The Effect of a Voice Treatment on Facial Expression in Parkinson’s Disease: Clinical and Demographic Predictors

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THE EFFECT OF A VOICE TREATMENT ON FACIAL EXPRESSION IN PARKINSON’S DISEASE: CLINICAL AND DEMOGRAPHIC PREDICTORS

by

AMANDA D. BONO

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This manuscript has been read and accepted by the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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ABSTRACT

The Effect of a Voice Treatment on Facial Expression in Parkinson’s Disease: Clinical and Demographic Predictors

by

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Parkinson’s disease (PD) is a neurodegenerative disease associated with a wide range of motoric, cognitive, and behavioral symptoms. Impairments in facial mobility and emotional expressivity are common and can impair communication, in turn, affecting daily functioning and quality of life. Previous research suggests that the Lee Silverman Voice Treatment © (LSVT LOUD; Ramig et al., 2001, 2011) increases vocal loudness and facial expressivity in individuals with PD compared to PD and healthy controls. This study extends the literature by examining the effects of LSVT and an articulation-based control treatment (i.e., ARTIC) on multiple aspects of facial expressivity (i.e., emotional frequency [EF], emotional variability [EV], emotional intensity [EI], and social engagement [SE]) as well as non-emotional facial mobility (FM). Further, we examined whether demographic, clinical, cognitive, and affective variables predict facial expressivity and mobility improvement via LSVT.

Participants included 40 individuals with idiopathic PD (67.5% male) and 14 demographically-matched healthy controls (60% male). The PD participants were randomly assigned to one of the following conditions: the LSVT LOUD treatment group (n = 13), a control
therapy (Articulation Treatment [ARTIC]; $n = 14$), or an Untreated Control Condition ($n = 13$). All posers (PDs & HCs) were video-taped, before and after treatment (for the LSVT & ARTIC PD groups) or at baseline and after a 4-5 week waiting period for (for the Untreated PDs [UPDs] & HCs), while producing emotional (Happy, Sad, & Angry) monologues from the New York Emotion Battery (Borod et al., 1998; Borod, Welkowitz, & Obler, 1992). The monologues were randomized and divided into 15-second segments, and evaluated by 18 naïve raters for 4 different aspects of facial emotional expression and facial mobility. Separate training sessions were held for each of the five facial rating variables (i.e., FM, EF, EV, EI, & SE), and interrater reliability was largely in the high range.

Findings revealed that PD posers displayed lower facial expressivity than HCs on three out of five variables, however, these effects were moderated by gender and emotion. In terms of gender, women were more expressive than men on all facial expression variables. Treatment results showed that individuals in the LSVT group showed significant improvements from pre- to post-treatment in facial expressivity for four out of the five variables examined (i.e., FM, EF, EV, & EI), however, for EV, this interaction was moderated by Gender, with significant increases from pre- to post-treatment for men but not for women in the LSVT group. There were no significant differences observed pre- to post-treatment for ARTIC or from baseline to 4-5 weeks later for the UPD and HC groups. In terms of predictive findings, demographic, clinical, cognitive, and affective variables did not predict facial improvement in LSVT participants, likely due to low power.

This study has multiple clinical and research implications. First, we examined facial expression through a multifactorial approach, involving mobility, expressivity, and social judgment of others, which has not been done in other studies with PD and which may provide a
better understanding of the specific facial impairments in PD. Clinically, our treatment findings for LSVT are important to the rehabilitation therapy literature, because there are very few empirically-validated treatments targeting facial emotional expressivity and facial mobility in individuals with PD.
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## Table of Contents

**Introduction** 1

The Role of Emotional Processing in Daily Functioning 1

Symptoms in Parkinson’s Disease (PD) 2

Epidemiology and symptomatology 2

Motor symptoms and neural mechanisms 3

Non-motor symptoms 4

Vocal communication deficits 5

Emotion processing deficits 5

Facial emotional expression 6

Posed versus spontaneous facial expression of emotion 6

Facial mimicry 7

Emotional experience 9

Emotional perception 11

Gender differences in emotion processing 12

Impression Formation Regarding PD: Social Consequences 13

Channel Compensation 16

Rehabilitation Treatments 17

Lee Silverman Voice Treatment 17

Articulation Treatment 19

Predictors of Outcome in Rehabilitation Treatments 19

Aims and Hypotheses 20

Aim 1 20
Hypothesis 1 20
Hypothesis 2 21
Hypothesis 3 21
Aim 2 21
Hypothesis 4 21
Hypothesis 5 21
Hypothesis 6 22
Aim 3 22
Hypothesis 7 22
Methods 23
Participants 23
Posers 23
Treatments 24
Raters 25
Procedures 26
Poser monologue procedures 26
Poser voice treatment procedures 27
Monologue rating procedures 27
Rater training procedures 28
Exemplar training phase 29
Conferencing training phase 29
Inter-rater reliability training phase 30
Experimental rating phase 30
Hypothesis 2

Hypothesis 3

Aim 2: Treatment Effects

Hypotheses 4 & 5

Hypothesis 6

Aim 3: Predictive Analysis

Hypothesis 7

Discussion

Aim 1, Hypothesis 1: Facial Expression, PD versus HC Participants

Aim 1, Hypothesis 2: The Effect of Emotional Valence on Facial Expression

Aim 1, Hypothesis 3: The Effect of Gender on Facial Expression

Aim 2, Hypothesis 4: The Effect of LSVT on Facial Expression

Aim 2, Hypothesis 5: The Effect of ARTIC on Facial Expression

Aim 2, Hypothesis 6: Differential Effects of LSVT on Facial Emotional Expression for Positive versus Negative Emotion

Aim 3, Hypothesis 7: Predictive Analysis for LSVT

Study Limitations

Future Directions

Clinical Implications

Conclusions

References
### Tables

Table 1: Demographic, Clinical, Cognitive, and Affective Characteristics for Poser Participant Groups

Table 2: Demographic Characteristics of Rater Participants

Table 3: Intra-class Correlations for Training Sessions: Conferencing, Inter-rater Reliability, and Experimental Rating Data

Table 4: Aim 1, Poser Group by Gender by Emotion ANCOVA (2 x 2 x 3), Significance of Effects

Table 5: Aim 1, Means for Main Effect of Gender

Table 6: Aim 2, Poser Group by Gender by Time by Emotion ANCOVA (4 x 2 x 2 x 3), Significance of Effects

Table 7: Aim 2, Means for Poser Group by Gender by Time by Emotion Interaction for FM

Table 8: Aim 2, Means for Poser Group by Gender by Time by Emotion Interaction for EF

Table 9: Aim 2, Means for Poser Group by Gender by Time by Emotion Interaction for EI

Table 10: Correlations between Demographic, Clinical, Cognitive, and Affective Variables and Face Variables for LSVT

Table 11: Multiple Regression Analyses, LSVT Change Score and Demographic, Clinical, Cognitive, & Affective Variables

Table 12: Multiple Regression Results for SE Positive Emotion
Figures

Figure 1: Group x Gender Interaction for Facial Mobility 73

Figure 2: Group x Emotion Interaction for Emotional Variability: Group Comparisons 74

Figure 3: Group x Emotion Interaction for Social Engagement: Group Comparisons 75

Figure 4: Group x Emotion Interaction for Emotional Variability: Emotion Comparisons 76

Figure 5: Group x Emotion Interaction for Social Engagement: Emotion Comparisons 77

Figure 6: Gender x Emotion Interaction for Facial Mobility: Gender Comparisons 78

Figure 7: Gender x Emotion Interaction for Social Engagement: Gender Comparisons 79

Figure 8: Gender x Emotion Interaction for Facial Mobility: Emotion Comparisons 80

Figure 9: Gender x Emotion Interaction for Social Engagement: Emotion Comparisons 81

Figure 10: Poser Group x Time Interaction for FM 82

Figure 11: Poser Group x Time Interaction for EF 83

Figure 12: Poser Group x Time Interaction for EI 84

Figure 13: Poser Group x Time Interaction for EV 85

Figure 14: Poser Group x Gender x Time for FM 86

Figure 15: Poser Group x Gender x Time for EV 87

Figure 16: Poser Group x Gender x Time for EI 88
Introduction

The Role of Emotional Processing in Daily Functioning

Emotion communication occurs through multiple channels, including facial, prosodic/intonational, postural, gestural, and lexical (i.e., speech content) expression (Borod, 1993b). Although most emotions are expressed simultaneously through several channels, facial expression is considered to be one of the most important channels for emotional communication (Assuras, Barry, Borod, Halfacre, & Crider, 2005; Borod & Koff, 1984). Effective emotional communication and social interaction play a vital role in one’s ability to operate within human society (Dowding, Shenton, & Salek, 2006), affecting quality of life (Behari, Srivastava, & Pandey, 2005; McKinley et al., 2008; Schrag, 2006; Slawek, Derejko, & Lass, 2005). Of note, Charles Darwin theorized that facial emotional expression has adaptive value and is critical for the survival of the human species (Darwin, 1859).

Facial expression of emotion is an important aspect of the emotional processing framework. Evidence from decades of emotion research supports the existence of universal discrete facial emotional expressions (e.g., happiness, sadness, anger, disgust, fear, and surprise) that are produced and recognized across cultures (Ekman, 1992; Izard, 1994; Russell, 1994; Walbott & Scherer, 1986). According to Borod (1993b), there are four components of emotion processing; these include the channel of communication (e.g., facial, prosodic/intonational, lexical [i.e., verbal content], gestural, and postural), modes of processing (e.g., expression, perception, experience, and physiological arousal), discrete emotions (e.g., happiness, sadness, anger, disgust, fear, and surprise), and emotional dimensions (e.g., pleasant/unpleasant and approach/withdrawal). Emotion expression denotes the production and communication of an emotion whereas emotion perception is defined as the ability to discern and interpret the
emotional expressions of other individuals. Previous studies have revealed multiple differences between expression and perception in healthy (e.g., Fridlund, Ekman, & Oster, 1987) and brain-damaged populations (e.g., Borod, Koff, Lorch, & Nicholas, 1986). Additionally, there are documented dissociations between emotional expression and experience (Borod et al., 2008). These differences among the above constructs (e.g., expression, perception, and experience) demonstrate that emotional processing variables are discrete constructs, thereby allowing researchers to examine emotional processing modes independently. Other evidence to support the theory that expression, perception, and experience are discrete entities includes the finding that impairment in one area of emotional processing may occur despite intact functioning in another mode. For instance, evidence suggests that individuals with Parkinson’s disease display deficits in facial expressivity although they report experiencing emotions with the same intensity as healthy controls (Borod et al., 2008; for reviews, see Borod & Brickman, 2001; McCabe, Borod, Meltzer, Spielman, & Ramig, 2010; Zgaljardic, Borod, Foldi, & Mattis, 2003).

Symptoms in Parkinson’s Disease

Epidemiology and symptomatology. PD is the second most common neurodegenerative disease in the world (de Lau & Breteler, 2006), and it affects approximately 1-2% of the population over 65 years of age and 3-5% of the population 85 years of age and over (Fahn, 2003). It is estimated that six to eight million individuals over the age of 65 are currently living with PD around the world (Sapir, Ramig, & Fox, 2008), with over one million of the cases reported in the United States (Kandel, Schwartz, & Jessell, 2000). These figures are expected to increase, as the number of individuals with PD over age 50 in the top 10 most populated Western countries is projected to double by 2030 (Dorsey et al., 2007). PD poses a significant burden on
the economy and healthcare system in the US, costing about $26 billion each year (Dodel et al., 1998), underscoring the need for reliable, effective, and efficient treatment.

**Motor symptoms and neural mechanisms.** Parkinson’s disease (PD) was originally described by James Parkinson (1817) as the “Shaking Palsy.” Today, it is conceptualized as a progressive neurodegenerative disorder characterized by spontaneous motor impairments due to the reduction of dopaminergic neurons in the substantia nigra pars compacta (SNC) of the basal ganglia (e.g., Jankovic, 2008). Characteristic motor impairments in PD include akinesia, bradykinesia, resting tremors, motor rigidity, postural instability, hypokinetic dysarthria, and masked facies (for reviews, see Jankovic, 2008; Ramig, Fox, & Sapir, 2008). Akinesia refers to difficulty initiating motor movements, resulting in the reduction of spontaneous, voluntary movements, whereas bradykinesia denotes reduced amplitude and speed of motor movement (Kandel et al., 2000). Resting tremors are typically unilateral, prominent in the distal part of an extremity (e.g., hands), and typically occur at a frequency between 4 and 6 Hz (Jankovic et al., 2008). Motor rigidity is characterized by increased muscular resistance to passive guided movement in proximal (e.g., neck, shoulders, and hips) or distal (e.g., wrists and ankles) limbs and is usually accompanied by an underlying tremor. Rigidity is reported by patients to be very painful and is typically one of the initial symptoms of PD, commonly misdiagnosed as arthritis (Stamey, 2007). Postural instability usually appears later in the disease and frequently causes impaired balance and unsteady or magnetic gait (Blumenfeld, 2002). According to imaging studies, a possible mechanism for the motor deficits frequently seen in individuals with PD is the severe reduction of dopamine in the caudal putamen, an area of the striatum that is associated with the cortico-basal ganglia-thalamo-cortical motor circuit (Brooks, 2000). Additional evidence suggests that the dopamine loss in PD is often widespread, affecting multiple
subcortical structures, including the subthalamic nucleus of thalamus (STN), the globus pallidus internal segment (GPi), striatum, and the substantia nigra pars reticulata (SNr), in addition to cortical areas (Kandel, Schwartz, Jessell, Siegelbaum, & Hudspeth, 2012). The impact of dopamine reduction on cortical areas may explain the non-motor symptoms of PD (i.e., symptoms involving mood and cognition).

**Non-motor symptoms.** In addition to the classical motor symptoms experienced by individuals with PD, many cognitive and behavioral deficits have been documented. The cognitive sequelae of PD include deficits in processing speed, attention (especially divided attention), episodic memory, and executive functioning (e.g., working memory, problem-solving, set-shifting, planning, organization, and inhibition tasks; Zgaljardic, Borod, Foldi, & Mattis, 2003; Zgaljardic et al., 2006). Changes in mood and behavior frequently include symptoms of depression (experienced by 40-70% of individuals with PD), apathy (16-50%), anxiety (approximately 40%), hallucinations (approximately 30%), fatigue (approximately 40%), and sleep-related issues (approximately 80%; for reviews, see Frisina, Borod, Foldi, & Tenenbaum, 2008; McKinley et al., 2008; Raskin, Borod, & Tweedy, 1990; Zgaljardic, Foldi, & Borod, 2004; Zgaljardic et al., 2007). These cognitive and mood symptoms are displayed by the majority of PD patients (over 77%; McKinley et al., 2009) and have been found to affect quality of life (Behari, Srivastava, & Pandey, 2004; McKinley et al., 2009; Schrag, 2006; Slawek, Derejko, & Lass, 2005). Additionally, the aforementioned cognitive and mood symptoms (e.g., depression) frequently occur prior to the onset of motor symptoms (Tolosa, Compta, & Gaig, 2007); in fact, early recognition may improve treatment options (e.g., Ravina et al., 2007). Since the focus of this study will be on emotional expression, we will review these deficits in more detail.
**Vocal communication deficits.** A deficit in vocal communication is another common PD symptom that affects approximately 70 to 90% of individuals with PD (Hartelius & Svensson, 1994; Ramig et al., 2008). The collective term for the speech-related impairments in PD is “hypokinetic dysarthria.” Symptoms of hypokinetic dysarthria include reduced vocal volume (hypophonia), restricted vocal range, difficulty articulating consonants (hypokinetic articulation), difficulty with the coordination involved with swallowing and speaking, a breathy or harsh vocal tone, and dysregulated rate of speech (Schulz & Grant, 2000). The literature suggests that individuals with hypophonia are frequently unaware of their low vocal volume and are likely to overestimate the loudness of their speech during casual conversation, leading to the development of this low vocal volume as their new baseline (Ho, Bradshaw, & Iansek, 2000; Liotti et al., 2003). Additionally, many individuals with PD report difficulties initiating speech, which may be related to akinesia, making it exceedingly difficult to maintain the typical back-and-forth dialogue commonly seen in social interaction. Prosodic emotional expression deficits are also documented in PD (Borod et al., 1990; McCabe et al., 2011; Zgaljardic et al., 2003), likely due to the above symptoms. The aforementioned vocal impairments likely contribute to social communication impairments in PD (Pell, Cheang & Leonard, 2006) and the resulting social withdrawal and low self-esteem (Miller, Noble, Jones, & Burn, 2006).

