseline, immediate post treatment, and three-month maintenance data for the Communicative Effectiveness Survey (CES), completed by both the participant and the participant's spouse prior to treatment, immediately following treatment, and three months post-treatment. The CES asks individuals and caregivers to rate the individual with dysarthria's communicative effectiveness on a four-point scale from 1 (not at all effective) to 4 (very effective) across eight items representing everyday situations. Immediately post-treatment, the total score improved for both the participant and spouse responses, indicating an overall improvement in communicative effectiveness and participation. Specific areas of improvement were noted for conversing with a stranger over the phone, being part of a conversation in a noisy environment, and having a conversation with someone at a distance. Overall, participant and spouse perception of communicative effectiveness improved immediately post-treatment. Three months post-treatment, both the participant and his spouse noted a decrease in communicative effectiveness. The participant's score returned to pre-treatment levels, and the spouse's score decreased to one point above pre-treatment levels.

Table 6. Results: Voice Handicap Index (VHI)

Results from the Voice Handicap Index (VHI)

	Baseline		Immediately Post treatment		3 Months Post treatment	
Domain	**Score**	**Interpretation**	**Score**	**Interpretation**	**Score**	**Interpretation**
Functional	20	Severe	19	Severe	12	Moderate
Physical	22	Severe	17	Moderate	7	Mild
Emotional	24	Severe	29	Severe	24	Severe
Total:	**66**	**Severe**	**65**	**Severe**	**43**	**Moderate**

Table 6 displays the baseline, immediately post treatment, and three-month post-treatment data for the Voice Handicap Index. The VHI measures the influence of voice on quality of life across three domains: functional, physical, and emotional. The respondee indicates a response of 0-never, 1-almost never, 2-sometimes, 3-almost always, or 4-always to a series of statements describing the effects of the voice on daily life. A higher total score indicates a higher level of severity of perceived handicap from the voice. Immediately post treatment, no substantial improvement was noted in the functional and emotional domains. Modest improvement was noted in the physical domain post treatment. The participant's overall score indicates the participant continued to experience severe impact from his voice post treatment. Three months post treatment, the participant's perception of functional impacts of voice decreased to the moderate range, and his perception of physical impacts of his voice decreased to the mild range. Three months post treatment, his overall severity decreased by 22 points to a score of 43, which is considered moderate. A change in total score of 18 points or greater indicates a shift that is not solely a result of VHI variability.

Speech intelligibility was assessed by asking an unfamiliar listener (i.e., clinician who was not providing treatment to the participant in this study) to estimate the percent intelligibility of a connected speech sample (i.e., conversation and reading). The listener estimated the participant's overall intelligibility at 80% pre-treatment, and at 90% post treatment. Perceptually, the participant was judged to be slightly less intelligible in reading tasks than in spontaneous conversation speech pre-treatment. Post treatment, greater gains in intelligibility were noted in reading tasks and intelligibility was judged to be more similar across reading and conversational tasks. Three months post treatment, no measurable change in intelligibility was observed.

Cognitive Measures

Table 7. Results: Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)

Results From the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)

	Form A- Baseline	Form B- Post Treatment

Index Score	Percentile	Score Interpretation	Percentile	Score Interpretation
Immediate Memory	16th	Low Average	16th	Low Average
Attention	0.1st	Very Low	0.4th	Very Low
Language	2nd	Very Low	16th	Low Average
Visuospatial	1st	Very Low	16th	Low Average
Delayed Memory	1st	Very Low	5th	Low
Total score:	**0.3rd**	**Very Low**	**2nd**	**Low**

Table 7 displays the participant's RBANS results by index score and total score in percentile rankings derived from standard scores. The participant's overall score improved from very low (0.3rd %ile) to low (2nd %ile), indicating modest improvement in overall cognitive abilities post treatment. Immediate memory scores remained stable, and improvements were observed in attention, language, visuospatial skills, and delayed memory. Most notably, language and visuospatial scores improved from falling in the very low range pretreatment to low average range post treatment.

Table 8. Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) Discrepancy Analysis

Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) Discrepancy Analysis		
Total Scale Index Score	**Difference between pre/post index score**	**Statistical significance 0.15 level**
Immediate memory	0	10.1
Visuospatial	18*	10.4
Attention	3	10.6
Language	4	10.1

**indicates significant difference*

Table 8 displays the discrepancy analysis of Total Scale Index Scores from the RBANS Form A administered pre-treatment and RBANS Form B administered post treatment.

