The Effects of Two Speech Interventions on Speech Function in Pediatric Dysarthria

Erika S. Levy, Ph.D., CCC-SLP

Program in Speech and Language Pathology, Department of Biobehavioral Sciences, Teachers College, Columbia University, New York, NY

Lorraine O. Ramig, Ph.D., CCC-SLP

University of Colorado at Boulder, Department of Speech, Language, & Hearing Sciences, University of Colorado at Boulder, Boulder, CO

Stephen M. Camarata, Ph.D.

Vanderbilt University School of Medicine, Nashville, TN

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Reduced speech function is a primary disability in children with cerebral palsy (CP) who have the motor speech disorder of dysarthria. Interventions for pediatric dysarthria with evidence of efficacy are greatly needed. The present exploratory study examined the effects of two intervention methods on three children with CP: (1) Lee Silverman Voice Treatment (LSVT LOUD), an intensive single-focus intervention protocol that increases sound pressure level (SPL), intelligibility, and vowel space in adults with dysarthria due to Parkinson Disease (PD) and has recent evidence suggesting effectiveness for children with CP, and (2) "Traditional" intervention, representing "treatment as usual," consisting of instruction on breath control, positioning, articulation, and other behaviors. Examination of caregiver questionnaires, articulation assessment, and blinded listener ratings revealed greater speech function and articulatory precision, as well as utterances more often preferred and perceived as "easier to understand" after intervention. LSVT LOUD resulted in increases in speech function and SPL. Traditional resulted in increased speech function without increasing SPL. Thus, both interventions show promise for yielding increased speech function in children with dysarthria, although success may vary across linguistic levels and children.

INTRODUCTION

Children with dysarthria are an underrepresented population in intervention research (Hodge & Welllman, 1999; Yorkston, Hakel, Beukelman, & Fager, 2007). Approximately 2.4 of 1000 children in the United States have cerebral palsy (CP; Hirtz, Thurman, Gwinn-Hardy, Mohamed, Chaudhuri, & Zalutsky, 2007). A multiple baseline single-subject study has revealed positive effects of voice intervention for this population (Fox & Boliek, 2012), and descriptive studies have suggested improvement of speech production when a systems approach involving breath support and prosody is used (e.g., Pennington, Miller, Robson, & Steen, 2010). However, despite the large number of children with dysarthria, no controlled group studies or randomized controlled trials

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have investigated effects of intervention on pediatric dysarthria (Pennington, Miller, & Robson, 2009). Moreover, the few descriptive studies reported have little information about effects of intervention on spontaneous speech (as opposed to, e.g., isolated words) (Warner, 2012). Thus, speech-language pathologists (SLPs) have little evidence to guide their intervention strategies.

This exploratory study examined the impact of two speech interventions on speech function in three children with dysarthria due to CP. LSVT LOUD and Traditional represent speech interventions with sound theoretical motivations and preliminary indications of success for children with dysarthria (Fox & Boliek, 2012; Pennington et al., 2010). It is well established that deficits in respiration, resonance, phonation, and articulation contribute to intelligibility deficits in this population. Whereas LSVT LOUD targets one goal (healthy loudness), Traditional targets the subsystems of speech production. This study examined whether the LSVT LOUD and Traditional interventions increased children's speech function, as judged by pre- to post-intervention differences in caretakers' responses regarding functional impact, scores on a standardized articulation test, and blinded listeners' perceptions of the children's word-level and spontaneous speech utterances.

METHOD

Participants

Three native American English–speaking girls with spastic CP (per neurologist report) and associated dysarthria were recruited through the Center for Cerebral Palsy at Teachers College, Columbia University. The children were tested with a battery of speech sound, language, and cognitive assessments, including the Test of Auditory Comprehension of Language-3 (TACL-3) (Carrow-Woolfolk, 1998) and Kaufman Brief Intelligence Test-2 (KBIT-2) (Kaufman & Kaufman, 2004), as well as informal assessment. P1 was 8 years, 10 months old with mild dysarthria and age-appropriate receptive language but expressive language delays (e.g., Mean Length of Utterance (MLU) = 3.2). P2 was 3 years, 3 months old with moderate dysarthria who displayed age-appropriate receptive and expressive language (e.g., MLU = 3.7) but delayed phonological acquisition. P3 was 9 years, 7 months old with moderate dysarthria and apraxia, cognitive and receptive and expressive language delays (e.g., MLU = 1.8). All children passed a hearing screening at 20dB at 500, 1000, 2000, and 4000 Hz.