**Emotion processing deficits.** There is a large body of literature documenting emotion processing (i.e., expression and perception) impairments in PD. Deficits in emotional expressivity are evident in both the facial (Borod et al., 1990; McCabe et al., 2016; Smith, Smith, & Ellgring, 1996) and vocal channels (Borod et al., 1990; Zgaljardic et al., 2003) of individuals with PD, although their subjective experience of emotion typically remains intact (for review, see McCabe et al., 2010). Additionally, facial emotional perception deficits have been

Facial emotional expression. Impairment in facial emotional expression, termed “masked facies” (Borod et al., 1990; Smith et al., 1996), is a common motor symptom of PD, characterized by a reduction in speed, elasticity, and coordinated muscle movement involving the brow, eyes, cheeks, and lips (Tickle-Degnen, Zebrowitz, & Ma, 2011). PD patients display greater facial expressivity deficits when producing spontaneous facial expressions (involuntary) versus posed expressions (volitional) of emotion (for review, see Borod & Koff, 1984). Of note, a large body of research (over 70 years) suggests that posed and spontaneous facial expressions are mediated by distinct neural mechanisms (Borod & Koff, 1984). Posed facial expressivity impairments are commonly due to cortical lesions in the motor strip or in the corticobulbar projections from the motor strip to the brainstem (Rinn, 1984, 2007). Deficits in spontaneous expression are usually caused by subcortical (usually basal ganglia-related) dysfunction (Borod, Haywood, & Koff, 1997; Borod & Koff, 1984; Dumer et al., 2014; Rinn, 1984). The basal ganglia are the primary brain area impacted by PD. A large body of research has documented posed and spontaneous facial emotional expressivity impairments in PD and addresses how these deficits differ from the participants’ subjective experience of emotion, which usually remains intact (for review, see McCabe et al., 2010).

Posed versus spontaneous facial expression of emotion. Individuals with PD typically present with significant deficits in spontaneous facial emotional expression while displaying less impairment in posed facial expression, although generally not as intact as healthy individuals (e.g., McCabe et al., 2010; Simons, Pasqualini, Reddy, & Wood, 2004). Smith and colleagues
(1996) used the Facial Action Coding System (FACS; Ekman & Friesen, 1978) to examine the difference between posed and spontaneous facial emotional expression in individuals with PD for 5 discrete emotions (happiness, sadness, fear disgust, and anger). They found that the individuals with PD displayed less facial mobility and expressed facial emotions with less intensity than healthy controls when producing spontaneous facial expressions elicited by emotionally salient popular film segments. Posed emotional expressions were elicited by instructing participants to display how their face would look while experiencing each of the five discrete emotions. The authors found that although the posed expressions of happiness produced by the PD participants were lower in intensity than those produced by the healthy controls, this difference was not significant, and, overall, there were no significant differences among healthy controls, mild PD participants, and moderate PD participants for posed facial emotional expressions (Smith et al., 1996). Additionally, the PD participants’ ratings of subjective emotional experience were similar to ratings made by the healthy controls, consistent with Borod et al. (2008). Katsikitis and Pilowsky (1988) examined spontaneous facial emotional expression elicited by viewing cartoons. They found that participants with PD smiled less frequently and displayed a reduced range of movement (i.e., opened their mouths less) than did healthy controls. Overall, the literature suggests that individuals with PD display more deficits in spontaneous than posed facial expression, which may contribute to negative social consequences.

**Facial mimicry.** Facial mimicry is defined as the spontaneous echoing of the distinct facial muscle movements and expressions of others (Hess & Fischer, 2013; Hietanen, Surakka, & Linnankoski, 1998; Lang, Greenwald, Bradley, & Hamm, 1993). Healthy individuals are able to quickly and, often, unconsciously react to the facial expression of their conversation partner by mimicking their facial muscle movements (Dimberg, Thunberg, & Elmehed, 2000), which
promotes effective social interaction and increases the accuracy and speed of emotional perception (e.g., Chartrand & Barch, 1999; Niedenthal, 2007; Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Oberman, Winkielman, & Ramachandran, 2007; Sonnby-Borgström, Jönsson, & Svensson, 2003; Stel & van Knippenberg, 2008; Wood, Rychlowska, Korb, & Niedenthal, 2016). According to prior studies, individuals who display slower and restricted facial movement are judged as being insincere (Pentland, Gray, Riddle, & Pitcairn, 1988; Pitcairn, Clemie, Gray, & Pentland, 1990), as it may appear to the conversation partner that the person with facial mimicry impairment is either not paying attention or empathizing (when appropriate) with their narrative. Multiple PD motor symptoms, namely, akinesia, bradykinesia, and hypokinesia, are likely to negatively impact one’s ability to mimic the facial movements of others. Akinesia (slowed movement initiation) and bradykinesia (reduced speed of movement) could delay or eliminate the facial mimicry response, whereas hypokinesia (restricted amplitude of movement) could reduce the intensity of facial mimicry (Berardelli, Rothwell, Thompson, & Hallett, 2001; Jankovic, 2008; Ling, Massey, Lees, Brown, & Day, 2012; Livingstone, Vezer, McGarry, Lang, & Russo, 2016; Péron, Dondaine, Le Jeune, Grandjean, & Vérin, 2012). Studies suggest that there is a link between facial mimicry and the perception of emotion, such that eliminating facial mimicry responses in healthy individuals through experimental manipulation reduces the speed of emotion perception (Niedenthal et al., 2001; Oberman et al., 2007). A recent study evaluating the presence and extent of facial mimicry deficits in PD evaluated the facial mimicry response of 27 non-depressed PD patients and 28 age-matched controls through facial muscle electromyography (EMG) recordings while they watched videos and listened to audio-recordings involving calm, happy, sad, angry, and fearful emotions. The recordings consisted of neutral statements (e.g., “Dogs are sitting by the door.”) produced in a calm, happy, sad, angry, or
fearful tone of voice by experienced professional actors (2 male and 2 female). As the participants were watching the video stimuli, their facial mimicry responses were recorded via EMG. The researchers found that PD participants displayed significantly lower amplitude (little to no movement) and delayed onset (beginning approximately 350 milliseconds later) of the zygomaticus muscle region following happy stimuli relative to healthy controls. Similarly, individuals with PD evidenced weaker activity in the medial frontalis region following the presentation of sad stimuli as compared to healthy controls. In contrast, PD patients and healthy controls showed similar activation of the corrugator supercilii muscle area in response to sad and fearful presentations. In sum, PD patients displayed profound deficits in the facial mimicry of positive emotions, with relatively intact mimicry for negative emotions (Livingstone et al., 2016). The ventral striatal region of the basal ganglia, a region typically impacted by PD pathology, is associated with the processing and regulation of positive emotions, such as happiness (Hamann & Mao, 2002; Kim & Hamann, 2007), whereas the medial prefrontal and anterior cingulate cortex (a brain region that is less impacted by PD) is involved with the processing of negative emotions. The above findings are consistent with previous literature showing that individuals with PD are perceived as looking more negative and withdrawn since they produce smiles with less frequency and intensity (Pentland, Pitcairn, Gray, & Riddle, 1987; Pitcairn et al., 1990). Additionally, previous studies have reported positive relationships among the intensity, frequency, and duration of zygomaticus muscle activation and self-reported happiness (Cacioppo, Petty, Losch, & Kim, 1986), suggesting that reduced smiling mimicry may negatively impact subjective positive affect.

**Emotional experience.** Emotional experience has been defined as the subjective experience of emotion based on the evaluation of physiological arousal patterns in response to
stimuli (Barrett, 2006; Dalgleish, 2004). The facial feedback hypothesis (FFH) supports the theory that facial expression may influence emotional experience (e.g., Buck, 1980; Davis, Senghas, & Ochsner, 2009; Izard, 1971) through feedback from facial muscles. More specifically, the FFH proposes that facially expressive movements (e.g., smiling by pulling back the corners of one’s mouth and showing the teeth) may use a bottom-up neural mechanism to enhance the corresponding emotional experience (Buck, 1980). Of note, multiple studies have found a relationship between facial expressivity and emotional experience, such that reduced facial expressivity is correlated with reduced intensity of emotional experience (Borod et al., 2008; Davis et al., 2009; McIntosh, 1996; Montreys & Borod, 1998; Niedenthal, 2007; Strack, Martin, & Stepper, 1988). Additionally, multiple behavioral (Adelmann & Zajonc, 1989; Davis, Senghas, Brandt, & Ochsner, 2010; Mori & Mori, 2009, 2010; Niedenthal, 2007; Soussignan, 2002; Strack et al., 1988) and neuroimaging studies (Hennenlotter et al., 2009; Wiens, 2005) also support the FFH. To illustrate, a classic study supporting FFH examined the emotional experiences of individuals who were required to read comedic cartoons while holding pens in their mouths in ways that inhibited or facilitated smiling. The participants with facilitated smiles reported finding that they rated the cartoons as funnier than the participants in the inhibited smiling condition (Strack et al., 1988). More recently, Davis et al. (2010) evaluated the self-reported emotional reaction of individuals who had received facial Botox injections (which resulted in temporary partial facial paralysis) while watching emotionally arousing video clips. They found that the participants in the Botox condition did not differ from controls in their reactions to strong negative or strong positive video stimuli, however, they showed lower emotional reactions than did healthy controls to mildly positive stimuli (Davis et al., 2010). Based on these findings, one may logically believe that individuals with PD would report
decreases in subjective emotional experience as they typically have severe facial expressivity
deficits (e.g., Borod et al., 1990; McCabe et al., 2010; Smith et al., 1996). However, the literature
suggests that individuals with PD experience emotion similarly to healthy individuals (e.g.,
Borod et al., 2008; Mikos et al., 2009; Smith et al., 1996; Vicente et al., 2011), despite the well-
documented profound facial expressivity deficits (Borod et al., 1990; Smith et al., 1996).
Evidence from the PD literature, in conjunction with the Davis et al. (2010) study, suggests that
facial emotional expression may have a subtle impact on subjective emotional experience, but
not enough to be impairing to individuals with PD.

**Emotional perception.** Many studies have documented impairments among individuals
with PD in the perception of negative discrete emotions, including fear, disgust (Kan et al., 2002;
Sprengelmeyer et al., 2003; Yip et al., 2003), anger (Sprengelmeyer et al., 2003), and sadness
(Sprengelmeyer et al., 2003; Yip et al., 2003). In addition, higher intensity of facial emotional
expression does not improve perception accuracy in individuals with PD (Dujardin et al., 2004).
Interestingly, there is a body of literature suggesting that the side of initial motor symptoms in
PD may play a role in emotion perception deficits. Individuals with left-sided onset of motor
symptoms display deficits in the perception of sad (Ariatti, Benuzzi, & Nichelli, 2008) and angry
d satisfies (Clark, Neargarder, & Cronin-Golomb, 2008; 2010), whereas individuals with right-sided
motor symptom onset show impaired perception of fear (Ariatti et al., 2008) and surprise (Clark
et al., 2008, 2010). A recent study investigating the contribution of motor symptom onset (left
versus right) to the neural processing of dynamic face stimuli found that PD participants with
left-sided motor symptom onset showed significant dynamic face processing deficits compared
to healthy controls (Garrido-Vásquez, Pell, Paulmann, Sehm, & Kotz, 2016), consistent with the
right-hemisphere hypothesis (e.g., Borod, 1996; Cattaneo et al., 2014; Kanwisher & Yovel,
2006). However, they found no significant differences among left-sided onset PD, right-sided onset PD, and controls on static facial recognition via the Benton Facial Recognition Test (Garrido-Vásquez et al., 2016), consistent with previous research showing no asymmetry effects or significant differences between PDs and controls in the processing of facial emotion (Blonder, Gur, & Gur, 1989; St. Clair, Borod, Sliwinski, Cote, & Stern, 1998; Ventura et al., 2012). Despite the disparate findings, there are studies pointing to pronounced deficits in the recognition and processing of facial emotion, which can lead to the misreading of nonverbal social cues and subsequent inappropriate responding to emotionally sensitive situations, thus, impairing social communication. Of note, this deficit is only seen in the perception of negative emotions (e.g., Ariatti et al., 2008; Clark et al., 2008, 2010).

**Gender differences in emotion processing.** Gender differences in the processing of emotion have been well documented in the literature (e.g., for reviews, see Borod et al., 2004; Borod & Madigan, 2000). Women experience emotions with higher intensity (Birditt & Fingerman, 2003; Fujita, Diener, & Sandvik, 1991; Grunwald et al., 1999) and produce more pronounced facial emotional expressions (Hall & Matsumoto, 2004; Scholten, Aleman, Montagne, & Khan, 2005; Thayer & Johnsen, 2000) than do men. There is also evidence documenting that women use more facial muscle movements when expressing negative emotions (e.g., sadness, anger, and fear; Schwartz, Brown, & Ahern, 1980) and smile more frequently than men (LaFrance, Hecht, & Paluck, 2003).

To our knowledge, there are no studies specifically documenting gender differences in facial emotional expressivity in PD. However, there is some evidence of gender differences in the clinical presentation of PD, such that more women initially present with tremor, whereas men present with bradykinesia or rigidity (Haaxma et al., 2007). Tremor is usually present in the
extremities, whereas bradykinesia and rigidity are likely to affect the face. Coupled with the evidence suggesting that men are already less expressive than women, it is likely that men will present with more facial expressivity deficits than will women.

**Impression Formation Regarding PD: Social Consequences**

Impression formation is a form of perception that involves many aspects of a person (e.g., physical appearance, facial expression, and speech) in order to form a judgment about that person (e.g., Schneider, Hastorf, & Ellsworth, 1979). Research on impression formation shows that individuals frequently make long-lasting inferences and judgments about others based on very limited information (Epley & Gilovich, 2006; Schneider et al., 1979). Our ability and natural tendency to form impressions and judgments of others during social interactions may be mediated by facial expressivity. For instance, a study investigating the role of facial expressivity in impression formation in healthy participants (Riggio & Friedman, 1986) found that increased levels of facial emotional variability (i.e., the number of noticeable changes from the poser participants’ typical neutral expression) were consistently related to more favorable first impression ratings.

Findings from other studies have investigated the social consequences of reduced facial expressivity in PD patients. Impairments in facial expressivity frequently interfere with social communication in PD, potentially due to inaccurate impressions formed by lay people regarding their facial expressions (Brozgold et al., 1998; Hemmesch, Tickle-Degnen, & Zebrowitz, 2009), as well as by healthcare professionals (Lyons, Tickle-Degnen, Henry, & Cohn, 2004; Tickle-Degnen et al., 2011; Tickle-Degnen & Lyons, 2004). A study by Brozgold et al. (1998), examining the relationship between facial emotional intensity and social functioning in patients with PD, right-hemisphere brain damage, unipolar depression, and schizophrenia and in
demographically-matched healthy control participants, found a positive relationship between the intensity of facial expressivity and social functioning (i.e., the more expressive a person’s facial emotional expressions, the higher their ratings of social functioning). The results of this study revealed that individuals with PD displayed reduced facial expression intensity and, more specifically, greater negative and reduced positive facial emotional expressions, which could account for their difficulty with social functioning (Brozgold et al., 1998). A study examining emotional frequency in patients with PD (Pitcairn et al., 1990) found that their facial expressions were rated as less frequent than those of healthy controls and that their positive facial expressions of happiness (e.g., smiling) were rated as “phony,” likely due to delayed (slowed initiation) facial response as well as less facial muscle involvement.

Tickle-Degnen et al. (2011) examined the effect that facial masking in PD has on the impressions formed by American and Taiwanese health-care practitioners. The health practitioners, who were well informed about facial masking, included 159 professional clinicians and 125 students in training. The researchers found that clinicians from both cultures judged PD patients with more facial masking as more depressed, less sociable, less socially supportive, and less cognitively competent than patients with less facial masking. Additionally, according to Hemmesch et al. (2009), older healthy adults reported less interest in starting relationships with women diagnosed with PD and presenting with facial masking than men with PD who had similar facial symptoms. These findings support the notion that these social consequences are likely more severe for women due to the different role that socialization plays in the lives of women versus men (Solimeo, 2008). Results from our laboratory supplement and support these findings, showing that the personality characteristics of PD patients (i.e., extraversion, dependence, anxiety, and likability) were perceived more negatively by naïve raters when
compared to those of age- and gender-matched healthy controls (Dumer et al., 2013). The results from these studies suggest that casual social partners, as well as experienced clinicians, are likely to use facial expressivity to form impressions about patients’ personality traits. Since personality traits are conceptualized by most lay people as well as researchers to be stable over time and across different situations (McCrae & Costa, 2003), inaccurate judgments of the personality of individuals with PD may affect future social interactions with the same people over time, leading to more problematic relationships with family members and healthcare providers. This is of particular concern for individuals with PD since their facial expressivity will likely become a less and less reliable reflection of their internal emotional states as the disease progresses, potentially worsening social communication and contributing to biased impressions.

