Treating Expressive Aprosodia: A Case Study

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Emerging evidence suggests that treatment of expressive aprosodia is amenable through imitative mechanism-based approaches. Evidence supporting the use of these behavioral treatments has primarily been restricted to perceptual measures. The parallel use of objective acoustic measures and subjective perceptual analyses may reveal added insights into the type and degree of treatment effects. The present case study describes a participant diagnosed with aprosodia who took part in an imitative mechanism-based treatment. Acoustic analysis examined changes in fundamental frequency (F0), intensity, and duration used to mark contrastive stress, questions, and emotional force. A subset of recordings from the contrastive stress and sentences with emotion datasets were selected for a perceptual experiment with 20 unfamiliar listeners. Results indicated that although the client made minimal progress across treatment in terms of acoustic cues, listeners were able to identify linguistic contrasts with increased accuracy across treatment sessions; however, the ability to discern emotional tone decreased as treatment progressed. Implementation of slow speaking rate appeared to facilitate the ability to mark some linguistic contrasts but had adverse consequences on conveying emotion. These findings underscore the importance of using acoustic and perceptual measures to assess treatment outcome and the need to evaluate treatment effects across communicative tasks.

Prosody is an aspect of language that varies and enhances the meaning of verbal communication and encompasses intonation, stress, and rhythm of utterances. These features make speech sound smooth and natural. In addition to playing many linguistic roles such as indicating differences between interrogative, imperative, exclamatory, and declarative statements, prosody is also important for conveying emotional tones such as anger, sadness, and excitement (Bolinger, 1989; Ellis & Young, 1993; Lehiste, 1970). Previously it was believed that prosody was primarily a right hemisphere function; however, recent findings contradict this lateralization hypothesis (Cancelliere & Kertesz, 1990; Karow et al., 2001; Pietrosemoli & Mora, 2002). Functional magnetic resonance

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imaging (fMRI) findings indicate multiple areas of the left and right hemispheres are involved in expressive and receptive prosody (Wildgruber, 2006). Damage to any of these brain regions may result in aprosodia which is characterized by a diminished ability to convey and/or interpret emotional prosody (Freeman, 2009).

Recently, a handful of single-subject design studies have suggested that two mechanism-based treatment approaches, imitative and cognitive-linguistic, may effectively ameliorate aprosodic speech patterns resulting from stroke (Jones et al., 2009; Leon et al., 2005; Rosenbek et al., 2004; Rosenbek et al., 2006;). The imitative approach is based on the assertion that aprosodia results from a disruption of motor programming/planning; whereas, the underlying hypothesis of the cognitive-linguistic approach is that the disorder results from a disruption of the nonverbal affect lexicon (Rosenbek et al., 2004; Rosenbek et al., 2006). Despite these differences, both approaches utilize a six-step cueing continuum where maximum cueing is provided initially and is systematically reduced as the patient progresses through the continuum. In the imitative approach, initial cueing consists of the clinician and patient producing sentences with the target emotional prosody in unison. In the final step the patient and clinician engage in conversation aimed at eliciting an array of different stress patterns and emotional tones. In contrast, the initial step of the cognitive-linguistic approach is to have the clinician provide the patient a card listing an emotion name, the vocal characteristics of an emotional tone of voice, and a picture illustrating the appropriate facial expression for the target emotion. During the final step the patient says a sentence using a tone of voice which the clinician names aloud and then removes the facial picture card (Rosenbek et al., 2004).

The evidence supporting the use of mechanism-based treatment approaches has primarily been restricted to perceptual measures. However, Jones et al., (2009) recently reported on acoustic changes (e.g. fundamental frequency and intensity) in patients who receive either imitative or cognitive-linguistic treatments. The current case study expands these findings by describing a patient with aprosodia secondary to bilateral strokes who underwent a mechanism-based treatment utilizing the imitative approach described by Rosenbek et al. (2006). Acoustic analyses of his speech in conjunction with perceptual judgments during the course of treatment are presented to explore the effectiveness of this treatment technique. The parallel use of objective acoustic measures and more subjective perceptual analyses may reveal added insights into the type and degree of treatment effects resulting from mechanism-based interventions.

METHOD

Participant

MR is a 46-year-old left-handed native speaker of American English who suffered two strokes within a span of 13 months. The first stroke resulted in a left posterior circulating artery distribution infarct while his second stroke led to infarcts of the anterior distribution of the left middle cerebral artery as well as the right frontal, parietal, and occipital lobes. MR has a high school education and had been employed as the lead cook for a buffet-style restaurant prior to his second stroke. MR reported no depression, had not been prescribed any medication, and reported his baseline cognition and communication as being independent. MR had not received any previous rehabilitation services following either stroke.

