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PROSODIC EMOTION IN UNILATERAL STROKE PATIENTS:
POSED EXPRESSION AND COMPREHENSION

by

NANCY A. VISCOVICH

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2004

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Abstract

PROSODIC EXPRESSION IN UNILATERAL STROKE PATIENTS: POSED
EXPRESSION AND COMPREHENSION

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NANCY A. VISCOVICH

Adviser: Professor Joan C. Borod

This study examined neural mechanisms underlying the expression and comprehension of prosodic emotion in brain-damaged and healthy control subjects. There were 54 participants: 18 normal controls (NCs), 17 individuals with left-sided damage (LBDs), and 19 individuals with right-sided damage (RBDs). There were no significant group differences for age, education, occupational status, or months post stroke onset. Using participants' posed output to examine prosodic expression, three positive and five negative emotions were analyzed for fundamental frequency (F_0) mean, F_0 standard deviation, and duration. Intensity and accuracy ratings were also obtained from trained judges. The relationship between acoustical parameters and raters' evaluations was determined. For comprehension, accuracy scores based on participants' responses to emotionally intoned sentences were analyzed. Results yielded limited support for the right-hemisphere hypothesis for emotional expression. However, when emotions were categorized by motoric direction or arousal level, the RBD group was rated as significantly less intense than the LBD group. The current study, however, yielded more support for the valence hypothesis. For positive emotions, the LBD group was rated as significantly less accurate than the RBD and NC groups. For negative emotions, RBDs

were rated as significantly less accurate than LBDs and NCs. Across all emotions, no effects of group for any of the acoustic measures were found. However, RBDs were less appropriate in their F_0 production for sadness and disgust than were NCs. For accuracy ratings, there was a significant main effect of group, such that LBDs were less accurate than NCs, suggesting that the LBDs might have had some linguistic problems processing the tasks conceptually. For intensity ratings, there was no main effect of group. However, RBDs were rated as less intense for fear and interest than were LBDs, and LBDs were less intense than RBDs and NCs for pleasant surprise. The current study also measured the relationship between acoustic analysis and human perception of emotion; results revealed that F_0 mean semitone difference scores were positively correlated with judges' ratings of emotional intensity. This is important, as using a visual biofeedback system to improve emotional expression could have implications for treatment of emotional communication and interpersonal relationships.

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Introduction

The focus of the current study is to gain more insight into the role of expression and comprehension of affective prosody in unilateral brain damage. The tasks that were utilized are part of the New York Emotion Battery (NYEB; Borod, Welkowitz, & Obler, 1992), and the prosodic stimuli are composed entirely of material developed by Borod, et al. (1992). The aims of this study are to infer the role of different brain regions (laterality and caudality) for prosodic expression of emotions, to assess the ability to identify and discriminate among different emotional tones within each brain-damaged group, to identify the listeners' (raters) ability to perceive these emotions across brain-damaged groups, as well as in normal controls, and lastly, to gain a better understanding of possible gender differences across brain-damaged groups.

Three primary objectives were explored. First, the study inspected features of prosodic expression in posed speech by brain-damaged participants. Using posed emotional speech features, sentences were analyzed for fundamental frequency (F_0) mean, F_0 standard deviation, duration, and correlation to ratings of human intensity and accuracy. A posed task was chosen since it involves discrete behaviors and affords experimental control. It can address whether or not a participant can produce a particular emotion regardless of their ability to identify it, and it prevents the use of more generalized or idiosyncratic communication strategies, such as attitudes and/or previous experiences.

Secondly, in order to further understand the effects of brain damage, emotional prosody was examined by having brain-damaged participants comprehend emotionally intoned sentences produced by actors, using identification and discrimination measures.

Identification measures were used to explore the specialized ability of the right hemisphere to categorize emotional expressions. The discrimination task was used to assess participants' basic ability to perceive the actual stimulus configuration, at a lower level of difficulty than identification. Overall, this study examined participants' ability to express and comprehend eight different emotions within the prosodic channel of communication.

Finally, in order to gain a better understanding of emotional prosodic expression as it relates to a listener's ability to perceive the affective meaning in speech, this study compared intensity and accuracy ratings for the posed prosodic expression-to-command task (Canino, 2001) to the acoustical parameters of F_0 mean, F_0 variability, and duration, the dependent variables currently under investigation. A significant positive correlation between acoustic measures and human perception of emotional expression may have implications for cognitive rehabilitation. Using a visual computerized feedback program, patients may improve accuracy of emotional expression and in turn, improve interpersonal relationships and socialization.

In addition to the three primary objectives of the current study, demographic characteristics known to affect emotional processing were closely examined. Since gender differences have been observed in previous literature (e.g., Banse & Scherer, 1996), in the current study, it was expected that women in the normal control group would perform better than men on emotional tasks. Additionally, it was expected that women with right-brain-damage and left-brain-damage would also better retain their ability to express and comprehend emotions than will the men in these groups.

The effects of discrete emotions (i.e., happiness versus sadness), arousal level (i.e., high versus low), and item valence (i.e., positive versus negative), on expression and perception were also explored in participants with unilateral right versus left or anterior (i.e., frontal lobe) versus posterior (i.e., parietal, temporal, or occipital) brain damage. If the right hemisphere hypothesis were operative, it was expected that right-hemisphere-damaged participants would be equally impaired in positive and negative emotions, and there would be less variability among the discrete emotions. If the valence hypothesis were in effect, it would be expected that the RBD group would be impaired processing negative emotions, while the LBD group would be impaired processing positive emotions. On an exploratory basis examining lesion caudality, it was also expected that participants with anterior lesions would be more impaired in their ability to express emotions, whereas those with posterior lesions would have greater difficulty with comprehension of emotion. Again, it was expected that women would perform better than men within each group.

Literature Review

As far back as the 1800's, Hughlings-Jackson observed that patients with severe aphasic deficits, usually associated with left-hemisphere pathology, retained their ability to communicate emotions through their voice (Ross, Edmonson, & Seibert, 1986). This observation helped to promote the future distinction between linguistic and non-linguistic aspects of language. Non-linguistic features of prosody typically include pitch, volume, melody, duration, stress, and affective content, which have been classified by Ross (1993) as the prosodic aspects of language.

The production of prosody allows a person to convey emotional states or attitudes, and the comprehension of emotional prosody allows an individual to better

understand emotionally intoned speech, by interpreting the speaker's tone of voice (Wymer, Lindman, & Booksh, 2002). Apraxia, then, is the inability to impart or comprehend emotional tone in speech (Ross, 1988). Without this basic ability to incorporate prosodic speech into the linguistic content of conversations, social and emotional difficulties may arise (Gorelick & Ross, 1987). Therefore, the ability to identify prosodic disturbance is critical, as is rehabilitation of this important communication tool (Stringer, 1996).

Affective prosody has typically been elicited through two paradigms (Borod, 1993). Spontaneous procedures examine the elicitation of emotion involuntarily (e.g., Bachorowski & Owren, 1995), whereas posed procedures involve explicitly asking subjects to deliberately produce a particular emotion (e.g., Banse & Scherer, 1996). One method of examining participants' ability to accurately produce different emotions has been through the use of rating procedures (e.g., Canino, Borod, Madigan, Tabert, & Schmidt, 1999). This method has been deemed to be a reasonable way to assess human communicative abilities (for review, see Ekman, Friesen, & Ellsworth, 1972; Pittam & Scherer, 1993). Another method is to analyze the acoustical parameters of participants' speech samples by means of computerized software programs (e.g., CSL, Kay Elemetrics, 1994; [Banse & Scherer, 1996; Pell, 2001, Pell & Baum, 1997; Ross, Edmondson, Seibert, & Homan, 1988; Ryalls, Joannette, & Feldman, 1987; Shapiro & Danly, 1985; Van Lancker & Sidtis, 1992]).

Acoustical Parameters in Prosodic Expression

A number of researchers have investigated various characteristics of acoustic speech signals (e.g., F_0 and amplitude) and speakers' ability to express and comprehend

emotion in speech in both healthy normal (Bachorowski & Owren, 1995; Banse & Scherer, 1996; Klasmeyer, 1998; McRoberts, Suddert-Kennedy, & Shankweiler, 1995; Pell, 1999; Ross, Edmondson, & Seibert, 1986; Scherer, 1991; Sobin & Alpert, 1999; Whiteside, 1999) and brain-damaged populations (Blonder, Pickering, Heath, Smith, & Butler, 1995; de Bleser & Poeck, 1985; Gandour, Larsen, Dechongkee, Ponglorpisit, & Khunadorn, 1995; Pell & Baum, 1997; Ross, Thompson, & Yenkosky, 1997; Ryalls, et al., 1987; Samuel et al., 1998; Shapiro & Danly, 1985; Van Lancker & Sidtis, 1992).

Many different methods to obtain different aspects of acoustic speech signals have been utilized, such as duration (e.g., Gandour et al., 1995; Pell & Baum, 1997; Ryalls et al., 1987), amplitude (e.g., Banse & Scherer, 1996; Dykstra, Gandour, & Stark, 1995; Pell & Baum, 1997; Scherer, Banse, Wallbott, & Goldbeck, 1991; Sobin & Alpert, 1991), and jitter and shimmer (e.g., Bachorowski & Owren, 1995; Rabinov, Kreiman, Gerratt, & Bielamowicz, 1995; Whiteside, 1995). However, mean F_0 of the vocalization waveform is one of the most commonly studied acoustical measures (Banse & Scherer, 1996) and potentially the best determinant of what listeners perceive as pitch in vocal expression (Scherer, 1982; Frick, 1985; Kent & Read, 1992). According to Scherer (1982), pitch has yielded the most consistent evidence about the vocal externalization of speaker stress, emotion, and psychopathology. Thus, the first method of analyzing emotional expression in the current study is through the measurement of F_0 mean and F_0 variability.

In a non-disordered voice measured in Hertz (Hz), F_0 is the lowest frequency present in sound during phonation and directly corresponds to the rate of vocal-fold vibration (Ross et al., 1988). With modern computer-assisted techniques, F_0 can be

measured over time, resulting in quantitative data concerning the mean and variability of intonational change within an utterance (Ross et al., 1988). These have been used for the analysis of F_0 in propositional speech in normal individuals (Fitzsimons, Sheahan, & Staunton, 2001; Gelfer, 1995; McRoberts et al., 1995; Ryalls et al., 1987; Schirmer, Alter, Kotz, & Friederici, 2000) and in brain-damaged populations (Bradvik, Holtas, Rosen, Ryding, & Ingvar, 1991; deBleser, 1985; Samuel et al., 1998; Shapiro & Danly, 1985). Analysis of F_0 has also been measured in studies examining affective prosody, or emotionally intoned speech, in normal individuals (Bachorowski & Owren, 1995; Banse & Scherer, 1996; Klasmeyer, 1998; Scherer, Banse, Wallbott, & Goldbeck, 1991; Sobin & Alpert, 1991) and in brain-damaged individuals (Blonder, Pickering, Heath, Smith, & Butler, 1995; Bradvik et al., 1990; Gandour et al., 1995; Pell, 1999, 2001; Ross et al., 1988; Ross, et al., 1997; Starkstein, Federoff, Price, Leiguarda, & Robinson, 1994; Van Lancker & Sidtis, 1992).

Since modulation of prosody of spoken language can cause alterations in meaning and affect, the role of F_0 in the examination of prosody has predominantly been to measure propositional prosody and affective prosody. Studies measuring propositional prosody have primarily focused on identifying stress in single words and sentences (Weintraub, Mesulam, & Kramer, 1981) and analyze acoustical parameters of declarative and interrogative sentences (Fitzsimons et al., 2001). In order to determine hemispheric lateralization, Shapiro and Danly (1985) and Van Lancker and Sidtis (1992) carried out the simultaneous examination of propositional and affective prosody in order to determine whether the left hemisphere controls propositional prosody while the right controls affective prosody, or whether the right hemisphere is dominant for all prosodic

characteristics of speech. For the purposes of the current study, the focus is on affective prosody and the influence of the right hemisphere.

F₀ mean. F₀ mean has been used to examine affective prosody in normal populations to identify the specific vocal expression patterns for discrete emotions (Pittam & Scherer, 1993; Banse & Scherer, 1996). There is evidence that differing states of emotion and arousal level produce changes in respiration, phonation, and articulation. In part, these changes determine the parameters of the acoustic signal (Scherer, 1982; 1996), namely effects on F₀. In addition, much of the research has been extended to include neurological populations, in order to ascertain information regarding hemispheric specialization (Ross et al., 1988; Bradvik, 1990; Van Lancker & Sidtis, 1992; Ross et al., 1994) and intrahemispheric (e.g., anterior, posterior) origination of emotional processing (Shapiro & Danly, 1985; Ryalls et al., 1987). Studies investigating emotional expression using F₀ mean have demonstrated that patients with right-brain damage (RBDs) produce lower F₀ means than those with left-brain damage (LBDs) and normal controls (e.g., Ross et al., 1988). Similar findings have been observed for the comprehension of affective prosody (e.g., Starkstein et al., 1994). However, findings have been inconsistent. For example, Ryalls et al. (1987) found no significant differences between RBD and NC participants when imitating neutral-content, emotionally intoned sentences. However, this study did not include LBD participants or women.

F₀ variability. Across longer speech segments, such as sentences, F₀ can vary quite extensively. Thus, research has shown that F₀ variability (standard deviation) is considered to be another critical element in emotional expression (Scherer, 1982; Stringer, 1996). Scherer (1982) reports that one of the most important ways of looking at

F_0 variability is a plot of consecutive F_0 values that results in a contour, in which one can see the highest and lowest deviations from the mean F_0 , or the steepness of the rise and fall. Simply stated, standard deviation refers to the average variability around each individual's mean rather than the standard deviation of the group mean. Similar to F_0 mean, data are represented in Hz, but are typically logarithmically transformed to semitones (Ross et al., 1986). Semitone conversions are required because it is an interval-preserving pitch scale, and the perception of equal pitch intervals is not represented by a constant span of Hz (Ross et al., 1986).

When investigating affective prosodic expression within the brain-damaged population, Shapiro and Danly (1985) found that a significant change in F_0 variability was observed in individuals with right-hemisphere pathology. Ross et al. (1987) reported that subjects with right-hemisphere damage were “emotionally flat” in comparison to normal controls. This pattern of results was confirmed by Blonder et al. (1995), Van Lancker & Sidtis (1992), and Pell (1999). In terms of specific emotions, it has been suggested that F_0 variation plays a primary role in differentiating between negative and positive emotional states (for review, see Pakosz [1983]). For example, Scherer, Banse, Wallbott, and Goldbeck (1991) found that fear and anger were characterized by greater increases in F_0 variability, joy to a lesser extent, and sadness by a decrease in F_0 variability.

Duration. While prosody generally refers to variations in the acoustic properties of F_0 , duration (timing) is another important element in the communication of emotion. Some studies have indicated that F_0 and timing may be separately disrupted depending on the site of lesion (e.g., Schirmer et al., 2000; Van Lancker & Sidtis, 1992). This

measurement of prosody is generally thought to be processed in brain regions separate from those regions involved in F_0 identification (Robin, Tranel, & Damasio, 1990). One explanation might be related to hemispheric differences in the auditory processing of acoustic cues. For example, Alcock, Wade, Anslow, and Passingham (2000) found that pitch perception was preserved in individuals with left-brain damage, while rhythm perception was disturbed. However, the opposite was found to be true for patients with right-brain damage. Similarly, other studies have found that individuals with left-hemisphere-damage are impaired in their ability to perceive temporal information, while individuals with right-brain damage rely on this acoustic cue to recognize affective prosody (Dykstra et al., 1995). In contrast, Fitzsimmons et al. (2001) found that pitch range and duration cues were significantly correlated. However, this study only investigated speech prosody within a normal population; thus, hemispheric laterality of timing and pitch may be more dissociable within the context of affective aprosodia.

In summary, studies have found that the acoustical parameters most associated with the right hemisphere are F_0 mean and F_0 variability, while the left hemisphere mediates temporal processing.

Comprehension of Posed Emotional Prosody

The second focus of the current study is to examine hemispheric specialization for emotional perception in unilaterally brain-damaged participants. Previous research has demonstrated that RBD participants, relative to LBD and NC participants, are more impaired in making judgments about the emotional tone of speech. (For reviews, see Borod, 1996; Borod, Bloom, Brickman, Nakhutina, & Curko, 2002; Borod, Bloom, & Santschi-Haywood, 1998). These findings were consistent across discrete emotions (e.g.,

happiness, sadness) and valence (e.g., pleasantness, unpleasantness), and were equally affected in both identification and discrimination of emotions (Pell & Baum, 1997).

In a study conducted by Tucker, Watson, and Heilman (1977), RBD subjects made significantly more errors than LBD subjects in the comprehension and discrimination of affective speech presented in an angry, happy, or indifferent tone of voice; the naming of emotions and discrimination scores (i.e., “same/different”) were significantly correlated to each other. They concluded that patients with right temporoparietal dysfunction have a defect in the comprehension of affective speech. Similarly, Tompkins and Flowers (1985) reported that individuals with RBD were worse than LBD and NC participants in identifying emotions in short phrases. Starkstein et al. (1994) found that subjects with aprosodia improved their emotional identification performance when provided with congruent semantic cues (i.e., happy-content sentence spoken in a happy tone of voice), but performance deteriorated when there were semantic conflicts with emotional intonation (i.e., happy-content sentence spoken in a sad tone of voice). In that study, subjects with right temporoparietal and basal ganglia lesions were most impaired, for both happy and sad conditions. Finally, in a study examining individuals with unilateral brain damage, conducted by Geigenberger and Zeigler (2001), LBD participants were significantly impaired in emphatic stress whereas individuals with RBD were relatively spared within this linguistic process. However, LBD participants were relatively spared in the processing of emotional and conversational prosodic condition, while those with RBD demonstrated significant impairments.

In a study measuring regional cerebral blood flow in normal individuals who were listening to sentences focusing on affect and sentences focusing on propositional prosody

(George et al., 1996), the prefrontal cortices, more left than right, exhibited greater activation during the propositional prosody task. Within the affective prosodic condition, increased activation was seen in the right prefrontal cortex. Similarly, in a study conducted by Buchanan et al. (2000) examining neural areas involved in the recognition of both emotional prosody and phonemic components of words via functional magnetic imaging (fMRI), right frontal activation was seen for emotion detection whereas the left frontal region of the brain was activated during the verbal detection condition.

In summary, there are still inconsistencies among researchers in ascribing hemispheric specialization for emotional processing. For the most part, the predominant empirical findings support that the right hemisphere is specialized for emotional prosody, while the left hemisphere facilitates the linguistic aspects of prosodic speech. This was found to be true in studies examining individuals with brain-damage, as well as in studies examining normal individuals using functional neuroimaging.

Judges Rating Procedures

In general, rating procedures have been a long-standing method of measuring emotional expression in individuals with brain damage, as well as within the normal population. The most commonly used types of rating procedures include pitch, variation in pitch, intensity, accuracy, and valence. In some studies, these procedures have yielded support for right hemisphere specialization for emotional processing (e.g., Hughes, Chan, & Su, 1983), while other studies found that the right hemisphere is implicated in prosody in general, rather than specific for emotions (Weintraub et al., 1981).

The second method of analyzing emotional expression in the current study is through the use of judges rating procedures. Rating systems have been developed

throughout the years to evaluate emotional communication in a variety of communication channels and have been deemed to be a valid way to assess communication skills (Borod, 1993; Ekman, Friesen, & Ellsworth, 1972). Alpert et al. (1989) developed a rating system for acoustical parameters for prosodic information. Canino et al. (1999) trained human raters to evaluate posed expressions of emotion across three different channels of communication (facial, lexical, and prosodic). The posed expressions were evaluated by raters for intensity and accuracy. Interrater reliability was deemed to be sufficiently high. Therefore, these intensity and accuracy measures were incorporated into the current investigation in order to compare reliable human ratings to objective acoustical parameters.

Rating procedures have also been utilized in studies examining emotional expression and comprehension within the brain-damaged population (Bradvik et al., 1990; Cancelliere & Kertesz, 1990; Geigenberger & Ziegler, 2001; Hughes et al., 1983; Tucker et al., 1977; Weintraub et al., 1981). The uses of rating measures are diverse. For instance, some of these studies have used results of pitch, variation of pitch, intensity, valence or accuracy measures to characterize affective comprehension discrimination and/or identification deficits (Tucker et al., 1977), to determine if right-hemisphere lesions affect other nonemotional components of prosody (Weintraub et al., 1981), or to identify sensory aprosodia as a specific and sensitive marker of the inferior right middle carotid artery (Darby, 1993).

Besides looking at discrete emotions, ratings studies have also examined arousal level (i.e., high/low [Fredrickson, 1998; Mandal, 1986; Mandal et al., 1999]) and motoric direction (i.e., approach/withdrawal [Mandal et al., 1999]). The term arousal has been

described as being orthogonal to valence, and refers to the intensity of the emotional activation, ranging from highly excited to tranquil (Lane, Chua, and Dolan, 1999). Research has demonstrated a link between physiological arousal level and right hemisphere processing (e.g., Eidelberg and Galaburda, 1984; Tucker and Williamson, 1984), such that high arousal emotions are more difficult to process in individuals with right-brain damage (Peper and Irle, 2002). As demonstrated by Mandal et al. (1999), the motoric direction hypothesis suggests that the right hemisphere processes withdrawal emotions (e.g., fear), while approach emotions (e.g., happiness) are processed by the left hemisphere (Davidson, 1984). Overall, these studies have found that patients with right-brain-damage exhibited greater difficulties processing high arousal emotions and withdrawal emotions, suggesting that the right hemisphere controls emotional processing for these particular parameters.

Within the normal population, rating procedures have been used in conjunction with acoustical analysis procedures (Banse & Scherer, 1996; Gandour et al, 1995; Ross et al, 1987; Ross et al, 1997; Scherer et al, 1991). However, in general, rating results have been used to select pure emotion samples within the normal population for acoustical analysis rather than being used as a direct comparison of all emotionally intoned sentences, regardless of accuracy or intensity (e.g., Banse & Scherer, 1996).

Emotion: Theories and Empirical Findings

After performing an extensive literature search, it has been concluded that a universally accepted theory of emotional functioning does not exist. Theorists have approached the subject from many different viewpoints, but for the current study, the review will include a right hemisphere superiority theory because it is connected to the right

hemisphere hypothesis. In addition, the valence hypothesis will be reviewed since the current study was designed to test whether the right hemisphere theory or the valence theory is operative. Other sections included are reviews of studies of emotional communication, particularly emotional expression and perception, across brain-damaged groups, and a discussion of Ross's "aprosodias" as it relates to equivalent left-hemisphere "linguistic" neuroanatomical components of speech and language.

Right-Hemisphere Specialization Theory

Gainotti (1972) suggested hemispheric specialization for emotions, with differential emotional reactions for right- versus left-hemisphere cortical damage. The right-hemisphere specialization theory states that the right hemisphere is specialized for processing all emotions, including expression, experience, and comprehension, regardless of whether the emotion is positive or negative (Borod, 1992; Borod, Cicero, et al., 1998; Heilman, Bowers, & Valenstein, 1993). It has also been suggested that the right hemisphere modulates intensity or arousal level of emotions (i.e., high/low), as well as withdrawal-type emotions such as fear, disgust, and sadness (Mandal et al., 1999).

The right hemisphere hypothesis is based on the observation that emotional processing requires strategies for which the right hemisphere is both functionally and structurally equipped (Borod, 1992). Research studying individuals with unilateral brain damage have consistently pointed to the right hemisphere as being dominant for the prosodic expression of emotion (Blonder et al., 1995; Borod, 1993; Ross, 1993; Tucker et al., 1977).

Baum and Pell (1999) suggested that all aspects of prosody are processed in the right hemisphere and integrated with linguistic information via callosal connections. They

reported a functional lateralization hypothesis, stating that the right hemisphere subserves affective or emotional prosody, whereas the left hemisphere is specialized for propositional prosody. Results of other studies (e.g., Blonder et al., 1995) have indicated the contribution of right fronto-temporal regions, anterior parietal regions, the anterior limb of the internal capsule, and the globus pallidus. Other investigators have found that right posterior lesions were involved in hypermelodic speech, while anterior lesions lead to monotonous or flattened affective speech (Ryalls et al., 1987; Shapiro & Danly, 1985).

Finally, in another study examining the comprehension of prosodic processing in left- and right-brain-damaged populations, it was found that while deficits were found in both groups, the profiles were different across tasks (Geigenberger & Ziegler, 2001). The processing of propositional prosody (i.e., emphatic stress) was significantly impaired in the LBD group, while relatively spared in the RBD group. In contrast, the RBD group demonstrated significantly inferior processing of emotional and conversational prosodic information. These findings appear to implicate the right hemisphere as mediating the pitch or “melody” of speech, since inferior processing was found for conversational speech in addition to emotional prosody. The authors suggest that the left hemisphere is specialized for the analysis of the representational aspects of spoken language, such as phonological, syntactic, or semantic structure, whereas the right hemisphere is specialized for holistic analysis, as needed in expressive prosodic patterns (e.g., continuous prosodic contour of speech). This would mean that RBD individuals would have difficulty interpreting a speaker’s attitude or emotional state.

Prosodic Expression. Prosodic expressive deficits can be dissociated from prosodic comprehension deficits (Ross & Mesulam, 1979). Ross (1981, 1993) proposed a

classificatory system for affective prosodic deficits, termed the aprosodias. He suggested that the organization of affective prosody in the right hemisphere is comparable to the left hemisphere's organization for linguistic or propositional speech, such that the aprosodias (e.g., motor aprosodia, sensory aprosodia, conduction aprosodia, and transcortical aprosodia) parallel the aphasias seen after left-hemisphere damage. The results of many of these studies (Ross, 1981, 1993; Ross & Gorelick, 1987; Ross & Mesulam, 1979) have indicated that temporal lobe lesions resulted in impaired affective comprehension, whereas deficits in spontaneous emotional expression were seen in individuals with inferior frontal lobe damage. In contrast, Bradvik et al. (1990, 1991) contended that subcortical damage may be more likely to yield prosodic production deficits rather than cortical right-hemisphere damage, as suggested by Ross. Bradvik et al. (1990, 1991) concluded that Ross's theory may be true within the acute phase of brain damage, but at chronic stages, prosodic deficits may dissipate. Results of a study conducted by Cancelliere and Kertesz (1990) also did not support Ross's model of analogous regions of the left and right hemispheres. Instead, they found that the basal ganglia was most often implicated in dysprosody, and suggested the possibility that the basal ganglia works in conjunction with cortical structures to mediate voluntary control of complex motor functions (i.e., motoric organization required for modulation of affective displays) necessary in prosodic expression.

Prosodic Comprehension. With regards to affective prosodic comprehension, the right-hemisphere hypothesis has been highly supported. In a study conducted by Heilman, Schwartz, and Watson (1978), RBD participants with temporo-parietal lesions were significantly impaired, compared to individuals with LBD, in their ability to identify auditorily presented emotions, by pointing to corresponding facial expressions. Semantic

meaning was intact for both groups. Tucker et al. (1977) demonstrated that participants with RBD had poorer comprehension of emotional prosody than did individuals with LBD, for both identification and discrimination measures. Again, right-sided temporoparietal lesions were implicated in this study. Right hemisphere lateralization for the perception of prosodic emotional stimuli has been found in studies using the dichotic listening paradigm, pairing emotionally with nonemotionally intoned sentences. In a study conducted by Ley and Bryden (1982) examining normal individuals, a left-ear advantage was observed during a dichotic listening task for judging emotions, but a right-ear advantage was seen for the nonaffective linguistic condition. Using similar dichotic listening techniques, other investigators have also demonstrated support for right hemispheric specialization of prosodic emotional processing using emotionally intoned words (Bryden, Free, Gagne, & Groff, 1991; Bryden & MacRae, 1989), phrases (Strauss & Goldsmith, 1987), and nonsense syllables (Erhan, Borod, Tenke, & Bruder, 1998).