The biased impressions that can result from impaired facial expressivity can support interpersonal self-fulfilling prophecies, such that the individual may act in a way that will confirm the biased impression experienced by their conversation partner (e.g., Snyder, Tanke, & Berscheid, 1977). For instance, as indicated above, recent studies (Tickle-Degnen et al., 2011) have suggested that clinicians form the impression that patients with higher levels of facial masking are less psychologically, cognitively, and socially capable, as well as more negative and less engaged, than those with lower levels of masking. Such impressions may, in turn, lead to interviewing or interacting differently with patients with higher facial masking levels, which could lead to the elicitation of different behaviors. A study (Takahashi, Tickle-Degnen, Coster, & Latham, 2010) evaluating the difference in facial expressivity response between PD patients asked adaptive coping questions (e.g., “What did you find satisfying last week?”) versus problem-oriented questions (e.g., “What did you find difficult last week?”) found that interviewers asking positive adaptive coping questions elicited more positive facial expressivity
and less facial masking than those that asked problem-oriented questions. In addition, the patients who were asked more problem-oriented questions were judged as being more hopeless and apathetic during their interview relative to patients with lower levels of facial masking (Takahashi et al., 2010). These biased observations and interviewing styles may result in negative medical consequences, such as ill-suited treatment plans or misdiagnoses.

Evidence from longitudinal studies of PD show that individuals with PD report feeling more emotionally vulnerable and socially isolated as the disease progresses (Alves, Weentzel-Larsen, Aarsland, & Larsen, 2005; Forsaa, Larsen, Wentzel-Larsen, Herlofson, & Alves, 2008; Karlsen, Tandberg, Årsland, & Larsen, 2000; Post et al., 2011), possibly due to communication difficulties related to the progression of motor and facial expressivity deficits. This is problematic as social support and engagement are important for the physical and mental health, as well as the quality of life of older adults (Buchman et al., 2009; Holt-Lunstad, Smith, & Layton, 2010; Pinquart & Sörensen, 2000).

**Channel Compensation**

There is evidence from the Facial Palsy (FP) literature that individuals may compensate for facial expressivity deficits through other channels of communication (e.g., Bogart, Tickle-Degnen, & Ambady, 2014). Individuals with FP experience similar social consequences (e.g., misinterpreted as unfriendliness and disengagement) as individuals with PD due to reduced or asymmetrical facial expressivity (Bogart et al., 2014; Hemmesch et al., 2009; Tickle-Degnen & Lyons, 2004). The study by Bogart and colleagues (2014) investigated impressions of 27 individuals with FP using a thin-slice design, meaning that rater participants (termed “perceivers;” 121 university students who were blind to the FP severity and to the study hypotheses) viewed and rated short (20-second) video clips of individuals with severe and mild
unilateral and bilateral FP. The perceivers were randomly assigned to one of the following channel conditions: 1) face, voice, voice + speech, 2) body, voice + speech + body, or 3) all four channels. Next, the perceiver participants rated the facial expressivity, as well as compensatory expressivity (i.e., use of vocal and bodily expression), from “1” (low expressivity) to “5” (high expressivity). They found that the perceivers rated severe FP individuals as displaying significantly less happiness than those with mild FP but rated them as equally sad, congruent with the PD literature showing that higher levels of facial masking lead to less positive evaluations from peers, family members, and professionals (Hemmesch et al., 2009; Tickle-Degnen et al., 2011; Tickle-Degnen & Lyons, 2004). However, the more communication channels that the raters observed, the higher they rated the emotional expression intensity (for both happiness and sadness) of the perceived FP participant, suggesting that individuals with facial palsy may be able to compensate for reduced facial expressivity through other communication channels (Bogart et al., 2014). However, unfortunately, individuals with PD frequently display deficits in multiple channels of emotional expression (i.e., face, voice, and body; for reviews, see Borod et al., 1990; Jankovic, 2008; McCabe et al., 2010; Ramig et al., 2008), emphasizing the need for treatments that target multiple aspects of motor impairment.

**Rehabilitation Treatments**

**Lee Silverman Voice Treatment.** The clinical rehabilitation literature has documented multiple types of voice and speech therapies that are aimed at the rehabilitation of speech and vocal symptoms. The only voice treatment demonstrating long-term effectiveness is the Lee Silverman Voice Treatment (LSVT; Ramig et al., 1995; Ramig, Fox, & Sapir, 2011; Ramig, Sapir, Fox, & Countryman, 2001; Sapir, Ramig, & Fox, 2011). LSVT is a voice therapy that targets common speech and motor symptoms of PD, including vocal loudness, swallowing, limb
gesture, and limb function. The focus of LSVT is to maximize vocal loudness, optimize phonatory effort, and increase accurate perception of loudness during speech. In addition to targeting vocal and speech deficits, there is anecdotal evidence from the patients themselves and their spouses (Speilman, Borod, & Ramig, 2003) and quantitative evidence from preliminary studies suggesting that LSVT indirectly improves facial expressivity (Alterescu, 2012; Alterescu et al., 2013; Spielman et al., 2003).

LSVT is thought to improve facial expressivity due to the theory of an integrated system of emotion suggesting that facial and prosodic communication channels work together when producing an emotional response (Borod, 1993b; Kaiser & Scherer, 1998; Porges, 2001). Strong empirical evidence supporting these theories includes positive relationships between facial and prosodic expression in healthy adults (Borod et al., 1985; Malatesta, Davis, & Culver, 1984) and in neuropsychiatric populations (Borod et al., 1985, 1990). Due to this relationship, improvement in one component of emotional expressivity through LSVT (i.e., intonational and prosodic expression) may exert influence on another component (e.g., facial expressivity). There is also neurological evidence supporting this theory: facial and vocal systems display similar neural pathways for posed and spontaneous emotional expression. Posed expression is mediated via neocortical pathways whereas spontaneous expressions are mediated by subcortical and limbic pathways (for reviews, see Borod, 1993a; Borod & Koff, 1984). In addition, there is considerable overlap between the neural structures regulating facial and vocal expression, including the anterior cingulate cortex, peraqueductal grey, thalamus, and basal ganglia (Devinsky, Morrell, & Vogt, 1995; Jurgent & Zwirner, 1996). Neural evidence of vocal and facial systems working together to produce speech sounds is demonstrated through neural coupling between orofacial muscle systems and laryngeal and respiratory structures (McClean & Tasko, 2002).
Articulation Treatment. Articulation Treatment (ARTIC), also developed by Ramig and colleagues (Ramig et al., 1995; Spielman et al., 2012) is a control treatment for LSVT to be used in PD populations. ARTIC, therefore, is structured to be as similar to LSVT as possible with respect to the number of sessions, treatment length, clinician contact, and amount of feedback. The main focus of ARTIC is articulatory effort, and participants are asked to repeat over-articulated vowel-vowel, consonant-consonant, and vowel-consonant sounds. Evidence from a subset of this dataset found that ARTIC does not significantly improve facial expressivity (Alterescu, 2012). The theoretical basis for the differential findings between LSVT and ARTIC is that ARTIC targets higher level components of speech production (i.e., articulation), controlled by the neocortex, whereas LSVT targets more primitive aspects of vocal production (e.g., respiration and phonation), exerting its influence on older phylogenetic brain regions (e.g., subcortical areas), which are more involved in emotional processing and are more affected in PD.

Predictors of outcome in rehabilitation treatments. A significant amount of effort is contributed by patients, their families, and medical professionals in determining the most efficacious treatment for a particular patient. It is, therefore, important to investigate variables (e.g., demographic, cognitive, and mood) that may impact treatment outcome to increase confidence that patients are engaging in the proper treatment. Prior research examining factors influencing rehabilitation treatment outcome has yielded variable results, with some reports that cognitive status (Fusco et al., 2009; Hershkovitz, Gottlieb, Beloosesky, & Brill, 2006; Landi et al., 2002), age (Nieuwboer, De Weerdt, Dom, & Bogaerts, 2002), disease severity (Nieuwboer et al., 2002), depression (Fusco et al., 2009), and level of motoric function (Ellis et al., 2008) play a role in predicting successful outcome. Most of these studies consisted of stroke or mixed
geriatric populations (including individuals with PD) and studied improvement in physical therapy or activities of daily living.

To our knowledge, only one study investigated rehabilitation outcome based on clinical characteristics of individuals with Parkinson’s disease. Nieuwboer and colleagues (2002) evaluated whether clinical factors, including disease severity (measured by the Unified Parkinson’s Disease Rating scale, UPDRS; Fahn & Elton, 1987), cognitive ability (measured by the Mini-Mental Status Exam [MMSE]; Folstein, Folstein, & McHugh, 1975), age, and mood (measured by the Geriatric Depression Scale; Montorio & Izal, 1996) can predict functional outcome following physiotherapy in home- and hospital-based settings. They found that disease severity was the only predictor of short-term physiotherapy treatment benefit in the home setting and that none of the factors predicted functional outcome in hospital settings. Cognitive status and age predicted maintenance of gains at follow-up. Prediction studies of this nature can help to improve appropriate treatment selection for patients with PD.

**Aims and Hypotheses**

**Aim 1.** We examined differences in facial emotional expressivity (i.e., emotional frequency [EF], emotional variability [EV], emotional intensity [EI], &social engagement [SE]) and facial mobility (FM) between PD participants and demographically-matched healthy adult control participants (HCs), as well as between men and women, using the pretreatment baseline data.

**Hypothesis 1.** We hypothesized that PD patients would display significantly reduced facial expression (i.e., EF, EV, EI, and SE) and facial mobility (FM) compared to HCs due to substantial evidence showing facial expression impairments in PD (e.g., Borod et al., 1990; Brozgold et al., 1998; Katisikitis & Pilowsky, 1988; Smith et al., 1996).
**Hypothesis 2.** We predicted that PD patients would display reduced facial emotional expressivity in positive versus negative monologues based on literature showing that PD patients are better at expressing negative than positive emotion (e.g., Brozgold et al., 1998; McCabe, 2013; Pitcairn et al., 1990).

**Hypothesis 3.** We predicted that women would be significantly more facially expressive than men in both PD and HC groups due to evidence showing that women are perceived as more emotionally expressive than men (Borod & Madigan, 2000; Hall & Matsumoto, 2004; Huang & Hu, 2009; Scholten, Aleman, Montagne, & Kahan, 2005; Thayer & Johnson, 2000).

**Aim 2.** We examined changes in facial emotional expression (EF, EV, EI, and SE) and mobility (FM) over time from baseline to post-treatment for the Lee Silverman Voice Treatment (LSVT) and Articulation Treatment (ARTIC) PD groups and from baseline to 4-5 weeks later for untreated groups (i.e., UPDs and HCs).

**Hypothesis 4.** We predicted that PD patients in the LSVT group would display significantly more change over time in facial emotional expressivity (EF, EV, EI, and SE) than will PD participants treated with ARTIC, Untreated PDs, and HCs. An empirical rationale for this hypothesis is based on earlier findings with LSVT in PD showing significant improvements in facial expression (Alterescu et al., 2013; Spielman et al., 2003). A theoretical rationale for PD patients’ improvement in LSVT (e.g., Bono & Borod, 2016) is that the treatment focus is on respiration and vocal loudness, which has been found to engage subcortical structures within the basal ganglia, which are involved in voice production as well as facial emotional processing.

**Hypothesis 5.** We hypothesized that ARTIC would improve EF, EV, EI, SE, and FM over time significantly more than PD participants receiving no treatment and healthy control participants, but to a lesser extent than LSVT. We are making this prediction since ARTIC
focuses on articulation, which engages more frontal cortical structures, which do not affect emotional expression as much as subcortical structures (Alterescu, 2012; Liotti et al., 2003; McClean & Tasko, 2002).

**Hypothesis 6.** We predicted that PD patients in the LSVT and ARTIC groups would show more improvement over time for negative versus positive monologues based on literature showing that PD patients are better at expressing negative than positive emotion (e.g., Brozgold et al., 1998; McCabe, 2013; Pitcairn et al., 1990).

**Aim 3.** We proposed to extend the rehabilitation literature through examining whether demographic (age, gender, & years of education), cognitive (Mini Mental Status Exam [MMSE]; Folstein, Folstein, & McHugh, 1975), clinical (Hoehn & Yahr Stage, illness duration, & side of initial motor symptom), and affective (Beck Depression Inventory, Second Edition [BDI-II]; Beck, Steer, & Brown, 1996) status can predict changes in facial expressivity following LSVT.

**Hypothesis 7.** Based on previous literature (e.g., Ellis et al., 2008; Fusco et al., 2004; Hershkovitz & Brill, 2007; Landi et al., 2002; Nieuwboer & Weerdt, 2002), we predicted that lower age, Hoehn and Yahr Stage, PD duration, and BDI-II scores and higher years of education and MMSE scores would predict more change for the LSVT group. We also predicted that PD individuals with right-onset motor symptoms (RPDs) would display more change in facial expression following LSVT than PDs with left-onset motor symptoms (LPDs), based on findings from a subset of these data suggesting that individuals with RPD show higher levels of facial expressivity than those with LPD (e.g., Bono et al., 2017), in addition to neuropsychological studies regarding right-hemisphere specialization for facial emotional expression (e.g., Borod, 2000).
Methods

Participants

There are two sets of participants involved in this study: “posers” and “raters.”

Posers. The “posers” are the participants involved in the treatment portion of the study and were recruited as part of a larger study conducted through the laboratory of Lorraine O. Ramig, Ph.D. from the University of Colorado at Boulder. Participants were recruited from the Denver and Boulder regions through physician referrals, PD support groups, senior citizen centers, and IRB-approved advertisements. All participants were recruited and treated in accordance with the guidelines and standards set forth by both the Colorado Multiple Institutional Review Board (COMIRB) at the University of Colorado at Boulder and the Institutional Review Board (IRB) at Queens College of the City University of New York. Written informed consent was obtained from each participant, and participants were notified that they could discontinue at any time. All poser participants were financially compensated $10 for the screening process and $30 for their participation in the experimental treatment phase.

All PD participants were screened to determine eligibility for inclusion into the treatment phase of the study. Exclusion criteria included presence of moderate to severe cognitive impairment (assessed by a Mini-Mental Status Examination [MMSE] score of 26 or below; Folstein, Folstein, & McHugh, 1975); severe depression (as measured by a Beck Depression Inventory-II [BDI-II] score of 28 and above; Beck et. al., 1996); substance use disorders (including tobacco smoking); symptoms of a neurological condition other than PD (as diagnosed by a neurologist); history of cancer, gastrointestinal pathology, and/or laryngeal pathology; presence of any other disorder (other than PD) that could impair speech and language; severe temporomandibular joint (TMJ) disorder; pregnancy; and participation in any other intensive
speech treatment within the last two years. All participant history was evaluated by specialists, including otolaryngologists, neurologists, and speech-language pathologists.

The posers consisted of 40 individuals with idiopathic PD (PD; 67.5% male; $M$ age=66.8, $SD=8.6$) and 14 demographically-matched healthy control participants (HCs; 60% male; $M$ age=65.5, $SD=8.3$). There were three groups of PD posers, including 13 PD patients receiving LSVT (69.2% male; $M$ age=66.7, $SD=6.6$), 14 PD patients receiving an articulation control treatment (ARTIC; 64.2% male; $M$ age=68.4, $SD=10.2$), and 13 PD patients receiving no treatment (UPD; 69.2% male; $M$ age=65.3, $SD=8.8$). Demographic and clinical data were collected at baseline for all participants for screening purposes, including age, gender, years of education, BDI-II score, and MMSE score. For PD participants, Hoehn & Yahr Stage (Hoehn & Yahr, 1967), years since PD diagnosis, and side of initial motor symptoms were collected as well. Side of motor-symptom onset was based on self-report and information obtained from medical records.

**Treatments.** The Lee Silverman Voice Treatment (LSVT LOUD ©; Ramig et al., 1995; Ramig, Fox, & Sapir, 2011; Ramig, Sapir, Fox, & Countryman, 2001; Sapir, Ramig, & Fox, 2011) is a voice treatment that has been established in the treatment of Parkinson’s disease. LSVT stimulates the respiratory/phonatory system to improve healthy vocal loudness in speech production. Exercises include sustained vowels (“ah”), pitch exercises, and generalization of improved loudness to speech production. Patients are encouraged to sustain vowels as loudly and for as long as they can at high and low pitches. This is done to increase their vocal range in addition to vocal loudness for the purposes of more expressive and audible speech. Therapists will also record the patient so that they can have audible feedback throughout the process, since many PD patients are not reliable judges of their own vocal volume (Ho, Bradshaw, & Iansek, 2000). This helps to retrain sensory perception and internal cueing. During week one of LSVT,
the patients are encouraged to use their loud vowel voice to produce words and short phrases at the same volume; this is increased to sentences in week 2, to paragraphs in week 3, and to engaging in fluid dialogue with the therapist during week 4. This standardized treatment includes 16 individual 60-minute sessions 4 times per week for 4 weeks and includes daily homework to emphasize the generalizability of skills learned in therapy to daily life.

