Background

Right hemisphere stroke can impair an individual's ability to express emotion using different tones of voice. This condition, called expressive aprosodia, can have serious consequences for interpersonal relationships (Ross & Mesulam, 1979). Despite the fact that 30% of the approximately 315,500 right hemisphere strokes each year are affected by this condition (Blake, Duffy, Tompkins, & Myers, 2003; Blake, Duffy, Myers, & Tompkins, 2002), few behavioral treatments for expressive aprosodia exist. We combined the cognitive-linguistic and imitative components of a previous treatment (Rosenbek et al., 2006) with use of knowledge of performance (KP) in the form of visual and auditory feedback. The purpose of this study was to investigate the effect of this novel behavioral treatment in individuals with expressive aprosodia secondary to right hemisphere stroke.

Theoretical explanations regarding the underlying deficits associated with expressive aprosodia have evolved significantly over the last two decades, and one current explanation is that abnormal emotional expression results from a motor deficit (Baum & Pell, 1999). While some have suggested a breakdown at the level of execution (Blonder, Pickering, Heath, & Smith, 1995), a good deal of evidence suggests the problem occurs at the level of motor programming (van der Merwe, 1997; Boutsen & Christman, 2002; Zakzanis, 1999, Klouda, Robin, Graff-Radford, & Cooper, 1988). Thus, our approach was designed to treat expressive aprosodia as a deficit of motor programming/planning.

KP was selected as a treatment variable because principles of enhanced motor learning (Schmidt & Bjork, 1996) suggest that extrinsic feedback is important (Proctor & Dutta, 1995). KP, which incorporates specific information about why a response is correct or incorrect, is thought to be the most effective form of extrinsic feedback because it provides information about patterns of action (Schmidt & Wrisberg, 2004). This is perhaps most critical when learning a complex behavior and when processing of intrinsic information is impaired (Schmidt & Wrisberg, 2004). Given the complexity of speech production, the prevalence of anosognosia in right hemisphere populations, and the co-occurrence of receptive aprosodia in some patients, the use of KP could be critical in providing meaningful feedback regarding emotional expressivity. However, some have suggested that providing specific feedback can reduce retention because individuals are less engaged in information processing (Goodman and Wood, 2004). Additionally, frequency and timing of KP are important, as systematic reduction over time (Weeks & Kordus, 1998; Winstein & Schmidt, 1990, Winstein, Merians & Sullivan, 1999) and providing feedback following a delay (Knock, Ballard, Robin, Schmidt, 2000; Swinnen, Schmidt, Nicholson & Shapiro, 1990) have been demonstrated as vital in promoting skill learning. The current treatment was developed to exploit the benefits of KP with these factors in mind.

Methods

Participants

Participants were four right-handed, native speakers of English, who suffered a unilateral right hemisphere stroke at least six months prior to the time of enrollment (see Table 1 for demographic information). All participants provided written informed consent prior to initiation of study procedures.

Pre-Treatment Assessments

The Florida Emotional Expressive Battery (FEEB) Prosody to Command subtest and the Florida Affect Battery (FAB) Name the Emotional Prosody subtest (Bowers et al, 1998) were administered to determine presence and severity of expressive and receptive deficits, respectively (see Table 2 for results). A motor speech examination was administered to rule out presence of dysarthria, and the Zung Self-Rating Depression Scale (Zung, 1965) was administered to rule out presence of unmanaged depression.

Treatment Stimuli and Procedures

Four emotions (happy, angry, sad, and fearful) were treated for one hour, three times per week, for 10 weeks (n=30 sessions). During each session, participants practiced 60 sentences (n=4 per emotion). The sentences, which were recorded to provide a standard model for production, were emotionally congruent and standardized for syllable length (4-7 syllables) and word length (4-6 words).