Valence Hypothesis

The valence hypothesis purports that two versions of emotional processing exist. In the first version, the left hemisphere is dominant for positive emotions while the right hemisphere is dominant for negative emotions. This valence theory applies to expression, perception, and experience (Borod, 1992). This hypothesis first emerged when it was observed that individuals with left-hemisphere brain damage exhibited predominantly negative affect (Alford, 1933; Goldstein, 1939). In contrast, individuals with right-brain-damage were found to present with either euphoria or indifference (McGlynn & Schachter, 1989). Therefore, the valence hypothesis purports that the right hemisphere is specialized for the expression and comprehension of negative emotions,

while the left hemisphere controls processing of positive emotions (Sackeim, Greenberg, Weiman, Hungerbuhler, & Geschwind, 1982). This right-left distinction was termed the valence hypothesis by Silberman and Weingartner (1986). The valence theory was supported in a study using the Wada technique, in which individuals with left-sided interruption exhibited more positive affect, whereas those with right-sided injection displayed primarily a negative affect (Bear and Fedio, 1977). Similarly, in a study examining event-related fMRI of emotional memory, in which normals were presented with pleasant, unpleasant, and neutral pictures, there was greater activation in the left prefrontal cortex for pleasant pictures, whereas for unpleasant pictures, activation was greater in the right prefrontal cortex (Dolcas, Graham, LaBar, & Cabeza, 2002).

Other studies fail to support the valence hypothesis. For example, Borod, Cicero et al. (1998) found no hemispheric valence differences in emotional processing across lexical, facial, and prosodic channels of communication.

The second version of the valence hypothesis suggests that there is differential specialization for expression or experience of emotion as a function of valence, and that the right hemisphere is dominant for the perception of positive and negative emotions (Borod, 1992). Overall, most studies examining valence and laterality are more supportive of the right hemisphere hypothesis (Bowers, Bauer, & Heilman, 1993; Bryden & Ley, 1983).

Conclusions

In general, the literature supports right hemisphere superiority for emotional processing, for both prosodic expression and perception. This has been observed in studies measuring acoustical parameters of affective speech for both left- and right-hemisphere damaged individuals (Pell, 1999; Pihan, Altenmüller Ackerman, 1997; Ryalls

et al., 1987; Van Lancker & Sidtis, 1992) and in human rating studies (Hughes et al., 1983; Tompkins & Flowers, 1985; Tucker et al., 1977; Weintraub et al., 1981).

Acoustic profiles of emotion

Attempts have been made to find a defining pattern of characteristics for a select set of emotions. For example, Pittam and Scherer (1993) conducted a study using normal actors portraying five different emotions varying in arousal level via a mood-induction procedure. Arousal refers to a continuum that varies from calm to excitement (Dolcos & Cabeza, 2002). Anger was generally characterized by an increase in F_0 mean and variability, with increased rate of articulation. Fear was also associated with increases in mean F_0 and variability, as well as rate. For a subdued version of sadness, considered to have a low level of arousal, F_0 mean and standard deviation decreased. Similarly, rate of articulation was slower. Joy, often reported as elation, evidenced increased F_0 mean and variability, as well as an increased rate of speech. Finally, disgust yielded inconsistent results and was highly dependent on the differing acting styles. However, due to the limited number of emotions studied, Banse and Scherer (1996) conducted a similar study with 14 different emotions, using primary emotions (e.g., happiness and sadness) with low and high levels of arousal (e.g., elation and desperation). Results indicated that mean F_0 was highest for the highly aroused emotions of despair, hot anger, panic fear, and elation and was lowest for contempt and boredom. Happiness, anxiety, shame, pride, sadness, disgust, interest, and cold anger were located in the middle ranges. However, no neutral condition was utilized; thus, results were based on comparisons of each emotion around the mean of all emotions.

Previous investigations also support the notion that posed prosodic expressions of happiness are produced with higher F_0 means than are posed prosodic expressions of sadness (Banse & Scherer, 1996; McRoberts, Studdert-Kennedy, & Shankweiler, 1995). This finding was confirmed in a pilot study conducted by Viscovich et al. (2003).

Conclusions

Overall, acoustical studies measuring emotional prosodic expression have shown that there is a distinct, fundamental difference between discrete emotions, as well as their varying levels of arousal and valence. Significant differences between emotional expressions for F_0 mean and variability typically remain when performance on neutral sentences is controlled for (e.g., Sobin & Alpert, 1999). Therefore, differences between types of emotions represent a salient index of prosodic expression.

Purpose of the Study and Hypotheses

Primary Hypotheses

The first purpose of this study was to examine whether the right-hemisphere specialization hypothesis was in effect, or whether results demonstrated more support for the valence theory. Given extensive support for the right hemisphere theory, it was predicted that a statistically significant reduction in the ability to produce emotional expression would be observed for RBD participants, as compared to LBD and NC participants. Participants with RBD were expected to produce sentences with the lowest F_0 mean and F_0 variability, particularly for high arousal emotions (pleasant surprise, fear, anger), and for withdrawal emotions (sadness, fear, disgust). In addition, LBD and NC participants, compared to individuals with RBD, were expected to be more accurate and intense when expressing high arousal and approach emotions, demonstrated through human

accuracy and intensity ratings. Pearson product-moment correlations were expected to reveal a strong correlation between pitch and accuracy/intensity of emotional expression in the current study. Therefore, in support of the right-hemisphere hypothesis, RBD participants were expected to exhibit greater difficulty in emotional prosodic comprehension compared to LBD and NC participants. This was analyzed by comparing results of individual emotions, emotions categorized by arousal level and motoric direction, between groups (right hemisphere hypothesis).

The valence hypothesis was another theory being tested in the current study, which states that the right hemisphere processes negative emotions, while the left hemisphere controls positive emotions. Therefore, emotions were clustered into positive (happy, interest, pleasant surprise) and negative valences (sad, disgust, fear, anger, unpleasant surprise) when examining emotional prosodic expression and comprehension. Emotions were also classified by motoric direction (approach and withdrawal) and arousal (high and low). If the valence effect were operative, it was expected that the RBD group would perform worse than the LBD and NC group for withdrawal and low arousal emotions, while the LBD group, compared to the RBD and NC groups, would have greater difficulty processing approach and high arousal emotions.

The second hypothesis of this study was to investigate whether there is a separate emotional processor(s) involved in emotional prosodic comprehension versus expression. Regardless of lesion site, individuals with right-brain damage were expected to obtain lower accuracy scores for discrete emotions, as well as for low arousal and withdrawal emotions. On an exploratory bases, individuals categorized by lesion site were also analyzed in order to examine whether such an emotional processor exists, such that

posterior lesions tend to result in comprehension deficits, whereas anterior lesions produce impairments in emotional expression. Therefore, it was expected that participants with anterior lesions would exhibit greater difficulty in emotional prosodic expression, whereas individuals with posterior lesions would be significantly less accurate in comprehending emotional prosodic expression, as compared to those with anterior lesions. Participants with anterior and posterior lesions, combined, were expected to exhibit poorer performance in both emotional prosodic expression and comprehension, as compared to anterior or posterior lesion sites alone.

The third hypothesis of this study is to support lateralized specialization of acoustical parameters, such that the right hemisphere controls pitch and the left hemisphere controls duration or temporal measures of speech production. It was expected that regardless of emotion type, arousal level, or motoric direction, individuals with left hemisphere damage would present with significantly different durations than participants with right-brain-damage and normal controls.

Regardless of whether the hypotheses herein are supported or not, this research will be informative and important because perceptual emotional processes have not been directly compared to acoustical measures within the brain-damaged population for non-emotion induced posed emotional prosodic expression. If perceptual and objective measures are significantly correlated, objectively obtained measures (e.g., visual biofeedback) could be incorporated into a rehabilitation program, with results that could potentially generalize to improve social interaction and communication.

Secondary Hypotheses

Women in the normal control group were expected to perform with more accuracy than men on tasks of emotional expression and perception. It was also expected to hold true for women with brain damage as well, such that they were expected to perform significantly better than males in both emotional prosodic expression and comprehension tasks. It was also expected that listeners would perceive the emotional tone of sentences as less intense and less accurate for RBDs, compared to LBDs and NCs, especially for high arousal emotions and approach emotions, but more intense and accurate for women, when compared to men.

With regards to emotions, it was expected that emotions with a greater level of arousal (i.e., anger, fear, and pleasant surprise) would have higher F_0 means and standard deviation, as well as shorter duration, than the low arousal emotions (i.e., interest, disgust, and sadness [Banse & Scherer, 1996; Scherer et al., 1991]). Similarly, results of human intensity ratings would be significantly correlated to F_0 mean and variability, such that high arousal emotions would be rated as significantly more intense than low arousal emotions.

Methods

Participants

A total of 54 participants were selected for this study from a subset of brain damaged and normal control participants already enrolled in a larger NIH-sponsored study at Mount Sinai Medical Center. Participants were instructed on the purpose of the research, and informed consent was obtained prior to testing. They were paid for their time and travel expenses.

As presented in Table 1, 36 of the 54 participants were individuals with unilateral brain damage: 17 with left hemisphere damage and 19 with right hemisphere damage. Eighteen neurologically intact individuals served as normal controls. The brain-damaged participants had unilateral strokes that were confirmed by CT and/or MRI. Verification of stroke, relevant neurological history, and lesion site were determined by clinical medical records and a report of the neuroradiologist at the time of hospitalization (Canino, 2001).

All participants were right-handed, as determined by self-report and by the Coren, Porac, and Duncan (1979) lateral preference inventory, and were native English-speakers or had learned English before the age of 7. As part of a larger study, all participants were previously screened in order to eliminate those with any history of prior neurologic disease or insult, vocal disorder, mental retardation, learning disability, or psychiatric illness. Previous psychiatric illness was determined using the Schedule for Affective Disorders and Schizophrenia-Lifetime Version (SADS-L; Spitzer & Endicott, 1978), and all participants were included if they did not have any significant premorbid psychiatric disorder and/or a significant history of substance abuse. In addition, all participants were included in the current study if they met all criterion measures on screening tasks that measured general cognitive ability. In addition, a doctoral student in Speech and Hearing Sciences administered the Boston Diagnostic Aphasia Examination to all LBD participants (BDAE; Goodglass & Kaplan, 1983). For the current study, LBD groups were classified as no past or current history of aphasia and mild residual aphasia. No participants were classified with frank aphasia in the past or at the present.

All participants were categorized by lesion site for caudality (anterior versus posterior) and verticality (cortical versus subcortical), and were included if they did not have lesions involving only subcortical white matter structures. Another criterion for inclusion was completeness and quality of the collected data. All prosodic expression data were recorded and saved on audiotapes, which were reviewed following subject selection. Participants were excluded if any data were missing or deemed to be too poor in quality for acoustical procedures. Following all exclusionary criterion, of the 22 participants in the LBD group, 17 remained (10 men, 7 women). Of the 32 RBD group participants, 19 were selected after all exclusionary criteria were met (12 men, 7 women), including if their lesion site, caudality, and verticality features reasonably matched the LBD group. The categories of lesions sites are as follows: anterior cortical (frontal lobe and corona radiata [LBD, n = 2; RBD, n = 2]), posterior cortical (temporal, occipital, and/or parietal lobes [LBD, n = 4; RBD, n = 5]), posterior and subcortical white matter (parietal, temporal, and/or occipital lobes; subcortical white matter [LBD, n = 2; RBD, n = 3]), anterior and posterior (LBD, n = 4; RBD, n = 4), and subcortical only (basal ganglia, thalamus, internal and external capsule, claustrum, and/or putamen [LBD, n = 4; RBD, n = 4]). In addition, 2 RBDs with lesions in the right frontal cortex were selected because previous research has implicated the right frontal lobe's involvement in emotional expression (Borod, 1993). See Table 1 for categories of lesion site and Table 2 for summary of lesion site location.

Table 1.

Category of Lesions by Group

Category of Lesion	Sub #	LBD (N=17)	Sub #	RBD (N=17) {N=19}
Anterior Cortical	338	Frontal +SCWM (CR)	207	Frontal
	339	Frontal + SCWM (CR)	236	Frontal + SCWM (CR)
			234	{Frontal}
			219	{Frontal}
Posterior Cortical	335	Temporal	201	Temporal
	329	Temporal	246	Temporal
	306	Occipital	206	Occipital
	316	Parietal	243	Parietal
	346	Parietal		
Posterior + SCWM	328	Parietal + SCWM (non-specified)	224	Parietal + CR
	315	Temporal, Occipital, + IC	242	Parietal + SCWM (non-specified)
			228	Temporal, Occipital, Parietal, + optic radiations
Anterior + Posterior	318	Frontal, Parietal	299	Frontal, Parietal
	308	Frontal, Temporal, Parietal, + EC	227	Frontal, Temporal, + CR
	331	Frontal, Temporal, IC, EC, Claustrum, CR, Putamen	235	Frontal, Parietal, IC, EC, Claustrum, ExtrC
	334	Frontal, Temporal (Insula), Parietal	222	Frontal, Parietal, + CR
Subcortical Only	300	Basal Ganglia	202	Putamen, Globus Pallidus
	345	Thalamus	231	Thalamus, CR, IC, Putamen, Globus Pallidus, Basal Ganglia
	337	IC, Basal Ganglia	233	IC, Caudate
	320	EC, Claustrum, Putamen	216	EC, Claustrum, CR, IC, ExtrC

Note: SCWM=Subcortical White Matter; CR=Corona Radiata; IC=Internal Capsule; EC=External Capsule; ExtrC=Extreme Capsule

Table 2.

Summary of Anatomical Lesion Sites

Anatomical Structure	LBD (N=17)	RBD (N=17) {N=19}
Frontal Lobe	6	6 {8}
Temporal Lobe	6	4
Occipital Lobe	2	2
Parietal Lobe	6	7
Corona Radiata	3	6
Internal Capsule	3	4
External Capsule	3	2
Extreme Capsule	0	2
SCWM, other	1	2
Caudate	0	1
Putamen	2	2
Globus Pallidus	0	2
Basal Ganglia (not specified)	2	1
Clastrum	2	2
Thalamus	1	1
Total Structures	37	44 {46}

The normal control group ($n = 18$; 11 men, 7 women) consisted of individuals matched for all pertinent demographic variables, i.e., age, education, occupational status (Hollingshead, 1977), gender, and ethnicity. Similarly to the brain-damaged groups, all NC participants' data were reviewed, and participants were included based on completeness and quality of the audiotapes.

Demographic characteristics of the three participant groups, using one-way analyses of variance (ANOVAs) for group (LBD, RBD, and NC), yielded no significant differences for age (RBD $M = 64.6$ [65.6], $SD \pm 13.5$ [13.1], range: 39 - 89; LBD $M = 66.6$, $SD \pm 10.5$, range: 48 - 81; NC $M = 66.7$, $SD \pm 10.5$, range: 43 - 81; overall $M = 66.2$, $SD \pm 11.7$), $F_{(2, 49)} = 0.15$, $p = .862$, years of education (RBD $M = 13.6$ [13.5], $SD \pm 2.8$ [3.6], range: 5 - 20; LBD $M = 13.6$, $SD \pm 3.6$, ranges: 8 - 20; NC $M = 15.6$, $SD = 1.9$, range: 11 - 16; overall $M = 13.6$, $SD \pm 3.1$), $F_{(2, 29)} = 0.01$, $p = .991$; and occupational status using the Hollingshead scale (RBD $M = 5.8$ [5.7], $SD \pm 1.9$ [2.2], range: 1 - 9; LBD $M = 5.2$, $SD \pm 2.3$, range: 1 - 9; NC $M = 6.3$, $SD \pm 1.0$, range: 5 - 8; overall $M = 5.8$, $SD \pm 1.9$), $F_{(2, 49)} = 0.43$, $p = .651$. No significant differences remained between these variables when the two RBD participants with frontal lobe lesions were included in demographic analysis.

Furthermore, there was no significant difference in months post onset of stroke between the two brain damage groups, including the 2 frontal lobe RBD participants, (RBD $M = 33.8$, $SD \pm 37.8$, range: 3 - 144; LBD $M = 23.6$, $SD \pm 33.6$, range: 2 - 149; overall $M = 29.0$, $SD \pm 36.0$) $t(34) = 0.43$, $p = .510$, and without the 2 frontal lobe RBDs, (RBD $M = 35.6$, $SD \pm 39.6$) $t(32) = 0.60$, $p = .445$. No significant group differences in gender, with the 2 frontal lobe RBD participants, Chi Square (1,54) = 0.18, $p = 0.913$, or

without them, Chi Square (1, 52) = 0.06, $p = 0.969$, or ethnicity, Chi Square (1,54) = 0.00, $p = 1.000$, Chi Square (1, 52) = 0.06, $p = 0.969$, were observed. Also, in order to ensure that each group contained an equal portion of individuals with anterior, posterior, and anterior plus posterior lesions, a Chi Square test was conducted. Results indicated that no significant differences were observed, Chi Square (1, 37) = 1.316, $p = 0.518$. See Table 3 for participant demographics.

Table 3. Participant Demographics

DEMOGRAPHIC	GROUP	N	MEAN	STANDARD DEVIATION	One-Way ANOVA p-value
AGE	NC	18	66.7	11.9	.862 {.958}
	RBD	17 {19}	64.6 {65.6}	13.5 {13.1}	
	LBD	17	66.3	10.5	
	TOTAL	52 {54}			
EDUCATION	NC	18	15.6	1.9	.991 {.992}
	RBD	17 {19}	13.6 {13.5}	2.8 {3.6}	
	LBD	17	13.6	3.6	
	TOTAL	52 {54}			
HOLLINGSHEAD (SES)	NC	18	6.3	1.0	.651 {.696}
	RBD	17 {19}	5.8 {5.7}	1.9 {2.2}	
	LBD	17	5.2	2.3	
	TOTAL	52 {54}			
MONTHS POST CVA	NC	N/A			t-test: .354 {.404}
	RBD	17 {19}	35.6 {33.8}	39.6 {37.8}	
	LBD	17	23.6	33.6	
	TOTAL	34 {36}			
	Group	N		Ratio	Chi Square* p-value
GENDER (% Male)	NC	18		61	.969 {.913}
	RBD	17 {19}		65 {63}	
	LBD	17		59	
ETHNICITY	NC	18		11W:6B:1A	.969 {1.00}
	RBD	17 {19}		10W:7B {11W:8B}	
	LBD	17		11W:5B:1O	
* Chi Square with unequal frequencies	expected				

Note: W=White; B=Black; A=Asian; O=Other

Screening Measures

Prior to undergoing the experimental procedures, all participants were initially administered screening tasks that measured general cognitive ability in order to make certain that they possessed the fundamental cognitive skills required for each experimental condition. See Table 4. The Block Design subtest of the Wechsler Adult Intelligence Scale – Revised (WAIS-R; Wechsler, 1981) was administered to the NCs and the LBDs in order to assess overall cognitive ability within the nonverbal domain. The Information subtest was administered to the NCs and RBDs to test overall cognitive ability within the verbal domain. Other screening tests included the Attention and Memory subtest of the Mattis Dementia Rating Scale (MDRS; Mattis, 1988) and the Complex Ideational Material subtest of the Boston Diagnostic Aphasia Examination (BDAE; Goodglass & Kaplan, 1983) to ensure the participants' basic cognitive and linguistic skills were commensurate with the experimental tasks. The SADS-L (Spitzer & Endicott, 1978) was administered in order to assess participants' psychiatric status, and those with a significant psychiatric history were excluded. In order to meet criteria for completing the experimental tasks, all participants were expected to perform within 1-2 standard deviations around the normal mean. All participants in the final analyses of the current study met the pre-established criteria for entry into the study. As displayed on Table 4, one-way ANOVAs were run on six tasks to determine if there were group differences in performance on these tasks (Canino, 2001). The only significant difference was for the DRS Attention task, $F(2, 49) = 4.73, p = 0.01$, which revealed that individuals with RBD performed worse than LBD and NC participants. However, given

that the difference was less than one point, it was not considered to be clinically significant (RBD $M = 35.47$, LBD $M = 36.53$, NC $M = 36.28$).

Table 4.

Descriptive Statistics for Screening Measures

TASK	RANGE	GROUP*	N	MEAN	Standard Deviation	p-value
WAIS Block Design	0-51	NC	18	21.6	10.7	.716
		LBD	17	22.9	10.7	
WAIS Information	0-29	NC	18	22.1	4.7	.115 {.125}
		RBD	17 {19}	19.5 {19.4}	4.5 {5.7}	
BDAE Com. Ideat. Material	0-12	NC	18	10.8	1.1	.844 {.821}
		RBD	17 {19}	10.8 {10.7}	1.5 {1.5}	
		LBD	17	11.0	1.3	
DRS Memory	0-25	NC	18	24.4	.9	.325 {.355}
		RBD	17 {19}	23.7 {23.8}	2.3 {2.2}	
		LBD	17	23.6	2.0	
DRS Attention	0-37	NC	18	36.3	.9	.013 {.006}
		RBD	17 {19}	35.5 {35.4}	1.5 {1.4}	
		LBD	17	36.1	.6	
Beck Depression Inventory	0-63	NC	18	1.9	2.3	.316 {.189}
		RBD	17 {19}	3.5 {3.8}	3.5 {3.9}	
		LBD	17	2.8	2.9	

Raters

Raters were undergraduate students from Queens College who responded to posted advertisements circulated throughout the campus. They were paid an hourly wage

for their time. All raters were subjected to the same screening procedures as the brain-damaged group, in order to rule out a history of neurological insult, significant substance abuse, major psychiatric disorder, or learning disability. All raters were native English speakers or learned to speak English before 7 years of age. Four raters were selected for the experimental ratings of the brain-damaged groups. A separate group of raters was selected to rate control data in order to prevent carry-over effects due to exposure from the brain-damaged population's emotional expression task. Since it was expected that rating the control data would be easier, in terms of less variability between participants, only three raters were chosen for this group. Therefore, the 2 groups needed to be matched on age, gender, and education. One-way ANOVAs were conducted for each demographic variable to ensure that the group of raters did not significantly differ. There were no significant differences for men and women between groups for age (overall $M = 24.8$, $SD \pm 8.22$) and education (overall $M = 15.25$, $SD \pm 0.5$). See Table 5 for demographic characteristics of all raters. A total of 4 raters were selected to rate the emotional intensity and accuracy the experimental data, and 3 raters were chosen to rate the control task.

Table 5.

Rater Demographics

DEMOGRAPHIC	GROUP	N	MEAN	STANDARD DEVIATION	One-Way ANOVA p Value
AGE	BD*	4	24.75	8.22	0.518
	NC*	3	21.33	1.53	
	TOTAL	7	23.29	6.16	
EDUCATION	BD	4	15.25	0.50	0.074
	NC	3	14.33	0.58	
	TOTAL	7	14.86	0.69	
GENDER (% male)	BD	4		75	*Chi Square P Value .257
	NC	3		66.7	
	TOTAL	7		71.4	
ETHNICITY	BD	4		3W: 1B	.705
	NC	3		2W: 1B	
	TOTAL	7		5W: 2B	

Note: * Chi Square with unequal frequencies expected; BD = raters who evaluated Brain

Damage group; NC = raters who evaluated The NC group.

Experimental Tasks

For the posed prosodic emotional expression task (Borod, Welkowitz, & Obler, 1992), all participants were informed of the purpose of the study and were told they were being audiotaped. For this task, eight different emotions were examined, derived from the studies of Ekman and Friesen (1975) and Izard (1977). Three emotions were considered positive (i.e., happiness, pleasant surprise, and interest), and five were negative (i.e., sadness, disgust, unpleasant surprise, fear, and anger). Emotions were further classified by motoric direction, with approach emotions including happy, interest, and anger, and withdrawal emotions consisting of sadness, fear, and disgust. In addition, within each valence category, 5 emotions were considered to have a high level of arousal (i.e., fear, anger, happiness, pleasant surprise, and unpleasant surprise), and 3 were considered to have a low level of arousal (i.e., interest, sadness, and disgust). These levels were determined on an a priori basis of experimenter judgment, as well as emotional arousal levels described in previous literature (Viscovich et al., 2003; Banse & Scherer, 1996; Scherer et al., 1991). Happiness was omitted from analysis because this emotion can be considered a low arousal emotion (i.e., content) or a high arousal emotion (i.e., elation). Unpleasant surprise was also omitted since it has a similar arousal level as pleasant surprise. A neutral expression was used as a nonemotional control measure.

Prosodic Expression to Command (PPE). For the Prosodic Expression to Command Task, participants were required to produce each of the eight target emotions. Emotions were randomly presented using four different orders. The neutral expression was always requested at the end of the task as the ninth expression. The task utilized four neutral-content, six-syllable sentences (e.g., “She put it on the tray”) that were selected for comprehensibility; similar grammar, rhythm, and length; and limited emotional tone.

For each trial, a neutral-content sentence was presented by the examiner in a neutral tone of voice and simultaneously displayed to the participant on a laminated white sheet of 8½ x 11 in. paper. Sentences were randomly presented using four different orders; within each order, each of the four neutral-content sentences appears twice. For the current posed prosodic expression experiment, participants were requested to produce each of the nine expressions twice, using one of the neutral-content sentences, while they were being audiotaped. Participants were requested to exaggerate each of the emotional expressions as if they were an actor or an actress. The first trial was for practice purposes and was not included in the acoustical analysis. For the practice trial, instructions to participants were as follows (e.g., for happiness): “When I say ‘ready go’, I’d like you to say ‘They found it in the room’ in a happy tone of voice. Ready, go.” For the second trial, instructions to participants for the same emotion were the following: “O.K. Let’s say ‘They found it in the room’ in a happy tone of voice again. Ready, go.”

In addition, for the Prosodic Expression to Command Task, at the very beginning of the task, there are examples of each of the eight emotions intoned using one of the neutral-content sentences. Because piloting proved that participants had a difficult time generating the non-standard emotions (i.e., pleasant surprise, unpleasant surprise, and interest), one example of each of these emotions plus the other five emotions, was played for demonstration before the actual task commences. For these eight examples, there were two different orders, which are randomized and counterbalanced for actor’s gender. The mean level of the rated accuracy of the example sentences is 89.3%. These sentences were posed by eight actors and actresses and rated by 22 normal adults for emotion-category accuracy. For details regarding the elicitation procedures used to

obtain the emotional expression produced by the actors and for information regarding the characteristics of the raters, see Borod, Cicero, et al. (1998).