Articulation Treatment (ARTIC) is a speech treatment (Spielman et al., 2012) that was designed to be as similar to LSVT as possible, except that it focuses on the articulatory system. Tasks include many repetitions of over-articulated consonant combinations (e.g., /t-k/), consonant vowels (e.g., “pa”), consonant vowel consonants (e.g., “tat”), vowel-vowel combinations (e.g., “oo-ee-oo-ee;” Dumer et al., 2012), and generalization of improved articulation to speech production. Similar to LSVT, patients are encouraged to use their skills to produce words, phrases, full sentences, paragraphs, and fluid conversations while focusing on the articulation of their words (as opposed to the vocal loudness in LSVT). ARTIC also consists of 16 individual 60-minute sessions, 4 times per week for 4 weeks; includes daily homework and carryover; and focuses on retraining sensory perception and internal cueing. Treatment outcomes for both speech therapies were measured by several voice criteria, including vocal loudness and a sound pressure measure.

Raters. Raters included 18 undergraduate students from Queens College, CUNY who were recruited to be trained to rate videos of facial expressions that were obtained from the posers at baseline and post-treatment. Raters were recruited in three cohorts (50% male) through the use of IRB-approved flyers posted throughout the Queens College campus. All raters were given IRB-approved consent forms before starting the training and rating sessions. Raters were trained and paid $9 per hour for their time spent during training and rating sessions. Inclusion
criteria for raters consisted of the following: Caucasian, between the ages of 20 and 35, right-handed, and a native English-speaker (i.e., individuals who learned to speak English by age 7). Only Caucasian raters were recruited for this study, because the posers were almost exclusively Caucasian due to the minimal diversity of the geographical area (i.e., Boulder, CO) from which the poser participants were recruited. This decision was made due to the “in-group advantage” (Elfenbein, Beaupre, Levesque, & Hess, 2007), which supports the theory that individuals are more accurately able to perceive the emotional expressions of members of their own cultural group rather than those from other groups (Elfenbein et al., 2007). Exclusion criteria included history of neurological or psychiatric disorders, head trauma, learning disabilities, and/or substance abuse. Handedness and medical history were assessed through the verbal self-report of the potential raters.

**Procedures**

**Poser monologue procedures.** For the emotion assessment, posers were seated in a sound-resistant booth in a dental exam chair with a headrest. Posers in all four groups were videotaped while prompted to recall and speak about a happy, sad, and angry emotional event, using monologue elicitation procedures from the New York Emotion Battery (NYEB; Borod et al., 1992; Monteays & Borod, 1998) at two time points (baseline and about one-month post-baseline). For the two treatment groups (i.e., LSVT and ARTIC), NYEB evaluation took place before and after treatment. For the two non-treatment groups (i.e., UPDs and HCs), the procedure took place at the same time interval (approximately 4 to 5 weeks). The monologues were elicited by an experimenter who was present for the duration of the procedure to give instructions and guidance. The following paraphrased instructions from the NYEB were used with the posers to elicit emotional monologues: “Please speak for approximately three 90-second
intervals describing experiences when you felt intense sadness, happiness, or anger.” The video data consisted of footage of the posers’ neck, face, and head and were recorded using a Canon XL1S mini DV video-camera positioned approximately 9 feet away from the poser throughout the monologues.

Poser voice treatment procedures. The clinicians facilitating the treatments (LSVT and ARTIC) included three licensed and experienced speech-language pathologists. All clinicians were female and treated PD patients in both treatment groups. The PD patients received all of their treatment sessions from the same clinician. The treating clinician was not present during the emotional monologues.

Monologue rating procedures. There were 3 cohorts of 6 raters, each evaluating about 1/3 of the data set. The posers chosen to be rated in each of the 3 cohorts were carefully selected, with poser demographics, including age, gender, years of education, and illness severity for the PD patients (Hoehn & Yahr stage; Hoehn & Yahr, 1967), matched as closely as possible across the 3 cohorts. Each group of raters viewed randomized 15-second monologue segments for the 4 poser groups (LSVT, ARTIC, UPD, and HC) and rated each segment for each of the 5 variables (emotional frequency [EF], emotional intensity [EI], emotional variability [EV], social engagement [SE], and facial mobility [FM]). A 7-point Likert scale was used to make ratings (“1” = no or minimal expression to “7” = maximal expression). Each rater rated the variables in the same order, only one variable at a time, starting with FM, followed by EF, EV, EI, and SE. FM had to be rated before the other variables because it represented facial muscle movements without emotional content.

Facial expression was evaluated for 4 aspects of emotional expressivity (EF, EI, EV, and SE) and for non-emotional facial mobility (FM). Frequency (EF) is defined as the number of
facial emotional expressions observed by the rater during each video segment. Facial mobility (FM) is a control (non-emotional) condition created to evaluate how much muscular movement the face produces during each monologue segment. EF can refer to the total number of distinct emotional expressions (e.g., a smile that indicates happiness following by trembling lips that indicate sadness) or the number of the same repeated emotional expression (e.g., several smiles separated by neutral facial expressions). Emotional Intensity (EI) is the intensity or amplitude with which facial emotional expressions were produced only in the emotional portions of the video segment (raters would not evaluate the intensity of a neutral face). Emotional variability (EV) refers to the total number of different types of facial emotional expressions (e.g., anger followed by sadness) or the total number of changes within the expression of a single emotion (e.g., a smile followed by a laugh, followed by another smile). Social Engagement is a rating of how engaged, attentive, connected, or involved the participant comes across facially to the rater.

**Rater training procedures.** All recruited raters were trained extensively by upper level M.A. and Ph.D. students in Dr. Joan Borod’s Emotion Laboratory at Queens College to experimentally rate facial expressivity using the rater training system developed by Canino, Borod, Madigan, Tabert, and Schmidt (1999), including an exemplar, conferencing, and interrater reliability training phases. Raters were trained with their respective cohort group (there were 3 cohorts of raters, with 6 raters per cohort) to make the training sessions interactive and to assess the reliability of the raters as a group once the training for each variable was complete. The purpose of the training sessions was to train the raters to reliably rate each of the four facial expression variables (EF, EI, EV, and SE) and the non-emotional control variable (FM) on a 7-point Likert scale (“1” = no or minimal expression to “7” = maximal expression). For each rater cohort, there was one training session held for each of the five face variables examined. Raters
were taught to attend to many parts of the face and to notice the possible movements that may occur (e.g., forehead can be wrinkled, vertical lines can be seen between the eyebrows, eyebrows can be raised or lowered, eye gaze may shift, or corners of mouth may be drawn back and up). Raters were also taught to disregard head movements, as well as movements that appeared to be random and unrelated to facial emotional expression (e.g., body tremor, head shaking, and excessive blinking), and to only attend to facial muscle movement. In addition, raters were instructed to take note of and to disregard each poser’s unique facial features in the ratings (e.g., age wrinkles could be misinterpreted as movement). Raters were taught that emotional expressions may occur in full form, that is, all parts of the face contributing to an expression of happiness, or in partial form (e.g., only the eyes or eyebrows are expressing an emotion without the accompanying expression in the mouth region) and to count both forms in their evaluation of the five variables.

*Exemplar training phase.* This phase of training was primarily instructional. The raters were introduced to the 7-point Likert scale, and the experimenter presented 14 15-second video clips of the posers’ emotional and non-emotional monologues (two examples for each point on the Likert scale presented in increasing order, from a rating of “1” to a rating of “7”).

*Conferencing training phase.* This phase of training was interactive, in that the goal was for raters to reach a consensus. The experimenter presented the raters with 12 quasi-randomly selected video segments and instructed each rater to independently rate the segment with the 7-point Likert scale. After each rater independently made their ratings, they shared their ratings with the group in order to determine if the raters achieved a sufficient level of consensus for each segment. If this level of consensus was not reached, the experimenter again discussed the
variable and tried to determine whether the low consensus was due to misunderstandings and/or outlier ratings. After the discussion, raters viewed and independently rated that segment again.

**Inter-rater reliability training phase.** The purpose of this training phase was to assess the inter-rater reliability of the raters as a cohort. Raters were instructed to rate 40 randomly selected segments independently. After all ratings were made, the experimenters calculated the inter-rater reliability for the rater cohort using average one-way random Intra-Class Correlations (ICC; Shrout & Fleiss, 1979). Raters in each cohort were qualified to rate the facial data as long as there was at least 75% agreement among raters’ responses (ICC ≥ .75).

**Experimental rating phase.** After completing the training sessions, raters were qualified and performed ratings for each variable independently over 2 to 3 weeks in the same room on the same Dell computer. All rating sessions were approximately 2 hours long and were supervised by a lab member to ensure that the raters maintained adequate effort and attention throughout their sessions and that distractions were eliminated. The raters were instructed to rate each segment from 1 to 7 on the computer screen using the mouse after viewing the 15-second video clip. Raters were able to view the same 15-second segment up to 3 times. When the ratings for a specific variable (e.g., FM) were completed by all six raters, the training session for the next emotional variable was scheduled.

**Training materials.** Each rater was provided with the following materials to rate the face data.

**Rating scale.** Each rater received a training packet that included a copy of the 7-point Likert scale they would use for rating, definitions of the variables, and specific guidelines for recognizing facial muscle movements that are associated with discrete emotions at the beginning of each training session.
Baseline faces. Raters were given a packet of baseline face photographs for each poser for their reference during the rating of experimental data. The baseline face photographs were color-printed pictures of emotionally neutral faces made by the posers, taken from the experimental data. These baseline faces were created so that raters could effectively distinguish true muscle movement or facial expressivity from facial age or Parkinsonian features that would appear in the resting face.

Preparation of training segments. Video training segments were selected using quasi-random sampling, ensuring that these segments were balanced for emotion, gender, poser group, and individual poser. The exemplar training segments were chosen by 3 to 5 lab members who were blind to the poser information in each segment. After viewing each of the 14 segments for each variable, each lab member independently made their own 7-point rating. The segments with good interrater reliability (defined as all ratings within 1 point of each other) were selected for the rater training sessions. When small discrepancies in ratings occurred, the final segment rating would be based on a majority vote. This was the same procedure used to select the conferencing training video segments.

Preparation of experimental video segments. Each 1.5 to 3 minute emotional and non-emotional poser monologue was divided into 15-second segments for rating purposes. This was completed by using video editing software (i.e., Corel Video Studio ProX3) to eliminate any irrelevant parts of the monologue (e.g., experimenter providing instructions to participant) from the beginning and end of each monologue. The monologues were divided into 15-second segments, starting from the end of the monologue and working backward. This procedure is based on previous research (Kazandjian, Borod, & Brickman, 2007) suggesting that the most emotionally intense sections within these types of monologues are at the middle and end of the
monologue. As such, any discarded portions of the monologue that are too short to analyze (i.e., the very beginning of the monologue) are likely to be the least emotionally intense monologue sections.

The clips were presented to raters on Dell computers with a video-stimulus presentation software programmed into Microsoft Access version 2007. Presentation of video clips was randomized, so that each rater rated the video segments in a different order than the other raters in their cohort, preventing order effects with respect to individual rater, poser group, monologue type, and gender. All video segments during training and experimental ratings were presented without audio to prevent the influence of extraneous variables (i.e., intonational, prosodic, or lexical/verbal expression) on the raters’ ratings.

**Clinical and Demographic Variables for the Posers**

Data for a number of demographic (i.e., age, gender, and years of education), clinical (i.e., Hoehn & Yahr Stage, illness duration, and side of initial motor symptom), cognitive (i.e., MMSE), and affective (i.e., BDI-II) variables were collected at baseline and are described in detail below.

**Beck Depression Inventory-II (BDI-II).** The BDI-II (Beck, Steer, & Brown, 1996) is a 21-item self-report inventory that assesses the intensity of depressed mood in clinical and healthy populations. Each item addresses a symptom of depression according to the DSM IV-TR and arranges multiple-choice responses in increasing severity order. Participants rate the severity of each symptom (described in each item) on a four-point scale, ranging from “0” (lack of or minimal symptom) to “3” (highest level of the symptom experienced). The total score for the inventory ranges from “0” to “63,” with 0-13 indicating “minimal depression,” 14-19 “mild depression,” 20-28 “moderate depression,” and 29-63 “severe depression” (Beck, Steer, &
Brown, 1996). The BDI-II is a psychometrically sound instrument (Coefficient Alpha = .92, based on a clinical sample; Coefficient Alpha = .93, based on a non-clinical sample; Beck, Steer, & Brown, 1996). For our sample, we screened for severe depression and excluded participants with scores of 28 and above on the BDI-II. The mean score for our PD sample was 8.05, and the standard deviation was 5.64. In general, about 50% of patients with PD have clinical depression (Frisina et al., 2008; Raskin et al., 1990).

**Mini Mental Status Exam (MMSE).** The MMSE (Folstein, Folstein, & McHugh, 1975) is a 30-question exam administered by an examiner that evaluates general cognitive functioning, with questions assessing orientation, attention span, learning, memory, and visuospatial functioning. Scores range from 0 to 30, with a score of 25 and below indicating probable cognitive impairment (Folstein et al., 1975). The MMSE is a well-established, reliable, and valid measure, with test-retest reliability levels ranging from $r = .83$ to $.98$ depending on patient population (Folstein et al., 1975). Participants’ scores in each of the groups ranged from 26 to 30 to ensure that cognitive impairment was not a significant factor in this study. For our PD sample, the mean was 28.80, and the standard deviation was 1.22. In general, about 30% of individuals with PD are diagnosed with dementia (Raskin et al., 1990; Zgaljardic et al., 2003).

**Modified Hoehn and Yahr Stage.** The Hoehn and Yahr Scale (Hoehn & Yahr, 1967) was created to describe parkinsonian symptoms and illness progression and is commonly used in clinical and research settings. The stages range from 1 to 5, 1 indicating lowest level of impairment and 5 indicating the highest level of impairment. For this study, the modified Hoehn and Yahr Scale (Hoehn, 1992) was used and the progression is as follows: 1 = unilateral impairment only, minimal or no functional impairment; 1.5 = Unilateral and axial involvement; 2 = Bilateral or midline involvement, with no impact on balance; 2.5 = Mild bilateral impairment
with recovery on pull test; 3: mild to moderate bilateral impairment with some postural
instability, physical independence; 4 = severe disability, but still able to walk or stand without
assistance; 5 = Mobility only with assistance, wheelchair bound or bedridden. (Goetz et al.,
2004; Hoehn, 1992). For our PD sample, the mean was 2.13 and the standard deviation was 0.67.

**Other demographic variables.** The other demographic and clinical variables entered
into our prediction analysis include duration of illness (in years), side of initial motor
impairment, education (in years), and age (in years). These variables were gathered through
patient self-report.

**Data Analysis**

**Poser group equivalence assessment.** To ensure that there are no significant
demographic differences among the four poser groups, a one-way ANOVA, with Poser Group
(4) as the between-subjects variable will be performed for each of the demographic (gender [1 =
men & 2 = women], age, & years of education) and two of the clinical variables (BDI-II score &
MMSE score). For the PD-specific clinical variables (i.e., Hoehn & Yahr stage and illness
duration [in years]), a one-way ANOVA, with Poser Group (3) as the between-subjects variable,
will be performed for each variable. Main effects will be followed up by the Tukey HSD post-
hoc test. A chi-square analysis will be done to ensure equivalent gender distribution among the 4
poser groups. Throughout this paper, significant findings ($p \leq .05$) and trends ($p \leq .10$) will be
reported. Effect sizes will be provided for significant and trend-level main effects and
interactions using partial eta squared ($\eta_p^2$; Field, 2013). As per Field (2013), for partial eta
squared, a small effect = 0.010 to 0.059, a medium effect = 0.060 to 0.139, and a large effect =
0.140 and above. As needed for data interpretation, trend-level post hoc analyses will be
followed up by Cohen’s d ($d$; Cohen, 1992); small effect = 0.20, medium effect = 0.50, and a large effect = 0.80.

**Interrater reliability analyses.** Rater cohorts needed to reach an intra-class correlation (ICC) equal to or greater than .75 during training in order to proceed to rate the experimental data. ICC analysis on the experimental ratings will be conducted for each facial variable (FM, EF, EV, EI, & SE) for each rater cohort (i.e., I, II, & III), yielding 15 ICC coefficients.

**Aims**

**Aim 1.** We aim to examine facial emotional expression and facial mobility in individuals with PD versus Healthy Controls using the ratings described above. We hypothesize that all PD posers ($n = 40$) will display significantly reduced facial emotional expression (i.e., EF, EV, EI, & SE) and non-emotional facial mobility (FM) when compared to Healthy Controls.