Intervention and Testing

Children who were able to participate 4 days per week were administered the LSVT LOUD intervention; the participant who was not available 4 days per week was administered the Traditional intervention. LSVT LOUD was administered to P1 and P2. Sessions took place four times weekly for 50 to 60 minutes plus 10 minutes of homework and one carryover assignment daily for 4 weeks. The intervention was provided by the first author, an SLP with LSVT LOUD training. The LSVT LOUD adult protocol (Ramig & Fox, 2010), adapted for children by means of motivational games (Fox & Boliek, 2012), used core exercises designed to increase healthy loudness followed by tasks involving increasing cognitive loads while maintaining feedback on loudness. Functional phrases and generalization outside of the intervention room were also used.

P3 received Traditional intervention twice weekly for 50 minutes with homework for 4 weeks. This intervention followed the client-directed protocol described by Pennington et al. (2010), including discussion of posture, speech clarity, monitoring of speech, breathing at the start of exhalation for simple phrases, activities involving stress and intensity regulation, and breath control. The intervention was provided by two SLP master's (and now doctoral) students supervised by the first author.

In this Phase I small group pre- versus post-intervention design, children were tested twice pre-intervention and once post-intervention. Testing included questionnaires on functional impact (Fox & Boliek, 2012) completed by caregivers. In addition, children were recorded (1) naming pictures in the Arizona Articulation Proficiency Scale (AAPS; Fudala, 2001), (2) naming photographs of contrastive words ("meat-mitt-knot-nut-soap-soup-pan-pen-chip-ship") (Levy, Leone, Garcia, & Baigorri, 2010; see also Ansel & Kent, 1992), and (3) producing spontaneous speech in play activities. Data collectors post-intervention differed from intervention providers.

Recordings took place in a sound-attenuated booth at Teachers College following standard procedures (Fox & Boliek, 2012; Tjaden & Wilding, 2004). The children were asked to be seated as they usually sit. A Shure headset-microphone was 8 cm from each child's lips. Calibration involved generating a tone (produced by a KORG LCA-120 Chromatic Tuner) adjacent to the microphone. The experimenter noted the exact sound-pressure level (SPL) on a Galaxy SP-meter 30 cm from the microphone at the beginning and end of each session, for later correction of the SPL analysis of the audio recordings yielded by the commercial software program Praat (Boersma & Weenink, 2005). The signal passed through a Shure (Prologue 200M) mixer to a Turtle Beach Riviera sound card of a Dell Pentium 4 desktop computer using Soundforge software with a sample rate of 22,050 Hz, 16-bit resolution, on a mono channel.

For the blinded listener task, 10 female naïve native monolingual American English listeners (mean age = 26 years) were presented with pre- and post-intervention stimuli (with an interstimulus interval of 1.5 sec) in contrastive words and spontaneous speech. (Listeners passed the hearing screening described earlier.) As in previous studies (e.g., Fox & Boliek, 2012), Praat (Boersma & Weenink, 2005) analyzed the dB SPL value for each calibration tone in the audio recording of each session. This value was subtracted from the exact SPL indicated on the Galaxy SP-meter, thus yielding a correction factor for each session. The correction factor was then applied to the Praat value of each stimulus on the audio recording of each session. Thus, a calibrated dB SPL at 8 cm across all subjects and recording sessions was yielded (see Fox & Boliek, 2012). All corrected stimuli were then presented free field at 50 cm distance from the listener. For the word stimuli, listeners saw the word written on an Excel spreadsheet. Spontaneous speech presented was the first 10 sentences uttered in the spontaneous speech task, and no orthographic representation was listed. Listeners responded on the spreadsheet whether they preferred the first or the second utterance and which was "easier to understand." Listeners heard two tokens of each word and one token of each sentence per speaker, totaling 120 word and 30 sentence presentations. Half of the pre-intervention stimuli were from baseline 1 (B1) and the other half from baseline 2 (B2), all presented in counterbalanced order.