Prosodic Perception: Identification (PID). During the prosodic identification task, participants were required to listen to 24 sentences portrayed in one of the eight target emotions presented in normal cadence. Similar to the expression task, this condition utilized four neutral-content, six-syllable sentences (e.g., “She put it on the tray”) that were selected for comprehensibility; similar grammar, rhythm, and length; and low emotionality ratings. There were 24 gender-balanced trials, each emotion appearing three times, and two practice trials that were in two randomized stimulus sets. Participants listened to each sentence twice, and then either verbally identified the target emotion and/or pointed to an 8 ½ x 11 inch white response card listing each emotional category. Instructions to participants were as follows. “You are going to hear some tape-recorded sentences. Each sentence is stated with an emotional tone of voice. The tone of voice will express one of the eight emotions that are listed on the card in front of you. You will hear each sentence twice. Please listen carefully to each sentence, then point to or tell me the emotion that the tone of voice is expressing. Before we begin, I would like you to read the choices in front of you to me, one at a time, going from top to bottom.” The raw data that were subjected to analysis are displayed in Table 6.

Table 6.

Prosodic Perception: Identification Task Accuracy Scores

Emotion		Men		Women	
		<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
<u>Fear</u>	RBD:	0.418	0.353	0.141	0.176
	LBD:	0.400	0.410	0.286	0.364
	NC:	0.334	0.300	0.427	0.318
<u>Disgust</u>	RBD:	0.471	0.302	0.190	0.263
	LBD:	0.501	0.325	0.380	0.232
	NC:	0.364	0.349	0.476	0.327
<u>Anger</u>	RBD:	0.668	0.349	0.620	0.232
	LBD:	0.701	0.532	0.667	0.385
	NC:	0.637	0.379	0.667	0.274
<u>UPS^a</u>	RBD:	0.389	0.344	0.143	0.263
	LBD:	0.400	0.345	0.286	0.301
	NC:	0.485	0.275	0.380	0.357
<u>Sadness</u>	RBD:	0.473	0.302	0.380	0.357
	LBD:	0.501	0.325	0.574	0.254
	NC:	0.515	0.432	0.619	0.302
<u>PS^a</u>	RBD:	0.473	0.302	0.379	0.300
	LBD:	0.266	0.264	0.381	0.302
	NC:	0.393	0.360	0.524	0.327
<u>Happy</u>	RBD:	0.443	0.261	0.047	0.125
	LBD:	0.332	0.223	0.380	0.357
	NC:	0.272	0.251	0.334	0.431
<u>Interest</u>	RBD:	0.557	0.386	0.237	0.252
	LBD:	0.466	0.283	0.334	0.335
	NC:	0.516	0.405	0.284	0.356

Note: ^aUPS = unpleasant surprise, PS = pleasant surprise.

Prosodic Perception: Discrimination (PDISC). For discrimination, two sentences intoned by the same poser with the same or different emotional tone were presented on audiotape, generated using one of the eight emotional expressions. Participants were required to indicate whether the two sentences were intoned in the “same” or “different” emotion. For each pair, sentences were presented in normal cadence (about 3 s), with a 1-second inter-stimulus interval. There were two equivalent stimulus sets (A, B), each consisting of 28 gender-balanced pairs. The 56 pairs comprising the entire set included

28 different trials and 28 same trials; there were three practice trials in each set.

Participants were provided with an 8 ½ x 11 inch white response card indicating the words “same” or “different” and another response card signifying each emotional response. Instructions to participants were as follows. “Now you are going to hear a sentence stated with an emotional tone of voice. This will be followed by another sentence. Please listen carefully to each sentence and tell me whether the two sentences are stated with the same or with different emotional tones. You may refer to the list of emotions and response choices in front of you if you find them helpful.” Raw data (accuracy scores) that were later analyzed are presented in Table 7.

Table 7.

Prosodic Perception: Discrimination Task Accuracy Scores

Emotion	Men		Women	
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
<u>Positive</u> RBD:	0.910	0.076	0.918	0.076
LBD:	0.976	0.046	0.918	0.076
NC:	0.948	0.096	0.959	0.070
<u>Negative</u> RBD:	0.963	0.049	0.948	0.035
LBD:	0.974	0.034	0.893	0.041
NC:	0.940	0.090	0.936	0.050
<u>Mixed</u> RBD:	0.911	0.104	0.865	0.150
LBD:	0.901	0.136	0.770	0.182
NC:	0.924	0.133	0.941	0.111
<u>Total</u> RBD:	0.938	0.019	0.910	0.025
LBD:	0.950	0.021	0.861	0.025
NC:	0.937	0.020	0.945	0.025

There were two equivalent forms for the discrimination tasks (28 pairs each -- 14 different trials and 14 same trials) and two random orders for the identification tasks.

In order to obtain prosodic poses from actors and actresses ($n = 8$), instructions were incorporated from Ekman and Friesen (1975, 1976), Izard (1971, 1977, 1983), and Scherer (1979, 1981, 1982, 1989). For each of the eight emotions, information was provided on description of the experience of the emotion, circumstances which may elicit the emotion, and vocal characteristics of each emotion. After many practice trials, posers were audiotaped while producing each prosodic emotion to four different neutral-content sentences. These poses were then randomized and presented to raters (12 female and 10 male normal adults) for category accuracy ratings. The rating data were used to select the final stimuli for each emotional experimental task (see Borod, Cicero et al., 1998).

Nonemotional Control Tasks

To control for features of prosodic communication that are not related to emotional processing, participants completed various control tasks. First, to control for nonemotional expression accuracy, participants were given a task, Intonation Contours, that required them to intone nonsense syllable-sentences (e.g., “Ba-ta-ga”) to indicate a question, a statement, or a command (Borod, Welkowitz, & Obler, 1992). The Intonation Contours expressions were prepared in a similar fashion as the experimental posed prosodic expression data. Each nonsense sentence was presented to the raters twice, with three seconds between each presentation, with an inter-trial interval of six seconds. The tape was randomized by participant. The raters were required to select which intonation they thought was posed, and then was scored a “1” if the rating matched the target intonation, and “0” if it was incorrectly matched.

Second, to control for posed prosodic expression intensity, within the posed prosodic expression to command task, raters were also required to indicate how “intense” neutral sentences were expressed, randomized within the eight target emotions.

Third, as reported above, to control for acoustical parameters for each of the eight target emotions, neutral sentences were included in the posed expression experimental task.

Finally, for the perceptual tasks (identification and discrimination), participants were administered Intonation Contours Perception (Borod, Welkowitz, & Obler, 1992), a task which required them to listen to a tape and identify twenty four randomly presented nonsense syllable-sentences, expressed as either a question, statement, or command. They were provided with an 8 ½ x 11 white piece of paper with the three choices written on them, and asked to either name or point to the correct response. See Table 8 for a list of emotion experimental tasks and their comparative non-emotional control tasks.

Table 8.

Experimental Tasks Matched With Nonemotional Control Tasks

Emotion Tasks	Variables	Nonemotional Tasks	Variables
Prosodic Expression to Command -	F ₀ Mean F ₀ Standard Dev. Duration Rater Accuracy Rater Intensity	Neutral Condition Intonation Contours: Neutral Condition	F ₀ Mean F ₀ Standard Dev. Duration Rater Accuracy Rater Intensity
Prosodic Perception Identification -	Total Accuracy Score	Intonation Contours: Perception	Total Accuracy Score
Prosodic Perception Discrimination -	Total Accuracy Score	Intonation Contours: Perception	Total Accuracy Score

Rating Procedures

The rating procedures utilized in the current study originated from a study conducted by Canino (2001) with the same participants (LBD, RBD, and NCs). Two separate rating parameters were included in the examination of affective prosodic expression. Level of intensity was rated to capture the degree of emotionality produced by participants, and category accuracy was determined in order to assess participants' ability to pose emotions identifiably.

Emotional intensity was defined as the degree of emotionality conveyed, measured on a 7-point Likert scale. Intensity was rated to capture the degree of expressiveness and emotional tone of sentences expressed by the experimental group participants. Each rater was presented with rating tapes from the posed emotional

prosodic expression task, along with a printed version of the 7-point Likert intensity scale and response booklet. All raters were trained to determine overall emotional intensity by listening to exemplars prior to rating the experimental data. The focus was on varying degrees of amplitude and pitch in the voice.

Category accuracy was also undertaken to determine how well participants could communicate target emotions. For this task, raters were instructed to select the emotion category that a participant's expression best fits. The sentences were presented to the raters in the same way as they were presented for intensity ratings. They were additionally provided with a randomized list of the eight emotions from which they were to choose their response. The raters selected the emotion that most accurately identified the expression (Canino, 2001), and the raw data, presented as percentages, are displayed in Tables 9 and 10.

Table 9.

Posed Prosodic to Expression Task: Rater Intensity Scores

Emotion		Men		Women	
		<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
<u>Fear</u>	RBD:	3.83	0.93	3.64	1.49
	LBD:	3.96	1.48	3.14	1.71
	NC:	3.39	0.87	4.43	0.81
<u>Disgust</u>	RBD:	3.96	1.42	4.39	0.93
	LBD:	3.30	1.09	3.54	1.39
	NC:	3.14	0.82	4.11	1.20
<u>Anger</u>	RBD:	4.81	1.03	3.64	0.94
	LBD:	3.70	1.26	3.79	1.45
	NC:	4.05	1.62	4.75	1.07
<u>UPS^a</u>	RBD:	3.96	1.18	3.89	1.18
	LBD:	3.78	1.11	3.36	1.27
	NC:	3.89	1.31	4.25	1.19
<u>Sadness</u>	RBD:	3.23	1.16	2.43	0.86
	LBD:	2.60	0.83	3.00	1.71
	NC:	2.05	0.68	2.64	0.88
<u>PS^a</u>	RBD:	4.21	0.79	3.36	0.67
	LBD:	3.93	1.03	3.96	1.45
	NC:	4.57	0.54	4.39	0.50
<u>Happy</u>	RBD:	4.10	1.16	3.89	1.73
	LBD:	3.60	1.37	4.07	1.43
	NC:	4.34	1.17	4.64	1.16
<u>Interest</u>	RBD:	4.10	0.86	3.25	0.63
	LBD:	3.13	1.01	3.46	1.47
	NC:	3.55	0.98	3.75	1.30
<u>Neutral</u>	RBD	3.96	0.80	3.60	0.65
	LBD	1.65	0.44	1.73	0.52
	NC	3.09	0.96	3.11	0.80

Note: ^aUPS = unpleasant surprise, PS = pleasant surprise.

Table 10.

Posed Prosodic to Expression Task: Rater Accuracy Scores

Emotion		Men		Women	
		<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
<u>Fear</u>	RBD:	0.104	0.225	0.036	0.094
	LBD:	0.150	0.242	0.107	0.197
	NC:	0.250	0.336	0.179	0.189
<u>Disgust</u>	RBD:	0.021	0.072	0.036	0.094
	LBD:	0.150	0.129	0.025	0.354
	NC:	0.068	0.117	0.179	0.313
<u>Anger</u>	RBD:	0.375	0.292	0.286	0.267
	LBD:	0.225	0.343	0.357	0.284
	NC:	0.409	0.358	0.357	0.244
<u>UPS^a</u>	RBD:	0.292	0.344	0.179	0.278
	LBD:	0.150	0.269	0.321	0.313
	NC:	0.296	0.400	0.393	0.349
<u>Sadness</u>	RBD:	0.250	0.261	0.321	0.401
	LBD:	0.350	0.338	0.250	0.250
	NC:	0.568	0.372	0.464	0.336
<u>PS^a</u>	RBD:	0.292	0.258	0.429	0.313
	LBD:	0.175	0.206	0.286	0.225
	NC:	0.273	0.261	0.250	0.250
<u>Happy</u>	RBD:	0.042	0.097	0.071	0.189
	LBD:	0.000	0.000	0.036	0.094
	NC:	0.023	0.075	0.107	0.197
<u>Interest</u>	RBD:	0.458	0.298	0.500	0.289
	LBD:	0.150	0.211	0.357	0.349
	NC:	0.386	0.323	0.357	0.244

Note: ^aUPS = unpleasant surprise, PS = pleasant surprise.

Acoustical Processing Analysis

Each sentence was originally recorded on a Marantz PMD-201 portable cassette recorder. Audio recordings were converted from analog to digital at the sampling rate of 22,050 Hz, using a 16 bit analog-to-digital converter. By means of commercially available software, an acoustical analysis was performed on all utterances (Computerized Speech Lab CSL 4300b; Kay Elemetrics, 1994). F_0 mean and standard deviations were automatically extracted for each target emotion, as well as for the neutral expression. F_0

was computed directly from the waveform using a CSL pitch-extraction algorithm that employed a time domain approach to pitch analysis. Glottal pulse markers were positioned on a display of the acoustic waveform and inspected before a pitch contour was produced. Cycle markings were verified by hand tracking and errors were manually corrected. Signals lacking a reliably repeating period were eliminated from statistical analysis. The resulting periods were subjected to statistical analyses, and data are presented in Hertz (Hz). See Tables 11 through 13 for the raw data (F_0 means and F_0 standard deviations and semitone conversion scores), separately for group (RBD, LBD, NC) and gender, that were subjected to data analysis.

Table 11.

Posed Emotional Expression to Command Task: Means and Standard Deviations for Fundamental Frequency and Semitone Variables (Normal Controls)

Emotion		Men		Women		
		<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	
<u>Fear</u>	Frequency:	<u>M</u>	133.03	26.31	205.50	39.27
		<u>SD</u>	31.03	21.56	43.05	23.80
	Semitones:	<u>M</u>	36.01	3.15	43.57	3.10
		<u>SD</u>	3.99	2.67	3.88	2.36
<u>Disgust</u>	Frequency:	<u>M</u>	115.88	30.89	184.77	28.49
		<u>SD</u>	26.10	25.90	35.61	12.34
	Semitones:	<u>M</u>	33.47	3.78	41.78	2.87
		<u>SD</u>	3.68	2.96	3.44	1.24
<u>Anger</u>	Frequency:	<u>M</u>	145.37	42.37	199.98	34.88
		<u>SD</u>	40.42	22.89	51.06	15.28
	Semitones:	<u>M</u>	37.11	5.28	43.13	2.93
		<u>SD</u>	4.79	2.32	3.88	2.36
<u>UPS^a</u>	Frequency:	<u>M</u>	132.88	24.71	201.39	32.75
		<u>SD</u>	34.64	17.44	51.42	19.99
	Semitones:	<u>M</u>	35.99	3.29	43.29	2.66
		<u>SD</u>	4.47	2.15	4.49	1.90
<u>Sadness</u>	Frequency:	<u>M</u>	105.58	18.16	175.05	11.76
		<u>SD</u>	33.47	3.87	40.05	1.14
	Semitones:	<u>M</u>	32.07	2.87	41.00	1.19
		<u>SD</u>	3.78	3.15	2.93	1.66
<u>PS^a</u>	Frequency:	<u>M</u>	172.77	26.35	209.42	27.32
		<u>SD</u>	47.00	12.54	55.40	20.53
	Semitones:	<u>M</u>	40.63	2.71	44.02	2.25
		<u>SD</u>	4.77	1.16	4.72	1.87
<u>Happy</u>	Frequency:	<u>M</u>	161.11	33.00	221.99	37.10
		<u>SD</u>	41.48	15.78	53.71	14.10
	Semitones:	<u>M</u>	39.23	3.93	44.94	2.99
		<u>SD</u>	4.37	1.23	4.19	0.78
<u>Interest</u>	Frequency:	<u>M</u>	137.75	36.20	181.99	32.20
		<u>SD</u>	36.56	17.20	52.51	11.18
	Semitones:	<u>M</u>	36.45	3.94	41.49	2.98
		<u>SD</u>	4.50	1.50	5.14	1.32
<u>Neutral</u>	Frequency:	<u>M</u>	114.53	26.72	161.34	17.90
		<u>SD</u>	26.65	19.96	29.14	12.85
	Semitones:	<u>M</u>	33.31	3.77	39.54	1.92
		<u>SD</u>	4.00	2.84	3.18	1.46

Note: ^aUPS = unpleasant surprise, PS = pleasant surprise.

Table 12.

Posed Emotional Expression to Command Task: Means and Standard Deviations for Fundamental Frequency and Semitone Variables (Right Brain Damage Group)

Emotion		Men			Women	
		<u>M</u>	<u>SD</u>		<u>M</u>	<u>SD</u>
<u>Fear</u>	Frequency:	<u>M</u>	146.42	43.04	179.37	44.84
		<u>SD</u>	30.64	20.50	39.29	25.75
	Semitones:	<u>M</u>	37.23	5.30	40.92	4.87
		<u>SD</u>	3.47	1.60	4.80	5.27
<u>Disgust</u>	Frequency:	<u>M</u>	144.52	47.26	184.12	30.76
		<u>SD</u>	31.01	18.12	38.62	14.33
	Semitones:	<u>M</u>	36.92	5.45	41.68	3.18
		<u>SD</u>	3.58	1.56	3.75	1.46
<u>Anger</u>	Frequency:	<u>M</u>	149.11	40.18	191.91	36.68
		<u>SD</u>	37.04	20.24	39.96	9.25
	Semitones:	<u>M</u>	37.64	4.98	42.35	3.38
		<u>SD</u>	4.40	2.12	3.70	0.99
<u>UPS^a</u>	Frequency:	<u>M</u>	140.92	40.16	193.00	49.40
		<u>SD</u>	29.70	22.12	42.72	18.23
	Semitones:	<u>M</u>	36.62	5.08	42.11	5.33
		<u>SD</u>	3.43	1.86	3.79	1.13
<u>Sadness</u>	Frequency:	<u>M</u>	136.51	42.11	186.49	32.82
		<u>SD</u>	34.38	5.63	40.19	3.04
	Semitones:	<u>M</u>	35.94	5.00	41.91	1.19
		<u>SD</u>	2.74	2.23	2.21	1.32
<u>PS^a</u>	Frequency:	<u>M</u>	164.33	44.23	185.96	28.94
		<u>SD</u>	39.98	14.74	40.31	14.86
	Semitones:	<u>M</u>	39.43	4.33	41.91	2.64
		<u>SD</u>	4.55	2.11	3.77	1.43
<u>Happy</u>	Frequency:	<u>M</u>	154.81	47.21	207.18	37.10
		<u>SD</u>	35.26	18.44	52.93	21.85
	Semitones:	<u>M</u>	38.23	5.03	43.69	3.40
		<u>SD</u>	4.08	2.28	4.66	2.22
<u>Interest</u>	Frequency:	<u>M</u>	142.83	29.50	177.74	31.33
		<u>SD</u>	30.66	17.84	33.46	18.27
	Semitones:	<u>M</u>	37.14	3.91	41.07	3.09
		<u>SD</u>	3.73	2.08	3.42	2.25
<u>Neutral</u>	Frequency:	<u>M</u>	126.41	24.72	153.19	43.48
		<u>SD</u>	23.48	22.07	16.00	4.69
	Semitones:	<u>M</u>	35.10	3.45	37.95	6.04
		<u>SD</u>	3.02	2.29	1.92	0.64

Note: ^aUPS = unpleasant surprise, PS = pleasant surprise.

Table 13.

Posed Emotional Expression to Command Task: Means and Standard Deviations for Fundamental Frequency and Semitone Variables (Left Brain Damage)

Emotion		Men			Women	
		<u>M</u>	<u>SD</u>		<u>M</u>	<u>SD</u>
<u>Fear</u>	Frequency:	<u>M</u>	134.96	32.55	203.34	29.57
		<u>SD</u>	29.90	21.99	37.36	21.93
	Semitones:	<u>M</u>	36.16	3.72	43.47	2.56
		<u>SD</u>	3.79	2.38	3.08	1.44
<u>Disgust</u>	Frequency:	<u>M</u>	123.12	19.31	189.97	26.55
		<u>SD</u>	28.38	20.05	31.05	21.04
	Semitones:	<u>M</u>	34.75	2.85	42.32	2.37
		<u>SD</u>	3.92	2.66	2.76	1.61
<u>Anger</u>	Frequency:	<u>M</u>	132.93	30.89	199.92	18.00
		<u>SD</u>	35.01	22.39	35.71	14.85
	Semitones:	<u>M</u>	35.87	3.97	43.28	1.57
		<u>SD</u>	4.67	3.17	3.11	1.31
<u>UPS^a</u>	Frequency:	<u>M</u>	135.89	31.32	192.14	23.15
		<u>SD</u>	36.89	19.65	34.73	16.16
	Semitones:	<u>M</u>	36.27	3.77	42.54	2.12
		<u>SD</u>	4.65	2.16	3.08	1.18
<u>Sadness</u>	Frequency:	<u>M</u>	117.20	19.62	188.73	37.78
		<u>SD</u>	34.08	2.18	39.04	3.90
	Semitones:	<u>M</u>	33.89	2.78	42.01	3.78
		<u>SD</u>	3.08	1.82	2.72	0.76
<u>PS^a</u>	Frequency:	<u>M</u>	154.33	43.10	199.98	38.19
		<u>SD</u>	37.22	17.40	47.36	23.02
	Semitones:	<u>M</u>	38.34	4.33	43.06	3.42
		<u>SD</u>	4.21	1.74	3.92	1.47
<u>Happy</u>	Frequency:	<u>M</u>	152.42	44.79	203.78	24.26
		<u>SD</u>	40.09	19.01	39.70	23.98
	Semitones:	<u>M</u>	37.94	5.29	43.57	2.00
		<u>SD</u>	4.75	2.51	3.29	1.78
<u>Interest</u>	Frequency:	<u>M</u>	130.71	22.63	203.57	34.90
		<u>SD</u>	33.68	27.03	45.08	25.50
	Semitones:	<u>M</u>	35.76	2.9	43.43	3.00
		<u>SD</u>	4.24	2.83	3.74	1.88
<u>Neutral</u>	Frequency:	<u>M</u>	104.92	13.47	180.31	22.23
		<u>SD</u>	23.48	4.68	16.00	4.68
	Semitones:	<u>M</u>	32.05	2.25	41.43	2.24
		<u>SD</u>	2.30	1.25	2.61	1.51

Note: ^aUPS = unpleasant surprise, PS = pleasant surprise.

Standard deviation refers to the average variability around each individual's mean rather than the standard deviation of the group mean. Mean and standard deviation data were transformed into semitones, which are an interval-preserving pitch scale, because the perception of equal pitch intervals is not represented by a constant span of Hz (Ross et al., 1986). Mean F_0 in Hz was converted to semitones using a standard formula (Ross et al., 1986; Baken & Orlikoff, 2000): $N = 39.86 [\log_{10} (F_0/16.35)]$. The semitone conversion formula used for the F_0 standard deviation was the following: $N = (12/0.301) \times \log [(F_0 \text{ mean} + F_0 \text{ SD}/2) \div (F_0 \text{ mean} - F_0 \text{ SD}/2)]$.

Duration measures were obtained simply by placing cursors at the onset of each sentence, where the first sound was made, and at end of the final sound. Table 14 displays the raw data, in seconds, that were later subjected to statistical analyses.

Table 14.

Posed Emotional Expression to Command Task: Duration in Seconds

Emotion		Men		Women	
		<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
<u>Fear</u>	RBD:	1.678	0.503	1.653	0.283
	LBD:	1.530	0.337	1.662	0.579
	NC:	1.609	0.412	1.575	0.352
<u>Disgust</u>	RBD:	1.655	0.494	1.597	0.365
	LBD:	1.673	0.442	1.750	0.658
	NC:	1.534	0.311	1.699	0.277
<u>Anger</u>	RBD:	1.492	0.376	1.668	0.359
	LBD:	1.622	0.533	1.657	0.519
	NC:	1.675	0.323	1.726	0.234
<u>UPS^a</u>	RBD:	1.538	0.262	1.505	0.269
	LBD:	1.593	0.518	1.903	0.563
	NC:	1.623	0.285	1.627	0.182
<u>Sadness</u>	RBD:	1.723	0.572	1.798	0.379
	LBD:	1.847	0.721	1.682	0.383
	NC:	1.611	0.403	1.622	0.164
<u>PS^a</u>	RBD:	1.429	0.350	1.431	0.299
	LBD:	1.484	0.427	1.790	0.565
	NC:	1.432	0.269	1.635	0.288
<u>Happy</u>	RBD:	1.450	0.353	1.506	0.400
	LBD:	1.396	0.349	1.803	0.734
	NC:	1.439	0.212	1.564	0.172
<u>Interest</u>	RBD:	1.479	0.164	1.544	0.189
	LBD:	1.689	0.680	1.788	0.502
	NC:	1.478	0.164	1.544	0.189
<u>Neutral</u>	RBD:	1.490	0.260	1.326	0.197
	LBD:	1.438	0.448	1.502	0.573
	NC:	1.354	0.318	1.459	0.149

Note: ^aUPS = unpleasant surprise, PS = pleasant surprise.

Results

Statistical Procedures

Overview. Statistical analyses were used to investigate the three separate objectives of this study. The primary analyses investigated potential group differences (RBD, LBD, and NC) for each of the three task conditions (Posed Prosodic to

Expression, Prosodic Identification, and Prosodic Discrimination tasks) for the semitone conversion scores of F_0 mean and F_0 standard deviation, duration measures, and accuracy scores for the comprehension tasks.

Mixed factorial repeated-measures analyses of variance (ANOVAs) were conducted for each of the dependent variables, with group (RBD, LBD, & NC) as the between-subjects factor and task (PPE, PID, and PDISC) as the within-subjects factor. Separate ANOVAs were run for acoustic data (F_0 mean, F_0 standard deviation, & duration), comprehension data (identification & discrimination), and rater data (accuracy & intensity). In instances where control measures were significant across groups, ANCOVAs were conducted to control for group differences. Tasks were also analyzed separately for emotion (happy, pleasant surprise, interest, sad, disgust, fear, anger, unpleasant surprise), valence (positive, negative), motoric direction (approach, withdrawal), and arousal level (high, low). Post-hoc tests using LSD procedures, with a significant criteria p value set at .05, were conducted for any significant main or interaction effects.

The secondary objectives investigated differences among discrete emotions (8 levels: happy, pleasant surprise, interest, sad, disgust, fear, anger, and unpleasant surprise), valence of emotions (2 levels: positive and negative), motoric direction (2 levels: approach and withdrawal), and arousal level of emotions (2 levels: high, low), as well as potential effects of gender on encoding and decoding emotional stimuli. The three groups were analyzed as separate between-subjects factors, with emotion as the within-subjects factor. The Group by Gender by Emotion analysis was carried out separately for acoustical parameters (F_0 mean, F_0 standard deviation, & duration), comprehension data

(identification & discrimination), and rater data (accuracy & intensity). Separate Group by Gender ANOVAs were also analyzed for emotional valence, motoric direction, and arousal level.

Each group (RBD, LBD, NC) was studied separately in terms of gender and emotion, valence, motoric direction, and arousal, using mixed three-way repeated-measures analyses of variance (ANOVAs) with the same sets of dependent variables described above. On an exploratory basis, the relationship between acoustic data (F_0 mean, F_0 standard deviation, duration) and rater data (accuracy & intensity) was examined by performing 6 sets of correlational analyses for each group categorized by laterality (RBD, LBD). Pearson product-moment correlations were utilized to examine the relationship between acoustic and rater data, separately for each discrete emotion and for emotions categorized by valence, motoric direction, and arousal level.

To examine whether brain damage impairs emotional processing globally, Pearson Product-Moment correlations were conducted on expression and comprehension of emotionally intoned sentences. Additionally, correlations were used to look at the expression-perception relationship between the experimental groups' ability to accurately identify discrete emotions, as well as emotions categorized by valence, motoric direction, and arousal level, as compared to raters' ability to rate the accuracy of the participants' emotional expression.