Discrepancy analysis indicated a statistically significant increase in visuospatial skills post-treatment at the 0.15 significance level. Score changes in other areas were not found to be statistically significant.

Table 9. Results: Behavior Rating Inventory of Executive Function–Adult Version (BRIEF-A) Self-Report Form

Results: Behavior Rating Inventory of Executive Function–Adult Version (BRIEF-A) Self Report Form

	Baseline		Immediately Post Treatment	
Executive Function	**T-Score**	**Percentile**	**T-Score**	**Percentile**
Inhibit	54	80th	58	87th
Shift	58	85th	58	85th
Emotional Control	71*	98th	71*	98th
Self-monitor	61	86th	56	75th
Initiate	61	87th	61	87th
Working Memory	71*	95th	52	66th
Plan/organize	59	85th	59	85th
Task Monitor	63	89th	68*	98th
Organization of materials	69*	93rd	72*	98th

*t-scores of 65 or greater are considered clinically significant

Table 9 displays t-score and percentiles for participant responses to the BRIEF-A both pre- and post-treatment. Higher scores on the BRIEF-A indicate more impact in a particular area of executive functioning, whereas lower scores indicate less impact. A t-score of 65 or greater is considered clinically significant. Results indicate working memory improved post treatment, and that task monitoring declined post treatment. T-scores for working memory, emotional control, and organization of materials were elevated to clinically significant levels prior to treatment. Following treatment, the t-score for working memory was no longer in the clinically significant range. T-scores for emotional control and organization of materials remained elevated in the clinically significant range following treatment. The t-score for task monitoring did not fall in the clinically significant range prior to treatment, however, was elevated to clinically significant levels post treatment.

CHAPTER V

DISCUSSION

This study sought to determine whether LSVT LOUD would improve vocal features, communicative effectiveness, quality of life, and cognition for a multilingual participant with complex comorbidities seeking treatment for hypokinetic dysarthria. Immediately post treatment, vocal intensity and vocal quality improved for less complex speaking tasks (e.g., sustained phonation and sentence repetition). Additionally, the participant and his spouse's perception of communication effectiveness and vocal quality improved post treatment. Three months post treatment, positive changes in vocal quality and intelligibility were maintained, and the participant's perception of negative impacts of voice in the physical and functional domains decreased from immediate-post-treatment levels.

Acoustic findings

The main acoustic findings of this study were that vocal quality (measured as smooth cepstral peak prominence) increased post-treatment during sustained phonation, sentence repetition, and picture description tasks. Three months post-treatment gains in vocal quality were maintained across tasks, and improved beyond immediate post-treatment levels in conversation. Vocal intensity (measured as mean vocal intensity) increased for sustained phonation and sentence repetition immediately post-treatment. Three months post-treatment, vocal intensity dropped below baseline levels on all tasks. No meaningful change in f_o range was observed across tasks both immediately post-treatment and three months post treatment.

Immediately post-treatment, vocal quality and vocal intensity improved in simpler, less cognitive-demanding speaking tasks. The higher cognitive load required in more complex speaking tasks (e.g., conversation, reading, speaking while multitasking), as well as the effects of fatigue in tasks with longer duration, are possible explanations for less consistent use of target voice during more complex speaking tasks. The participant demonstrated increased self-cueing of target voice during treatment sessions per clinician observation, particularly in less complex speaking tasks. It is also possible that due to the higher cognitive load and duration of the activity, that the participant performed self-cueing behaviors less frequently in more complex tasks. It is also important to consider how difficult the reading tasks may have been for the participant. Untreated diplopia, paired with a possible history of dyslexia, English as his third language and cognitive deficits make reading a particularly difficult task for this individual.

The improvement in vocal quality observed three-months post-treatment suggests increased generalization and automaticity of target voice during conversational speech. The observed decrease in vocal intensity may also play a role in the participant's improved vocal quality. The participant's voice was loud with a strained vocal quality prior to treatment, and treatment sessions focused on shaping a level of loudness that supported a healthy vocal quality. Given the shaping used in sessions, the time since intensive treatment, and participant reports of no longer completing daily homework tasks, it is unsurprising that a decrease in vocal intensity was measured.