RESULTS

On functional impact questionnaires (Fox & Boliek, 2012), all caregivers (three per child), including parents, relatives, and teachers, reported positive functional impact for all children. For example, for "Speaks so others can understand," ratings increased a median of 2.5 points (P1), 3 points (P2), and 1.5 points (P3), where 1 = never, 9 = always. Ratings for "Talks when playing with kids" increased a median of 2 points (P1), 4.5 points (P2), and 1 point (P3). Comments included "More eager to engage other children."

An SLP and two master's students scored the sound files for the articulation assessment. The file names were coded so that the scorers were blinded to whether the files were pre-intervention or post-intervention. As indicated in Table 1, articulatory proficiency scores increased post-intervention for all children (increase for P1 = 13 points, P2 = 17–19 points , P1 = 7–9 points). According to Fudala (2001), a higher articulatory proficiency score suggests greater intelligibility, although P2's post-intervention score of 44 (rise from 35 and 37 from B1 and B2, respectively) remained in the "unintelligible" category (albeit the high end), which includes scores from 0 to 44.5. P1's voicing errors, in particular, decreased after LSVT LOUD. Vowel changes perceived by the scorers included P2 producing the more central vowel in vowel space (Flege, Bohn, & Jang, 1997) in "bus" produced for "fish" pre-intervention and a more peripheral vowel in "bes" post-LSVT LOUD intervention. P3, in contrast, produced "fish" as "fot" pre-intervention and more centrally as "fuff" following Traditional.

In the blinded listener task, the posttest was preferred more often for words (58%, 59%, and 54% for P1, P2, and P3, respectively) and for spontaneous speech (79%, 75%, and 75%), as shown in Table 2. Similarly, listeners indicated that

TABLE 1. Scores on the Arizona Articulation Proficiency Scale (Fudala, 2001)

Articulatory-Proficiency Score	Pre-Intervention		Post-Intervention
	B1	B2	
P1 LSVT LOUD	85	85	98
P2 LSVT LOUD	60	62	79
P3 Traditional	35	37	44

LSVT LOUD = Lee Silverman Voice Treatment.

TABLE 2. Pre- vs. Post-intervention Preference for Words and Spontaneous Speech

	Pre-Intervention	Post-Intervention
% Words Preferred		
P1 LSVT LOUD	42	58
P2 LSVT LOUD	41	59
P3 Traditional	46	54
% Spontaneous Speech Preferred		
P1 LSVT LOUD	21	79
P2 LSVT LOUD	25	75
P3 Traditional	25	75

LSVT LOUD = Lee Silverman Voice Treatment

TABLE 3. Pre- vs. Post-intervention Results for "Easier to Understand" Words and Spontaneous Speech

	Pre-Intervention	Post-Intervention
% Words "Easier to Understand"		
P1 LSVT LOUD	39	61
P2 LSVT LOUD	39	61
P3 Traditional	47	53
% Spontaneous Speech "Easier to Understand"		
P1 LSVT LOUD	25	75
P2 LSVT LOUD	25	75
P3 Traditional	20	80

LSVT LOUD = Lee Silverman Voice Treatment

the post-intervention stimuli were "easier to understand" more often than the pre-intervention stimuli (words = 61%, 61%, and 53%; spontaneous speech = 75%, 75%, and 80%) (Table 3).

Actual SPL was determined for each stimulus as described earlier. Figure 1 displays the mean pre-intervention and post-intervention SPL in contrastive words (left) and spontaneous speech (right). For children who received LSVT LOUD, SPL increased overall, although baselines were highly variable (B1, B2 for P1 = 63, 59; P2 = 59, 73; P3: 60, 67 dB for contrastive words and P1 = 67, 63; P2 = 64, 65; P3 = 71, 80 dB for spontaneous speech; see also standard deviation bars in the figure). For P1, SPL increased at word level but did not generalize to spontaneous speech. For P2, SPL increased primarily in spontaneous speech. The SPL of the child receiving Traditional did not increase overall.