In order to ascertain baseline levels of fundamental frequency in the different types of expressions for men and women in each group, the mean F_0 was examined for the neutral sentences. F_0 means were compared on the neutral expressions for men and women using student t-tests. There was a significant differences between the mean values

for men and women ($t(52) = -5.990, p < .001$), such that men produce significantly lower F_0 means than did women. These expected differences have to be taken into account in order to measure emotional differences. Therefore, Hz data were first transformed into semitones (Baken & Orlikoff, 2000; Ross et al., 1986), and difference scores were created by subtracting values for each of eight emotions from the value for neutral. Then, four separate mixed repeated-measured ANOVAs were computed on the semitone difference scores (Group [3] x Gender [2] x Emotion [8]; Valence [2]; Motoric Direction [2]; Arousal [2]). On an exploratory basis, mixed repeated-measures ANOVAs were also examined for Group (RBD, LBD) x Lesion Location (anterior, posterior, anterior/posterior) x Valence (positive, negative).

Nonemotional Control Tasks.

Prior to conducting analyses on the emotional data, scores obtained on the nonemotional control tasks were tested for group differences, in order to determine whether or not it would be necessary to control for these factors in the analysis of the experimental data. One-way ANOVAs on group were conducted for each control task. As seen in Table 16, there were no significant group differences for the Intonation Contours: Expression task ($p = .699$), Posed Prosodic Expression to Command task, neutral condition (F_0 mean [$p = .965$], F_0 standard deviation [$p = .121$], and duration [$p = .455$]), and Intonation Contours: Perception task ($p = .187$). However, for the neutral condition for intensity ratings, there was a significant group difference, $F = 40.23, p < .001$, such that NC individuals presented as significantly more intense than RBD participants ($p = .003$) and LBD individuals ($p < .001$). Therefore, for intensity ratings, repeated-measures ANCOVAs were undertaken, covarying for the neutral condition. For

a listing of nonemotional control tasks and their comparative experimental tasks, please refer to Table 8.

Table 15.

NonEmotional Perceptual Control Variables

Prosody	Group	Mean	SD	<i>F</i>	<i>p</i>
Intonation Contours: Expression				0.36	.699
	RBD	.619	.16		
	LBD	.601	.18		
	NC	.648	.15		
Intonation Contours: Perception				1.73	.187
	RBD	.728	.22		
	LBD	.792	.20		
	NC	.845	.15		
Prosodic Expression To Command: neutral		$F_0 \bar{X}$		0.036	.965
		$F_0 \underline{SD}$		2.198	.121
		Dur.		0.804	.455
	RBD	$F_0 \bar{X}= 36.15$	4.63		
		$F_0 \underline{SD}= 2.62$	1.91		
		Dur.= 1.57	0.17		
	LBD	$F_0 \bar{X}= 35.91$	5.26		
		$F_0 \underline{SD}= 2.43$	2.43		
		Dur.= 1.37	0.25		
	NC	$F_0 \bar{X}= 35.73$	4.41		
		$F_0 \underline{SD}= 3.68$	2.38		
		Dur.= 1.49	0.46		

Expression Tasks

See Tables 16 through 36 for relevant data on the following analyses.

Acoustical Analyses

From this point on, F_0 mean refers to F_0 mean semitone difference scores, and F_0 variability refers to F_0 standard deviation semitone difference scores. F_0 mean, F_0

standard deviation, and duration were analyzed and summarized in Table 16 (*p* values).

Each of these analyses is discussed below.

Emotions

F₀ Mean. In the Group (3) x Gender (2) x Emotion (8) analysis for F₀ mean, there was a significant main effect for Emotion, $F(7, 54) = 12.67, p = <.001$. As presented in Table 18, there was also a significant Gender x Emotion interaction, $F(7, 54) = 3.18, p = .003$ (see Figure 1), as well as a trend towards significance for Group x Gender, $F(2, 54) = 2.71, p = .076$ (see Figure 2), and Group x Emotion, $F(14, 54) = 1.64, p = .068$ (see Figure 3). Tables 17 and 18 present the means for the Group x Emotion and the Group x Gender interactions, respectively.

Follow-up of the Emotion main effect with pairwise comparisons indicated that the F₀ mean for Happy was significantly greater than Interest ($p = <.001$), Anger ($p = .023$), Fear ($p = .004$), Unpleasant Surprise ($p = .004$), Disgust ($p = <.001$), and Sad ($p = <.001$). The F₀ mean for Pleasant Surprise was significantly greater than Interest ($p = <.001$), Anger ($p = .011$), Fear ($p = <.001$), Unpleasant Surprise ($p = .002$), Disgust ($p = <.001$), and Sad ($p = <.001$). For Interest, the F₀ mean was significantly greater than the F₀ mean for Sad ($p = .004$). The F₀ mean for Anger was significantly greater than Disgust ($p = .002$) and Sad ($p = <.001$). Similarly, Unpleasant surprise was significantly greater than Disgust ($p = .029$) and Sad ($p = <.001$), as was the F₀ mean for Fear and Disgust ($p = .008$) and Fear and Sad ($p = <.001$). See Table 17 for total mean semitone difference scores across emotions.

Table 16.

Summary of Statistics for Group by Gender by Emotion for All Acoustic Expression
Dependent Variables.

<u>D.V.</u>	<u>Group</u>	<u>Gender</u>	<u>Emotion</u>	<u>Group x Gender</u>	<u>Group x Emotion</u>	<u>Gender x Emotion</u>	<u>G x G x E</u>
F0 X	ns	ns	<.001**	.076	.068	.003**	ns
F0 SD	ns	ns	.007**	ns	ns	ns	ns
Duration	ns	ns	.007**	ns	ns	ns	ns

Note: * = significant p values at .05 level, ** = significant at .001 level.

Table 17.

Summary of F₀ Mean Semitone Difference Scores: Group and Gender Across Emotions.

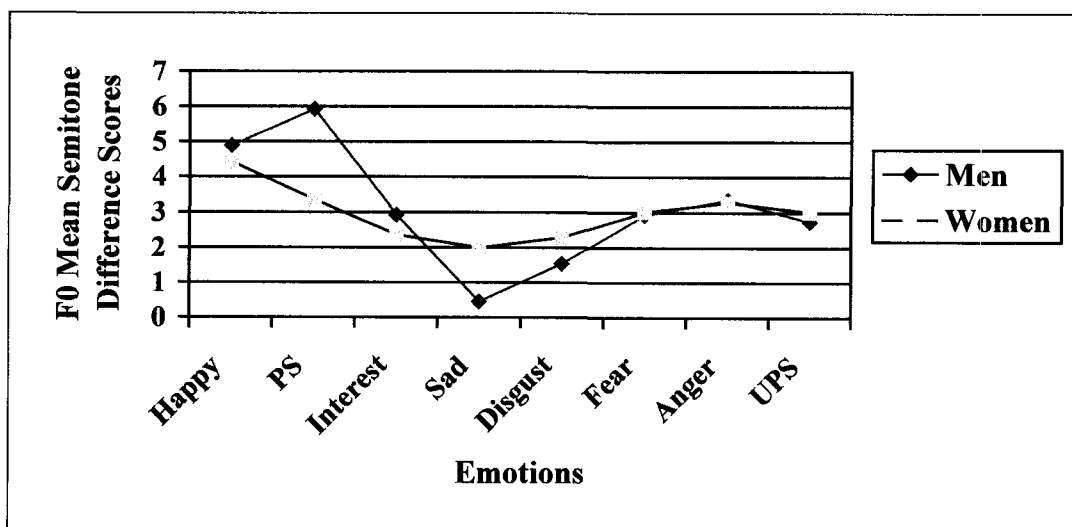
	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	4.093	4.198	2.441	1.989	2.529	2.441	3.229	2.497
LBD	4.346	4.370	3.005	1.320	1.949	3.253	3.005	2.943
NC	5.717	6.213	2.675	-.189	0.972	3.220	3.721	3.096
Men	4.898	5.921	2.913	.449	1.536	2.919	3.349	2.730
Women	4.424	3.357	2.357	2.001	2.286	3.015	3.280	3.005
Total	4.714	4.924	2.697	1.053	1.828	2.956	3.322	2.837

Table 18.

Summary of Gender F_0 Mean Semitone Difference Scores for Emotions Across Groups.

	RBD	LBD	NC
Men	2.298	4.071	3.060
Women	4.005	1.528	3.364

Post hoc tests of the significant Gender x Emotion interaction indicated that overall, men presented with significantly higher F_0 means than women for pleasant surprise ($p = .021$). There was a trend towards significance for the emotion of sadness, such that women demonstrated higher F_0 means than did men ($p = .085$). Follow-up of the Group x Gender interaction revealed a trend for the LBD group, such that men presented with higher F_0 means than did women ($p = .100$).

Figure 1. Gender by Emotion Interaction for F_0 Mean Semitone Difference Scores.

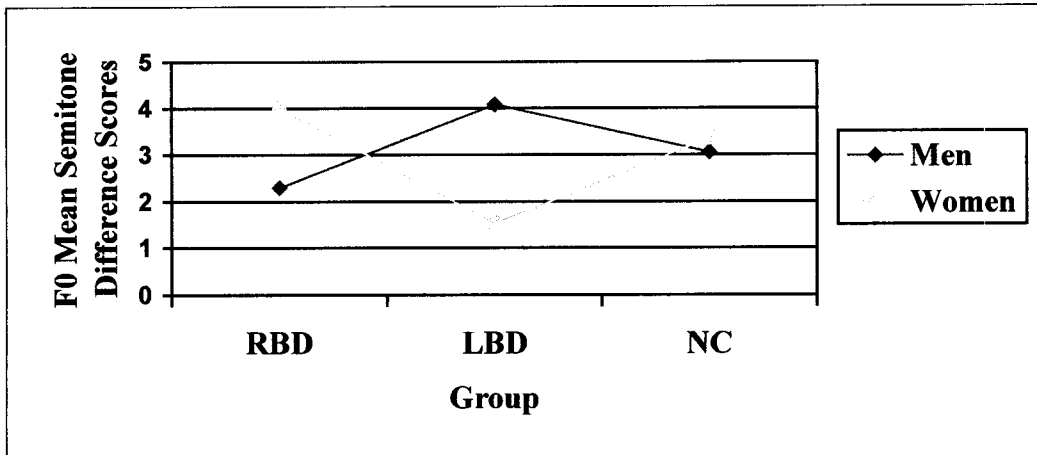


Figure 2. Group by Gender Interaction for F₀ Mean Semitone Difference Scores.

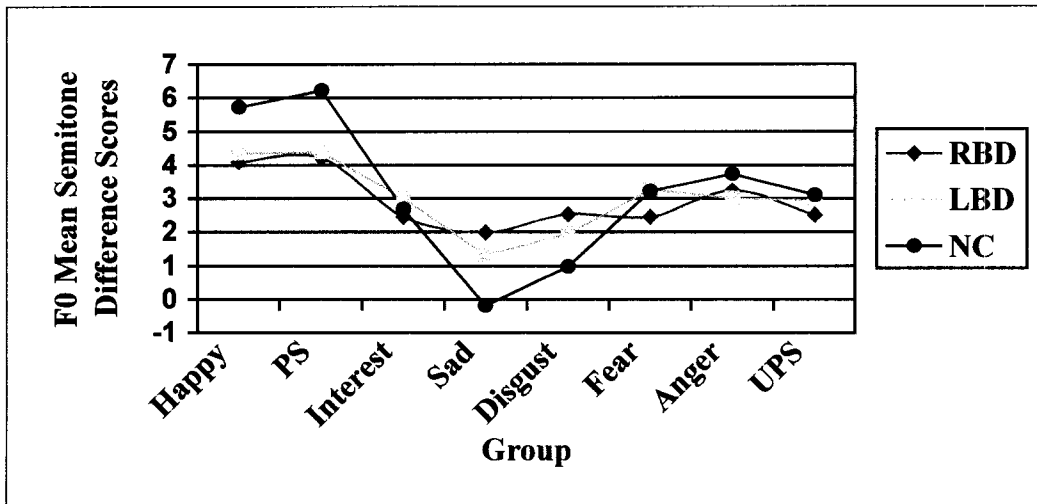


Figure 3. Group by Emotion Interaction for F₀ Mean Semitone Difference Scores.

F₀ Standard Deviation. In the Group (3) x Gender (2) x Emotion (8) analysis for F₀ standard deviation semitone difference scores, there was only a significant main effect for Emotion, $F(7, 54) = 2.83, p = .007$. Follow-up pairwise comparisons indicated that the F₀ standard deviation for Happy was significantly greater (i.e., more variability) than Disgust ($p = .040$) and Sad ($p = .023$). Pleasant Surprise was also significantly more variable than Disgust ($p = .013$) and Sad ($p = .010$). The emotion of interest was also

greater than Sad ($p = .028$), but there was only a trend towards significance compared to Disgust, such that Interest was more variable ($p = .064$). This was also true for Anger versus Disgust ($p = .059$) and Sad ($p = .041$). Lastly, there was a significant difference between Unpleasant Surprise and Sad ($p = .042$), such that Unpleasant Surprise was significantly more variable than sadness.

Duration. For the final acoustic variable in the Group (3) x Gender (2) x Emotion (8) analysis, Duration, there was only a main effect of Emotion, $F(7, 54) = 2.848$, $p = .007$. See Table 16 for p values. Follow-up pairwise comparison revealed that the duration of the sentences spoken in the emotional tone of voice for sadness was significantly slower than the sentences intoned for Pleasant Surprise ($p = .001$), Happy ($p = .007$), and Interest ($p = .043$). Disgust was significantly slower than Pleasant Surprise ($p = .002$) and Happy ($p = .042$), as was Unpleasant Surprise ($p = .008$) and Happy ($p = .044$), respectively. The duration of sentences spoken in an angry tone of voice was also significantly longer than Pleasant Surprise ($p = .014$), and there was a trend towards significance, such that the duration of Anger was slower than the duration of the Happy sentences ($p = .060$). Sentences intoned in a fearful voice were significantly slower than sentences posed for Pleasant Surprise ($p = .042$).

Valence

To determine if the valence hypothesis of emotional expression was operative, we reran the analyses that had been conducted to explore the right hemisphere hypothesis with the addition of Valence as a within-subjects factor. Therefore, separate analyses were conducted for the same acoustic variables for emotions categorized by valence (positive, negative).

F₀ Mean. With regards to F₀ mean for the Group (3) x Gender (2) x Valence (2) analysis, there was a significant main effect of Valence, $F(1, 54) = 35.85, p < .001$, such that positive emotions ($M = 4.11, \pm 3.54$) had significantly higher F₀ means than negative emotions ($M = 1.36, \pm 1.92$). See Table 19 for all significant p values for Valence. There was also a significant Group x Gender interaction, $F(1, 54) = 3.39, p = .042$, and a trend towards significance for Gender x Valence ($p = .052$ [see Figures 4 and 5, respectively]). See Table 20 for overall F₀ means across Valence and Gender.

Table 19.

Summary of p Values for all Group by Gender by Valence Analyses for Acoustical Parameters.

<u>D.V.</u>	<u>Group</u>	<u>Gender</u>	<u>Valence</u>	<u>Group x Gender</u>	<u>Group x Valence</u>	<u>Gender x Valence</u>	<u>G x G x V</u>
F0 X	.ns	ns	<.001**	.042*	ns	.052	ns
F0 SD	ns	ns	.010*	ns	ns	ns	ns
Duration	ns	ns	.001**	ns	ns	ns	ns

Note: * = significant p values at .05 level, ** = significant at .001 level

Table 20.

Interaction Effects of Group by Gender and Gender by Valence for F_0 Mean.

	Positive	Negative	Gender Total
RBD	3.577	1.675	
Men	3.172	0.948	2.060
Wom.	4.273	2.920	3.596
LBD	3.907	1.591	
Men	5.296	2.311	3.804
Wom.	1.921	0.562	1.242
NC	4.868	-.189	
Men	5.457	0.377	2.917
Wom.	3.944	1.505	2.725
Total	4.010	1.437	

Post hoc tests of the significant Group x Gender interaction indicated that for negative emotions, men in the LBD group presented with significantly higher F_0 means than men in the NC group ($p = .016$) and, to a lesser extent, than men in the RBD group ($p = .078$). For women, just the opposite was observed, such that women in the RBD

group had significantly higher F_0 means for the negative emotions, than did women in the LBD group. When gender differences were analyzed separately by group, post hoc testing revealed that for the RBD group, there was no significant difference between men and women for the F_0 means of positive emotions ($p = .425$). However, for negative emotions, women produced significantly greater F_0 means ($M = 2.92 \pm 2.27$) than did men ($M = 0.95 \pm 1.73$), $F = 4.58$, $p = .047$. Within the LBD group, there was a trend towards significance for positive emotions, $F = 3.35$, $p = .087$, such that men produced higher F_0 means for positively valenced emotions ($M = 5.30 \pm 3.96$) than did women ($M = 1.92 \pm 3.38$). This was also true for the negative emotions, $F = 3.62$, $p = .077$, such that men produced higher F_0 means ($M = 2.31 \pm 1.75$) than did women ($M = 0.56 \pm 2.03$). Finally, post hoc testing within the NC group revealed no significant differences between gender for both positive emotions ($p = .429$) and negative emotions ($p = .140$).

Follow-up post hoc testing for the observed trend of the Gender x Valence interaction revealed no significant differences. However, when men and women were analyzed separately using Paired Samples t-tests, there was a significant difference for men, $t(1, 32) = 5.55$, $p < .001$, such that positive emotions had significantly higher F_0 means ($M = 4.58 \pm 3.55$) than did negative emotions ($M = 1.17 \pm 1.87$). The same was true for women, in that positive emotions ($M = 3.38 \pm 3.48$) were expressed with significantly higher F_0 means than the negative emotions ($M = 1.67 \pm 2.01$), $t(1, 20) = 3.35$, $p = .003$.

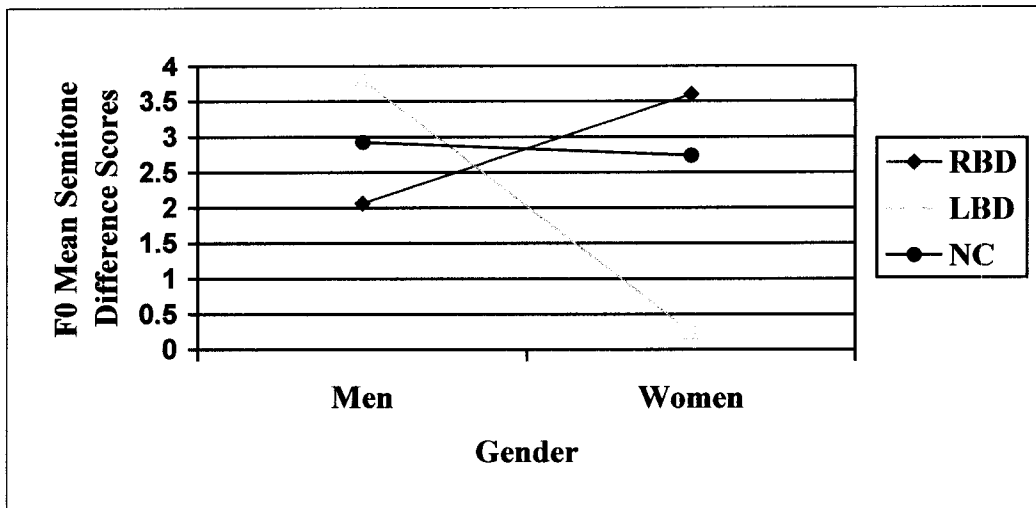


Figure 4. Interaction Effect of Group by Gender for F_0 Mean Semitone Difference Scores for Valence.

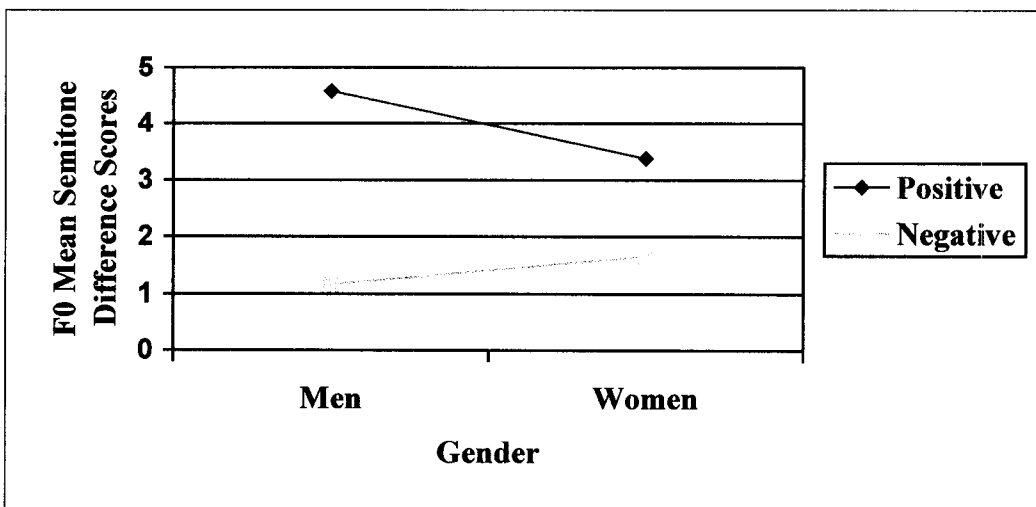


Figure 5. Interaction Effect of Gender by Valence for F_0 Mean Semitone Difference Scores (trend).

F_0 Standard Deviation. In the Group (3) x Gender (2) x Valence (2) analysis for F_0 standard deviation, there was a significant main effect of Valence, $F(1, 54) = 7.17, p = .010$, such that positive emotions ($M = 1.46, \pm 2.30$) were expressed with significantly greater F_0 variability than negative emotions ($M = 0.68, \pm 1.51$).

Duration. Similarly, for the Group (3) x Gender (2) x Valence (2) analysis for Duration, there was only a significant main effect of Valence, $F(1, 54) = 13.30, p = .001$, such that positive emotions ($M = 1.54, \pm 0.33$) were expressed significantly faster than negative emotions ($M = 1.65, \pm 0.34$).

Motoric Direction

F₀ Mean. In order to measure group and gender differences for emotional expressions categorized by Motoric Direction, analyses were conducted across acoustic variables. For F₀ mean, the Group (3) x Gender (2) x Motoric Direction (2) analysis revealed a significant main effect of Motoric Direction, $F(1, 54) = 37.96, p < .001$, such that Approach emotions ($M = 2.93, \pm 2.57$) were expressed with significantly higher F₀ means than Withdrawal emotions ($M = 0.87, \pm 2.13$). There was also a significant Group x Gender interaction, $F(1, 54) = 3.72, p = .031$ (see Figure 6), and a significant Gender x Motoric Direction interaction, $F(1, 54) = 4.12, p = .048$ (see Figure 7). A trend towards significance was observed for Group x Motoric Direction, $F(1, 54) = 2.98, p = .060$ (see Figure 8). See Table 21 for all p values for Motoric Direction.

Table 21.

Summary of p Values for Motoric Direction F_0 Mean Semitone Difference Scores for Acoustic Variables.

<u>D.V.</u>	<u>Group</u>	<u>Gender</u>	<u>Motoric Direct.</u>	<u>Group x Gender</u>	<u>Group x Motoric Direct.</u>	<u>Gender x Motoric Direct.</u>	<u>G x G x MD</u>
F0 X	ns	ns	.001**	.031*	.060	.048*	ns
F0 SD	ns	ns	.002**	ns	ns	ns	ns
Duration	ns	ns	.031*	ns	ns	ns	ns

Note: * = significant p value at .05 level, ** = .001 level.

Post hoc tests of the significant Group x Gender interaction indicated that for RBD participants, there was a trend towards significance, $F(1, 18) = 3.878, p = .065$, in that women produced higher F_0 means ($M = 3.22, \pm 0.73$) than did men ($M = 1.40, \pm 0.56$). Within the LBD group, while there were no significant gender differences, the pattern of performance was opposite among individuals with RBD, such that men ($M = 2.82, \pm 0.71$) produced higher F_0 means than did women ($M = 0.97, \pm 0.84 [p = .113]$). Finally, for the NC group, there was no significant difference for gender ($p = .582$). See Table 22 for F_0 means for Motoric Direction.

Table 22.

Interaction Effect for the F_0 Mean Semitone Difference Scores For Motoric Direction
Between Groups and Gender

	Approach	Withdrawal	Total
RBD	2.686	1.451	2.308
Men	2.185	0.613	1.399
Women	3.545	2.888	3.216
LBD	2.984	1.136	1.897
Men	3.991	1.653	2.822
Women	1.546	0.398	0.972
NC	3.133	0.008	1.616
Men	3.281	-.529	1.376
Women	2.899	0.811	1.855
Total	2.908	0.972	

There was a significant interaction effect of Gender x Motoric Direction ($p = .048$). Analysis of Gender revealed that men generated significantly higher F_0 means for approach emotions ($M = 3.10 \pm 2.60$) than withdrawal emotions ($M = 0.55 \pm 1.92$), $t(1, 32) = 5.77, p < .001$. This was also true for women, $t(1, 20) = 3.11, p = .006$, such that approach emotions ($M = 2.67 \pm 2.58$) were expressed with significantly higher F_0 means than withdrawal emotions (1.37 ± 2.37). However, by visual inspection, the gap between the women's approach and withdrawal emotions was smaller than the difference was for men. In examining the trend of Group x Motoric Direction, post hoc testing indicated that participants in the RBD group demonstrated significantly higher F_0 means than did NC participants, for the withdrawal emotions ($p = .037$). Separately by group, individuals in the RBD group expressed approach emotions ($M = 2.68 \pm 2.00$) with significantly greater F_0 means, $t(1, 18) = 3.17, p = .005$, than withdrawal emotions ($M =$

1.45 ± 2.49). The LBD group expressed significantly higher means, $t(1, 16) = 3.14, p = .006$, for approach emotions ($M = 2.98 \pm 3.25$), than withdrawal emotions ($M = 1.14 \pm 1.87$). This was also seen in the NC group, such that approach emotions ($M = 3.13 \pm 2.53$) were also produced with greater F_0 means, $t(1, 17) = 5.04, p < .001$, than withdrawal emotions ($M = .007 \pm 1.74$).

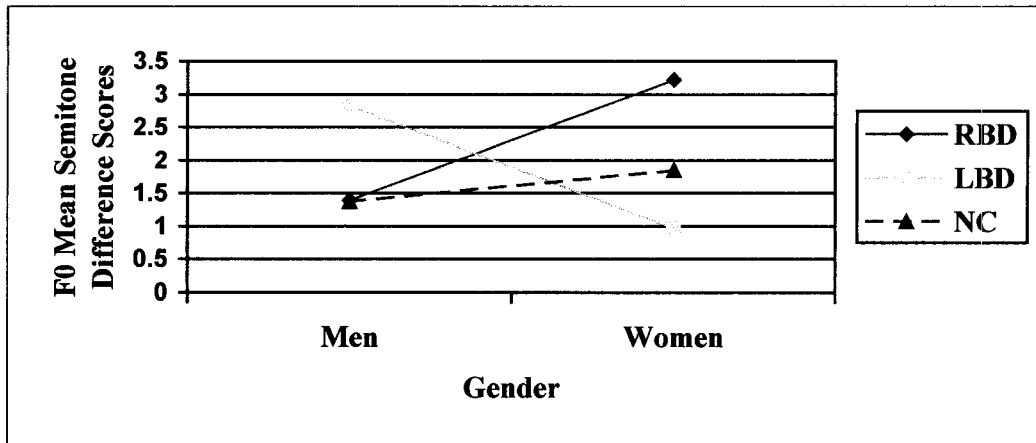


Figure 6. Interaction Effect of Group by Gender for F_0 Mean Semitone Difference Scores for Motoric Direction.