The statistical approach used to examine this aim will be to conduct a 3-way (2 x 2 x 3) repeated-measures Analysis of Variance (ANOVA), with Participant Group (PD & HC) and Gender (Male & Female) as the between-subjects variables and Monologue Type (Happy, Sad, & Angry) as the within-subject variable. This analysis is evaluating baseline data only in order to isolate the facial expressivity of PD and HC groups in the absence of treatment effects. This 2 x 2 x 4 ANOVA will be conducted, separately, for each of the facial variables (EF, EV, EI, SE, & FM). In line with Hypothesis 1, we would expect to find a significant Main Effect for Group, with the PD group displaying significantly lower emotional expressivity and facial movement across monologues. If there is support for Hypothesis 2 (i.e., that PD participants display reduced facial emotional expressivity in the Happy relative to the Sad and Angry monologues), we would expect significant Group X Emotion interactions. Finally, if there is support for Hypothesis 3,
there would be significant main effects of Gender, with women displaying significantly higher ratings of facial expressivity than men.

**Aim 2.** We propose to examine changes in facial emotional expression (EF, EV, EI, & SE) and mobility (FM) over time (from baseline to post-treatment for LSVT & ARTIC groups and from baseline to 4-5 weeks later for non-treatment groups [i.e., UPDs & HCs]) across the 4 treatment groups. In Hypothesis 4, we predicted that PD patients in the LSVT group would display significantly more change over time in facial expressivity (EF, EV, EI, & SE) and mobility than will PD participants with ARTIC treatment, UPDs, and HCs. According to Hypothesis 5, ARTIC participants would display more improvement in facial expressivity than will UPDs and HCs but less improvement than LSVT. For Hypothesis 6, we predicted that PD patients in the LSVT and ARTIC groups would show more improvement over time for negative than positive monologues.

The statistical approach used to examine Aim 2 was a 4-way (4 x 2 x 2 x 3) repeated-measures ANOVA, with Treatment Group (LSVT, ARTIC, UPD, & HC) and Gender (Male & Female) as the between-subjects variables and Time (Baseline & Post-Treatment) and Monologue Type (Angry, Happy, & Sad) as within-subjects variables. This 4-way ANOVA was conducted for each of the five face variables. Results supporting our first and second hypotheses (i.e., that facial expressivity would be most improved after LSVT, followed by ARTIC) would show a significant Treatment Group x Time interaction, with LSVT showing the highest levels of facial expressivity improvement, followed by ARTIC, and with UPDs and HCs showing lower, yet equivalent, levels of facial change. Results supporting Hypothesis 6 would include a significant Treatment Group x Time x Monologue interaction, with the LSVT group showing significantly more facial expressivity improvement for negative (i.e., Sad & Angry) than positive
(i.e., Happy) and neutral monologues. We predict that participants in the ARTIC group will show a similar pattern to those in the LSVT group in terms of the Treatment Group x Time x Monologue interaction.

**Aim 3.** We proposed to extend the rehabilitation literature by examining whether demographic (age, gender, & years of education) and clinical (BDI-II, MMSE, Hoehn & Yahr Stage, illness duration, & side of initial motor symptoms) status can predict facial expressivity change from LSVT. In Hypothesis 7, we predicted that lower age, Hoehn & Yahr Stage, illness duration, and BDI-II and that higher years of education and MMSE scores will predict facial expressivity change over time for LSVT (Hershkovitz & Brill, 2007; Nieuwboer & Weerdt, 2002). We also predicted that individuals with right-sided-onset PD (RPD) would display more change in facial expression following both rehabilitation treatments than will individuals with left-sided-onset PD (LPD), based on findings from a subset of these data suggesting that individuals with RPD show higher levels of facial expressivity than do those with LPD (Bono et al., 2017), in addition to neuropsychological research regarding right-hemisphere specialization for facial emotional expression (for reviews, see, for example, Borod, 2000; Borod, Bloom, Brickman, Nakhutina, & Curko, 2002). The side of motor onset variable is a two point score (1 = RPD & 2 = LPD).

The statistical approach used to examine this aim was a multiple regression analysis, which was performed, separately, for each facial expression variable (EF, EI, EV, SE, & FM) for both the positive and negative emotion monologues for the LSVT Treatment Group. Predictor variables were the demographic and clinical variables that achieved a significant correlation ($p \leq .05$) with the particular dependent variable. The dependent variable will be the pre-post testing change scores (i.e., post-pre) for each of the 5 facial expression variables for the positive
(i.e., Happy) and negative (i.e., composite score for Angry & Sad) monologues. Before running the regression analysis, to minimize Type 1 error, we created a composite score for the negative emotions by calculating the mean of the Angry and Sad ratio change scores for each of the 5 facial variables (i.e., EF, EI, EV, SE, & FM). Next, we correlated each of the 3 demographic and 5 clinical variables with each facial expression variables (i.e., EF, EI, EV, SE, & FM), separately, for the positive and negative monologues. We included any demographic or clinical variable that achieved a significant ($p \leq .05$) correlation in the multiple regression analysis for each facial expression change score to which we are predicting.

**Results**

**Preliminary Analyses: Treatment Group Characteristics**

Demographic, cognitive, clinical, and affective information for the 4 poser treatment groups (i.e., LSVT, ARTIC, UPD, & HC) are displayed in Table 1.

The 4 poser groups were carefully matched on demographic variables (i.e., gender, age, & education [in years]) and on basic cognitive ability (i.e., MMSE score). In addition, the 3 PD groups were matched on clinical variables (i.e., Hoehn & Yahr disease stage [Hoehn & Yahr, 1967] and duration of illness [in years]). One-way ANOVAs or Chi-square tests comparing the 4 poser groups on demographic and cognitive variables revealed no significant differences for gender, $X^2 [3, n = 54] = .15, p = .985$; age, $F(3, 52) = .38, p = .765$; education, $F(3, 51) = .53, p = .662$; or MMSE score, $F(3, 52) = 1.63, p = .205$.

In terms of clinical variables, there were no significant differences among the 3 PD groups on Hoehn and Yahr stage, $F(2, 37) = .327, p = .723$ or duration of illness, $F(2, 37) = .477, p = .625$. On an exploratory basis and to be comprehensive, the 3 PD poser groups were compared to each other on the demographic and cognitive variables. There were no significant
group differences for gender $X^2[2, n = 40] = .10, p = .951$; age, $F(2, 37) = .456, p = .637$; education, $F(2, 37) = .031, p = .970$; or MMSE, $F(2, 37) = .648, p = .529$.

In addition, to ensure group equivalence for the Aim 1 analyses, Chi-square tests or independent-sample t-tests were conducted to compare all of the PDs ($n = 40$) to the HCs ($n = 14$). See Table 1 for group means and standard deviations for the demographic and cognitive variables for all PDs. There were no significant differences between the 2 groups for gender, $X^2[1, n = 54] = .05, p = .826$; age, $t(52) = .475, p = .637$; education, $t(50) = -1.26, p = .212$; or MMSE score, $t(52) = -1.80, p = .078$.

Of note, when examining the gender distributions in our sample, there were unequal numbers of men and women in the PD group, overall (27 vs. 13), and within each of the 3 PD treatment groups (see Table 1). There were approximately twice as many men as women. Our data are consistent with the general PD population, where the incidence of PD is reported to be significantly higher in men than in women (e.g., Van Den Eeden et al., 2003).

Finally, the participant groups were compared on affective functioning, as assessed by the Beck Depression Inventory, Second Edition (BDI-II; Beck, Steer, & Brown, 1996). When comparing the 4 poser treatment groups on this variable via ANOVA, there was a significant main effect of Group, $F(3, 52) = 4.92, p = .005$. Post-hoc comparisons revealed that the HC group ($M = 3.21, SD = 3.68$) obtained significantly lower BDI-II scores than the LSVT ($p < .001$; $M = 10.50, SD = 6.46$) and ARTIC groups ($p = .038; M = 7.21, SD = 5.00$) but not than the UPD group ($p = .162; M = 5.92, SD = 4.25$). None of the other post-hoc comparisons were significant.

Finally, for the Aim 1 analyses, all PDs were compared to the HCs on the BDI-II score. There was a significant difference, $t(52) = 2.98, p = .004$, with PDs reporting more depression ($M = 8.05; SD = 5.64$) than HCs ($M = 3.21; SD = 3.68$).
These findings for the BDI-II scores are not surprising in light of previous research documenting the occurrence of depression in about 40-50% of individuals with PD (for reviews, see Frisina, Borod, Foldi, & Tennenbaum, 2008; Gotham, Brown, & Marsden, 1988; Raskin, Borod, & Tweedy, 1990; Zgaljardic, Borod, Foldi, & Mattis, 2003). Due to the significant group differences for the BDI-II score in our data set and the facts that depression can affect the facial expression of emotion (e.g., Borod et al., 1990; Jaeger, Borod, & Peselow, 1985) and that flat affect (e.g., reduced facial expressivity) is a frequent symptom of depression (American Psychiatric Association, 2013), we decided to control for depression in the Aim 1 and 2 analyses to follow by covarying for the BDI-II scores.

**Rater group characteristics**

The raters selected for this study were matched with respect to education and gender such that an equal number of men and women were in each cohort. The demographic information for the raters is presented in Table 2.

**Inter-rater reliability**

We assessed the inter-rater reliability among our raters for each facial variable by conducting a series of one-way Intra-Class Correlations (ICCs). Four sets of reliability analyses were conducted. The first two sets were conducted during the training sessions (i.e., conferencing and inter-rater reliability stages of training). The third set of reliability analysis was conducted on the experimental ratings for each cohort, and the final analyses were conducted for each variable across all 3 cohorts. The results for the training reliability analyses are displayed in Table 3. The raters had high levels of agreement for their ratings of all five facial variables in all three cohorts. These results for the experimental reliability analyses are also displayed in Table 3. Raters had high agreement with each other across the facial variables. The inter-rater
reliability in Cohort 2 for SE and in Cohort 1 for EV are lower than the other ratings, but are still within the acceptable range.

**Aim 1: Assessment of differences between PDs and HCs**

In order to assess differences between male and female PDs and HCs, we conducted five 3-way mixed-model ANCOVAs (2 x 2 x 3), with Group (PD & HC) and Gender (Men & Women) as the between-subjects variables, Emotion (Happy, Sad, & Angry) as the within-subjects variable, and the BDI-II score as the covariate. We conducted a separate ANCOVA for each of the five facial variables, including Facial Mobility (FM), Emotional Frequency (EF), Emotional Variability (EV), Emotional Intensity (EI), and Social Engagement (SE). Results of these ANCOVAs are displayed in Table 4. To examine significant or trend-level interactions, post-hoc analyses, using the Hayden-Fisher LSD test (e.g., Williams & Abdi, 2010), were conducted to compare PDs to HCs.

**Hypothesis 1.** Contrary to Hypothesis 1, there were no significant or trend-level Main Effects of Group (PD vs. HC) for any of the facial variables: SE, \( F(1, 46) = 1.05, p = .311, \eta_p^2 = .022, \beta = .171; \) EF, \( F(1, 46) = .26, p = .616, \eta_p^2 = .006, \beta = .078; \) EI, \( F(1, 46) = .07, p = .793, \eta_p^2 = .002, \beta = .058; \) FM, \( F(1, 46) = 2.16, p = .149, \eta_p^2 = .045, \beta = .301; \) and EV, \( F(1, 46) = 1.60, p = .212, \eta_p^2 = .034, \beta = .236. \) However, there were significant or trend-level interactions involving the Poser Group variable that went in the predicted direction for 3 of the 5 facial expression variables. There was a trend-level Group by Gender interaction for FM, \( F(1, 46) = 2.96, p = .092, \eta_p^2 = .061, \beta = .392. \) (see Figure 1). Post-hoc tests revealed that PD men displayed significantly lower facial ratings than HC men \( (p = .008). \) Contrary to our prediction, there was no significant difference between PD and HC women \( (p = .947). \) Also in line with Hypothesis 1, there was a significant Group (PD vs. HC) by Emotion (Angry, Happy, & Sad) interaction for
EV, $F(2, 92) = 3.35, p = .040, \eta_p^2 = .068, \beta = .619$. When post-hoc tests were conducted comparing the 2 groups on each of the three emotions, there was a trend with a medium effect size ($p = .068; d = 0.606$) for Sad, with PDs lower than Healthy Controls. While the findings for Angry and Happy were not significant, they were going in the expected direction, with PDs displaying lower facial expressivity than HCs (see Figure 2). Finally, there was a Group by Emotion trend for SE, $F(2, 92) = 2.95, p = .057, \eta_p^2 = .060, \beta = .562$. Although, none of the post-hoc comparisons for any emotion was significant or a trend, upon inspection of mean differences, findings were going in the predicted direction for all 3 emotions, with PDs rated as less expressive than HCs (see Figure 3). Taken together, while there were no significant main effects of Poser Group, there were two-way interactions involving the Poser Group variable, with medium effect sizes for three out of the five facial expressivity variables (i.e., FM, EV, &SE) that went in the predicted direction (i.e., with PDs displaying lower facial expressivity than HCs as a function of Gender or Emotion). However, it is notable that power was significantly below the benchmark for adequate power $\beta = .80$, suggesting that there is not enough power in this analysis to have achieved significant findings with this analysis.

**Hypothesis 2.** Contrary to our Hypothesis 2 prediction (i.e., that PD participants would display reduced facial emotional expressivity in positive versus negative monologues), PDs showed significantly higher expressivity ratings for Happy than for Angry ($p = .002$) or Sad monologues ($p < .001$) for SE (see Figure 5). In a similar vein, for EV, the PDs showed significantly higher expressivity for Happy than Sad ($p = .013$). While there was no significant difference between Angry and Happy for EV, PD ratings were higher for Happy. There were no significant differences among the emotions for the HCs (see Figure 4).
Hypothesis 3. As predicted in Hypothesis 3, women were more facially expressive than were men; this was the case for 4 out of 5 face variables. There was a significant main effect of Gender for EF, $F(1, 46) = 6.31, p = .016, \eta^2_p = .121, \beta = .691$; EI, $F(1, 46) = 10.36, p = .002, \eta^2_p = .184, \beta = .883$; FM, $F(1, 46) = 8.15, p = .006, \eta^2_p = .150, \beta = .798$; and EV, $F(1, 46) = 9.12, p = .004, \eta^2_p = .165, \beta = .841$, with women displaying significantly more facial expressivity than men (for mean values, see Table 5). These main effects, in two cases, were superseded by interactions with Emotion. Although there was no significant main effect of Gender for SE, $F(1, 46) = 1.17, p = .285, \eta^2_p = .025, \beta = .185$, the data for this variable went in the same direction with women ($M = 3.12, SE = .22$) having higher values than men ($M = 2.82, SE = .17$). There were also Gender by Emotion interactions for FM, $F(2, 92) = 4.94, p = .009, \eta^2_p = .097, \beta = .797$, and SE, $F(2, 92) = 4.24, p = .017, \eta^2_p = .084, \beta = .730$. Post-hoc analyses for FM revealed that women were significantly ($p = .054$) more expressive than men for all three emotions (see Figure 6). For SE, there was a trend-level difference ($p = .071$) for Happy, with women rated as more expressive than men; post-hoc tests for Angry ($p = .484$) and Sad were not significant ($p = .621$), see Figure 7.

Also of interest is the fact that within a gender group for FM, men showed the highest level of facial expressivity for Angry (significantly higher than Happy [$p = .047$] or Sad [$p = .006$]) and women showed the highest level of expressivity for Happy (significantly higher than Angry [$p = .029$] or Sad [$p = .003$]; see Figure 8). For SE, men were rated significantly lower for Sad when compared to Angry ($p = .024$) or Happy ($p = .040$), while women, once again, showed the highest level of expressivity for Happy, which was significantly higher than Angry ($p = .009$) or Sad ($p < .001$); see Figure 9. Further, there were no significant or trend-level interactions for Group x Gender x Emotion for any of the face variables.
In sum, as predicted, there were significant main effects of Gender for four out of the five facial expressivity variables (i.e., FM, EF, EI, &EV), with women being more expressive than men. The effect size was large for three of these variables (i.e., FM, EI, & EV) and medium for EF. Of note, for FM, the main effect was superseded by a significant Gender by Emotion interaction (medium effect). A significant Gender by Emotion interaction emerged for SE, as well, with a medium effect size. For both of these interactions, women were significantly more expressive than men for all three emotions, however, women showed the highest level of expressivity for Happy and men were most expressive for Angry. The power was in the adequate range for the majority of main effects and interactions with the Gender variable.

**Aim 2: Treatment Effects**

To examine Aim 2 and to test Hypotheses 4, 5, and 6, we conducted a series of 4-way (4 x 2 x 2 x 3) repeated-measures ANCOVAs, with Treatment Group (LSVT, ARTIC, UPD, & HC) and Gender (Men & Women) as between-subjects variables, with Time (Baseline & Post-Treatment) and Emotion (Angry, Happy, & Sad) as within-subjects variables, and with the BDI-II score as the covariate. The 4-way ANCOVA was conducted, separately, for each of the five face variables. Significant and trend-level main effects and interactions were examined via post-hoc analyses using the Hayden-Fisher LSD test (e.g., Williams & Abdi, 2010). The results of the 5 ANCOVAs are displayed in Table 6.