While no meaningful change in vocal range (as measured by f_o range) was observed in the acoustic data, changes in prosodic variation were observed by the clinician using perceptual methods. The measure of f_o range may not have been the best measure to represent functional changes in prosody. The measure of f_o range compares the entire range of frequencies used in each speech sample of interest. This type of data does not reflect pitch changes within words or phrases. It is possible that while the participant maintained the same overall vocal range that he increased the variation within that range during speech. It is also important to note that other factors (e.g., stress, loudness, vocal quality) also influence the perception prosody and are not captured by measures of f_o range and may account for the clinician's perception of improved prosodic variation.

Perceptual findings

The main perceptual findings of this study were improved vocal quality, more consistency in vocal quality within and across tasks, and modest increases in intelligibility immediately post-treatment. These treatment effects were maintained three months post-treatment.

Improved vocal quality was indicated by the CAPE-V and the participant and his spouse's responses to the LSVT LOUD Perceptual Rating Form. Results from the CAPE-V indicated roughness, breathiness, pitch, strain and overall severity were judged to be less deviant following LSVT LOUD treatment. Three months post-treatment, a slight decrease in deviance was observed across all parameters and in the overall impression of voice. Strain and roughness were no longer noted consistently in the participant's voice, indicating improvement in vocal quality in some speaking tasks. Overall, vocal quality gains were maintained and improved upon three months post-treatment.

Immediately post-treatment, both the participant and spouse noted that the participant's voice was louder, less shaky, less scratchy, and less strained per the LSVT Perceptual Rating Form. They also indicated the participant mumbled less often and was more likely to start a conversation. Three months post-treatment, results from the participant and spouse LSVT Perceptual ratings forms were mixed. This was unusual given their pre-treatment and immediate post-treatment responses were frequently in agreement with one another. It is possible that personal factors, changes in perception, or expectations of performance post-treatment affected responses. The participant's responses indicated maintained or improved levels of perception of voice. However, he noted a decrease in conversational participation and initiation that fell below pre-treatment levels. The spouse rated "always loud enough," "always participates in a conversation," and "always starts a conversation" above baseline levels and below immediate post-treatment levels. Both the participant and his spouse indicated an increase in use of monotone voice compared to pre-treatment levels. It is plausible that once other features of voice and speech were addressed that the monotone quality became more evident.

When considering intelligibility, it is important to note that the participant's French accent impacts his intelligibility in addition to his dysarthria. Modest increases in clinical estimates of intelligibility were found post treatment. Post treatment, greater gains in intelligibility were noted in reading tasks and intelligibility was judged to be more similar across reading and conversational tasks. These gains were maintained three months post treatment.

Communicative Effectiveness and Quality of Life Findings

Improvements in both communicative effectiveness and quality of life were measured immediately post-treatment. Three months post-treatment, participant perception of physical and functional impact of voice improved from immediate post-treatment levels, and communicative effectiveness across common speaking situations decreased from immediate post-treatment levels.

Positive changes in perception of the impact of voice handicap were measured post-treatment and continued to improve three months post-treatment. Immediately post-treatment, the participant's overall score on the VHI did not change by a significant factor and indicated a severe impact. However, the impact from the Physical domain changed from severe to moderate post-treatment. Given that LSVT LOUD is intensive, physical exercise for the systems that support speech production, it makes sense to see improvement in this area following treatment. Three months post-treatment, the participant's overall score on the VHI improved by 22 points (a total score change of 18 points or greater indicates a shift that is not solely a result of VHI variability), and indicated a moderate impact. While the participant still reports a severe emotional impact from his voice, the participant's perception of functional impacts of voice decreased to the moderate range, and his perception of physical impacts of his voice decreased to the mild range. The observed improved vocal quality and use of improved vocal quality in conversational speech likely contributed to the participants' increased satisfaction with function and physical aspects of his voice.