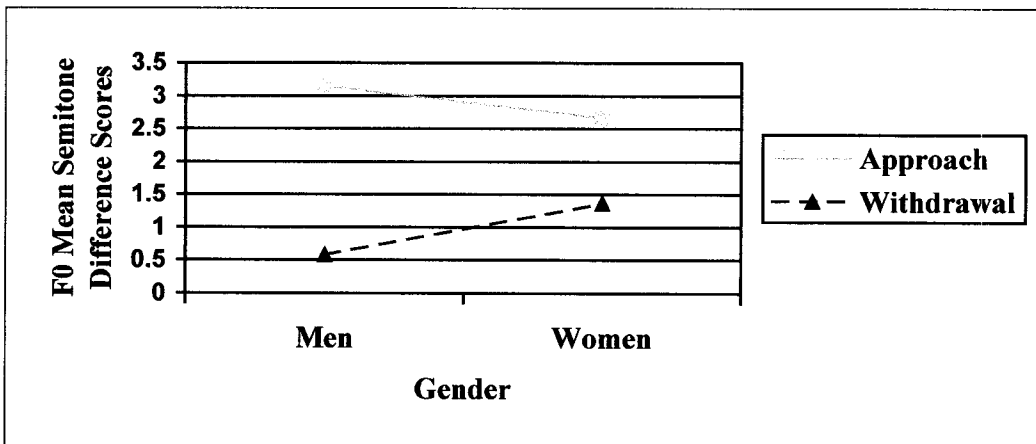


Figure 7. Interaction Effect of Gender by Motoric Direction for F_0 Mean Semitone Difference Scores.

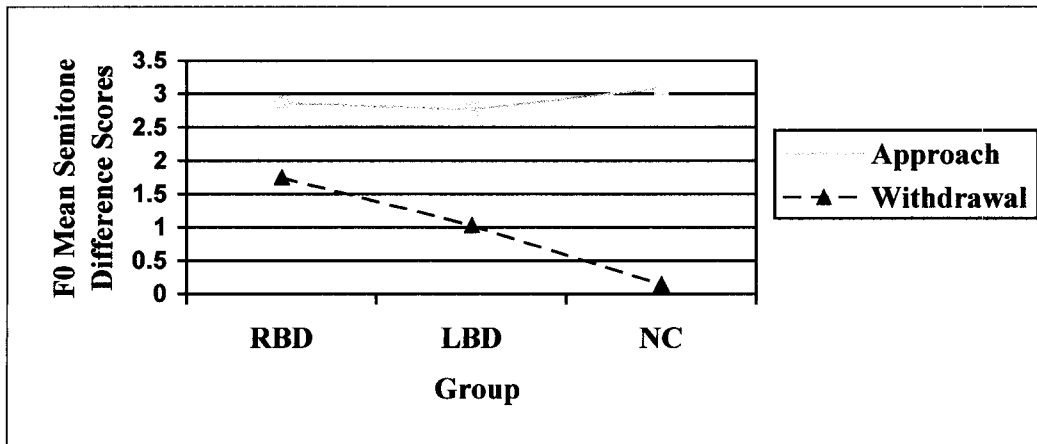


Figure 8. Interaction Effect of Group by Motoric Direction for F₀ Mean Semitone Difference Scores.

F₀ Standard Deviation. In the Group (3) x Gender (2) x Motoric Direction (2) analysis for F₀ standard deviation, there was a significant main effect of Motoric Direction, $F(1, 54) = 10.26, p = .002$, such that emotions in the Approach category ($M = 1.31, \pm 2.02$) were expressed with significantly higher F₀ means than emotions within the Withdrawal category ($M = 0.52, \pm 1.56$).

Duration. For duration scores, the Group (3) x Gender (2) x Motoric Direction (2) analysis also revealed a significant main effect of Motoric Direction, $F(1, 54) = 4.93, p = .031$, indicating that Approach emotions ($M = 1.57, \pm 0.32$) were expressed significantly faster than Withdrawal emotions ($M = 1.66, \pm 0.38$).

Arousal Level

F₀ Mean. Finally, acoustic variables were analyzed for emotions separated by arousal level (high, low). For F₀ mean, the Group (3) x Gender (2) x Arousal (2) analysis yielded a significant main effect for arousal level, $F(1, 54) = 12.21, p = .001$, such that high arousal emotions ($M = 2.40, \pm 2.13$) had significantly higher F₀ means than low arousal emotions ($M = 1.47, \pm 2.21$). There was also a significant Gender x Arousal

Level interaction, $F(1, 54) = 5.45, p = .024$ (see Figure 9), and a trend towards significance for the Group x Gender interaction, $F(1, 54) = 3.151, p = .052$ (see Figure 10), and Group x Arousal Level, $F(1, 54) = 2.59, p = .086$ (see Figure 11). See Table 23 for p values for Arousal Level.

Table 23.

Summary of p Values for Arousal Level F_0 Mean Semitone Difference Scores.

<u>D.V.</u>	<u>Group</u>	<u>Gender</u>	<u>Arousal Level</u>	<u>Group x Gender</u>	<u>Group x Arousal Level</u>	<u>Gender x Arousal Level</u>	<u>G x G x AL</u>
F0 X	ns	ns	<.001**	.052	.086	.024*	ns
F0 SD	ns	ns	.041*	ns	ns	ns	ns
Duration	ns	ns	.002*	ns	ns	ns	ns

Note: * = significant p value at .05 level, ** = .001 level.

Follow-up examination of the significant Gender x Arousal interaction indicated that, while post hoc comparisons did not reach clinical significance, the pattern of interaction suggested that men expressed high arousal emotions ($M = 2.67, \pm 2.00$) with greater F_0 means than their expression of low arousal emotions ($M = 1.32, \pm 2.01$). In comparison, women demonstrated less of a difference between high arousal emotions ($M = 1.97, \pm 2.30$) and low arousal emotions ($M = 1.70, \pm 2.54$). See Table 25 for overall F_0 means. When analyzed separately by gender, men demonstrated significantly greater F_0 means for high arousal emotions than low arousal emotions, $t(1, 32) = 4.23, p < .001$. However, for women, there was no significant difference for the F_0 mean of high versus low arousal, $p = .398$.

Follow-up testing of the Group x Gender interaction revealed that men in the LBD group expressed low arousal emotions ($M = 2.39, \pm 1.84$) with significantly higher

F_0 means, $p = .033$, than did men in the NC group ($M = 0.52, \pm 2.00$). For women, no significant differences in emotional expression for F_0 mean existed between groups. When gender was analyzed separately by group, no significant gender differences were revealed for the RBD group ($p = .451$). However, for the LBD group, men produced significantly higher F_0 means for high arousal emotions, $F(1, 15) = 5.33, p = .036$, than did women. For low arousal emotions, there were no significant gender differences within the LBD group ($p = .196$). Finally, for the NC group, there were no significant gender differences for high ($p = .556$) or low arousal emotions ($p = .451$).

The Group by Arousal Level interaction revealed a trend towards significance ($p = .086$). For the RBD group, there were no significant differences between the expression of high arousal emotions ($M = 2.35 \pm 2.20$) and low arousal emotions ($M = 1.82 \pm 2.41$), $p = .210$. The same pattern was seen for the LBD group, with no significant difference between high arousal emotions ($M = 2.35 \pm 2.50$) and low arousal emotions ($M = 1.78, 2.27$), $p = .113$. However, for the NC group, there was a significant difference between the high and low arousal emotions, with high arousal emotions ($M = 2.49 \pm 1.75$) significantly greater, $t(1, 17) = 3.86, p = .001$, than low arousal emotions ($M = 0.80 \pm 1.86$). Refer to Table 24 for group mean F_0 semitone difference scores.

Table 24.

Interaction Effects of Group by Gender (trend), Group by Arousal (trend), and Gender by Arousal for F₀ Mean Semitone Difference Scores for Arousal Level.

	Hi Arousal	Low Arousal	Total
RBD	2.355	1.817	2.260
Men	2.053	1.146	1.599
Women	2.872	2.968	2.920
LBD	2.348	1.781	1.888
Men	3.385	2.391	2.888
Women	0.867	0.909	0.888
NC	2.494	0.797	1.656
Men	2.695	0.522	1.609
Women	2.177	1.228	1.702
Total	2.341	1.527	

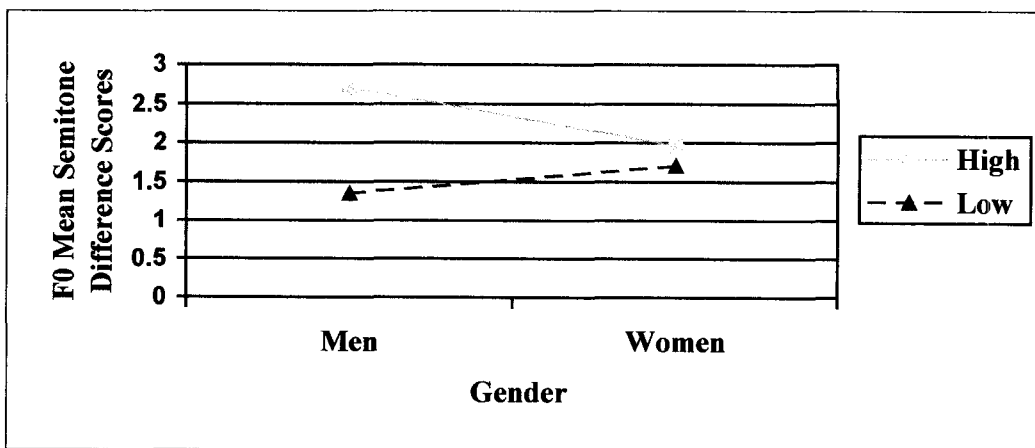


Figure 9. Interaction Effect of Gender by Arousal Level for F₀ Mean Semitone Difference Scores.

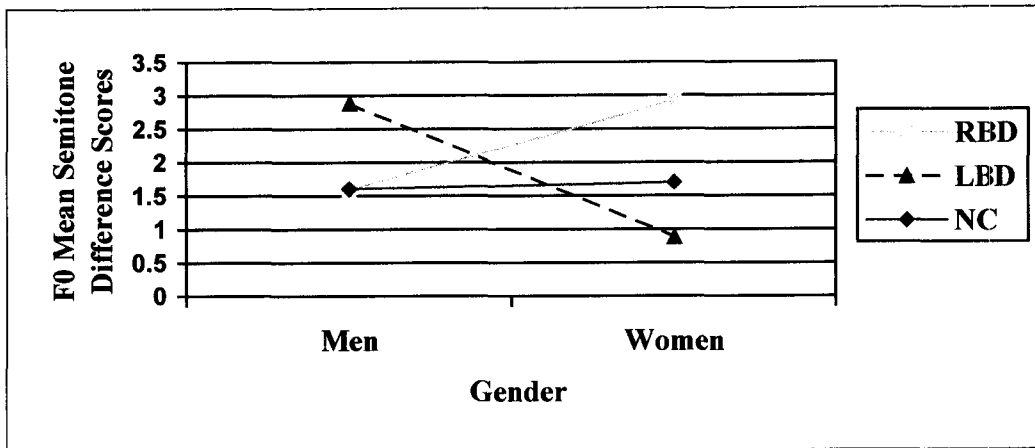


Figure 10. Interaction Effect of Group by Gender for F₀ Mean Semitone Difference Scores for Arousal Level.

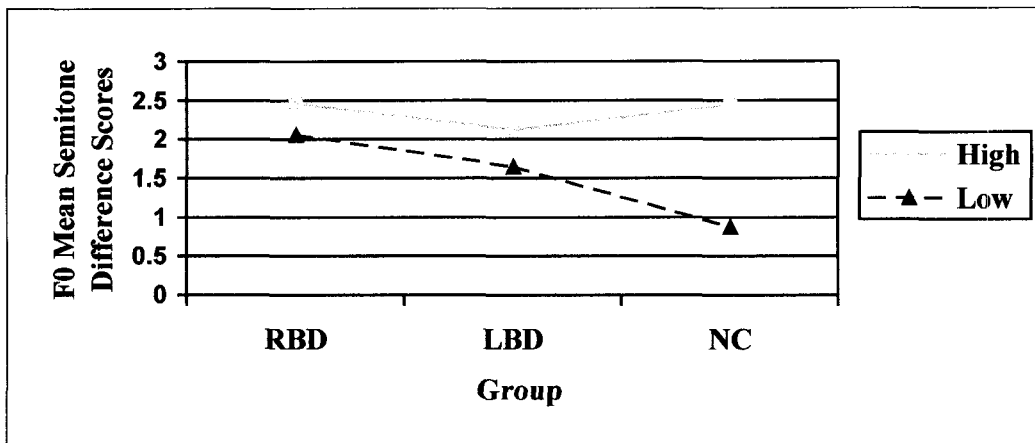


Figure 11. Interaction Effect of Group by Arousal Level for F₀ Mean Semitone Difference Scores.

F₀ Standard Deviation. The Group (3) x Gender (2) x Arousal Level (2) analysis for F₀ standard deviation revealed a significant main effect of Arousal, $F(1, 52) = 4.40, p = .041$. Follow-up pairwise comparisons indicated that high arousal emotions ($M = 1.24, \pm 2.00$) were expressed with greater F₀ variability than low arousal emotions ($M = 0.41, \pm 2.35$).

Duration. For duration measures, the Group (3) x Gender (2) x Arousal Level (2) analysis showed a significant main effect of Arousal Level, $F(1, 54) = 10.33, p = .002$,

such that high arousal emotions ($M = 1.66, \pm 0.37$) were expressed with significantly faster speed than low arousal emotions ($M = 1.54, \pm 0.31$).

Table 25.

Summary of p Values for Emotions for Intensity and Accuracy Ratings

<u>Depend. Variables</u>	<u>Group</u>	<u>Gender</u>	<u>Emotion</u>	<u>Group x Gender</u>	<u>Group x Emotion</u>	<u>Gender x Emotion</u>	<u>G x G x E</u>
Intensity	ns	ns	ns	ns	<.001**	ns	ns
Accuracy	.093	ns	<.001**	ns	ns	ns	ns

Note: * = significant p value at .05 level, ** = .001 level.

Human Rating Analyses

Intensity Ratings

Emotion. In the Group (3) x Gender (2) x Emotion (8) analysis for intensity ratings, a mixed-repeated ANCOVA revealed a significant main effect of Emotion, $F(7, 54) = 7.44, p < .001$. See Table 25 for a summary of p values. There was also a significant Group x Emotion interaction, $F(7, 54) = 5.25, p < .001$ (see Figure 12). Refer to Table 26 for a summary of means across groups and emotions.

Table 26.

Main Effect of Emotion and Interaction Effect of Group by Emotion for Intensity Ratings.

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	3.89	3.93	4.02	3.01	3.76	2.93	4.11	4.38
LBD	3.79	2.47	3.26	3.94	3.26	3.74	3.67	3.43
NC	4.46	4.50	3.63	2.28	3.51	3.79	4.32	4.03
Total	4.05	3.66	3.65	3.06	3.52	3.49	4.04	3.96

Follow-up pairwise comparisons of the Emotion main effect indicated that the Happy was rated as significantly more intense than Pleasant Surprise ($p = .027$), Fear ($p < .001$), Disgust ($p = .003$), Interest ($p = .012$), and Sad ($p < .001$). On the other extreme, Sad was rated as significantly less intense than Fear ($p = .006$), Disgust ($p = .016$), Anger ($p < .001$), Unpleasant Surprise ($p < .001$), Pleasant Surprise ($p = .009$), and Interest ($p < .001$). In between, Fear was rated as significantly lower than Unpleasant Surprise ($p = .018$) and Anger ($p < .001$). Anger was also rated as significantly more intense than Disgust ($p = .007$), Pleasant Surprise ($p = .029$), and Interest ($p = .006$).

Post hoc tests of the significant Group by Emotion interaction indicated that significant group differences existed between the emotions of Sad ($p < .001$), Fear ($p = .041$), Unpleasant Surprise ($p = .050$), and Pleasant Surprise ($p < .001$). More specifically, individuals in the NC group expressed the emotion of Pleasant Surprise more intensely than participants in the LBD group ($p < .001$), and LBD individuals were rated as significantly less intense than participants in the RBD group ($p < .001$). For the emotion of Fear, individuals in the NC group were rated as more intense than those in the

RBD group ($p = .028$), and the LBD group was rated as more intense than RBD participants as well ($p = .030$). For interest, the RBD group was rated as significantly more intense than the LBD group ($p = .041$). Finally, for Sad, individuals in the RBD and LBD groups were rated as significantly more intense than NC participants ($p = .019$ and $p < .001$, respectively). The RBD group was rated as less intense than the LBD group as well ($p = .004$).

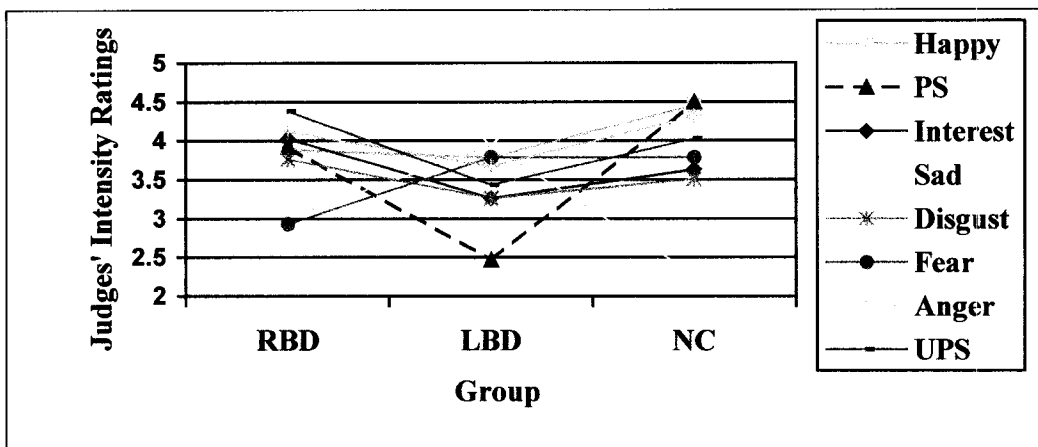


Figure 12. Interaction Effect of Group by Intensity Ratings for Emotions.

Valence. When groups were analyzed separately for emotions categorized by valence, the Group (3) x Gender (2) x Valence (2) analysis indicated no significant main effects. See Table 27 for p values. However, there was a significant Group x Valence interaction, $F(2, 54) = 5.79, p = .006$ (see Figure 13), Group x Gender interaction, $F(2, 54) = 3.87, p = .028$ (see Figure 13), and a trend towards significance for Gender x Valence $F(1, 54) = 2.86, p = .097$ (see Figure 15). See Table 28 for summary of group means across groups, gender, and valence.

Table 27.

Intensity and Accuracy Rating *p* Values for Emotions Separated by Valence.

<u>D.V.</u>	<u>Group</u>	<u>Gender</u>	<u>Valence</u>	<u>Group x Gender</u>	<u>Group x Valence</u>	<u>Gender x Valence</u>	<u>G x G x V</u>
Intensity	ns	ns	ns	.028*	.006**	.097	ns
Accuracy	ns	ns	ns	ns	.006**	ns	ns

Note: * = significant *p* value at .05 level, ** = .001 level.

Table 28.

Summary of Intensity Ratings for Significant Group by Valence, Group by Gender, and Gender by Valence (trend) Interactions.

	Positive	Negative	Total
RBD	3.79	3.90	
Men	4.10	4.14	4.22
Women	3.25	3.50	3.38
LBD	3.99	3.89	
Men	4.22	4.12	4.17
Women	3.67	3.58	3.62
NC	4.19	3.59	
Men	4.15	3.30	3.73
Women	4.26	4.04	4.15
Total	3.93	3.62	
Men	4.15	3.85	
Women	3.73	3.70	

While post hoc comparisons did not reach statistical significance for the Group by Valence interaction, the pattern of the interaction suggested that individuals in the NC

group ($M = 4.19, \pm 0.70$) and the LBD group ($M = 3.99, \pm 0.72$) expressed positive emotions with greater intensity than individuals in the RBD group ($M = 3.79, \pm 0.87$). For negative emotions, LBD ($M = 3.89, \pm 0.75$) and RBD group participants ($M = 3.90, \pm 0.73$) appeared to express emotions with greater intensity than those in the NC group ($M = 3.59, \pm 0.81$). When analyzed separately by group, there was no significant difference between the intensity rating of the positive emotions and the negative emotions for the RBD group, $p = .389$, or the LBD group, $p = .480$. However, within the NC group, there was a significant difference, $t(1, 17) = 3.58, p = .002$, such that positive emotions ($M = 4.19 \pm 0.71$) were rated as significantly more intense than negative emotions ($M = 3.59 \pm 0.81$).

Follow-up post hoc testing of the significant Group by Gender interaction suggested that for the RBD group, men were rated as significantly more intense than women, $F(1, 17) = 5.44, p = .032$. However, for the LBD group there were no significant differences between men and women ($p = .109$). This was true for the NC group as well ($p = .200$). When gender was analyzed separately by group, for RBD individuals, men were rated as significantly more intense than women for the positive emotions, $F(1, 17) = 5.26, p = .035$, with a trend towards significance for the negative emotions, $p = .063$. Within the LBD group, however, there were no significant gender differences between both positive and negative emotional intensity ratings ($p = .125$). This was also true for individuals in the NC group ($p = .757$).

Although the Gender by Valence interaction was reaching significance, post hoc testing was conducted, and results indicated that men were rated as significantly more intense than women for positive emotions ($p = .047$). When analyzing all men across

valence, Paired Samples t-tests revealed that men were rated as significantly more intense for the positive emotions than for negative emotions, $t(1, 32) = 2.39, p = .023$. However, women did not demonstrate this pattern of performance, and no significant differences were shown for the rated intensity of positive and negative emotions ($p = .865$).

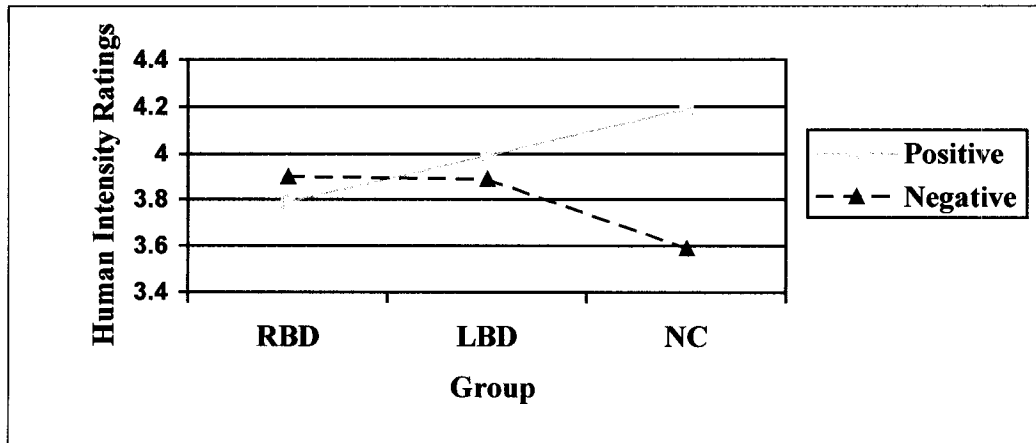


Figure 13. Interaction Effect of Group by Valence for Intensity Ratings Categorized by Valence.

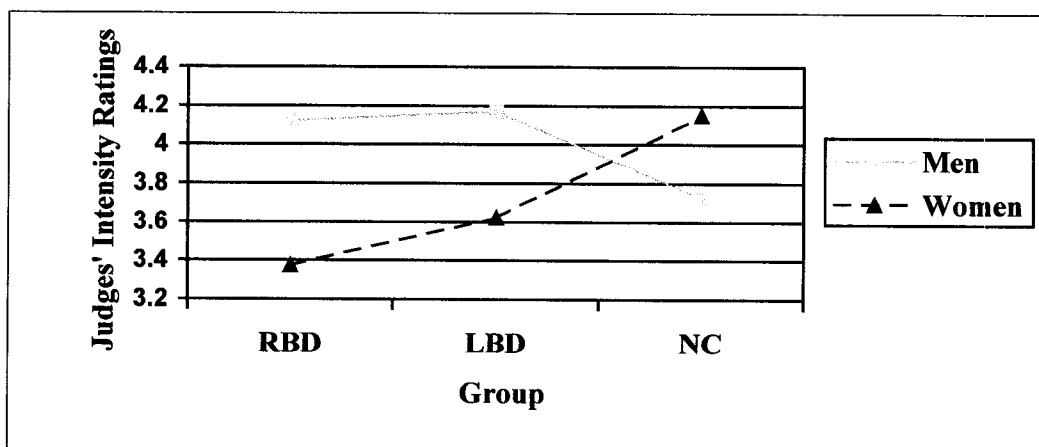


Figure 14. Interaction Effect of Group by Gender for Intensity Ratings Categorized by Valence.

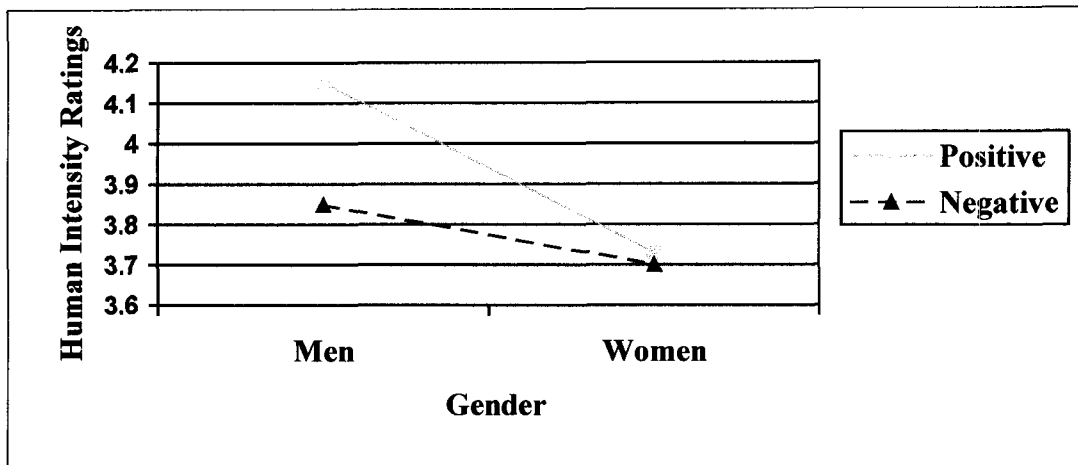


Figure 15. Interaction Effect Trend of Gender by Valence for Intensity Ratings Categorized by Valence.