**Hypotheses 4 and 5.** For Hypothesis 4, we predicted that LSVT participants would display increases in facial expressivity from pre- to post-treatment. Our Hypothesis 5 prediction was that the ARTIC group would also improve facial expressivity from pre- to post-treatment, yet to a lesser extent than the LSVT group. Consistent with Hypothesis 4, there were significant or trend-level Group by Time interactions for four out of five face variables: FM, $F(3, 46) =$
3.65, \( p = .020, \eta^2_p = .207, \beta = .760 \); EI, \( F(3, 46) = 3.30, p = .029, \eta^2_p = .191, \beta = .712 \); EF, \( F(3, 46) = 4.44, p = .043, \eta^2_p = .175, \beta = .661 \); and EV, \( F(3, 46) = 2.40, p = .082, \eta^2_p = .146, \beta = .559 \) (see Figures 10, 11, 12, & 13). However, please note that three of these interactions (i.e., for FM, EI, & EV) were superseded by Group by Gender by Time interactions, as well as Group by Gender by Emotion by Time interactions, which are discussed in the following paragraph. Post hoc analyses revealed that LSVT participants displayed significant improvement from pre- to post-treatment for FM \( (p = .019) \), EI \( (p = .020) \), and EF \( (p = .022) \). For EV, there was a borderline trend with a small effect \((p = .107; d = 0.167)\), with LSVT participants rated higher at post- than pre-treatment. Contrary to the Hypothesis 5 prediction, Hayden-Fisher LSD post hoc analyses revealed that ARTIC participants’ facial ratings remained relatively stable over time for FM \( (p = .514) \), EF \( (p = .281) \), EI \( (p = .343) \), and EV \( (p = .225) \). When the control groups were examined for these 4 face variables, UPDs displayed a significant decrease over time for FM \( (p = .036) \) and trend-level decreases for EI \( (p = .085) \) and EV \( (p = .104) \). HC participants’ facial expressivity ratings remained stable over time for each of the four variables discussed above \( (i.e., FM \ (p = .907), EF \ (p = .682), EI \ (p = .851), \& EV \ (p = .839)) \). Finally, for SE, the Group by Time interaction was not significant, \( F(3, 46) = .16, p = .925, \eta^2_p = .011, \beta = .076 \).

There were also significant Group by Gender by Time interactions for FM, \( F(3, 46) = 2.90, p = .046, \eta^2_p = .172, \beta = .650 \); EI, \( F(3, 46) = 4.09, p = .012, \eta^2_p = .226, \beta = .810 \); and EV, \( F(3, 46) = 3.54, p = .023, \eta^2_p = .202, \beta = .746 \), suggesting that the treatment effect for these variables was moderated by Gender (see Figures 14, 15, & 16). For FM, post-hoc tests revealed significant improvement with a small effect size \((p = .052; d = 0.307)\) from pre- to post-treatment for LSVT men and a trend-level change with a small effect size \((p = .071; d = 0.427)\) in the same direction for LSVT women. For EI, post-hoc analyses showed trend-level increases with small
effect sizes for both LSVT men ($p = .082; d = 0.336$) and LSVT women ($p = .062; d = 0.120$) from pre- to post-treatment. For EV, LSVT men displayed significant change ($p = .046$) over time, but the change for women was not significant ($p = .359; d = 0.169$). Contrary to our Hypothesis 5 prediction, ARTIC participants’ facial ratings from pre- to post-treatment were either stable (i.e., for FM men [$p = .385$], FM women [$p = .128$], EV men [$p = .539$], & EI men [$p = .347$]) or significantly decreased (i.e., EV women [$p = .043$] & EI women [$p = .052$]). In addition, UPD women showed significant decreases in facial expressivity from pre- to post-treatment for EV ($p = .040$), FM ($p = .017$), and EI ($p = .018$). The facial ratings for UPD men and HC participants (i.e., both men & women) for EV, FM and EI remained stable over time. Finally, no 3-way Group by Gender by Time interactions emerged for EF, $F(3, 46) = 1.63, p = .197, \eta_{p}^{2} = .104, \beta = .396$ or SE, $F(3, 46) = .65, p = .590, \eta_{p}^{2} = .044, \beta = .174$.

In sum, significant or trend-level Group by Time interactions with large effect sizes emerged for four out of the five facial expressivity variables (i.e., FM, EF, EI, and EV), showing that individuals in the LSVT improved significantly more than the other three groups. However, for FM, EI, and EV, these two-way interactions were superseded by 3-way Group by Gender by Time interactions, each of which also had large effect sizes. Post-hoc analyses revealed that both men and women in the LSVT groups showed significant or trend-level improvements following treatment for both FM and EI (small effect sizes), but that only LSVT men showed significant improvements for EV. For the ARTIC and UPD groups, women displayed significant decreases for multiple variables whereas men in both groups were stable over time. HCs were also stable over time. The power ranged from $\beta = .559$ to $\beta = .810$ for the significant and trend-level two- and three-way interactions, suggesting that there may not have been adequate power to detect
significant results for the trend-level findings. Furthermore, the two- and three-way interactions for SE were significantly below the benchmark for adequate power.

**Hypothesis 6.** Consistent with our Hypothesis 6 prediction (i.e., that individuals in the LSVT group would increase more from pre- to post-treatment for the negative monologues [i.e., Angry and Sad] than for the positive monologue [i.e., Happy]), there were significant or trend-level 4-way Group by Gender by Time by Emotion interactions for FM, $F(6, 84) = 2.19, p = .053, \eta_p^2 = .135, \beta = .747$; EF, $F(6, 84) = 1.91, p = .089, \eta_p^2 = .120, \beta = .676$; and EI, $F(6, 84) = 1.83, p = .103, \eta_p^2 = .116, \beta = .654$(see Tables 7, 8, & 9). Post-hoc analyses showed a significant increase from pre- to post-treatment for LSVT women for the Sad monologue for FM ($p = .004$), EF ($p = .004$), and EI ($p = .007$). There were also significant or trend-level increases for LSVT men for the Happy monologue for FM with a small effect size ($p = .096; d = 0.347$) and EF ($p = .050$). Contrary to our prediction for the ARTIC group, post-hoc analyses showed that ARTIC women exhibited significant decreases from pre- to post-treatment for the Sad monologue for FM ($p = .026$), EF ($p = .012$), and EI ($p = .022$), but stable ratings over time for both Angry and Happy. No significant differences from pre- to post-treatment were seen for men in the ARTIC group. In addition, for the UPD group, women showed significant decreases over time for FM Angry ($p = .048$), FM Happy ($p = .027$), and EI Angry ($p = .042$). There were no significant changes in facial expressivity over time for UPD men or for HC participants (i.e., men & women) for any of the emotions.

Taken together, there were significant and trend-level Group by Gender by Emotion by Time interactions for FM, EF, and EI, all with medium effect sizes, all of which supersede the 2- and 3-way interactions discussed in the preceding paragraphs. Overall, in these interactions, post-hoc analyses revealed that significant increases following LSVT occurred for women for
Sad and for men for Happy. Women in both the ARTIC and UPD groups displayed significant decreases in facial expressivity for multiple face variables whereas men were stable. HCs were also stable over time. Of note, the power for all of these analyses was below the adequate level.

**Aim 3: Predictive Analysis**

In order to examine this aim, we conducted a multiple regression analysis, separately, for each facial expression variable (EF, EI, EV, SE, & FM) for both the positive (i.e., Happy) and negative (i.e., mean score of Sad & Angry) emotion monologues for the LSVT treatment group. Predictor variables were the demographic and clinical variables that achieved a significant correlation ($p \leq .05$) with one or more of the dependent variables (i.e., Gender, Illness Duration, MMSE score, & BDI-II score; see Table 10). The dependent variables were the pre-post testing change scores (i.e., the post score minus the pre score) for each of the 5 face variables for the positive and negative monologues.

For the preliminary correlations, there were significant Pearson Product-Moment correlations between the BDI-II score and the following LSVT baseline scores: FM Negative, $r = .67, p = .017$; FM Positive, $r = .63, p = .029$; and EV Positive, $r = .60, p = .040$. There were also significant correlations between Gender and the following face variables: FM Negative, $r = .72, p = .005$; EV Negative, $r = .55, p = .050$; FM Positive, $r = .71, p = .007$; EF Positive, $r = .55, p = .051$; and EV Positive, $r = .62, p = .026$. Significant correlations also emerged between the MMSE score and SE Positive, $r = -.61, p = .037$ and between Illness Duration and FM Positive, $r = .63, p = .030$ (see Table 10). Therefore, for the regression analyses to follow, we used Gender, Illness Duration, MMSE score, and BDI-II score as the predictor variables.

**Hypothesis 7.** For Hypothesis 7, we predicted that lower Illness Duration and BDI-II scores and that higher MMSE scores would predict facial expressivity improvement in LSVT
participants. We also predicted that female participants would show more facial improvement following LSVT than would male participants. Contrary to these predictions, none of the multiple regression analyses involving 4 predictor variables yielded significant results for any of the 10 face variables (i.e., Positive & Negative Emotion X 5 face variables; see Table 11). However, there was one trend-level finding for SE Positive Emotion, Multiple $R = .81$, $R^2 = .66$, $p = .077$, with Gender ($t = -2.42, p = .046; \text{men changing more}$), BDI-II score ($t = 2.37, p = .050; \text{individuals with higher levels of depression changing more}$), and MMSE ($t = 1.93, p = .094; \text{individuals with higher cognitive functioning changing more}$) making significant or trend-level contributions to the analysis (see Table 12).

**Discussion**

This dissertation examined differences in facial mobility and expression between PD and HC individuals as well as the impact of a voice treatment (i.e., LSVT) on facial change in PD. Lastly, in order to extend the rehabilitation literature, we examined the impact of demographic and clinical factors in predicting facial change through LSVT.

**Aim 1, Hypothesis 1: Facial Expression, PD versus HC Participants**

In Aim 1, we hypothesized that individuals with PD would display significantly reduced facial mobility and emotional expression relative to healthy controls. Our findings were somewhat consistent with this expectation, revealing significantly lower facial mobility (FM) and emotional variability (EV) for the PD participants as compared to HCs. However, these effects were moderated by emotion and gender. For FM, PD men displayed significantly lower facial ratings than HC men, while there were no significant group differences for women on this variable. This finding is in line with gender differences in the clinical presentation of PD (Haaxma et al., 2007), such that more women initially present with tremor, whereas men present
with bradykinesia or rigidity. According to these authors, symptoms of bradykinesia and rigidity affect the face whereas tremor affects the extremities. For EV, PDs presented with significantly lower expressivity than HCs for the Sad monologue, but there were no significant group differences for Happy or Angry monologues. Also, for social engagement (SE), there was a trend with a medium effect size for the Group by Emotion interaction. Although none of the post-hoc comparisons were significant, the findings were going in the predicted direction, with PDs rated as less expressive than HCs for all three emotions. The findings for Social Engagement are of interest, as, instead of focusing on individual aspects of facial expression and movement, the SE variable is a subjective rating of how engaged, attentive, connected, or involved the individual appears. Importantly, individuals with PD have difficulties in social situations and have been reported to have communication problems and difficulties in interpersonal interactions (e.g., Coker & Burgoon, 1987; Riggio & Friedman, 1986; Spielman et al., 2003). Overall, the findings for FM and EV are consistent with the literature, where evidence of reduced facial expression and mobility in PD has been previously observed (Borod et al., 1989; Buck & Duffy, 1980; Dumer et al., 2014; Katsikitis & Pilowsky, 1988, 1991; Simons et al., 2004; Smith et al., 1996; for reviews, see Bono & Borod, 2016; Halfacre et al., 2009).

**Aim 1, Hypothesis 2: The Effect of Emotional Valence on Facial Expression**

Contrary to our prediction and the literature documenting more impairment in PD for positive than negative emotional expressions (e.g., McCabe, 2013; McCabe et al., 2016; Pitcairn et al., 1990), individuals with PD displayed significantly higher EV and SE (medium effect size) while producing positive (i.e., Happy) than negative (i.e., Angry & Sad) emotion monologues. There were no significant or trend-level Group by Emotion interactions for the three other face variables. It is possible that individuals with PD are evaluated by naïve observers as being
impaired across all emotions and that it is difficult to recognize the impairment among discrete emotions without facial action coding experience (e.g., FACS; Ekman & Friesen, 1978), which has been used for facial expressivity analysis in the studies citing this difference (McCabe, 2013; Pitcairn et al., 1990). Given that our findings have a medium effect size, it brings into question the literature suggesting that PDs are more expressive for negative than positive emotions. In fact, consistent with the current study, a study by Borod et al., (1990) found that PDs produced positive facial expressions with more emotional intensity than negative expressions.

**Aim 1, Hypothesis 3: The Effect of Gender on Facial Expression**

As predicted, women displayed significantly more facial emotional expressivity (i.e., EF, EV, & EI) and facial mobility (FM) than did men, consistent with the extensive facial literature on gender differences in facial emotional expression (for reviews, see Borod & Madigan, 2000; Hall & Matsumoto, 2004; Huang & Hu, 2009; Scholten, Aleman, Montagne, & Kahan, 2005; Thayer & Johnson, 2000). Although there were no significant differences between men and women for the Social Engagement variable, the findings went in the same direction, with women being rated as more expressive than men.

Although women were found to be more expressive than men across the facial variables, these findings were modified by Gender by Monologue Type interactions for FM and SE. For these variables, women were most expressive for Happiness and men were most expressive for Anger. This is in line with related evidence from the healthy adult literature, indicating that women smile more frequently than men (LaFrance, Hecht, & Paluck, 2003) and that women experience more negative social consequences for displaying anger than do men (e.g., Brescoll & Uhlmann, 2008). Our findings are also consistent with the neuropsychology of emotion literature, which suggests that women are more lateralized for positive emotions, whereas men
are more lateralized for negative emotions (Borod & Caron, 1980). Lastly, evidence from developmental psychology suggests that girls are better at concealing negative emotions than are boys (Davis, 1995), possibly due to the negative social consequences women experience for displaying anger (e.g., Brescoll & Uhlmann, 2008). It is possible that some of our women participants felt uncomfortable expressing intense emotion regarding negative events due to cultural attitudes.

**Aim 2, Hypothesis 4: The Effect of LSVT on Facial Expression**

For Hypothesis 4, we predicted that PDs in the Lee Silverman Voice Treatment (LSVT) group would display significantly more improvement in facial mobility (FM), emotional frequency (EF), emotional variability (EV), emotional intensity (EI), and social engagement (SE) from pre-to-post treatment than would the Articulation (ARTIC), Untreated PD (UPD), and healthy control (HC) groups. Our findings supported this hypothesis, with significant or trend-level improvements with large effect sizes for the LSVT group for four out of the five face variables (i.e., FM, EF, EV, & EI). However, for EV, this interaction was moderated by Gender, with significant increases from pre- to post-treatment for men but no significant difference for women in the LSVT group.

These results, coupled with the large effect size, are consistent with earlier studies suggesting that LSVT improves facial expressivity (Alterescu et al., 2013; Halfacre et al., 2016; Spielman et al., 2003). Our findings are particularly important since there are few empirically validated treatments targeting facial expression and mobility in individuals with PD. Although the physical and occupational therapy literature reports (e.g., Dixon et al., 2007; Gauthier, Dalziel, & Gauthier, 1987) targeting facial expression as a part of a holistic treatment plan for individuals with Parkinson’s disease, there is limited empirical support documenting their
specific effectiveness for face, as many of the studies are evaluating treatment effectiveness through an aggregate score of motor symptomology (of which facial expressivity is a component), making it difficult to parse out the extent to which these interventions are improving facial expressivity. To our knowledge, there have only been two other studies specifically carried out to attempt to improve facial mobility and facial expressivity in Parkinson’s disease, one using orofacial physiotherapy (Katsikitis & Pilowsky, 1996) and the other using the active music therapy technique (Elefant, Lotan, Baker, & Skeie, 2012). However, the empirical support for each of these approaches is also quite limited (i.e., one article per approach). In fact, the majority of empirically supported treatments targeting the face were created for individuals with facial palsy, including video self-modeling (e.g., Coulson, Adams, O’Dwyer, & Croxson, 2006), mime therapy (e.g., Devriese & Bronk, 1977; Beurskens & Heymans, 2004, 2006), and facial neuromuscular re-education approach (e.g., Cronin & Steenerson, 2003; Lindsay, Robinson, & Hadlock, 2010; Nakamura, Toda, Sakamaki, Kashima, & Takeda, 2003; Pourmomeny, Zadmehre, Mirshamsi, & Mahmodi, 2014; Ross, Nedzelski, & McLean, 1991). Unfortunately, none of these treatments are validated approaches for individuals with PD.