Improved communicative effectiveness was indicated by the participant and his spouse's responses to the CES immediately post-treatment. The overall score improved in both participant and spouse reports, indicating increased communicative effectiveness. The participant reported gains in conversing with family and friends at home, conversing with a stranger on telephone, conversing in noisy gatherings, and talking in the car following LSVT LOUD treatment. However, these gains were not maintained when the CES was readministered three months post-treatment. Both the participant and spouse noted a decrease in communicative effectiveness three months following treatment. The participant's score returned to pre-treatment levels, and the spouse's score to one point above pretreatment levels. A multitude of factors, such as no longer maintaining a home practice routine, changes in the family's personal circumstances, shifts in available social activities due to seasonal changes, and changes in expectations of performance may have played a role in the change in scores. It is also possible that the treatment gave a temporary inflated boost of communication confidence.

These results are comparable with results of other LSVT LOUD studies. Many studies of LSVT LOUD treatment in populations outside of PD only report immediate post-treatment effects and do not include maintenance data. In studies with maintenance data, a decline in communicative effectiveness in the maintenance period is common. Ramig and colleagues' (2018) randomized control trial of speech treatment in Parkinson's Disease re-administered the CETI-M seven months post-treatment and saw a decrease from levels reported immediately post treatment. Wenke and colleagues (2008) examined the short- and long-term effects of LSVT LOUD treatment in individuals with dysarthria following TBI and stroke and similarly found improvements on certain items of the Australian Therapy Outcomes Measures Scale (AusTOMs) did not maintain significant improvements six months post treatment. Additionally, many participants reported a lack of compliance with the home practice program six months post-treatment in the study.

Cognitive Findings

Cognitive measures indicated improvements in working memory, language, and visuospatial skills immediately post treatment. Cognitive measures were not repeated during the three-month post-treatment assessment but will be administered in future six month post-treatment testing.

BRIEF-A results indicated improved working memory and decreased task monitoring following LSVT LOUD treatment. RBANS results indicated statistically significant improvements in visuospatial skills post treatment. Modest improvements, though not statistically significant, were observed in the participant's overall score and attention, language, visuospatial skills, and delayed memory index scores. The participant's overall score on the RBANS improved from very low (0.3rd %ile) to low (2nd %ile), indicating improvement in cognitive functioning, and language and visuospatial index scores improved from the very low range to the low average range.

These results are interesting given improved cognition was not a target of the treatment administered and given the participant's degenerative condition. It is possible that the intensive communication therapy led to increased and improved socialization, which in turn may have played a role in the measured changes in cognitive functioning.

Clinical Considerations and Observations

The participant's case is particularly interesting because loudness, the target of LSVT LOUD treatment, was not a main concern for this individual at the start of treatment. LSVT LOUD was chosen for its low cognitive load and cross system effects to improve decreased vocal quality and intelligibility caused by the participant's hypokinetic dysarthria. In the first weeks of treatment, the participant's voice was often too loud (i.e., 90 dB or greater) when cued for loudness and was often harsh in quality. He also demonstrated inconsistent use of healthy vocal quality across phrase lengths and tasks. Clinician shaping of a healthy vocal quality and calibration of effort during LSVT LOUD treatment were instrumental in improving the participant's use of healthy vocal quality and clear speech.

Compliance with the home practice routine was a concern at the onset of treatment. In previous individual treatment sessions at the CU SLHC, this individual struggled with compliance for home practice activities. To increase compliance, the clinician communicated the importance of the home practice routine to the participant and his spouse. The clinician provided a video recording of herself completing the daily homework routine for the participant to follow along. Additionally, the clinician gave the participant a hard copy of the homework exercises each day for him to check off, then discuss and return in the next session. These measures proved effective, and the participant reported completing all homework sessions associated with treatment. Unfortunately, the participant reported stopping his home practice routine at the three-month post-treatment assessment session. It is likely that the daily reminders from the clinician, accountability measure of speaking with the clinician four days per week, lack of physical reminders (i.e., paper copy of homework), and the participant's low levels of initiation contributed to the discontinuation of the home practice program.

Throughout treatment, additional positive changes beyond chosen outcome measures were observed. The participant's respiratory support, vocal control, vocal quality, and pitch range all improved notably on the pitch glide tasks, which are indicative of the physiological cross-system effects of intensive LSVT LOUD treatment. The clinician also observed increased self-cuing behaviors (e.g., stopping speaking when using poor voice quality and restarting the utterance with target voice quality) during sessions as treatment progressed.