Motoric Direction. When emotions were analyzed separately for Motoric Direction, the Group (3) x Gender (2) x Motoric Direction (2) analysis revealed a trend towards significance for a main effect of Motoric Direction, $F(1, 54) = 3.68, p = .061$, such that Approach emotions ($M = 3.94, \pm 0.99$) were rated as significantly more intense than Withdrawal emotions ($M = 3.36, \pm 0.88$). There was also a trend towards significance for the main effect of group, $F(2, 54) = 2.45, p = .097$, such that individuals in the LBD group were rated as less intense than RBD participants ($p = .032$). See Table 29 for overall p values, and Table 30 for a summary of mean intensity scores across group, gender, and motoric direction. In addition to main effects, there was a significant Group x Motoric Direction interaction, $F(2, 54) = 3.53, p = .037$ (see Figure 16), as well as a trend towards significance for the three-way interaction of Group x Gender x Motoric Direction, $F(2, 54) = 2.57, p = .087$.

Table 29.

All Significant *p* Values for Intensity and Accuracy Ratings Categorized by Motoric Direction.

<u>D.V.</u>	<u>Group</u>	<u>Gender</u>	<u>Motoric Direct.</u>	<u>Group x Gender</u>	<u>Group x Motoric Direct.</u>	<u>Gender x Motoric Direct.</u>	<u>G x G x MD</u>
Intensity	.097	ns	.061	ns	.037*	ns	.087
Accuracy	<.001**	ns	ns	ns	ns	ns	ns

Note: * = significant *p* value at .05 level, ** = .001 level.

Table 30.

Summary of Means for Rated Intensity Across Group, Gender, and Motoric Direction.

	<u>Approach</u>	<u>Withdrawal</u>	<u>Total</u>
RBD	4.06	3.61	3.77
Men	4.34	3.67	
Women	3.60	3.49	
LBD	3.60	3.26	3.44
Men	3.48	3.30	
Women	3.77	3.23	
NC	4.13	3.19	3.74
Men	3.98	2.86	
Women	4.38	3.73	
Total	3.94	3.36	
Men	3.96	3.29	
Women	3.92	3.48	

While post hoc comparisons did not reach clinical significance for the Group x Motoric Direction interaction, the pattern of scores revealed that LBD individuals were rated as less intense than the NC group and RBD groups for approach and withdrawal emotions (see Table 30 for mean intensity ratings). However, when Motoric Direction

was analyzed within groups, the RBD group demonstrated significantly more intensely rated approach emotions than withdrawal emotions, $t(1, 19) = 2.88, p = .010$. The NC group also demonstrated a significant difference between emotion categories, $t(1, 18) = 6.18, p < .001$, with approach emotions rated as significantly more intense than withdrawal emotions. However, within the LBD group, there was only a trend towards significance, $p = .065$, with approach emotions being rated only slightly higher than withdrawal emotions.

The three-way Group x Gender x Motoric Direction trend was also analyzed for follow-up comparisons. Results indicated that for approach emotions, men in the RBD group were rated as significantly more intense than LBD men ($p = .042$). For the withdrawal emotions, RBD men were rated as more intense than men in the NC group ($p = .026$). No significant differences were shown for women between groups. When analyzed separately by gender within each group, RBD men's rated intensities for approach emotions were significantly greater than the withdrawal emotions, $t(1, 11) = 3.28, p = .007$. However, within this group, there were no significant differences between approach and withdrawal emotions for women, $p = .635$. For the LBD group, men did not present with statistically significant differences between these emotional categories ($p = .495$). However, women in this group did show significant differences between emotional categories, $t(1, 6) = 3.29, p = .017$, with approach emotions being rated as significantly more intense than withdrawal emotions. Within the NC group, men presented with significant differences for Motoric Direction, $t(1, 10) = 5.66, p < .001$, such that approach emotions were rated as significantly more intense than withdrawal emotions. This was also true for women, $t(1, 6) = 3.14, p = .020$.

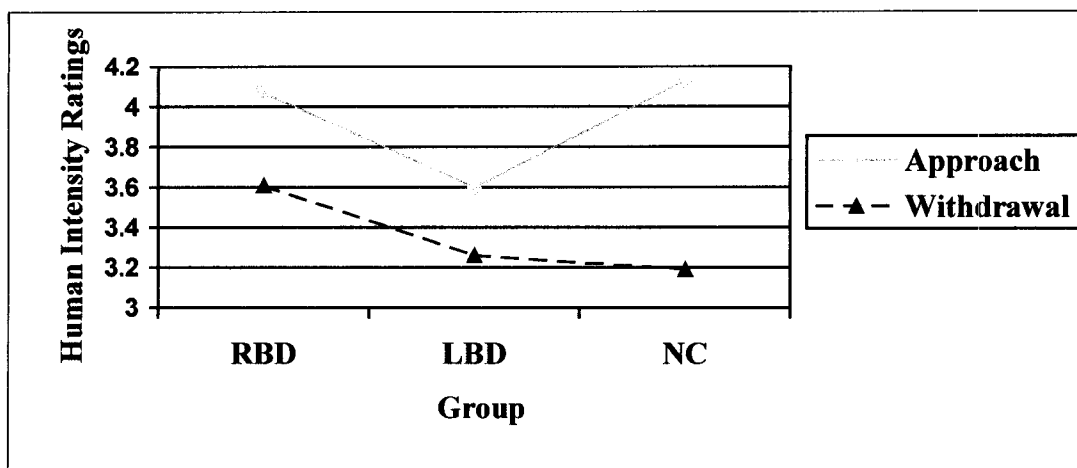


Figure 16. Interaction Effect of Group by Motoric Direction for Intensity Ratings.

Arousal Level. Finally, for emotions categorized for arousal level, the Group (3) x Gender (2) x Arousal Level (2) showed a significant main effect for group, $F(2, 54) = 3.53, p = .037$. Pairwise comparisons revealed that individuals in the RBD group were rated as significantly more intense than LBD participants ($p = .013$), and a trend towards significance suggested that NC participants were also rated as more intense than the LBD group ($p = .057$). See Table 31 for p value chart and Table 32 for summary of group by gender by arousal level means. There was also a trend towards significance for the main effect of gender, $F(1, 54) = 2.82, p = .100$, such that women ($M = 3.78, \pm SEM = .147$) were rated as more intense than men ($M = 3.47, SEM = .117$). In addition, a significant Group x Arousal Level interaction was revealed, $F(2, 54) = 12.85, p < .001$ (see Figure 17).

Table 31.

Summary of Significant p Values for Intensity and Accuracy Ratings on Emotions
Categorized By Arousal Level.

<u>D.V.</u>	<u>Group</u>	<u>Gender</u>	<u>Arousal Level</u>	<u>Group x Gender</u>	<u>Group x Arousal Level</u>	<u>Gender x Arousal Level</u>	<u>G x G x AL</u>
Intensity	.037*	.100	ns	ns	<.001**	ns	ns
Accuracy	<.001**	ns	.091	ns	ns	ns	ns

Note: * = significant p value at .05 level, ** = .001 level.

Table 32.

Overall Mean Intensity Ratings for Emotions Categorized by Arousal Level, Across
Group, Gender, and Arousal Level.

	High	Low	Total
RBD	3.64	3.60	3.62
LBD	3.34	3.51	3.43
NC	4.26	3.20	3.63
Men	3.64	3.31	3.47
Women	3.88	3.58	3.78

Post hoc comparisons of the significant Group x Arousal Level interaction showed that for high intensity emotions, a trend towards significance was seen, such that individuals in the NC group were rated as significantly more intense than those in the LBD group ($p = .003$), with a trend towards being rated as more intense compared to the RBD group ($p = .060$). For the low arousal emotions, there was a trend towards significance, such that RBD individuals were rated as more intense than the NC group ($p = .100$). Within the RBD group, there were no significant differences in rated intensity for high arousal and low arousal emotions, $p = .748$. LBD individuals did not show a

significant difference between emotional categories as well, $p = .172$. However, there was a significant difference between high and low arousal intensity ratings for participants in the NC group, $t(1, 17) = 6.57, p < .001$, with high arousal emotions being rated as significantly more intense than low arousal emotions.

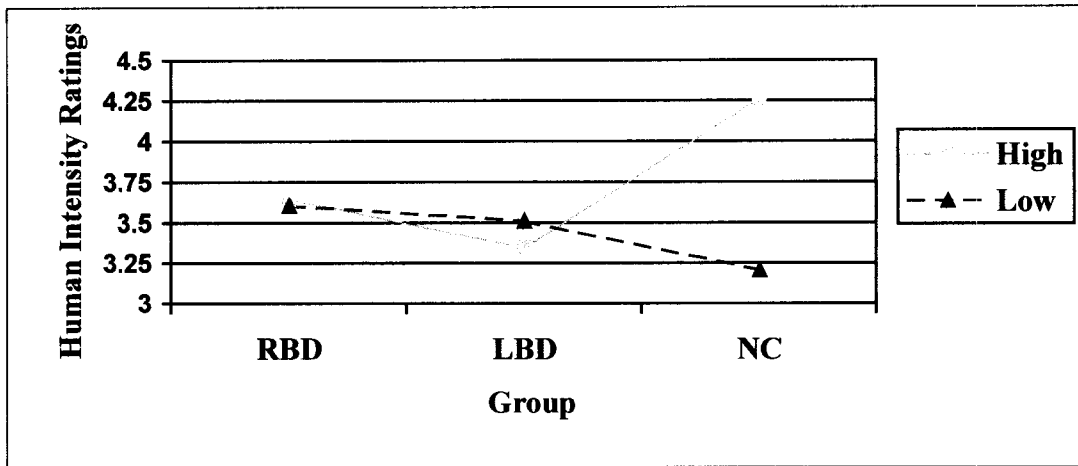


Figure 17. Interaction Effect of Group by Arousal Level for Intensity Ratings.

Accuracy Ratings

Emotion. An analysis was conducted for Group (3) x Gender (2) x Emotion (8) for all accuracy ratings. Results demonstrated a significant main effect of emotion, $F(7, 54) = 11.48, p < .001$, such that Happy was rated significantly less accurate than all other emotions, including Pleasant Surprise ($p < .001$), Interest ($p < .001$), Sad ($p < .001$), Unpleasant Surprise ($p < .001$), Anger ($p < .001$), Fear ($p = .011$), and Disgust ($p = .024$). Fear was rated significantly less accurate than Pleasant Surprise ($p = .005$), Interest ($p < .001$), Sad ($p = .001$), Unpleasant Surprise ($p = .017$), and Anger ($p < .001$). Disgust was also rated significantly less accurate than the emotions of interest ($p < .001$), sadness ($p < .001$), unpleasant surprise ($p = .020$), and anger ($p < .001$). See Table 33 for a summary of means.

This analysis also yielded a trend towards significance for the main effect of Group, $F(2, 54) = 2.50, p = .093$. Follow-up with pairwise comparison revealed that participants in the NC group were rated significantly more accurately than individuals in the LBD group ($p = .035$). See Table 34 for overall group means.

Table 33.

Mean Accuracy Rating Scores for the Main Effect of Emotion Across All Groups.

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
Total	.042	.278	.366	.370	.107	.144	.338	.269

Table 34.

Means for Accuracy Ratings Across All Emotions, Collapsed by Group.

	RBD	LBD	NC
Total	.231	.207	.285

Valence. In the Group (3) x Gender (2) x Valence (2) analysis for Accuracy Ratings, while there were no significant main effects of Group, $F(2, 54) = 2.30, p = .112$, Gender $F(1, 54) = 1.49, p = .228$, or Valence $F(1, 54) = 0.25, p = .619$, there was a significant Group x Valence interaction, $F(2, 54) = 5.74, p = .006$ (see Figure 18). Refer to Table 35 for mean accuracy scores.

Table 35.

Summary of Mean Accuracy Scores for the Group by Valence Interaction Effect for Accuracy Ratings.

	Positive	Negative
RBD	.290	.195
LBD	.157	.227
NC	.232	.317

Post hoc comparisons of the significant Group x Valence interaction indicated that for positive emotions, individuals in the NC group were significantly more accurate than those in the LBD group ($p < .001$), and RBD individuals were significantly more accurate than LBD participants ($p < .001$). However, for the negatively valenced emotions, participants in the NC group were rated significantly more accurately than LBD individuals ($p < .001$), and RBD individuals were rated with the least accuracy, as compared to LBD and NC participants ($p < .001$). When analyzed separately by group, no significant differences were revealed for the accuracy ratings of positive versus negative emotions for participants in the RBD group ($p = .109$), LBD group ($p = .587$), and NC group ($p = .497$).

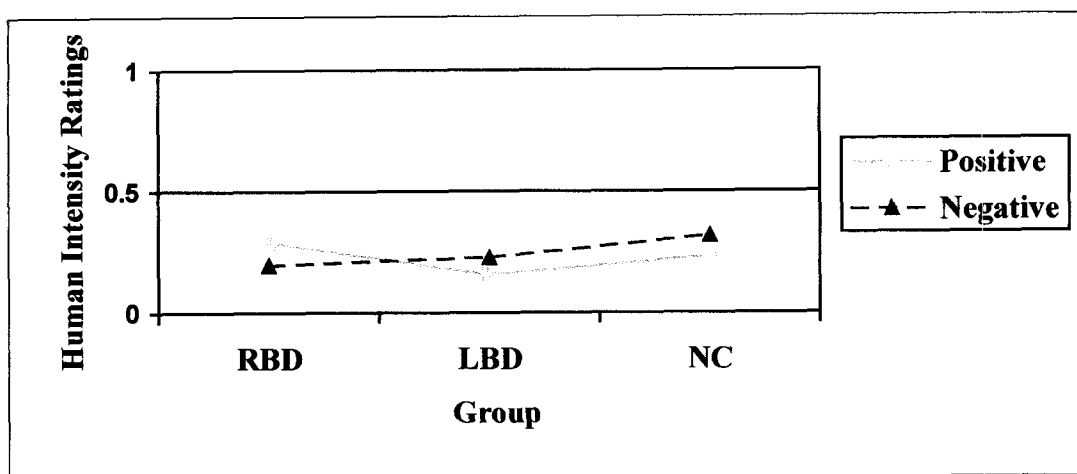


Figure 18. Interaction Effect of Group by Valence for Accuracy Ratings.

Motoric Direction. When emotions were categorized by Motoric Direction, the Group (3) x Gender (2) x Motoric Direction analysis yielded a significant main effect of Group, $F(2, 54) = 11.85, p < .001$. Follow-up post hoc comparisons showed that individuals in the NC group were rated significantly more accurately than LBD ($p = .002$) and RBD ($p < .001$) individuals. However, there were no significant differences between the right- and left-brain-damaged groups ($p = .192$). See Table 36 for a summary of group means.

Table 36.

Main Effects of Group for Accuracy Rating in the Motoric Direction Condition.

	RBD	LBD	NC
Total	.169	.207	.301

Arousal Level. Finally, in the last analysis for accuracy ratings with emotions separated by arousal level, a significant main effect of Group was revealed, $F(2, 54) = 9.48, p < .001$, such that individuals in the NC group ($M = .31, SEM = .024$) were rated significantly more accurately than LBD participants ($M = .17, SEM = .024 [p < .001]$),

with a trend towards significance when compared to RBD individuals ($M = .26, \pm .023$ [$p = .093$]). RBD group participants were also rated more accurately than individuals in the LBD group ($p = .010$). There was also a trend towards significance for the main effect of Arousal Level, $F(1, 54) = 2.97, p = .091$, such that low arousal emotions ($M = 0.27, \pm 0.17$) were rated more accurately than high arousal emotions ($M = 0.22, \pm 0.15$). No significant interaction effects were demonstrated.

Perception Data

See Tables 37 and 38 for relevant data on the following analyses.

Comprehension Accuracy

Emotion. In the Group (3) x Gender (2) x Emotion (8) analysis for comprehension identification accuracy scores, there was a significant main effect of Emotion, $F(1, 54) = 8.60, p < .001$. Follow-up pairwise comparisons revealed that the identification accuracy of Anger was significantly higher than any other emotion. Anger was greater than Fear ($p < .001$), Disgust ($p < .001$), Unpleasant Surprise ($p < .001$), Pleasant Surprise ($p = .001$), Happy ($p < .001$), Interest ($p < .001$), and Sad ($p = .012$). The second most accurately identified emotion was sadness, which was significantly more accurately identified than Fear ($p = .001$), Disgust ($p = .036$), Unpleasant Surprise ($p = .002$), and Happy ($p < .001$). No significant main effects were seen for Group ($p = .513$) or Gender ($p = .166$), and no one-way or two-way significant interactions were observed. For a summary of mean identification accuracy scores across emotions, see Table 37.

Table 37.

Mean Identification Accuracy Scores Across Emotions.

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
Total	.314	.401	.439	.506	.407	.346	.661	.364

Valence. When emotions were analyzed by valence type, the Group (3) x Gender (2) x Valence (2) analysis for comprehension identification accuracy showed a significant main effect of Valence, $F(1, 54) = 5.56, p = .023$. Follow-up pairwise comparisons demonstrated that negatively valenced emotions ($M = 0.46, \pm 0.23$) were identified significantly more accurately than positively valenced emotions ($M = 0.38, \pm 0.22$). No significant Group ($p = .586$) or Gender ($p = .142$) main effects were observed. In addition, no significant two-way or three-way interactions were demonstrated.

Motoric Direction. When emotions were grouped into Motoric Direction, the Group (3) x Gender (2) x Motoric Direction (2) analysis for comprehension identification accuracy indicated no significant main effects of Group ($p = .539$), Gender ($p = .162$), or Motoric Direction ($p = .253$). In addition, analysis revealed no significant two-way or three-way interactions.

Arousal Level. Similarly, when emotions were categorized by arousal level, the Group (3) x Gender (2) x Arousal Level analysis indicated no significant main effects of Group ($p = .679$), Gender ($p = .310$), or Arousal Level ($p = .289$). Two-way and three-way significant interactions were not obtained in this analysis.

Discrimination Accuracy

Finally, total accuracy scores for all emotions and emotions categorized by valence (Positive, Negative, and Mixed) were analyzed for the prosodic perception discrimination task.

Emotions. In the Group (3) x Gender (2) x Total Emotion univariate analysis, there was a significant main effect of gender, $F(1, 54) = 4.35, p = .042$, such that men ($M = 0.95, \pm 0.06$) were more accurate in distinguishing between emotions than were women ($M = 0.91, \pm 0.06$). There was no significant main effect of Group ($p = .325$) or two-way interaction of Group x Gender ($p = .102$).

Valence. When emotions were separated by valence, the Group (3) x Gender (2) x Valence (3) analysis revealed a significant main effect of Valence, $F(2, 54) = 8.19, p = .001$, such that positively valenced ($M = 0.95, \pm 0.01$) and negatively valenced emotions ($M = 0.95, \pm 0.06$) were more accurately discriminated between than were emotions in the mixed category ($M = 0.89, \pm 0.14$). There was also a trend towards significance for the main effect of Gender, $F(1, 54) = 3.89, p = .054$, and the interaction effect of Group x Valence, $F(4, 54) = 2.05, p = .093$ (see Figure 19). For overall group means separately for valence, see Table 38.

Table 38.

Summary of Group Means for Prosodic Perception Discrimination Task Across Emotions Categorized by Valence.

	Positive	Negative	Mixed
RBD	.932	.958	.894
LBD	.952	.941	.847
NC	.952	.938	.931
Total	.945	.946	.891

Follow-up of the trend of the Gender main effect with pairwise comparisons indicated that the total discrimination accuracy score was higher for men ($M = 0.94$, $SEM = .012$) than for women ($M = 0.91$, $SEM = .014$). Post hoc comparisons for the trend of the Group x Valence interaction showed that for the mixed category, participants in the LBD group were less accurate than individuals in the NC ($p = .076$). Within the RBD group, there were no significant differences between discrimination accuracy scores for positive and negative emotions ($p = .144$) and positive and mixed emotions ($p = .263$). However, when negative emotions were compared to emotions in the mixed category, there was a significant difference, $t(1, 18) = 2.35$, $p = .031$, such that negative emotions were identified more accurately than the discrimination accuracy scores between mixed categorical emotions. For the LBD group, while there was no significant difference between the discrimination accuracy score of the positive and negative emotions ($p = .397$), accuracy scores for positive emotions were significantly greater than those for the mixed emotional category, $t(1, 16) = 2.80$, $p = .013$. In addition, the negative emotional category was significantly more accurate than the mixed condition as well, $t(1, 16) = 3.04$, $p = .008$).

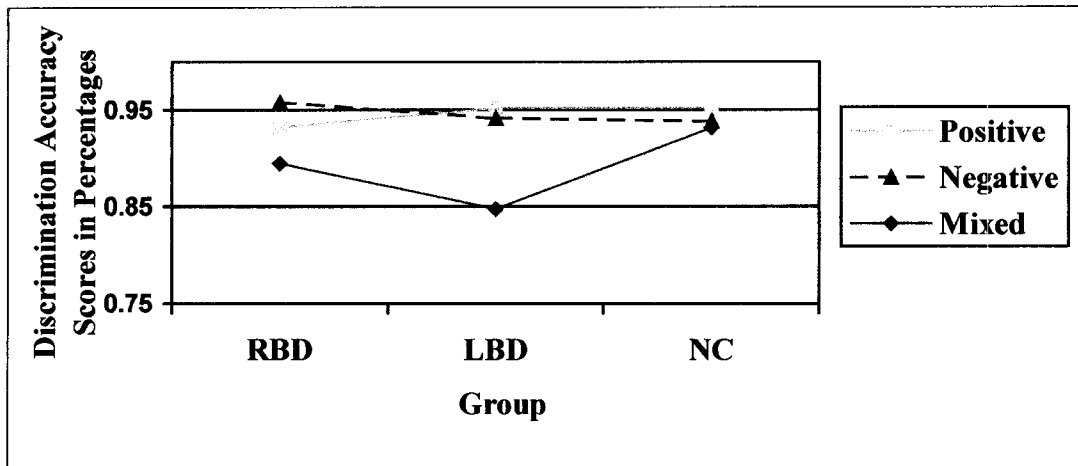


Figure 19. Interaction Effect of Group by Valence for the Prosodic Perception Discrimination Task.

Interrelationships among Variables

As proposed, the relationship between acoustical parameters and human ratings was explored as to how they related to one another across parameters. (See Tables 39 and 40 for Pearson product-moment correlations).

Intensity Ratings. The clearest pattern is that, for all participants ($n = 54$), the correlations between F_0 mean semitone difference scores and intensity ratings were significant for all emotions, except pleasant surprise and unpleasant surprise. When analyzed separately between groups, those in the LBD group presented with the most significant correlations. (See Table 39 for r values). Next, individuals in the NC group had only one significant correlation, which existed only for the emotion of Happy ($r = .85$), such that, the greater the F_0 mean difference score, the higher the rating the emotion received. Finally, for RBD participants, no significant correlations were revealed. When participants were categorized by Gender, across Group, for men, significant positive correlations were revealed between intensity ratings and F_0 mean semitone difference

scores for Happy ($r = .598$), Sad ($r = .357$), and Anger ($r = .573$). No significant correlations were shown for women.

Table 39.

Intensity Ratings versus F_0 Mean Semitone Difference Scores for All Emotions.

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	ns	ns	ns	ns	ns	ns	ns	ns
LBD	.549*	ns	.635**	.753**	ns	.492*	ns	ns
NC	.763**	ns	ns	ns	ns	ns	ns	ns
ALL	.515**	ns	.345*	.383**	.298*	.289*	.374**	ns
MEN	.598**	ns	ns	.357*	ns	ns	.573**	ns
WOM.	ns	ns	ns	ns	ns	ns	ns	ns
BD	.342*	ns	ns	ns	.348*	.346*	ns	ns

For F_0 standard deviation semitone difference scores, very few correlations existed. The greatest number of different emotions that were significantly correlated between objective and perceptive parameters existed for the LBD group. More specifically, the emotions of interest and unpleasant surprise were significantly correlated (see Table 40). For the NC group, the only significantly correlated emotion was unpleasant surprise ($p < .05$). RBD participants did not present with any significant correlations between intensity ratings and standard deviation semitone difference scores. When categorized by gender, men, separately from women, did not present with any significant correlations.

Table 40.

Intensity Ratings versus F_0 Standard Deviation Semitone Difference Scores Across Emotions.

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	ns	ns	ns	ns	ns	ns	ns	ns
LBD	ns	ns	.739**	ns	ns	ns	ns	.493*
NC	ns	ns	ns	ns	ns	ns	ns	.543*
ALL	ns	ns	ns	ns	ns	ns	ns	ns
MEN	ns	-.346*	ns	ns	ns	ns	ns	ns
WOM.	ns	ns	ns	ns	ns	ns	ns	ns
BD	ns	ns	ns	ns	ns	ns	ns	ns

For duration versus intensity ratings across all groups, the only significant correlation existed for sadness ($r = .277$). Within the LBD group, only Disgust was significantly correlated ($r = .48$). No significant correlations existed for the RBD or NC group.

Accuracy Ratings. When comparing accuracy ratings to acoustical variables, only a limited number of emotions were significantly correlated. When Pearson product-moment correlations were run for accuracy ratings versus F_0 mean semitone difference scores for all groups, only sadness was significantly correlated ($r = -.33$). The more accurately it was expressed, the lower the F_0 mean difference score. For the LBD group, a significant inverse relationship existed for Anger ($r = -.58$). The NC group presented with no significant correlations. When analyzed by gender, men demonstrated a

significant negative correlation for Sad ($r = -.502$). There were no other significant correlations for men, and women did not present with any significant correlations.

Correlations between accuracy ratings and F_0 standard deviation semitone difference scores revealed almost no significant correlations between these parameters. The only significant relationship existed for the NC group, for the expression of unpleasant surprise ($r = .49$).

When comparing accuracy ratings to duration measures, significant relationships only existed for the RBD group for Interest ($r = .48$), and within the LBD group for Happy ($r = -.67$). No significant correlations were found for the NC group.

Participant Expression vs. Perception. In order to investigate whether prosodic expression and perception are related, such that brain damage alters emotional processing regardless of input or output, Pearson Product-Moment correlations were undertaken for the F_0 mean and F_0 standard deviation semitone difference scores, and comprehension identification percent accuracy. For the F_0 mean semitone difference scores, as compared to accuracy scores from the prosodic comprehension identification task, no significant correlations were found for all groups combined. When separately analyzed by gender, no significant correlations existed for men. However, women demonstrated a positive significant correlation for the emotion of fear ($r = .490$) and a significant negative correlation for happy ($r = -.490$). For the NC group as a whole, no significant correlations were found. For NC men, there were no significant correlations as well. Women demonstrated significant positive correlations for anger ($r = .759$) and happy ($r = .822$). Separate analyses for the LBD group revealed no significant correlations for the entire group or for women. Men presented with a significant negative correlation for

anger ($r = -.641$). Participants in the RBD group did not present with significant correlations between expression and perception tasks. Women in this group, however, demonstrated a significant negative correlation for unpleasant surprise ($r = -.867$).

When the prosodic comprehension identification task was compared to F_0 standard deviation semitone difference scores, no significant correlations were found for all groups combined. For the NC group, men demonstrated a significant positive correlation for unpleasant surprise. No significant correlations were found for women. Separate analyses for individuals in the LBD group revealed a significant positive correlation for approach emotions ($r = .491$). This was also true for men in this group ($r = .640$). No significant correlations were found for women. For the RBD group, no significant correlations between expression and perception tasks were found.