Our treatment effect findings also provide support for the theory about an integrated system of emotion (Borod, 1993b; Kaiser & Scherer, 1998; Porges, 2001), which suggests that various communication channels (e.g., facial & vocal/prosodic) work together when producing an emotional response. Our findings also support the overlap in neural pathways between facial and vocal systems (i.e., for both systems, posed expression is mediated via neocortical pathways whereas spontaneous expression is mediated by subcortical and limbic pathways; for reviews, see Bono & Borod, 2016; Borod, 1993a; Borod & Koff, 1984), as well as the overlap in neural
structures regulating facial and vocal expression (i.e., anterior cingulate cortex, peraqueductal grey, thalamus, & basal ganglia; Devinsky, Morrell, & Vogt, 1995; Jurgent & Zwirner, 1996). Another theory regarding LSVT treatment mechanisms involves the neurotransmitter dopamine. Dopamine is the primary neurotransmitter impacted by PD and has a well-supported history of being associated with reward systems and goal-directed behavior (e.g., De la Fuente-Fernandez, Ruth, Sossi, Schulzer, Calne, & Stoessl, 2001; De la Fuente-Fernandez & Stoessl, 2002). Songbirds have been used as an animal model to study speech production due to the similarities between human speech and bird song. Findings from these studies suggest that basal ganglia circuits in songbirds and humans are similar in that dopaminergic functions appears to be critical for goal-directed changes in both speech and song output (Heimovics & Riters, 2008; Simonyan, Horwitz, & Jarvis, 2012). In this context, it is possible that engaging in an intensive vocal-based treatment may have an impact on the dopaminergic system, thereby exerting influence on motor symptoms in PD. In addition, it is possible that the social component involved in completing an intensive treatment may have reduced symptoms of depression, thereby improving facial expressivity. Indeed, recent studies with PD patients suggest that the expectation of symptom improvement may activate endogenous dopamine in the striatum, which may actually influence motor symptoms (e.g., Miwa, 2007).

The differential effects of LSVT as a function of Gender, with men improving more than women overall, were unexpected. However, it is interesting that this finding is consistent with gender differences in PD symptomology, such that men are more likely to present initially with motor symptoms of bradykinesia and rigidity, which are more likely to impact the face (Haaxma et al., 2007), and report more motor symptoms over the course of the disease than do women (Scott, Borgman, Engler, Johnels, & Aquilonius, 2000). It is possible that men treated with
LSVT showed more change than women because they present with more facial expressivity impairment at baseline, and may, therefore, be showing more visible change post treatment. Indeed, in our dataset, for facial mobility, PD men displayed significantly lower facial ratings than HC men, while there were no significant group differences for women. Another theory is that women with PD may be more conscious of their reduced facial expressivity and might overcompensate due to the social consequences associated with facial expressivity deficits (e.g., Hemmesch, Tickle-Degnen, & Zebowitz, 2009).

Aim 2, Hypothesis 5: The Effect of ARTIC on Facial Expression

Our fifth hypothesis was that FM, EF, EV, EI, and SE would also improve following ARTIC treatment, but to a lesser degree than after LSVT. Contrary to our expectation, there was no significant improvement in facial expressivity or mobility from pre- to post-treatment following ARTIC, regardless of large effect sizes. Though the power was variable for the different analyses, closer inspection of the means revealed stable performance. For the most part, the PD participants treated with ARTIC were stable over time, and, actually, significant decreases in expressivity were seen for EV and EI among female PDs. It is possible that ARTIC did not exert as much influence over facial expressivity and mobility as LSVT because ARTIC targets higher level components of speech production (i.e., articulation), which involve more neocortical than subcortical control (e.g., Dronkers, 1996; Hillis, Work, Barker, Jacobs, Breese, & Maurer, 2004). By comparison, LSVT targets more primitive aspects of vocal production (e.g., respiration & phonation), exerting its influence on older phylogenetic brain regions (e.g., subcortical areas), which are more involved in emotional processing and are more affected in PD (e.g., Jurgens, 2002). Relative to LSVT, ARTIC is not an effective treatment to increase facial expressivity and mobility in PD.
Aim 2, Hypothesis 6: Differential Effects of LSVT on Facial Emotional Expression for Positive versus Negative Emotion

Consistent with our Hypothesis 6 prediction (i.e., that individuals in the LSVT group would increase more from pre- to post-treatment for negative [Angry & Sad] than positive monologues [Happy]), there were significant or trend-level Group by Gender by Time by Emotion interactions with medium effect sizes for three out of five face variables (i.e., FM, EF, & EI), with LSVT women showing significant increases in facial expressivity from pre- to post-treatment for the Sad monologue. By contrast, ratings remained stable ratings over time for the Angry and Happy monologues for LSVT women. This is consistent with the literature suggesting that individuals with PD are more expressive for negative than positive emotions (e.g., Brozgold et al., 1998; McCabe, 2013; Pitcairn et al., 1990). Though there are no studies, to our knowledge, specifically exploring gender differences in facial emotional expressivity in PD, the gender literature shows that women use more facial muscle movements when expressing negative emotions than do men (Schwartz, Brown, & Ahern, 1980). By contrast, LSVT men showed a significant or trend-level increase over time in EF and FM for the Happy monologue but no change for the Angry and Sad monologues. In addition, ARTIC women exhibited significant decreases (large effect) from pre- to post-treatment for Sad for all three variables (i.e., FM, EF, & EI) but stable ratings for both Angry and Happy. UPD women showed significant decreases over time for FM Angry, FM Happy, and EI Angry but stable ratings for all other monologues and face variables. The findings for ARTIC and UPDs suggest that the impact of ARTIC on facial expressivity is minimal. No significant differences from pre- to post-treatment were seen for ARTIC men, UPD men, HC men, or HC women. Because of the unequivocal findings with
respect to emotional valence, future work in this area should utilize a larger number of both positive and negative emotions.

**Aim 3, Hypothesis 7: Predictive Analysis for LSVT**

When the multiple regression findings were examined for each of the facial variables, there was only one trend-level finding (i.e., for SE Positive), with Gender (men changing more over time), BDI-II score (individuals with higher levels of depression changing more), and MMSE (individuals with higher cognitive functioning changing more) making significant or trend-level contributions to the analysis. Contrary to our predictions, demographic and clinical factors only made contributions to one of the facial expressivity variables, which may be due to low power due to our small sample size. As such, it is possible that the overall finding for SE Positive may have some important clinical implications, since some of the specific findings were consistent with the rehabilitation literature. One of these findings includes the influence of cognitive status on rehabilitation treatments. In our study, the individuals in the LSVT group with higher overall cognitive functioning showed more facial expressivity improvement, consistent with previous literature examining the impact of cognitive status on treatment outcomes (Fusco et al., 2009; Hershkovitz, Gottlieb, Beloosesky, & Brill, 2006; Landi et al., 2002). Contrary to prior research (Fusco et al., 2009), we found that individuals with higher levels of depression increased their facial expressivity following treatment. As depression has a documented impact on facial expression (e.g., Borod et al., 1990; Jaeger, Borod, & Peselow, 1985), it is likely that individuals who were more depressed displayed less facial affect at the start of treatment and may have, therefore, showed more visible change from pre- to post-treatment. In terms of Gender, our data for SE positive showed that LSVT men changed more over time than LSVT women. Although there were no specific predictions for Gender with
respect to treatment, similar to what was noted in the Introduction, it is possible that women, in
general, are more conscious of reduced facial expressivity than are men and that they
overcompensate due to the social consequences associated with facial expressivity deficits (e.g.,
Brozgold et al., 1998), particularly for women in our western societies (e.g., Hemmesch, Tickle-
Degnen, & Zebrowitz, 2009).

Study Limitations

A limitation of this study, as well as many studies exploring facial expression in PD, is
the effect of depression on facial expression. Due to the high comorbidity of depression and PD,
individuals with severe depression were excluded from this study. The BDI-II was used as a
screening measure for poser participants; only participants with a score of 28 or lower were
included in the study. In addition, we covaried for the BDI-II in our data analyses in order to
statistically control for the possible effects of depression symptomology on each poser’s facial
expressivity scores.

Another limitation of this study is that the medication status of the PD participants was
not a factor in our analyses. It is possible that medication type, dosage, and side effects may have
affected the facial movement and expressivity of our PD participants. Future studies
investigating facial expression in PD should account for this variable.

The composition of our sample is another limitation of this study. All participants were
from the Boulder/Denver, Colorado area, and most were of Caucasian descent (i.e., 96.3%; 3.7%
Hispanic) and well-educated. These findings may not be generalizable to other ethnic and less-
educated groups. Future research with more culturally diverse samples is warranted. In addition,
the sample size in the current study was relatively small, and, to increase the power, future
studies should use larger numbers of participants.
Another potential limitation of our study is the type of facial rating system that was used. Although our raters were trained to high levels of interrater reliability, the ratings are subjective. There are systems that more objectively evaluate facial expression (i.e., FACS [Ekman & Friesen, 1978] & MAX [Izard, 1979]). However, of note, there was a study done with a component of the current dataset using FACS, which also found a significant effect of LSVT on facial expressivity (Dumer, 2011; Dumer et al., 2014).

**Future Directions**

One suggestion for future studies is to investigate the relationship between social engagement and facial expressivity in order to determine whether facial expressivity (i.e., EF, EV, & EI) contributes to being an engaging social partner. In a similar vein, the relationship between facial mobility and emotional expressivity could be examined and mobility controlled for when analyzing the measures of emotional expression. Future research suggestions specific to LSVT include exploring the impact of PD medication on facial and vocal change following LSVT as well as investigating the perceptions of facial improvement via LSVT by family members and healthcare workers. It would also be interesting to directly investigate the impact of LSVT on quality of life and interpersonal relationships. Lastly, neuroimaging studies would be useful to investigate the proposed neural mechanisms involved in LSVT, and to lend further support to the integrated theory of emotional expression.

**Clinical Implications**

There are multiple clinical implications that this study has for the PD and rehabilitation literature. Facial expression is examined through a multifactorial approach, involving mobility, expressivity, and social judgment of others, which has not been carried out in other studies with PD. In terms of treatment, our findings for LSVT are important to the rehabilitation therapy
literature because there are few empirically validated treatments targeting facial emotional expression and mobility for individuals with PD. Though earlier studies using a subset of these data have examined the impact of LSVT on facial expression, the differential effect of LSVT on emotional valence was not previously examined, and none of the earlier studies examined the effect of demographic, clinical, cognitive, and affective variables on facial emotional expression improvement through LSVT.

Conclusions

Parkinson’s disease is associated with a wide range of motoric, cognitive, and affective symptoms. Impairments in facial mobility and emotional expressivity are common and can impair communication, in turn, affecting daily functioning and quality of life. We found that individuals with PD were less facially expressive than healthy adult participants, though these findings were influenced by gender and emotion type. We also found that LSVT, a rehabilitation therapy initially created to improve vocal loudness, is also an effective treatment for facial expressivity. Contrary to our expectations, demographic, clinical, cognitive, and affective variables did not lead to significant improvements in LSVT, likely due to small sample size and low power.
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<td></td>
</tr>
<tr>
<td>Hoehn &amp; Yahr</td>
<td>2.2 (0.5)</td>
<td>2.2 (0.9)</td>
<td>2.0 (0.5)</td>
<td>2.1 (0.7)</td>
<td>--------</td>
</tr>
<tr>
<td>Stage</td>
<td>M ((SD))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illness</td>
<td>6.0 (8.3)</td>
<td>3.8 (3.2)</td>
<td>5.5 (4.5)</td>
<td>5.0 (5.5)</td>
<td>--------</td>
</tr>
<tr>
<td>Duration</td>
<td>M ((SD))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side of Initial Motor Symptom</td>
<td>RPD ((n = 6))</td>
<td>RPD ((n = 5))</td>
<td>RPD ((n = 4))</td>
<td>RPD ((n = 15))</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>LPD ((n = 5))</td>
<td>LPD ((n = 7))</td>
<td>LPD ((n = 8))</td>
<td>LPD ((n = 20))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UN ((n = 2))</td>
<td>UN ((n = 2))</td>
<td>UN ((n = 1))</td>
<td>UN ((n = 5))</td>
<td></td>
</tr>
<tr>
<td>BDI-II Score</td>
<td>10.5 (6.5)</td>
<td>7.2 (5.0)</td>
<td>5.9 (4.3)</td>
<td>8.1 (5.6)</td>
<td>3.2 (3.7)</td>
</tr>
<tr>
<td>M ((SD))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE Score</td>
<td>28.8 (1.6)</td>
<td>28.5 (1.2)</td>
<td>29.0 (0.8)</td>
<td>28.8 (1.2)</td>
<td>29.4 (0.7)</td>
</tr>
<tr>
<td>M ((SD))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. LSVT=Lee Silverman Voice Treatment; ARTIC=Articulation Treatment; UPD=Untreated Parkinson’s disease; All PD=All Parkinson’s disease participants; HC=Healthy Controls; RPD=right-sided PD onset; LPD=left-sided PD onset; UN=unknown PD onset; BDI-II=Beck Depression Inventory, 2nd edition; MMSE=Mini Mental Status Exam
<table>
<thead>
<tr>
<th>Cohort</th>
<th>Gender (% Women)</th>
<th>Age M (SD)</th>
<th>Education in Years M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort 1 (n = 6)</td>
<td>50%</td>
<td>25.3 (6.15)</td>
<td>15.5 (0.55)</td>
</tr>
<tr>
<td>Cohort 2 (n = 6)</td>
<td>50%</td>
<td>23.8 (2.03)</td>
<td>16.3 (0.75)</td>
</tr>
<tr>
<td>Cohort 3 (n = 6)</td>
<td>50%</td>
<td>23.8 (6.59)</td>
<td>14.5 (1.50)</td>
</tr>
</tbody>
</table>
Table 3  
*Intra-class Correlations for Training Sessions: Conferencing, Inter-rater Reliability, and Experimental Rating Data*  

<table>
<thead>
<tr>
<th>Training Variables</th>
<th>Cohort 1</th>
<th>Cohort 2</th>
<th>Cohort 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FM</td>
<td>EF</td>
<td>EI</td>
</tr>
<tr>
<td>Conferencing</td>
<td>.962</td>
<td>.918</td>
<td>.976</td>
</tr>
<tr>
<td>Inter-rater Reliability</td>
<td>.921</td>
<td>.910</td>
<td>.937</td>
</tr>
<tr>
<td>Experimental Rating Data</td>
<td>.812</td>
<td>.836</td>
<td>.849</td>
</tr>
<tr>
<td>Conferencing</td>
<td>.932</td>
<td>.943</td>
<td>.923</td>
</tr>
<tr>
<td>Inter-rater Reliability</td>
<td>.860</td>
<td>.883</td>
<td>.924</td>
</tr>
<tr>
<td>Experimental Rating Data</td>
<td>.896</td>
<td>.847</td>
<td>.731</td>
</tr>
<tr>
<td>Conferencing</td>
<td>.948</td>
<td>.946</td>
<td>.953</td>
</tr>
<tr>
<td>Inter-rater Reliability</td>
<td>.908</td>
<td>.875</td>
<td>.910</td>
</tr>
<tr>
<td>Experimental Rating Data</td>
<td>.867</td>
<td>.757</td>
<td>.885</td>
</tr>
</tbody>
</table>

*Note.* FM = Facial Mobility; EF = Emotional Frequency; EV = Emotional Variability; EI = Emotional Intensity; SE = Social Engagement.
<table>
<thead>
<tr>
<th>Effect</th>
<th>Facial Rating Variable</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FM</td>
<td>EF</td>
<td>EV</td>
<td>EI</td>
<td>SE</td>
</tr>
<tr>
<td>Group</td>
<td>.149</td>
<td>.616</td>
<td>.212</td>
<td>.793</td>
<td>.311</td>
</tr>
<tr>
<td>Gender</td>
<td>.006*</td>
<td>.016*</td>
<td>.004*</td>
<td>.002*</td>
<td>.285</td>
</tr>
<tr>
<td>Emotion</td>
<td>.006*</td>
<td>.030*</td>
<td>.010*</td>
<td>.029*</td>
<td>.000*</td>
</tr>
<tr>
<td>Group X Gender</td>
<td>.092†</td>
<td>.315</td>
<td>.317</td>
<td>.297</td>
<td>.375</td>
</tr>
<tr>
<td>Group X Emotion</td>
<td>.343</td>
<td>.795</td>
<td>.040*</td>
<td>.659</td>
<td>.057†</td>
</tr>
<tr>
<td>Gender X Emotion</td>
<td>.009*</td>
<td>.232</td>
<td>.201</td>
<td>.406</td>
<td>.017*</td>
</tr>
<tr>
<td>Group X Gender X Emotion</td>
<td>.355</td>
<td>.997</td>
<td>.157</td>
<td>.959</td>
<td>.690</td>
</tr>
</tbody>
</table>