The participant's reading rate improved throughout treatment, and fewer disfluencies while reading were noted in the post-treatment data collection session. He also began using a compensatory strategy (i.e., pointing along in the text with his finger) following clinician models to do so, which helped him slow his rate and avoid instances of rushed speech while reading. The participant continued to use this strategy in the three-month post-treatment session without prompting or modeling from the clinician.

The participant's length of utterance in conversational speech during sessions increased from one to two-word answers to complete sentences containing two relevant pieces of information in the final week of treatment during the conversational level of the speech hierarchy task. In the immediate post-treatment data collection, the participant spoke for a longer time and provided more details in the picture description task. The clinician also observed increased initiation of conversation with the clinician and other individuals in the clinic over the course of treatment. Three months post-treatment, the participant independently initiated conversation with the clinician and asked follow-up questions without clinician prompting or cuing.

Possible Effects of Additional Speech Assessment and Treatment on Maintenance Data

The participant completed an evaluation for an AAC device to use as his condition progresses and began individual treatment for one hour per week and group aphasia therapy for ninety minutes per week at the CU SLHC two months after the completion of LSVT LOUD treatment. It is possible that these sessions had an impact on the maintenance data taken three months post treatment. Deciding to purchase an AAC device may have affected both the participant and spouse's views on communicative effectiveness. Additionally, ongoing individual treatment and group therapy likely continued to provide cognitive stimulation and conversational practice, which support the maintenance of positive LSVT LOUD treatment effects. Aside from these considerations, the participant's goals and activities in individual and group therapy have little overlap with the goals of LSVT LOUD and are unlikely to have influenced his performance three months post-treatment with LSVT LOUD. The participant's individual and group therapy goals included copying clinician models of prosody, pairing verbal and nonverbal communication, and maintaining conversation across turns with clinician. While the clinicians measured intelligibility in conversation within sessions, treatment activities did not address improving intelligibility.

Limitations

A major limitation of conducting a case study of one person is that the generalization of effects to a larger population is unknown. While the participant's neurologist currently suspects Progressive Supranuclear Palsy, the neurological diagnostic status of the client is not clearly established.

The choice of f_o range as a measure of prosodic variation was not an appropriate measure for capturing true changes in prosodic variation, and as a result the study does not provide meaningful acoustic information on whether LSVT LOUD treatment improved the participant's use of prosody.

Treatment and assessment were completed in English, both because it is the participant's primary language at present and because the clinician and investigators are not fluent in French. Evidence was not collected to evaluate whether the observed post-treatment effects of treatment are also evident when the participant speaks French.

Future Directions

Future directions for this study include collecting data in future sessions during the 6-month post-treatment and 12-month post-treatment time frames. Use of intelligibility and naturalness measures in the future will also provide a more comprehensive look at the participant's speech. It would also be useful to collect and examine acoustic and perceptual data from speech samples in the participant's first language, French.

CHAPTER V

CONCLUSION

This study sought to determine whether LSVT LOUD will improve vocal features, communicative effectiveness, quality of life, and cognition for a multilingual participant with complex comorbidities seeking treatment for hypokinetic dysarthria. LSVT LOUD treatment was chosen for the participant due to the strengths and deficits he presented with prior to treatment, and for the anticipated challenges in treatment that may arise from the presence of multilingualism and impaired cognitive functioning.

This study found improvements in measures of vocal quality, vocal loudness, intelligibility, communicative effectiveness, quality of life, and increases in cognitive functioning immediately post-treatment. Three months post-treatment, improvements in vocal quality, intelligibility, and some measures of quality of life were maintained. LSVT LOUD proved to be an appropriate choice for the participant and resulted in some meaningful changes in vocal quality, intelligibility, and quality of life for this individual.

This case study illustrates that LSVT LOUD may be an effective treatment for complex clients who are multilingual and present with complex comorbidities and cognitive deficits.

Clinicians who work with complex patients may wish to consider the theoretical underpinnings of LSVT LOUD, client profile, and areas of client need, and ability and desire to complete a 16-week treatment program to determine if trialing LSVT LOUD is appropriate. The use of LSVT LOUD with complex clients may yield positive outcomes.

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