Evaluation and Treatment

Assessment and therapy sessions were conducted on an outpatient basis within a hospital setting. He underwent a comprehensive battery of cognitive-communication tests, hearing screening, and a laryngeal examination. He was administered the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001), Burns Right Hemisphere Inventory (BRHI; Burns, 1997), and the Boston Diagnostic Aphasia Evaluation (BDAE; Goodglass & Kaplan, 1972). Findings were consistent with expressive and receptive aprosodia in that the patient was unable to alter suprasegmentals to express emotion during speech production and demonstrated decreased ability to interpret emotion in speech (Tucker, Watson, & Heilman, 1977).

Treatment followed a six-step cuing continuum as described by Rosenbek and colleagues and consisted of nine sessions over a 14-week period. All sessions were recorded using a digital recorder (Olympus VN-4100 PC) in a sound attenuating booth to allow for off-line acoustic analysis. During each session, samples of three prosodic contrasts were recorded and used to document progress across treatment. These contrasts included four- to six-word sentences produced as (1) question versus statements, (2) with contrastive stress on one word within the utterance, and (3) with emotional force as happy, sad, or angry.

Acoustic analysis

Sound samples from each session beginning with baseline through follow-up were acoustically analyzed using Praat (Boersma & Weenink, 2008) to examine changes in fundamental frequency (F0), intensity, and duration for each of the three prosodic contrasts (question-statement; contrastive stress and emotional force) across treatment. At least 12 samples of contrastive stress and 9 samples of sentences with emotion were acoustically analyzed per session. First, the beginning and end of each word within each utterance was manually annotated (inter-labeler agreement, $r = 0.937$). Then customized routines were used to compute peak F0, peak intensity, and duration measures for each word in each utterance.

Perceptual analysis

A subset of 46 recordings from the contrastive stress and 49 sentences with emotion datasets were randomly selected for a perceptual experiment conducted with 20 unfamiliar listeners (10 M; 10 F; mean age = 30.3 years). For the contrastive stress tokens, listeners were asked to identify the location of stress within each utterance. Sentences with emotion were played backward to eliminate any bias resulting from the sentence content while preserving the prosodic cues (similar to Roy & Pentland, 1996). Listeners classified each utterance as happy, sad, or angry.

RESULTS

Acoustic Findings

In terms of contrastive stress, MR showed modest improvement in modulating prosody within an utterance during treatment sessions. However, this progress was not well maintained by the follow-up session (Figure 1A). He signaled contrastive stress using differences in intensity (decreased mean intensity of unstressed words), F0 (increased F0 of stressed words), and duration (increased length of stressed words). Data indicated that modulation of F0 was the only cue that was maintained following treatment.

While MR signaled happy, sad, and angry emotions using relatively distinct cues early on in treatment, toward the end, he tended to produce all three emotions using similar cues (Figure 1B). The main acoustic changes in MR's speech across treatment included a notable decrease in speaking rate (from an average of 195.6 words per minute at baseline to 135.7 words per minute at follow-up), marginal improvement in prosodic modulation within utterances and slightly more acceptable vocal loudness (baseline vocal intensity level = 81.6 dB; posttreatment average vocal intensity level = 72.4 dB).

Perceptual findings

Despite only marginal acoustic changes along any single prosodic cue, listener accuracy in identifying the location of stressed words was considerably higher for tokens produced posttreatment (86.5%) compared to baseline (58.9%). In terms of emotional force, listeners had more difficulty identifying angry and happy tokens compared to sad tokens (72%) and identification accuracy remained relatively unchanged from baseline (57.3%) to posttreatment (57.9%).

DISCUSSION

It appears that an imitative approach to treating aprosodia resulted in both acoustic and perceptual changes over time in this patient. These findings lend further support to previous research demonstrating treatment effects of mechanism-based approaches (Jones et al., 2009; Leon et al., 2005; Rosenbek et al., 2004; Rosenbek et al., 2006). This case study illustrates the importance of the parallel use of two common prosodic indices (acoustic and perceptual measures) in exploring treatment effectiveness. Utilizing both measures leads to a more comprehensive understanding of what aspects of prosody respond best to treatment. Interestingly, the acoustic changes noted in this patient's prosody were rather minimal, yet perceptually there was considerable change in identification of stressed words. Perhaps the acoustic signal in those with aprosodia needs to change only slightly to effect perception of prosody in unfamiliar listeners.