Note.
1 FM = Facial Mobility; EF = Emotional Frequency; EV = Emotional Variability; EI = Emotional Intensity; SE = Social Engagement.
2 BDI-II score was used as a covariate in this analysis
3 **p≤.01; *p≤.05; †p≤.10
Table 5
Aim 1: Means for the Main Effect of Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Men</th>
<th>Women</th>
<th>Men</th>
<th>Women</th>
<th>Men</th>
<th>Women</th>
<th>Men</th>
<th>Women</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.62</td>
<td>3.37</td>
<td>2.54</td>
<td>3.36</td>
<td>2.16</td>
<td>2.86</td>
<td>2.18</td>
<td>3.10</td>
<td>2.82</td>
<td>3.12</td>
</tr>
<tr>
<td>(SD)</td>
<td>(.16)</td>
<td>(.21)</td>
<td>(.19)</td>
<td>(.26)</td>
<td>(.14)</td>
<td>(.19)</td>
<td>(.17)</td>
<td>(.23)</td>
<td>(.17)</td>
<td>(.22)</td>
</tr>
</tbody>
</table>

Note. FM = Facial Mobility; EF = Emotional Frequency; EV = Emotional Variability; EI = Emotional Intensity; SE = Social Engagement.
Table 6
Aim 2: Poser Group by Gender by Time by Emotion ANCOVA (4 x 2 x 3 x 3), Significance of Effects (p-values)

<table>
<thead>
<tr>
<th>Effect</th>
<th>Facial Rating Variable</th>
<th>FM</th>
<th>EF</th>
<th>EV</th>
<th>EI</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poser Group</td>
<td></td>
<td>.168</td>
<td>.265</td>
<td>.158</td>
<td>.361</td>
<td>.193</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td>.000*</td>
<td>.004*</td>
<td>.001*</td>
<td>.001*</td>
<td>.236</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td>.166</td>
<td>.055†</td>
<td>.395</td>
<td>.144</td>
<td>.692</td>
</tr>
<tr>
<td>Emotion</td>
<td></td>
<td>.000*</td>
<td>.004*</td>
<td>.000*</td>
<td>.054*</td>
<td>.000*</td>
</tr>
<tr>
<td>Poser Group x Gender</td>
<td></td>
<td>.545</td>
<td>.513</td>
<td>.710</td>
<td>.726</td>
<td>.770</td>
</tr>
<tr>
<td>Poser Group x Time</td>
<td></td>
<td>.020*</td>
<td>.043*</td>
<td>.082†</td>
<td>.029*</td>
<td>.925</td>
</tr>
<tr>
<td>Poser Group x Emotion</td>
<td></td>
<td>.485</td>
<td>.903</td>
<td>.071†</td>
<td>.779</td>
<td>.013*</td>
</tr>
<tr>
<td>Gender x Time</td>
<td></td>
<td>.412</td>
<td>.957</td>
<td>.274</td>
<td>.322</td>
<td>.473</td>
</tr>
<tr>
<td>Gender x Emotion</td>
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<td>.015*</td>
<td>.104</td>
<td>.032*</td>
<td>.136</td>
<td>.008*</td>
</tr>
<tr>
<td>Time x Emotion</td>
<td></td>
<td>.729</td>
<td>.959</td>
<td>.275</td>
<td>.636</td>
<td>.960</td>
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<tr>
<td>Poser Group x Gender x Time</td>
<td></td>
<td>.046*</td>
<td>.197</td>
<td>.023*</td>
<td>.012*</td>
<td>.590</td>
</tr>
<tr>
<td>Poser Group x Gender x Emotion</td>
<td></td>
<td>.878</td>
<td>.988</td>
<td>.203</td>
<td>.976</td>
<td>.195</td>
</tr>
<tr>
<td>Poser Group x Time x Emotion</td>
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<td>.462</td>
<td>.311</td>
<td>.653</td>
<td>.354</td>
<td>.409</td>
</tr>
<tr>
<td>Gender x Time x Emotion</td>
<td></td>
<td>.119</td>
<td>.102</td>
<td>.221</td>
<td>.081†</td>
<td>.545</td>
</tr>
<tr>
<td>Poser Group x Gender x Time x Emotion</td>
<td></td>
<td>.052*</td>
<td>.089†</td>
<td>.125</td>
<td>.103†</td>
<td>.212</td>
</tr>
</tbody>
</table>

Note.
1FM = Facial Mobility; EF = Emotional Frequency; EV = Emotional Variability; EI = Emotional Intensity; SE = Social Engagement.
2BDI-II score was used as a covariate in this analysis.
3**p≤.01; *p≤.05; †p≤.10
Table 7
Aim 2: Means and Standard Deviations for the Poser Group by Gender by Time by Emotion Interaction for FM (p = .052)

<table>
<thead>
<tr>
<th>Group</th>
<th>LSVT</th>
<th></th>
<th></th>
<th>ARTIC</th>
<th></th>
<th></th>
<th>UPD</th>
<th></th>
<th></th>
<th>HC</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Angry</td>
<td>Happy</td>
<td>SAD</td>
<td>Angry</td>
<td>Happy</td>
<td>SAD</td>
<td>Angry</td>
<td>Happy</td>
<td>SAD</td>
<td>Angry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td>1.95</td>
<td>2.18</td>
<td>1.91</td>
<td>2.19</td>
<td>1.80</td>
<td>1.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.26)</td>
<td>(.25)</td>
<td>(.29)</td>
<td>(.24)</td>
<td>(.28)</td>
<td>(.25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td>3.24</td>
<td>3.22</td>
<td>3.17</td>
<td>3.61</td>
<td>2.59</td>
<td>3.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.57)</td>
<td>(.55)</td>
<td>(.63)</td>
<td>(.53)</td>
<td>(.62)</td>
<td>(.56)</td>
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<td></td>
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</tr>
</tbody>
</table>

Note. LSVT=Lee Silverman Voice Treatment; ARTIC=Articulation Treatment; UPD=Untreated Parkinson’s disease; All PD=All Parkinson’s disease participants; HC=Healthy Controls.
Table 8
Aim 2: Means and Standard Deviations for the Poser Group by Gender by Time by Emotion Interaction for EF (p = .089)

<table>
<thead>
<tr>
<th>Group</th>
<th>LSVT</th>
<th>ARTIC</th>
<th>UPD</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotion</strong></td>
<td>Angry</td>
<td>Happy</td>
<td>Sad</td>
<td>Angry</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSVT</td>
<td>1.96 (.34)</td>
<td>2.20 (.31)</td>
<td>1.95 (.34)</td>
<td>2.41 (.32)</td>
</tr>
<tr>
<td>ARTIC</td>
<td>2.27 (.75)</td>
<td>2.46 (.68)</td>
<td>2.73 (.75)</td>
<td>2.81 (.71)</td>
</tr>
<tr>
<td>UPD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HC</td>
<td>2.58 (.36)</td>
<td>2.39 (.33)</td>
<td>2.52 (.37)</td>
<td>2.70 (.35)</td>
</tr>
<tr>
<td>LSVT</td>
<td>3.23 (.45)</td>
<td>3.17 (.41)</td>
<td>3.53 (.45)</td>
<td>3.58 (.43)</td>
</tr>
<tr>
<td>ARTIC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPD</td>
<td>2.36 (.34)</td>
<td>2.57 (.31)</td>
<td>2.49 (.34)</td>
<td>2.57 (.33)</td>
</tr>
<tr>
<td>HC</td>
<td>3.96 (.58)</td>
<td>3.49 (.53)</td>
<td>4.70 (.58)</td>
<td>4.08 (.56)</td>
</tr>
<tr>
<td><strong>Note.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LSVT=Lee Silverman Voice Treatment; ARTIC=Articulation Treatment; UPD=Untreated Parkinson’s disease; All PD=All Parkinson’s disease participants; HC=Healthy Controls.
### Table 9
Aim 2: Means and Standard Deviations for the Poser Group by Gender by Time by Emotion Interaction for EI (p = .103)

<table>
<thead>
<tr>
<th>Group</th>
<th>LSVT</th>
<th>ARTIC</th>
<th>UPD</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Angry</td>
<td>Happy</td>
<td>Sad</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Men</td>
<td>1.83 (.29)</td>
<td>2.16 (.28)</td>
<td>1.88 (.30)</td>
<td>2.17 (.27)</td>
</tr>
<tr>
<td>Women</td>
<td>2.29 (.64)</td>
<td>2.33 (.61)</td>
<td>2.39 (.66)</td>
<td>2.67 (.59)</td>
</tr>
<tr>
<td>Men</td>
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<td>1.96 (.30)</td>
<td>1.97 (.32)</td>
<td>2.15 (.29)</td>
</tr>
<tr>
<td>Women</td>
<td>3.02 (.39)</td>
<td>2.83 (.37)</td>
<td>3.24 (.40)</td>
<td>3.07 (.35)</td>
</tr>
<tr>
<td>Men</td>
<td>2.25 (.29)</td>
<td>2.44 (.28)</td>
<td>2.34 (.31)</td>
<td>2.43 (.27)</td>
</tr>
<tr>
<td>Women</td>
<td>3.70 (.50)</td>
<td>2.96 (.47)</td>
<td>4.29 (.52)</td>
<td>3.34 (.46)</td>
</tr>
<tr>
<td>Men</td>
<td>2.60 (.31)</td>
<td>2.39 (.29)</td>
<td>2.44 (.32)</td>
<td>2.49 (.28)</td>
</tr>
<tr>
<td>Women</td>
<td>3.06 (.40)</td>
<td>3.28 (.38)</td>
<td>3.23 (.41)</td>
<td>3.23 (.37)</td>
</tr>
</tbody>
</table>

*Note.* LSVT=Lee Silverman Voice Treatment; ARTIC=Articulation Treatment; UPD=Untreated Parkinson’s disease; All PD=All Parkinson’s disease participants; HC=Healthy Controls.
Table 10
Correlations between Demographic, Clinical, Cognitive, and Affective Variables and Face Variables for LSVT

<table>
<thead>
<tr>
<th></th>
<th>FM Neg.</th>
<th>FM Pos.</th>
<th>EF Neg.</th>
<th>EF Pos.</th>
<th>EV Neg.</th>
<th>EV Pos.</th>
<th>EI Neg.</th>
<th>EI Pos.</th>
<th>SE Neg.</th>
<th>SE Pos.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.708**</td>
<td>.449</td>
<td>.551*</td>
<td>.553*</td>
<td>.614*</td>
<td>.409</td>
<td>.372</td>
<td>.246</td>
<td>.284</td>
</tr>
<tr>
<td>Age</td>
<td>.033</td>
<td>-.044</td>
<td>-.019</td>
<td>-.090</td>
<td>-.022</td>
<td>-.075</td>
<td>-.009</td>
<td>-.109</td>
<td>-.028</td>
<td>-.042</td>
</tr>
<tr>
<td>Education</td>
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<td>.552†</td>
<td>.426</td>
<td>.285</td>
<td>.297</td>
<td>.269</td>
<td>.227</td>
<td>.192</td>
<td>.345</td>
</tr>
<tr>
<td>BDI-II</td>
<td>.670*</td>
<td>.628*</td>
<td>.364</td>
<td>.546†</td>
<td>.572†</td>
<td>.599*</td>
<td>.458</td>
<td>.486</td>
<td>.416</td>
<td>.366</td>
</tr>
<tr>
<td>MMSE</td>
<td>-.539†</td>
<td>-.513†</td>
<td>-.32</td>
<td>-.469</td>
<td>-.540</td>
<td>-.473</td>
<td>-.418</td>
<td>-.403</td>
<td>-.507†</td>
<td>-.606*</td>
</tr>
<tr>
<td>H&amp;Y Stage</td>
<td>.421</td>
<td>.379</td>
<td>.312</td>
<td>.403</td>
<td>.397</td>
<td>.363</td>
<td>.345</td>
<td>.294</td>
<td>.441</td>
<td>.494</td>
</tr>
<tr>
<td>SMS</td>
<td>-.443</td>
<td>-.470</td>
<td>-.259</td>
<td>-.311</td>
<td>-.399</td>
<td>-.470</td>
<td>.326</td>
<td>-.381</td>
<td>-.129</td>
<td>.043</td>
</tr>
<tr>
<td>Illness Duration</td>
<td>.553†</td>
<td>.625*</td>
<td>.044</td>
<td>.204</td>
<td>.322</td>
<td>.280</td>
<td>.188</td>
<td>.204</td>
<td>.090</td>
<td>.106</td>
</tr>
</tbody>
</table>

Note.
1. FM = Facial Mobility; EF = Emotional Frequency; EV = Emotional Variability; EI = Emotional Intensity; SE = Social Engagement.
2. SMS = Side of Initial Motor Onset; Neg. = Negative Emotions (Sad & Angry); Pos. = Positive Emotion (Happy)
Table 11
*Multiple Regression Analyses: LSVT Change Scores and Demographic, Clinical, Cognitive, & Affective Variables*

<table>
<thead>
<tr>
<th></th>
<th>Positive Emotion</th>
<th>Negative Emotion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R^2$</td>
<td>p-value</td>
</tr>
<tr>
<td>FM</td>
<td>.27</td>
<td>.648</td>
</tr>
<tr>
<td>EF</td>
<td>.42</td>
<td>.367</td>
</tr>
<tr>
<td>EV</td>
<td>.25</td>
<td>.216</td>
</tr>
<tr>
<td>EI</td>
<td>.28</td>
<td>.637</td>
</tr>
<tr>
<td>SE</td>
<td>.66</td>
<td>.077</td>
</tr>
</tbody>
</table>

*Note. FM = Facial Mobility; EF = Emotional Frequency; EV = Emotional Variability; EI = Emotional Intensity; SE = Social Engagement.*
Table 12
Multiple Regression Results for SE Positive Emotion ($R^2 = .66, p = .077$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>-.565</td>
<td>-2.42</td>
<td>.046</td>
</tr>
<tr>
<td>MMSE</td>
<td>.529</td>
<td>1.93</td>
<td>.094</td>
</tr>
<tr>
<td>Illness Duration</td>
<td>.053</td>
<td>0.19</td>
<td>.858</td>
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<tr>
<td>BDI-II</td>
<td>.659</td>
<td>2.37</td>
<td>.050</td>
</tr>
</tbody>
</table>

*Note. SE = Social Engagement*
Figure 1

*Poser Group x Gender Interaction for Facial Mobility* (p=.092)

![Bar graph showing facial mobility ratings for PD and HC groups by gender.](graph.png)

**Note.** **p≤.01; *p≤.05; †p≤.10**
Figure 2
Group x Emotion Interaction for Emotional Variability (p=.040): Group Comparisons

Note. **p≤.01; *p≤.05; †p≤.10
Figure 3
*Group x Emotion Interaction for Social Engagement (p=.057): Group Comparisons*

![Bar chart showing facial rating for different emotions and groups.](image)

*Note.* **p≤.01; *p≤.05; †p≤.10*
Figure 4

*Group x Emotion Interaction for Emotional Variability (p=.040): Emotion Comparisons*

Note. **p≤.01; *p≤.05; †p≤.10
Figure 5

*Group x Emotion Interaction for Social Engagement (p=.057): Emotion Comparisons*

![Graph showing facial rating for groups PD and HC across emotions Angry, Happy, and Sad.](image)

Note. **p≤.01; *p≤.05; †p≤.10
Figure 6
*Gender x Emotion Interaction for Facial Mobility (p=.009): Gender Comparisons*

Note. **p≤.01; *p≤.05; †p≤.10
Figure 7
Gender x Emotion Interaction for Social Engagement (p=.017): Gender Comparisons

Note. **p≤.01; *p≤.05; †p≤.10
Figure 8
Gender x Emotion Interaction for Facial Mobility (p=0.009): Emotion Comparisons

![Figure 8](image_url)

Note. **p≤.01; *p≤.05; †p≤.10
Figure 9
Gender x Emotion Interaction for Social Engagement (p=.017): Emotion Comparisons

Note. **p≤.01; *p≤.05; †p≤.10
Figure 10
Poser Group x Time Interaction for Facial Mobility (p=.020)

Note. **p≤.01; *p≤.05; †p≤.10
Figure 11
Poser Group x Time Interaction for Emotional Frequency ($p=.043$)

Note. **$p \leq .01$; *$p \leq .05$; †$p \leq .10$
Figure 12
*Poser Group x Time Interaction for Emotional Intensity (p=.029)*

Note. **p≤.01; *p≤.05; †p≤.10
Figure 13
Poser Group x Time Interaction for Emotional Variability (p=.082)

Note. **p≤.01; *p≤.05; †p≤.10
Figure 14
Poser Group x Gender x Time for Facial Mobility ($p=.046$)

Note: **$p \leq .01$; *$p \leq .05$; †$p \leq .10$
Figure 15
Poser Group x Gender x Time for Emotional Variability (p=.023)

Note. **p≤.01; *p≤.05; †p≤.10
Figure 16
Poser Group x Gender x Time for Emotional Intensity ($p=.012$)

![Bar chart showing facial rating for different groups and time points.]

Note. **$p\leq.01$; *$p\leq.05$; †$p\leq.10$
References