VisiPitch IV® was utilized to display the frequency, intensity and duration of target sentences. The model appeared on the top half of the screen and the participant's response appeared on the bottom half of the screen, allowing for a direct comparison of prosodic features. The treatment was organized along a 7-step continuum. In Step 1, participants were provided a written description of the tone of voice associated with the target emotion. The target sentence was presented visually and auditorily, and KP was provided after each response. In Step 2 no written description of the tone of voice was provided. In Step 3, participants were only provided KP on alternating sentences. KP was further reduced to every third sentence in Step 4, and no KP was provided in Steps 5-7. Judgments about the adequacy of response were made by the clinician and participant on each trial, and accurate responses were those evaluated by both individuals as correct. Criterion for advancement from between steps was 80% accuracy on a minimum of 20 sentences.

Primary Outcome Measure

The primary outcome measure was a 96-item sentence-level battery (n= 24 sentences for each treated emotion). All sentences were of simple subject, verb, object construction, were semantically congruent with the target emotion, and ranged in length from four to seven words. The sentences were presented visually and the participant was given the opportunity to produce it to their satisfaction. If the participant deviated from the target sentence, the clinician pointed out the error and requested an accurate production. The outcome measure was administered three times at baseline and immediately post-treatment.

Perceptual Analysis

Performance on the primary outcome measure was judged by naive listeners in a perceptual listening task. Ten individuals (n=9 females, n=1 male), ages 22-30 years, completed the listening task in which they provided a rating of emotion magnitude on a scale of 0 (neutral, no emotion) to 6 (highest intensity). The sentences were blocked by participant and emotion, and the listeners rated each sentence five times. Sentences were presented randomly so that listeners were blind to time point. Mean ratings were calculated for all four emotions at both time points for each participant (see Table 3).

Results

A 2x4 repeated measures ANOVA, with Emotion (happy, angry, sad, fearful) and Time Point (baseline, post-treatment) as within-subjects factors, revealed a significant effect of Time Point [$F(1,3)= 39.3$, $p= .008$], indicating that participants improved significantly from baseline to post-treatment on the sentence-level outcome measure. There was no significant effect of Emotion [$F(3,9)= 1.43$, $p= .298$] and no Emotion by Time Point interaction [$F(3,9)= 3.177$, $p= .078$].

Conclusion

We hypothesized that KP in the form of visual/auditory feedback would be critical in the treatment of expressive aprosodia because signaling emotion with tone of voice is a complex motor behavior and because individuals with right hemisphere damage may not be able to utilize intrinsic information to process prosodic cues. Our results support this hypothesis by demonstrating improved emotional expressivity using this treatment approach. Further investigation comparing this approach to more traditional forms of clinician provided feedback is warranted. Additionally, inspection of the means for each emotion revealed no change in ability to produce sadness and equivalent change in ability to produce happiness and anger. Thus, further investigation is also necessary to determine whether certain emotions are more amenable to change.

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Table 1
Participant Demographic Information

	Age	Gender	Education (yrs) (years)	Time Post Onset (months)
P01	72	M	15	42
P02	72	M	22	60
P03	81	M	14	22
P04	69	M	22	7

Table 2
Severity Rating Based on Pre-Treatment Testing Results

	Expressive Aprosodia (based on FEEB)	Receptive Aprosodia (based on FAB)
P01	Mild	Mild
P02	Moderate	Moderate
P03	Severe	Moderate
P04	Moderate	Moderate

Table 3
Baseline and Post-Treatment Means for Treated Emotions

	Happy		Angry		Sad		Fearful	
	BL	PT	BL	PT	BL	PT	BL	PT
P01	3.19 (*.51*)	4.45 (*.33*)	3.62 (*.97*)	4.39 (*.63*)	2.79 (*.77*)	2.79 (*.55*)	2.73 (*1.5*)	4.99 (*.40*)
P02	1.34 (*.26*)	2.05 (*.40*)	1.83(*.26*)	3.49 (*.70*)	2.58 (*.35*)	2.49 (*.49*)	1.20 (*.27*)	1.63 (*.27*)
P03	1.60 (*.14*)	3.63 (2.*0*)	2.83 (*1.2*)	3.95 (*.82*)	3.99 (*.13*)	3.76 (*.53*)	2.63 (*.44*)	3.73 (*1.1*)
P04	3.45 (*.64*)	3.74 (*1.1*)	3.45 (*.64*)	4.62 (*.36*)	2.55 (*1.4*)	2.77 (*1.0*)	1.41 (*.16*)	1.83 (*.49*)