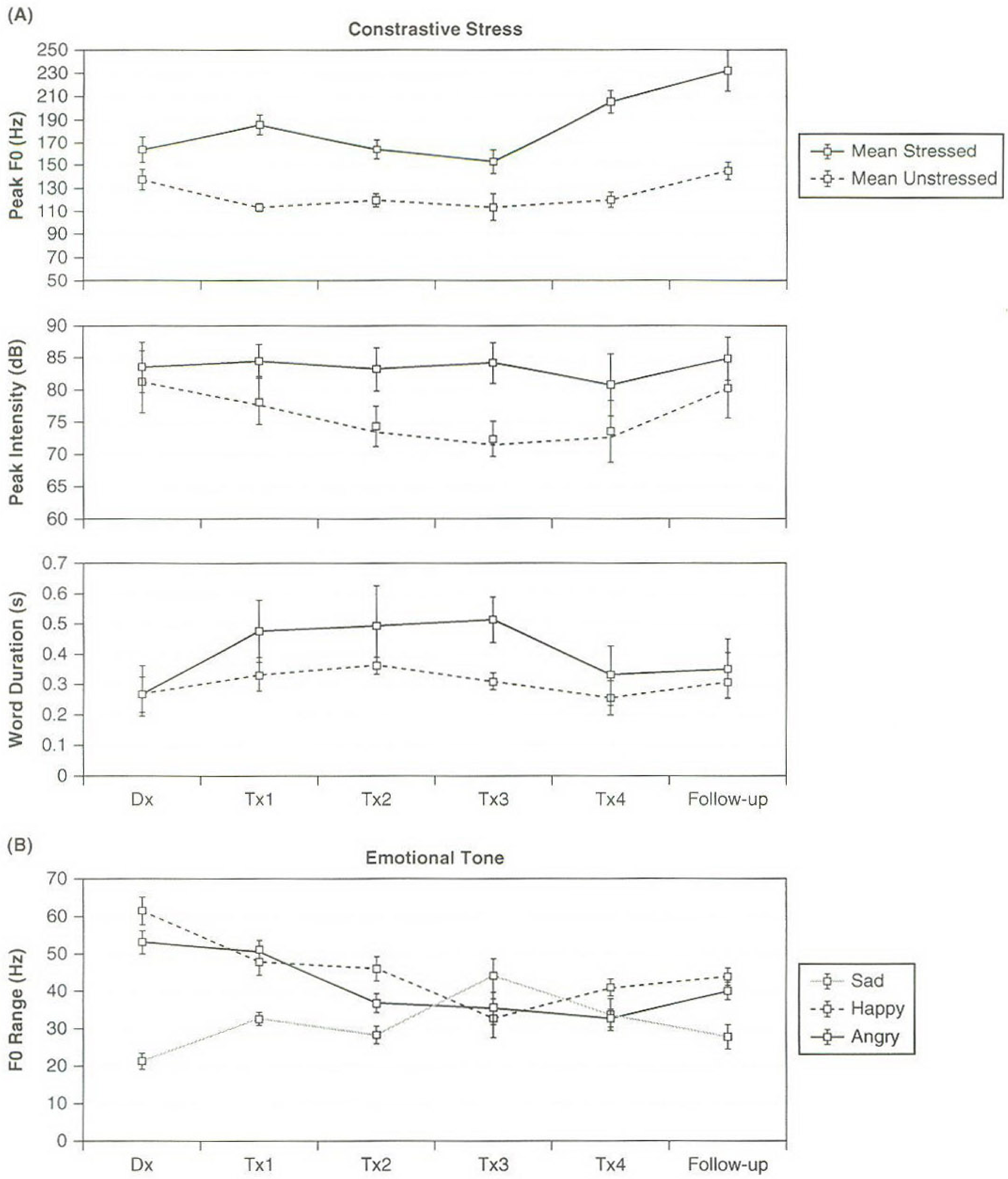

Figure 1. Acoustic Changes in Peak F0, Peak Intensity, and Word Duration for Stressed and Unstressed Words in Sentences with Contrastive Stress (A) and F0 Range in Sentences with Emotion (B) Plotted as a Function of Treatment Progress Extending from the Diagnostic Session (Dx), Through Treatment Sessions (Tx), and into the Follow-Up Session

Additionally, while slowed speaking rate and increased emphasis on modulating linguistic stress within an utterance should improve communicative effectiveness, this hypothesis needs to be assessed empirically. Furthermore, some treatment-induced behaviors have less desirable outcomes on overall communication. For example, acoustic and perceptual findings indicate that the patient used less distinct cues to convey emotions as treatment progressed compared to at the diagnostic session. Perhaps, as this patient implemented the slow-rate strategy modeled by the clinician, he had difficulty conveying emotions such as happy and angry which have a tendency to be produced at a faster rate.

Similar to Jones et al. (2009), we have demonstrated that in this participant acoustic changes resulted from use of a mechanism-based treatment approach to aprosodia resulting from stroke. It is important to note that acoustic changes may be subtle and may vary across tasks. Future work on examining the effectiveness of this treatment approach for remediating prosodic deficits using acoustic and perceptual measures is warranted. Interactions between treatment effects on improving segmental clarity and the impact of conveying prosodic contrasts also require further exploration. Last, further inquiry into the optimal frequency and intensity of treatment is necessary.

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