Perception Accuracy vs. Rated Accuracy. Pearson Product-Moment correlations were conducted between the total accuracy scores of emotion identification, across groups, and rater accuracy scores for the same emotions, in order to assess the relationship between one's ability to perceive emotions and their ability to express emotions appropriately so the listener perceives them accurately. For the RBD and LBD groups, no significant correlations were found when comparing accuracy scores across separate discrete emotions, valence, motoric direction, and arousal level. Within the NC group, a significant inverse relationship at the $p < .05$ level was found between comprehension identification accuracy and rated accuracy for the emotion of sadness ($r = -.492$).

Discussion

This study focused on the expression and comprehension of prosodic emotional processing across brain-damaged groups and healthy normal controls. One of the primary goals of this study was to assess two of the main theories of emotion, right-hemisphere specialization theory and the valence hypotheses, in the expression and perception of affective prosody across individuals with left- and right-brain damage and healthy normal controls. Based on an extensive literature search, it was expected that the right hemisphere theory would be supported. That is, it was expected that participants with right hemisphere lesions, relative to individuals with left hemisphere lesions and normal controls, would demonstrate deficits when they expressed posed emotions and when they perceived emotions produced by actors. Moreover, it was expected that intensity ratings collected in a prior study (Canino, 2001) would correlate highly with objective acoustical data. Another goal was to replicate findings from a pilot study (Viscovich et al., 2003) in which significant differences were found in the F_0 mean and standard deviations between the emotions of happiness and sadness. The current study expanded the spectrum of emotions (happiness, pleasant surprise, interest, sadness, disgust, fear, anger, unpleasant surprise) and include emotions categorized by valence (positive: happiness, interest, and pleasant surprise, and negative: sadness, disgust, fear, anger, and unpleasant surprise), motoric direction, (approach: anger, happiness, and interest, and withdrawal: sadness, fear, and disgust), and arousal level (high: pleasant surprise, anger, and fear, and low: interest, sadness, and disgust). Finally, gender differences were analyzed across groups, with the expectation that women would better express and identify emotional prosodic expression than men.

This discussion will first address findings regarding the right-hemisphere hypothesis for acoustical parameters and judges' ratings of emotional expressions, and identification and discrimination accuracy scores in the comprehension of emotional expression. This was tested by looking at acoustical parameters of pitch (F_0 mean and variability), timing, and perceptual parameters (judges' intensity and accuracy ratings).

Findings will also be discussed in terms of how lesion laterality and lesion location impact upon emotional processing, separately for emotions categorized by motoric direction and by arousal level. For the left-brain damaged participants, lateralized specialization of the acoustic processors of pitch and timing will be discussed, with expectations that LBDs will exhibit greater difficulty in timing and that RBDs will have impaired pitch. Secondly, the valence hypothesis was explored and results are described in terms of how emotions categorized into positive and negative valence are affected by lesion laterality. On an exploratory basis, the intrahemisphere hypothesis will be discussed in terms of how lesion location (i.e., anterior vs. posterior) impacts upon emotional expression. Further, correlations between acoustic and rating expression data will be discussed, with their implications for future research and application to cognitive remediation. Finally, secondary hypotheses will be explored regarding gender differences and differences related to discrete emotions and emotions categorized by valence, motoric direction, and arousal level.

Right Hemisphere Hypothesis

It has been postulated that the right hemisphere is specialized for the expression and comprehension of emotion, regardless of valence (Borod, Andelman, Obler, Tweedy, & Welkowitz, 1992; Borod, Koff, & Caron, 1983; Ross, Edmondson, Seiber, & Homan,

1988). The current study examined both acoustical and perceptual measures of prosodic emotional expression in order to evaluate the validity of the right hemisphere hypothesis. No significant main effects of group for F_0 mean were found when analyzing across all emotions. However, there was a significant Group by Emotion interaction for F_0 mean, but not for standard deviation or duration. The F_0 mean interaction stemmed from the fact that the RBDs demonstrated significantly greater F_0 means than those in the NC group only for the emotions of sadness and disgust. The LBD group was not significantly different than the RBD or NC groups. This suggests that RBD individuals have more difficulty appropriately modulating these negative emotions relative to normal controls, since high F_0 values for these negative emotions are considered inappropriate (for review of acoustic profiles for individual emotions, see Banse & Scherer, 1996).

In terms of emotional expressions rated by independent judges, for intensity ratings, there was a significant main effect of group when emotions were categorized by motoric direction and arousal level. Participants in the RBD group were rated as significantly more intense than in the LBD group. For the Group by Emotion analysis, a significant interaction was found, such that normal controls were rated as significantly more intense than individuals in the LBD group for the emotions of pleasant surprise and fear. However, LBD participants were rated as significantly more intense than NCs for the emotion of sadness. While LBD participants were also rated as more intense in the expressions of sadness and fear, compared to the RBD group, the RBDs were significantly more intense than LBDs for interest. Overall, for intensity ratings, the RBD group did not present with a decrease in emotional intensity when all emotions were grouped together, compared to the LBD and NC groups. Therefore, in this respect, the

right hemisphere hypothesis was not supported. When a different categorization of emotions was analyzed together (e.g., motoric direction that did not include the emotions of unpleasant and pleasant surprise), there was evidence that directly contradicted the right hemisphere superiority for emotional expression. More specifically, participants in the RBD group were rated as significantly more intense than participants in the LBD group when emotions were analyzed by motoric direction and arousal level. The disparity observed in the current study may be related to reasons why the literature has yielded inconsistent support for the right hemisphere hypothesis. In addition, perhaps the task may have been too linguistically challenging for the LBD group, as level of difficulty has been found to impact upon emotional processing within this group (Tompkins and Flowers, 1985). This suggests that greater uniformity in emotion selection and task difficulty merits consideration.

In terms of accuracy ratings, a significant group difference was found, such that individuals in the NC group were rated as more accurate than those in the LBD group. Mean accuracy ratings for RBD participants fell between the LBD and NC groups. The RBD group was not rated as less accurate than the LBD or NC group, suggesting that the right hemisphere hypothesis was not operative in the accuracy data.

In the analysis of comprehension of emotion (identification and discrimination), there was no significant main effect of Group or Emotion. In addition, there was no Group by Emotion interaction. These negative findings suggest that the RBD group was not more impaired than the LBD or NC group. Therefore, the right hemisphere hypothesis is not supported here. However, as this task was quite difficult, even for the normal controls, it may not differentiate among the groups well. For the discrimination

measure, there were no main effects or interaction effects. In contrast to the identification task, a lack of significant findings may be related to the fact that the discrimination task was quite easy, and results most likely demonstrate a ceiling effect.

In summary, in the current study, the RBD group demonstrated difficulty producing a select number of emotions, as compared to the LBD and NC groups. However, for the comprehension tasks, no group differences were revealed. These results suggest that brain regions responsible in producing prosody for specific emotions are not necessarily the same as regions that are involved in the comprehension of emotions. For select emotions, the current results are consistent with Ross et al. (1988) in which, utilizing an imitation paradigm of emotionally-intoned neutral-content sentences, he found that individuals who underwent a right-sided Wada procedure had a prominent loss of affective prosodic expression relative to individuals with left-sided “lesions.” Results of Ross’s study suggest that right anterior brain structures are responsible for the processing of emotional expression.

Gandour et al. (1995) also demonstrated support for the right hemisphere hypothesis. They measured F_0 mean and variability, as well as duration of emotional expression of neutral-content sentences in Thai RBD patients and Thai normal controls. This study was important as it examined prosody in individuals who spoke in a tonal language versus a non-tonal language such as English. Therefore, selective impairment in affective prosody alone in individuals with right brain damage would implicate the right hemisphere as the processor of affective prosody only, and not prosody in general (i.e., both linguistic and affective). Results indicated that RBD participants experienced significant problems in producing affective prosody when compared to NC individuals.

Importantly, these individuals maintained intact F_0 when producing linguistic information, but decreased performance when production was emotional in nature.

The right hemisphere hypothesis was also tested in a study where digitized sentences were computer-manipulated (i.e., change in F_0 mean and variability) in order to understand neuroanatomically what happens in emotional comprehension when F_0 is manipulated. Pihan (1997) found that pitch-manipulated stimuli (i.e., neutral-content sentences produced with happy and sad emotional tones) presented to non-brain-damaged individuals yielded a similar pattern of DC potentials that were characterized by significant lateralization effects implicating the right hemisphere. Results indicated that the right hemisphere not only mediated pitch control, but that it also controlled emotional intonational aspects of verbal utterances. In addition to right frontal areas, high activation was observed in the auditory cortex in the temporal planes. While the Pihan study has implications for understanding the neuroanatomical origins of emotional processing, it is limited in its generalization to the brain-damaged population, as various brain structures (e.g., right-temporoparietal regions, basal ganglia) have been found to affect the comprehension of emotionally-intoned speech (Starkstein et al., 1994).

As noted above, no group differences in the comprehension of emotional prosody were found in the current study. Factors that may have influenced these negative findings are that the identification task may have been too difficult and that the discrimination task may have been too easy for all the groups. However, in previous studies, right hemispheric specialization has been implicated in the comprehension of emotion. For example, Buchanan et al. (2000) examined the neural areas involved in the recognition of emotional prosody using echo-planar, functional magnetic resonance

imaging on 10 right-handed male participants. They found that detection of emotion compared with verbal detection, resulted in significant activity in the right inferior frontal lobe. Conversely, verbal stimuli detection activated the left inferior frontal lobes. Although their study provides neuroanatomic evidence of processing emotions within the “normal” brain, it cannot necessarily be generalized to individuals who have sustained brain injuries. Generalizing to patients with brain damage is important, as understanding the changes that may occur in emotional processing following brain damage is important in terms of its treatment implications. This study examined emotional comprehension in males only, and therefore, cannot be generalized to emotional processing in women.

The right hemisphere hypothesis was not supported in a study conducted by Dykstra et al. (1995). In this single-case study of a 20-year-old woman with a history of seizures in the right hemisphere, that evaluated the perception and production of propositional and affective prosody at the word, phrase, and sentence level, they found that both conversational and elicited speech were impaired for both affective and propositional prosody. Acoustic analysis further showed that timing and intensity were impaired, while fundamental frequency was relatively spared. As the length of the utterance increased, more disruption was seen in fundamental frequency as well as timing. Again, while this study contributes to the understanding of the diverse and complex underpinnings of the right hemisphere, it does not provide much information in terms of its generalizability. It provides, however, excellent information that is often missing from many studies, such as how variations in information length can greatly impact one’s ability to express or comprehend affective prosody.

As noted above, in the current study, there were no significant group differences for any of the acoustic and perceptual variables across all emotions. One important reason that group differences may not have been found could have been related to the fact that the range of months post onset for both groups was quite large (i.e., two months to 144 months), and recovery of function may have been a factor. For example, in a case study conducted by Ross and Mesulam (1979), a woman who was admitted to the hospital with symptoms of left hemiplegia and dysarthria had significant difficulties modulating her voice, as confirmed by formal neuropsychological assessment. She reported that she could not discipline her children because she could not intone her voice to accurately reflect her mood. However, approximately 18 months post stroke, there was noticeable improvement in her ability to modulate her voice and she reported that she could express emotion appropriately through her voice and gesture, as well as laugh and cry naturally. Upon testing, she did in fact present with normal prosody, facial animation, and appropriate bodily gestures. In a study conducted by Darby (1993), participants with 20 days post onset of stroke (i.e., right MCA lesions) demonstrated sensory aprosodia. However, in contrast, Bradvick et al. (1990) did not find any significant group differences between normal controls and RBD participants who were at least six months post onset of stroke. This was true for both expression and comprehension of affective prosody. Moreover, results of a study measuring recovery of emotional perception, conducted by Zgaljardic, Borod, and Sliwinski (2002), were limited. During initial testing, RBD men were significantly impaired compared to LBD and NC men for identification of emotional words and sentences. Following at least two years of initial testing, these RBD men no longer demonstrated impaired performance, suggesting recovery of

function. No group differences were found for women at initial testing and follow-up testing. Several factors may have contributed to limited findings. First, participants were initially assessed after an average of 18 months, and as indicated above, they may have already reached their peak recovery level. A similar pattern of recovery was found in a study examining mood disorders post-stroke (Robinson, Bolduc, & Price, 1987). Robinson et al. (1987) found that patients with major depression typically recovered one to two years following a stroke. Another factor that may have limited results in the Zgaljadic et al. (2002) study was that the sample size may have been too small to adequately capture group differences in recovery. This study does, however, confirm that men and women process emotions differently (i.e., group differences at time 1 for men, not women). In summary, another variable that may be contributing to the inconsistent findings within the literature is the timing in which the participants are being tested after sustaining brain damage.

Furthermore, as the LBD group was rated as less accurate in their ability to produce emotions than the NC group, this finding may be related to the fact that the LBD group had difficulty processing these tasks linguistically. The effects of task difficulty were demonstrated by Tompkins and Flowers (1985), in which they examined the perception of mood (via the tone-of-voice in semantically neutral phrases) following unilateral stroke, with experimental tasks that increased in cognitive demands (i.e., comprehension discrimination and two-choice and four-choice recognition). They found that the RBD group performed significantly lower than the NC group on all three tasks, whereas the LBD group fell to the RBD level for the hardest of the three tasks. Therefore, when the tasks relied more on basic emotional recognition, LBD subjects

performed normally. But when language demands increased, their performance was equivalent to the RBD group. This study helps explain some of the variability in the literature regarding the effects of lesion laterality, such that when the task is too cognitively challenging, the left-hemisphere group's performance may drop, thus washing out laterality effects. Thus, in the current study, for the comprehension tasks, it might have been hard for the LBDs to interpret the terms for the eight different emotions (i.e., maintaining the rules of the task while trying to encode/decode the emotions). However, it is important to consider that Tompkins and Flowers (1985) only measured affective prosodic comprehension in male participants and that the raters were also only men. Therefore, results cannot be generalized to female posers or female raters.

In conclusion, based on the current study and previous experiments that addressed the issue of the right hemisphere being the primary emotional processor for prosody, it is still unclear as to whether this is true. When all emotions were analyzed together, there were no significant group differences. Moreover, in contrast to the right hemisphere hypothesis, when emotions were categorized differently (i.e., omitting happiness and pleasant surprise for the condition of Arousal Level), the LBD group was rated as significantly less intense than the RBD group.

There were no significant group differences for the comprehension of emotional prosody. This may be related to the difficulty of the identification task and the easy level of the discrimination task. Therefore, taking together results of the current study and previous findings, it appears that variations in task design, level of cognitive demand, length of utterances to comprehend or express, and months post-onset of brain damage can dramatically alter the outcome of emotion research. Therefore, developing a uniform

method of data collection (e.g., prosodic expression/comprehension task, recording devices, large sample sizes, and equal gender ratio) may lead to more consistent findings.

Valence Hypothesis

According to this hypothesis, the right hemisphere is believed to be specialized for negative emotions and the left hemisphere is specialized for positive emotions (Borod, 1992). While many studies have implicated the right hemisphere as dominant for emotional processing, other studies have suggested that emotional expression and experience are differentially mediated by the two hemispheres as a function of valence (Sackeim et al., 1982; Van Lancker, 1992). The valence hypothesis was tested in the current study in two levels, with emotions categorized into positive (happy, interest, and pleasant surprise) and negative (sad, disgust, fear, anger, and unpleasant surprise) levels. Many significant interaction effects and trends were revealed for group and valence, thus, supporting the notion that lesion laterality differentially impacts upon the expression of positive and negative emotions. Specifically, the RBD group presented with inappropriate F_0 means for sadness and disgust, and reduced intensity ratings for fear, disgust, and sadness (i.e., withdrawal emotions). They also demonstrated inappropriately higher intensity ratings for withdrawal emotions and low arousal emotions. Meanwhile, the LBD group displayed reduced intensity levels for pleasant surprise, interest, approach emotions, and compared to the NC group, reduced intensity for high arousal emotions.

As expected, there was a main effect of valence for all acoustic variables and comprehension, such that positive emotions were expressed with significantly greater F_0 mean, F_0 variability, and shorter duration than negative emotions, and negative emotions

were comprehended more accurately than positive emotions. There was no significant difference in rater accuracy between any of the groups.

In general, lesion laterality and its impact on valence tended to be gender-specific. This was found to be true for the acoustic variable of F_0 mean and judges' intensity ratings. As reported in the Results section, a significant Group by Gender interaction effect was observed for F_0 mean, such that the men in the LBD group had greater F_0 means than the men in the NC and RBD group for negative emotions. While this supports lateralized hemispheric specialization, it is in contrast to the valence hypothesis, in that LBD men evidenced greater difficulty expressing negative emotions than positive emotions, relative to the other subject groups. For women, however, a valence effect was observed that is consistent with the valence theory. They displayed an opposite pattern than men, such that women in the RBD group evidenced significantly higher F_0 means than women in the LBD group for negative emotions. As noted earlier, when dealing with negative emotions, a higher value would be considered dysfunctional, and a lower value would be more consistent with normal performance (Banse & Scherer, 1996). Gender variations will be discussed in greater length in the Gender Differences sub-section.

While there was a significant Group by Valence interaction, results were not consistent with the valence hypothesis, in that both the RBD and the LBD group did not demonstrate significant differences in intensity of their production of negative and positive emotions. However, NC participants were rated as significantly more intense when producing positively intoned emotional expressions than negatively intoned emotional expressions.

A significant Group by Gender interaction effect was also seen for intensity ratings, such that women in the RBD group were rated as significantly less intense than the NC participants for positive emotions. This finding is in contrast to expectations that RBD individuals would perform comparably to the NC participants for positive emotions, with differences in their ability to express negative emotions. Similar findings were obtained by Borod et al. (2000), in which RBD participants were more impaired in pragmatic appropriateness while producing positive (happy) narratives, and LBD participants were more impaired while producing negative (sad and angry) narratives. This pattern of results was obtained for three of the six pragmatic features (i.e., relevancy, quantity, and conciseness). RBD participants were more impaired for positive emotions and LBD participants for negative emotions.

For men, in the current study, both the RBD and LBD groups were impaired in their ability to produce negatively intoned sentences, compared to the NC participants. Thus, emotional processing based on lesion laterality appears to be related more so to gender than to a single emotional processor for both men and women. That is, different brain regions may be involved in the processing of positive and negative emotions for men and women.

For accuracy ratings, there was a significant Group by Valence interaction, such that participants in the RBD group were significantly less accurate for negative emotions than were LBD and NC individuals. However, for positive emotions, LBD participants were significantly less accurate than were RBD and NC participants. This finding is in direct support of the valence hypothesis. Similarly, in an acoustic study conducted by Van Lancker and Sidtis (1992), they found that both left- and right-brain-damaged

participants were impaired relative to controls in their ability to produce affectively intoned neutral-content sentences. However, consistent with the valence hypothesis, their RBD group was significantly more likely than the LBD group to erroneously intone negative emotions as positive. Therefore, it appears that the valence hypothesis holds true for the accuracy of emotional expression rather than for the intensity at which it is produced. Erroneous production of the expression of negative emotions was also observed for RBD individuals in a study conducted by Pell (1999b), such that they produced neutral-content sentences intoned in a sad and angry tone of voice with significantly higher F_0 means than normal controls. However, the NC group was better at expressing the emotion of happiness than was the RBD group. In light of the results of the current study, it appears that even when emotions are not accurately expressed, it does not affect the listener's evaluation of their intensity.

In accordance with the valence hypothesis, emotions categorized by motoric direction were also assessed. Emotions were divided up differently, such that approach emotions consisted of happiness, interest, and anger, and withdrawal emotions consisted of sadness, fear, and disgust. It was hypothesized that participants in the RBD group would be less accurate and intense for the expression and comprehension of withdrawal emotions, whereas LBD individuals would present with greater difficulty processing approach emotions. The acoustical measure of F_0 mean revealed a significant main effect of motoric direction, such that approach emotions were expressed with significantly higher F_0 means than withdrawal emotions. Also, a trend towards significance was revealed for the Group by Motoric Direction interaction. Post hoc testing showed that RBD participants demonstrated significantly higher F_0 means for the withdrawal

emotions, than did NC participants. However, this higher F_0 mean score did not cause the raters to perceive withdrawal emotions as more intense.

For the RBD group, withdrawal emotions were rated as significantly less intense than approach emotions. Taken together, a significantly elevated F_0 mean for withdrawal emotions (i.e., impaired performance), in combination with reduced perceived intensity, suggests a right hemisphere superiority for the processing of withdrawal emotions. For the LBDs, there was only a small difference between their rated intensity of approach and withdrawal emotions, which did not reach statistical significance. When gender was taken into account, a trend towards significance for the Group by Gender by Motoric Direction interaction was revealed. Men in the RBD group demonstrated a similar profile to men in the NC group, with approach emotions being rated as significantly more intense than withdrawal emotions. For the LBD men, no significant differences were found for the two types of emotions. For women, LBD participants had a similar profile as NC women, with significant differences existing between approach and withdrawal emotions. However, women in the RBD group did not present with differences between the two groups of emotions. Results again demonstrate that selective deficits in emotional processing may be more gender specific in this particular sample rather than purely related to lesion laterality. This may account for the discrepancy in findings from the study conducted by Mandal et al. (1999) looking at the effects of lesion variables and emotion type on the perception of facial emotion. They found that RBD patients had specific deficits relative to LBD patients in processing negative and withdrawal emotions. However, they only assessed men, and as noted consistently in the current study, many of the effects of lesion site are dependent upon gender. In addition, this may be true for the

facial communication channel, but prosody in isolation is a much more cognitively difficult entity, and this may account for some of the differences in results.

Emotions were further separated into levels of arousal (i.e., high arousal and low arousal). There was a significant Group by Arousal interaction, in that NC individuals demonstrated significant differences in F_0 means between high and low arousal emotions. However, for both brain-damaged groups, no differences were found between the two categories of emotion. This finding is not in keeping with the notion that the right hemisphere is specialized for processing high arousal emotions. However, while results did not reach statistical significance, the pattern of scores showed that RBD individuals produced higher F_0 means for low arousal emotions than did LBD and NC participants. As higher F_0 means for low arousal emotions would be considered inappropriate or dysfunctional, which is what would be expected for the RBD group, perhaps, with a greater number of subjects, this finding would have been significant.

This pattern, although not significant, was also observed for rated intensity levels, such that RBD individuals were rated as more intense than NC participants for low arousal emotions. Although not significant, the pattern of scores shows that NC participants were rated as more intense for high arousal emotions than are LBD participants.

In summary, there appears to be consistent findings in group performance that imply that the valence hypothesis was operative in this study, when looking at men and women together, and that the right hemisphere mediates withdrawal emotions and low arousal emotions, whereas the left hemisphere controls approach and high arousal emotions. Future studies assessing valence, motoric direction, and arousal level, with

larger sample sizes, careful consideration of months post stroke, and examination of men and women separately, merits consideration, as results could have implications for better understanding of brain function, as well as implications for treatment (e.g., improving interpersonal relations).

Intrahemispheric Specialization

In addition to the theories that emotional processing is subserved by the right hemisphere or that each hemisphere is specialized for positive and negative emotions, previous literature has also pointed to intrahemispheric (i.e., anterior vs. posterior) differences (Borod, 1992). Intrahemispheric specialization for emotion was suggested by Ross (1985) in which he proposed a classification system of aprosodic syndromes, such that anterior regions are responsible for processing emotional expression, whereas posterior regions process the comprehension of emotions. In the current study, we examined lesion location by visual inspection of group means, because the number of subjects per lesion group was small. In keeping with Ross's theory, it was expected that participants with anterior lesions would be more impaired in their ability to express emotions with the appropriate prosodic intonation, whereas individuals with posterior lesions were expected to be more impaired in their ability to comprehend emotionally intoned sentences. Participants with both anterior and posterior lesions were expected to be globally impaired.

Studies have implicated selective brain regions for processing emotions with specific sensory input (e.g., visual). Lane et al. (1999) conducted a study using positron emission tomography (PET) and O₂-water to measure brain activity in male volunteers while they viewed emotional picture sets that could be classified according to valence or

arousal level. They found that pleasant emotion relative to neutral was associated with high activation in the putamen, medial frontal cortex, right anterior temporal cortex, and left extrastriate visual cortex. Unpleasant emotion, relative to neutral was associated with activation in the right extrastriate visual cortex. Valenced emotion (pleasant and unpleasant emotion) was associated with activation of bilateral extrastriate visual cortex and right anterior temporal regions. Processing high arousal emotions relative to low arousal stimuli was associated with bilateral extrastriate visual cortical activation and right anterior temporal activation. In addition, processing high arousal pleasant and unpleasant stimuli compared to low arousal pleasant and unpleasant stimuli was also associated with activation in the right extrastriate visual cortex, as well as activation in right anterior temporal cortex, left amygdala, thalamus, and medial prefrontal cortex.

In terms of the performance of brain-damaged subjects on prosodic emotional expression tasks, there is considerable literature implicating anterior brain structures in the expression of emotion within the RH (Borod, 1993; Borod et al., 1985; Ross, 1985). However, in one such study conducted by Cancelliere and Kertesz (1990), they attempted to explore the relationship between intrahemispheric lesion location and disturbance of emotional expression and comprehension in 28 RBD, 18 LBD, and 20 NC participants. They found that the basal ganglia was most frequently involved in aprosodic syndromes and in the comprehension of emotional facial expressions and depictions of emotional situations. The anterior temporal lobe, insula, and perisylvian regions also demonstrated a high frequency of involvement. Most RBD individuals did not present with specific aprosodic syndromes that supported Ross's classification theory (1988). They found that emotional expression and comprehension did not vary as a function of intrahemispheric

localization for patients with either left- or right-hemisphere pathology, but instead was more diffusely represented in both hemispheres. However, they felt that negative intrahemispheric findings might have been related to the small number of subjects per group and lack of consistency in lesion size. They did observe, however, that RBD patients with posterior lesions were more likely to be aprosodic. This led them to postulate that perhaps emotional expression and comprehension are more diffusely represented in the brain. Moreover, their patients may have been suffering from confusion or an attentional disturbance that may have interfered with their performance.

Various studies have indicated that for propositional prosody, RBD individuals with anterior and central lesions produce significantly reduced F_0 ranges compared to the exaggerated ranges for the posterior RBD participants (Behrens, 1988; Shapiro & Danly, 1985). In contrast, Ryalls et al. (1987) claimed that the artificial nature of the tasks used by Shapiro and Danly (i.e., reading lengthy stories) may have accounted for differences in findings, as Ryalls et al. did not find intrahemispheric differences when RBD participants were required to imitate responses at the sentence level. In addition, Ryalls et al. included more participants in their study.

In the current study, lesion location was examined by visual inspection of group means. See Table 1 for a description of lesion locations. We examined whether individuals with lesions involving anterior structures (RBD $n = 4$; LBD $n = 2$) were more impaired than those with posterior lesions (RBD $n = 6$, LBD $n = 8$) in the production of emotions categorized by valence, using a descriptive approach (i.e., visual inspection of group means). We also examined whether participants with posterior lesions were more impaired than those with anterior lesions in the prosodic comprehension of emotions.

Participants with anterior and posterior lesions (RBD n = 5, LBD n = 3) were expected to be the most impaired. See Tables 41 to 44 for means and standard deviations for the acoustic and perceptual variables for positively and negatively valenced emotions for each type of lesion site, separate for RBDs and LBDs.

Table 41.