SUMMARY AND DISCUSSION

Descriptive results of both the LSVT LOUD and Traditional interventions for dysarthria in three children with CP revealed (1) greater speech function post-intervention as reported by caregivers, (2) greater post-intervention articulatory proficiency according to the AAPS (Fudala, 2001), and (3) blinded listeners'

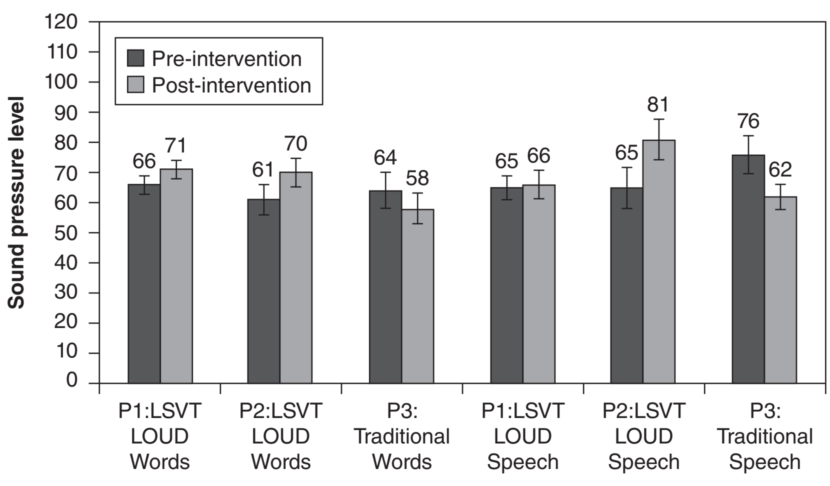

Figure 1. Mean pre-intervention (*black*) and post-intervention (*gray*) dB sound pressure level (with standard deviation bars) at 30cm from microphone for participants P1, P2, and P3 in contrastive words and spontaneous speech. LSVT LOUD = Lee Silverman Voice Treatment.

preference and judgment of greater intelligibility for post-intervention words and spontaneous speech. Thus, both interventions show promise for yielding increased speech function in children with dysarthria, although success may vary across linguistic levels and children. Speech after the LSVT LOUD intervention generally showed increased SPL and speech function. Traditional also led to increased speech function but without increasing SPL overall.

Although neither Traditional nor the LSVT LOUD intervention was originally designed for children with dysarthria, the described improvements in performance in this exploratory study may reflect, in part, the interventions' adherence to the parameters outlined in Strand's (1992) Child Talk Model of Language Production, including repetitive practice as a key to motor learning. In addition, both interventions control for language complexity (from word level to sentence level and beyond), as permitted by the child's linguistic level, also suggested by Strand. LSVT LOUD's single training target of loudness affects articulation, rate, intonation, voice quality, and loudness, thus impacting speech function with limited cognitive load. In adults, loudness is associated with larger vowel space and thus with greater intelligibility (Sapir, Spielman, Ramig, Story, & Fox, 2007); thus, the children's limited vowel space (Lee, Hustad, & Weismer, 2010) may have been expanded through LSVT LOUD, possibly accounting for P2's vowels perceived as more peripheral in vowel space (Flege et al., 1997) after the intervention. Moreover, Dromey, Ramig, and Johnson (1995) posit that after use of LSVT LOUD, improvements in (untreated) articulation in adult PD suggest that higher amplitude is associated with biomechanics of jaw displacement and reorganization to preserve phonetic distinctions**.** The systems approach of Traditional, targeting more directly each subsystem of respiration, resonance, articulation, phonation, and prosody, appeared to have a positive impact, as well, as also shown for adults with dysarthria (see Yorkston et al., 2007).

The results herein are promising but limited. Among the limitations is the high variability in SPL found within and across testing sessions, rendering it difficult to interpret the changes in SPL after intervention meaningfully. This variability appeared to reflect the child's level of comfort or fatigue during testing sessions. Future larger group studies and randomized controlled trials will permit comparison of intervention methods for this young population in need of enhancing their speech function for greater quality of life. Such studies will also aid with identification of individual differences that may predict which approach may be best suited for a particular child.

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Address Correspondence to *Erika S. Levy, Ph.D., CCC-SLP, Teachers College, Columbia University, Dept., of Biobehavioral Sciences, Box 5, 525 W120th St., NY 10027, USA, PHONE: (212) 678-6656, FAX: (212) 678-8233.*
e-mail: elevy@tc.columbia.edu

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