Means (and Standard Deviations) for All Acoustic and Perceptual Parameters for Positively Valenced Emotions in RBDs with Anterior, Posterior, and Anterior Plus Posterior Lesions

<u>Parameter</u>	<u>Anterior</u>	<u>Posterior</u>	<u>Anterior/Posterior</u>
F ₀ Mean ^a	40.0 (± 3.49)	38.6 (± 3.42)	38.9 (± 5.80)
F ₀ SD	3.42 (± 0.87)	4.84 (± 1.98)	4.26 (± 1.64)
Duration	1.38 (± 0.27)	1.41 (± 0.22)	1.52 (± 0.36)
Intensity	3.44 (± 0.47)	3.42 (± 0.80)	4.45 (± 1.16)
Accuracy	0.13 (± 0.14)	0.00 (± 0.00)	0.00 (± 0.00)
Comp ID	0.47 (± 0.32)	0.41 (± 0.18)	0.38 (± 0.15)
Comp Disc	0.96 (± 0.07)	0.90 (± 0.07)	0.91 (± 0.08)

Note: ^a = Semitone conversion scores.

Table 42.

Means (and Standard Deviations) for All Acoustic and Perceptual Parameters for Positively Valenced Emotions in LBDs with Anterior, Posterior, and Anterior Plus Posterior Lesions

Parameter	Anterior	Posterior	Anterior/Posterior
F ₀ Mean ^a	36.6 (± 0.22)	38.6 (± 3.93)	44.3 (± 1.78)
F ₀ SD	3.57 (± 2.80)	4.25 (± 1.52)	3.76 (± 2.01)
Duration	1.21 (± 0.33)	1.79 (± 0.48)	1.92 (± 0.22)
Intensity	4.42 (± 0.59)	3.85 (± 0.27)	3.81 (± 0.09)
Accuracy	0.13 (± 0.06)	0.20 (± 0.14)	0.19 (± 0.13)
Comp ID	0.39 (± 0.08)	0.36 (± 0.24)	0.37 (± 0.13)
Comp Disc	0.95 (± 0.00)	0.96 (± 0.07)	0.95 (± 0.08)

Note: ^a = Semitone conversion scores.

Table 43.

Means (and Standard Deviations) for All Acoustic and Perceptual Parameters for Negatively Valenced Emotions in RBDs with Anterior, Posterior, and Anterior Plus Posterior Lesions

<u>Parameter</u>	<u>Anterior</u>	<u>Posterior</u>	<u>Anterior/Posterior</u>
F ₀ Mean ^a	39.0 (± 4.12)	36.5 (± 5.32)	38.2 (± 5.78)
F ₀ SD	3.55 (± 0.45)	3.56 (± 1.69)	4.18 (± 1.74)
Duration	1.59 (± 0.49)	1.52 (± 0.20)	1.70 (± 0.41)
Intensity	4.00 (± 0.24)	3.63 (± 0.49)	4.32 (± 1.26)
Accuracy	0.27 (± 0.11)	0.31 (± 0.17)	0.25 (± 0.10)
Comp ID	0.47 (± 0.25)	0.43 (± 0.12)	0.25 (± 0.17)
Comp Disc	0.98 (± 0.04)	0.94 (± 0.05)	0.96 (± 0.04)

Note: ^a = Semitone conversion scores.

Table 44.

Means (and Standard Deviations) for All Acoustic and Perceptual Parameters for Negatively Emotions in LBDs with Anterior, Posterior, and Anterior Plus Posterior Lesions

<u>Parameter</u>	<u>Anterior</u>	<u>Posterior</u>	<u>Anterior/Posterior</u>
F ₀ Mean ^a	36.8 (± 0.21)	36.8 (± 4.08)	43.5 (± 1.80)
F ₀ SD	4.19 (± 4.04)	3.37 (± 1.29)	3.24 (± 1.27)
Duration	1.46 (± 0.63)	1.79 (± 0.47)	1.77 (± 0.31)
Intensity	4.28 (± 0.32)	3.56 (± 0.62)	4.05 (± 0.44)
Accuracy	0.08 (± 0.04)	0.21 (± 0.10)	0.32 (± 0.20)
Comp ID	0.23 (± 0.24)	0.48 (± 0.28)	0.53 (± 0.13)
Comp Disc	0.94 (± 0.00)	0.94 (± 0.05)	0.93 (± 0.07)

Note: ^a = Semitone conversion scores.

Upon visual inspection, our descriptive analyses revealed that for F₀ standard deviation, RBD participants with posterior lesions presented with greater variability than did participants with anterior lesions for positive emotions. This pattern of performance is consistent with Shapiro and Danly's findings (1985) in that individuals with right posterior (post-Rolandic) damage had greater pitch variation compared to right-anterior (pre-Rolandic) patients. They also reported that no such deficits were found in patients with left posterior damage. Another interesting finding from visually inspecting the data here was that participants in the RBD group with posterior lesions demonstrated lower accuracy scores for the comprehension identification and discrimination task, for both positive and negative emotions. This is consistent with Ross's theory of aprosodic

classification (1985), in which he suggests that posterior regions of the right hemisphere control comprehension of emotions. He further states that this region is analogous to the posterior left-hemisphere which mediates language comprehension functions. Finally, another pattern revealed by visual inspection was that the LBD individuals with posterior lesions were slower at producing emotionally intoned sentences than were participants with anterior lesions. This pattern was not true for individuals in the RBD group, regardless of lesion site. This finding is more consistent with the acoustical specialization hypothesis, in that individuals with LBD are more likely to make errors in timing, rather than in pitch. Therefore, in our data, the posterior region of the left hemisphere appears to have a role in timing. This may account for the fact that when all lesion sites were analyzed together, no significant differences were found.

When inspecting lesion sites categorized by caudality, a lack of significant findings in the current study may be attributed to the very small sample size per group. Moreover, lesion sites may have encompassed too many specific brain regions, thus reducing the specificity of brain functions. Additionally, examining both men and women together may have eliminated any effect of intrahemispheric specialization, since many of the results obtained in the study point towards the fact that men and women processed emotions differently. Future studies should include much larger sample sizes, with less diffusely located lesions. A comparison should be made that includes short and long utterances, since results of previous studies were inconsistent between those that examined single sentences (e.g., Ryalls et al., 1987) and those that measured utterances at the paragraph level (e.g., Shapiro & Danly, 1985). Studies may also want to examine emotions categorized by valence, motoric direction, and arousal level, as well as discrete

emotions. Of great importance, men and women should be analyzed separately, as in the current study, they consistently presented with very different patterns of emotional expression/comprehension and lesion site.

Lateralized Specialization of Acoustic Parameters

As noted earlier, the right hemisphere has been implicated in the processing of F_0 or “pitch,” whereas the left hemisphere has been found to control the timing of speech. In a study conducted by Van Lancker and Sidtis (1992), they suggested that as F_0 is the most salient cue of prosodic emotional expression and comprehension, it would be understandable that right-hemisphere-damaged participants would evidence the greatest difficulty processing emotions. Others studies observed this in the production of propositional prosody as well (i.e., Schirmer et al., 2000). However, they also showed that individuals with left-hemisphere damage seemed to have more difficulties in timing their speech production, while participants with right-hemisphere lesions mainly seemed to have difficulties with F_0 . Therefore, another question that the current study aimed to answer was whether or not acoustical parameters are differentially processed by the right and left hemispheres, such that the right hemisphere utilizes F_0 cues to express and comprehend affect in prosody, whereas the left hemisphere relies more on timing (i.e., temporal aspect of affect in prosody).

Results of the current study did not reveal hemispheric differences in right and left brain damaged patients on all the acoustical parameters. There were no significant differences between groups for F_0 mean, F_0 standard deviation, or duration of length of utterance. Therefore, results of this study did not provide evidence for differential specialization of acoustical parameters. This is consistent with findings from a study

conducted by Pell and Baum (1997), in which no differences between brain-damaged groups and normal controls were found for timing versus F_0 . Instead, they found that RBD individuals were impaired in expressing emotionally-intoned sentences compared to LBD individuals, whereas the LBD group exhibited greater difficulty producing propositional prosody than did individuals in the RBD group. Differences in the method used to obtain duration measures in each study, in addition to length of language sampled, may account for differences between the studies that have looked at these variables. For instance, Schirmer et al. (2000) measured time of onset of each word from its time of offset, whereas in the current study, the entire length of the sentences was included in duration. This allows for pauses to be included in duration, which is more ecologically valid in evaluating the ability to express and perceive emotional tone. They also required participants to read stimuli at the paragraph level, whereas the current study and Pell and Baum's study (1997) looked at stimuli at the sentence level. Interesting future studies might include examining different forms of duration measures, such as calculating the mean duration of each word versus sampling the entire sentence, to see if differences in rate of production exist between RBDs and LBDs. In addition, similar to Van Lancker and Sidtis (1992), sampling at the paragraph level would also be of interest, as this length of speech is more typical of daily conversation and has implications for one's ability to interact socially with others. Another reason that might account for the variability of results between studies is the way emotions were elicited (i.e., emotion induction procedures). In the current study, we examined emotions elicited through a posing procedure (see Methods section). However, many previous studies have used mood-induction procedures prior to the subjects' production of neutral-content sentences

(Klasmeyer, 1998; Samuel et al., 1998; Scherer et al., 1991). Thus, their posing process may have been potentially influenced by individual differences in producing genuine emotion. In contrast, our study used a voluntary/deliberate “posed” aspect of producing emotions that does not readily lend itself to the incorporation of materials from personal experience.

Correlations Between Participants’ Expressions and Participants’ Comprehension

Accuracy

If F_0 mean and variability correlate with how listeners perceive the patient’s affective prosody, it has implications for improved social communication and interpersonal skills. Therefore, the current study also examined the relationship between F_0 mean, F_0 standard deviation, duration, and judges intensity and accuracy ratings. This was undertaken for expression variables (i.e., F_0 mean and variability) and comprehension measures (i.e., identification and discrimination) for the accuracy of actors’ portrayals of the emotions. In order to investigate whether prosodic expression and perception are related, such that brain damage alters emotional processing regardless of input or output, correlations were undertaken for the F_0 mean and variability versus comprehension identification accuracy. In terms of the relationship between posed emotional expression and comprehension identification accuracy, there were very few relationships among expression and perception variables. The current study did not find significant correlations between these variables. A lack of significant positive correlations between expression and comprehension is consistent with Ross’s classification system of aprosodia, such that different brain regions process different aspects of emotional communication.

While results of the current study do not implicate specific brain regions for the processing of emotions regardless of input or output, results do confirm that men and women process emotions differently, and as a function of brain damage, impairment in emotional processing may present differently according to gender. Therefore, results of the current study suggest that future studies evaluating emotion should take into account gender differences, and gender should be included as a variable. Moreover, emotion studies should not incorporate only men or women in studies, as has often been done in the past (e.g., Buchanan et al., 2000; Ross et al., 1986; Ryalls et al., 1987; Shapiro & Danly, 1985; Sobin & Alpert, 1999; Tompkins & Flowers, 1985).

Correlations Between Participants' Expressions and Raters' Accuracy

The current study also examined the relationship between participants' ability to express emotions and judges' ability to accurately identify those emotions. Correlations were conducted between F_0 mean, F_0 variability, and duration versus judges' accuracy ratings. For the RBD and LBD group, no significant correlations were found when comparing accuracy scores across separate discrete emotions, as well as emotions categorized by valence, motoric direction, and arousal level. Within the NC group, a significant inverse relationship was found between comprehension identification accuracy and rated accuracy for the emotion of sadness. That is, for the NC participants in this study, although they had difficulty accurately identifying sentences intoned in a sad tone of voice, listeners perceived them as more accurate in the production of the emotion. A thorough review of the literature did not reveal any studies examining this relationship. As the comprehension identification task may have been too difficult for all groups, future studies utilizing a similar, yet easier task, such as minimizing the choice to

include emotions within the same category that vary in arousal level (i.e., happy and interest vs. happy and pleasant surprise), would be of interest.

Correlation Between Participants' Expressions and Raters' Intensity Judgments

In this study, we also looked at the relationship between acoustics and the raters' evaluation of the intensity of posers' expressions, since how one expresses oneself emotionally has implications for how listeners perceive the speakers' emotional communicative intent. Relationships were evaluated between F_0 mean, F_0 standard deviation, and duration *and* judges' intensity ratings. The clearest pattern found in the current study was that for all participants, F_0 mean semitone difference scores positively correlated with intensity ratings for all emotions except for pleasant and unpleasant surprise. When groups were separated by gender, significant correlations between the F_0 mean and intensity ratings of happiness, sadness, and anger existed for men. However, there were no significant relationships between these two variables for women. This further supports the idea that men and women process emotions differently.

An understanding of the neuroanatomical correlates of emotional processing has been a major endeavor for many researchers. However, there are relatively few studies that discuss emotional processing deficits in terms of the experimental task's diagnostic utility (Viscovich et al., 2003) and the implications of emotional processing in terms of treatment (Stringer, 1996; Wymer, Lyndman, Booksh, 2002). A thorough literature search yielded few attempts to rehabilitate patients diagnosed with aprosodia. Stringer (1996), however, presented a case study in which a 36-year-old woman with a right-sided subdural hematoma had a monotone voice and restricted facial affect, with normal intelligence and no other cognitive deficits after 5 months of treatment in a rehabilitation

hospital. Her goal following inpatient rehabilitation was to improve affective expression. She was given a test requiring her to imitate a model's tone of voice, as well as various facial expressions. Independent emotional expression was also required. A computerized speech program with a visual display of fundamental frequency and amplitude contours was used so that the patient could look at her performance as well as target performance. She underwent pitch biofeedback and expression modeling three times a week for two months. Her performance improved significantly during the two months of treatment, and continued after a follow-up 11 months post stroke.

Previous studies have collected both acoustic data as well as rater accuracy and intensity (Ross et al, 1988; Ross et al., 1997; Scherer et al., 1991; Schirmer et al., 2000; Sobin & Alpert, 1999). However, in these previous studies, correlations between F_0 mean and intensity or accuracy ratings were used to include only those emotions that were highly correlated into their acoustic study. That is, rating procedures allowed for the selection of prototype emotion samples to be used for statistical analysis (Sobin & Alpert, 1999). For Ross et al. (1997), ratings were used to test the validity of the acoustic measures made on patients' responses and help classify the kind of errors made by subjects in a repetition task.

In terms of variability, the LBD group again demonstrated the most significant positive correlations, which existed for the emotions of interest and unpleasant surprise. NC participants also demonstrated a significant positive correlation for unpleasant surprise. Again, RBD participants did not present with significant correlations. Very minimal correlations were revealed for the relationship between duration and intensity.

As noted in the Results section, very few weak correlations were found for each acoustic variable as compared to accuracy ratings.

Because significant group differences were found for intensity ratings, each group was analyzed separately in order to see if correlations existed for each participant group. Most of the positive correlations that existed for the F_0 mean and intensity rating occurred when all groups were analyzed together. However, significant correlations disappeared when analyzed separately by group. One reason for reduced correlational effects may be the result of decreased sample size per group. Therefore, a study increasing the number of participants in each group may reveal strong relationships between F_0 mean and intensity ratings. With equal representation of men and women within these groups, better comparisons can be made to see if significant positive correlations remain. Additionally, increasing the number of raters also may increase the power of results, again, with equal representation of men and women, since in the current study, men and women were found to perceive emotions differentially. This is an important area of research as the methods employed in the current study have implications for the rehabilitation of prosodic deficits. Behavioral change following rehabilitation may lead to potentially improved social skills and interpersonal relations, and warrants future research (Brozgold et al., 1998).

Secondary Hypotheses

Gender. Results of the current study are consistent with previous literature stating that men and women process emotions differently, with women expressing emotions with greater F_0 means than men (e.g., Bachorowski & Owren, 1995; Banse & Scherer, 1996; Scherer et al., 1991). In a pilot study (Viscovich et al., 2003), gender differences were

also found in healthy normal controls, such that women had higher F_0 mean values, with greater F_0 variability than men. These findings are not surprising given structural and anatomical differences with respect to larynx size and vocal fold length (Klatt & Klatt, 1990; Titze, 1989). However, when semitone conversions were used in the pilot study (Viscovich et al., 2003), gender differences were no longer significant among healthy normal controls. Results of that study suggested that the expression of emotion transcends gender differences. That is, differences between types of emotions represent a more salient index of prosodic expression than do sex differences. Similar to Bachorowski and Owren (1995), who found that men and women differentially produced emotions depending on preceding factors (i.e., praise vs. negative response), the current study revealed that men and women differentially processed discrete emotions, and emotions categorized by valence, motoric direction, and arousal level. In addition, emotional processing for gender varied as a function of brain damage.

When examining all eight separate emotions for F_0 mean, it was demonstrated that men from all three groups presented with significantly higher F_0 means than women for pleasant surprise. There was a trend towards significance for sadness, such that women produced this emotion with a greater F_0 mean than did men. No significant gender differences were found for F_0 variability or duration measures, even though it was predicted that men would speak with shorter duration than women (Fitzsimons et al., 2001). This was not the case for any of the groups. With regards to emotions categorized by valence, an interesting finding was revealed, such that men presented with higher F_0 means for positive emotions, than did women. For negative emotions, however, women produced significantly higher F_0 means than did men. This is opposite

to what was expected. However, when you take into account the gender differences that existed within each separate group, the results make sense and suggest differential gender effects in regards to brain damage. More specifically, in the RBD group, no gender differences were revealed for positive emotions, but for negative emotions, women produced significantly greater F_0 means than did men. In the LBD group, the opposite pattern was demonstrated, such that men not only produced positive emotions with greater F_0 mean than did women, but this was also true for negative emotions. However, consistent with our pilot study (Viscovich et al., 2003), no significant gender differences were found within the normal control group. Interestingly, these two samples were very different in terms of age (previous study's Mean = 29.2 years; current study's Mean = 66.2), suggesting that men and women do not differ in their overall mean F_0 as they age.

Finally, when analyzing emotions classified by arousal level, gender differences were revealed as a function of arousal level. Although post hoc testing did not reveal significant findings, the pattern of scores suggested that men expressed high arousal emotions with greater F_0 means than low arousal emotions. Although the same pattern was revealed for women, differences between arousal level were much smaller. This is most likely attributable to the gender differences that were seen as a function of group. For instance, within the RBD and NC group, no significant gender differences were revealed. However, for the LBD group, men demonstrated significantly higher F_0 means for high arousal emotions, than did women. No differences were revealed for low arousal emotions.

Taken together, as reported above, gender differences appear to exist in the face of brain damage, and even then, the presentation of deficits varies as a function of

emotion type, valence type, motoric direction, arousal level, and hemispheric lesion locations. It has been found that within the normal population, men and women process emotions differently. In a meta-analysis conducted by Wager, Phan, and Liberzon (in press), 65 PET and fMRI studies were reviewed to evaluate the differences between men and women in emotional processing. Overall, they found differential activation between men and women in regions of the medial prefrontal cortex. Women showed greater activation in the subcallosal anterior cingulate, whereas men demonstrated greater activation in the left frontal gyrus, anterior insula, and right putamen/globus pallidus. Women also showed more activation in the basal ganglia overall, but men showed more concentrated activation in the striatum in the right hemisphere. Cahill et al. (2001) found that right amygdala activity by emotionally negative films correlated with memory for the films in men, but for women, left amygdala activity was correlated with memory performance. Left activation in women may account for why in the current study, LBD women presented with the most problems expressing emotions. Also, given the findings that men appear to be more lateralized to the right hemisphere in emotional processing, it is understandable that many earlier studies have found consistent support for the right hemisphere hypothesis, as they often only included men in their studies (i.e., Tucker et al., 1977; Tompkins et al., 1985; Ross et al., 1986).

While previous studies have addressed gender differences within the normal population (e.g., Fitzsimons et al., 2001; Klasmeyer, 1998; Scherer et al., 1996), acoustic studies were not found that examined men and women with brain damage separately for emotions categorized by valence, motoric direction, and arousal level. Future research merits consideration that includes a greater number of participants in order to greater

appreciate gender differences, as results have implications on how to rehabilitate men and women individually, rather than prescribing a cognitive remediation program for improving emotional processing that is not gender-specific.

Emotion Type. The posed emotional expression to command task proved to be a valid method for examining emotional expression, as results of the current study revealed similar patterns of emotional expression differences seen in previous literature (Banse et al., 1991; Klasmeyer, 1998; Scherer et al., 1996; Viscovich et al., 2003; Whiteside, 1999). Significant differences were revealed for all dependent variables within the current study for discrete emotions. More specifically, sadness was expressed with the lowest F_0 mean and least variability than any other emotion, while pleasant surprise and happiness were produced with the highest F_0 means and greater variability. For emotions categorized by valence, all but accuracy ratings, revealed that positive emotions were expressed with greater F_0 mean, variability, intensity, and comprehension, as well as with a shorter duration than negative emotions. Approach emotions were expressed with higher F_0 mean and variability, and shorter duration than were withdrawal emotions. Similar findings were demonstrated for high arousal versus low arousal emotions. Except for level of arousal, findings are consistent with the differences observed for facial emotional perception and emotion type in a study conducted by Mandal et al. (1999).

Summary

In summary, while the right hemisphere hypothesis was predicted to be the most operative hypothesis, with individuals in the RBD group presenting with more global emotional processing deficits than those in the LBD group, this was not so. In contrast,

more evidence was revealed in support of the valence hypothesis. However, this appeared to be gender-specific, such that men with left-hemisphere brain-damage exhibited greater difficulty expressing negative emotions, while women with right-hemisphere-brain damage had difficulty appropriately intoning negative emotions. The latter is more consistent with the valence hypothesis, which suggests that the left hemisphere specializes in positive emotions, while the right hemisphere processes negative emotions (Borod, 1992).

Results of this study have implications for cognitive remediation programs to improve emotional communication that are developed individually for men and women. In addition, results suggest that patients who sustain brain damage, regardless of lesion location, should be tested for affective prosodic deficits, since right hemispheric specialization alone was not implicated in the current study. Finally, objective acoustical measures were significantly correlated with perceptual ratings for all groups combined, suggesting that visual biofeedback may be a viable form of treatment for emotional expression deficits. Treatment can include having the therapist model appropriate emotional expressions to specified “emotional scenarios” while the patient’s voice is being recorded on a visually displayed computerized speech program. Then, when the patient models the expression to a specific scenario, they can visually observe their own increases in F_0 means and variability of production, as compared to “normal” F_0 intonation contours. This visual feedback may improve their expression of different emotional tones. Their improved expression may be perceived more easily by people they regularly interact with, and this may help improve social communication and interpersonal relationships.

Appendix A.

Source Tables for Statistical Analyses

1. Group (3) x Gender (2) x Emotion (8)

a. Posed Prosodic Expression to Command Task: F₀ Mean Semitone Difference Scores:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
EMOTIONS	Sphericity Assumed	519.915	7	74.274	12.671	.000	.209	88.700	1.000
	Greenhouse-Geisser	519.915	5.716	90.964	12.671	.000	.209	72.425	1.000
	Huynh-Feldt	519.915	7.000	74.274	12.671	.000	.209	88.700	1.000
	Lower-bound	519.915	1.000	519.915	12.671	.001	.209	12.671	.937
EMOTIONS * GROUF	Sphericity Assumed	134.276	14	9.591	1.636	.068	.064	22.908	.885
	Greenhouse-Geisser	134.276	11.431	11.746	1.636	.085	.064	18.705	.828
	Huynh-Feldt	134.276	14.000	9.591	1.636	.068	.064	22.908	.885
	Lower-bound	134.276	2.000	67.138	1.636	.205	.064	3.273	.329
EMOTIONS * GENDE	Sphericity Assumed	130.555	7	18.651	3.182	.003	.062	22.273	.950
	Greenhouse-Geisser	130.555	5.716	22.842	3.182	.006	.062	18.187	.912
	Huynh-Feldt	130.555	7.000	18.651	3.182	.003	.062	22.273	.950
	Lower-bound	130.555	1.000	130.555	3.182	.081	.062	3.182	.416
EMOTIONS * GROUF * GENDER	Sphericity Assumed	50.830	14	3.631	.619	.849	.025	8.672	.393
	Greenhouse-Geisser	50.830	11.431	4.447	.619	.818	.025	7.081	.348
	Huynh-Feldt	50.830	14.000	3.631	.619	.849	.025	8.672	.393
	Lower-bound	50.830	2.000	25.415	.619	.543	.025	1.239	.147
Error(EMOTIONS)	Sphericity Assumed	1969.465	336	5.862					
	Greenhouse-Geisser	1969.465	274.349	7.179					
	Huynh-Feldt	1969.465	336.000	5.862					
	Lower-bound	1969.465	48.000	41.031					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	3822.829	1	3822.829	65.303	.000	.576	65.303	1.000
GROUP	13.303	2	6.652	.114	.893	.005	.227	.066
GENDER	3.230	1	3.230	.055	.815	.001	.055	.056
GROUP * GENDER	317.659	2	158.830	2.713	.076	.102	5.426	.512
Error	2809.935	48	58.540					

a. Computed using alpha = .05

b. Posed Prosodic Expression to Command Task: F₀ Standard Deviation
Semitone Difference Scores:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
EMOTIONS	Sphericity Assumed	96.821	7	13.832	2.826	.007	19.783	.919
	Greenhouse-Geisser	96.821	3.347	28.924	2.826	.035	9.461	.705
	Huynh-Feldt	96.821	4.003	24.185	2.826	.026	11.314	.764
	Lower-bound	96.821	1.000	96.821	2.826	.099	2.826	.378
EMOTIONS * GROUF	Sphericity Assumed	23.549	14	1.682	.344	.988	4.812	.213
	Greenhouse-Geisser	23.549	6.695	3.518	.344	.927	2.301	.151
	Huynh-Feldt	23.549	8.007	2.941	.344	.948	2.752	.163
	Lower-bound	23.549	2.000	11.775	.344	.711	.687	.102
EMOTIONS * GENDE	Sphericity Assumed	15.359	7	2.194	.448	.871	3.138	.197
	Greenhouse-Geisser	15.359	3.347	4.588	.448	.740	1.501	.144
	Huynh-Feldt	15.359	4.003	3.836	.448	.774	1.795	.154
	Lower-bound	15.359	1.000	15.359	.448	.506	.448	.101
EMOTIONS * GROUF * GENDER	Sphericity Assumed	99.966	14	7.140	1.459	.125	20.426	.836
	Greenhouse-Geisser	99.966	6.695	14.932	1.459	.189	9.768	.589
	Huynh-Feldt	99.966	8.007	12.485	1.459	.175	11.682	.649
	Lower-bound	99.966	2.000	49.983	1.459	.243	2.918	.297
Error(EMOTIONS)	Sphericity Assumed	1644.407	336	4.894				
	Greenhouse-Geisser	1644.407	160.677	10.234				
	Huynh-Feldt	1644.407	192.163	8.557				
	Lower-bound	1644.407	48.000	34.258				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	436.020	1	436.020	22.653	.000	.321	22.653	.997
GROUP	28.578	2	14.289	.742	.481	.030	1.485	.169
GENDER	1.278	1	1.278	.066	.798	.001	.066	.057
GROUP * GENDER	62.233	2	31.117	1.617	.209	.063	3.233	.325
Error	923.873	48	19.247					

a. Computed using alpha = .05

c. Posed Prosodic Expression to Command Task: Duration:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
EMOTIONS	Sphericity Assumed	1.430	7	.204	2.848	.007	19.933	.921
	Greenhouse-Geisser	1.430	5.814	.246	2.848	.011	16.556	.878
	Huynh-Feldt	1.430	7.000	.204	2.848	.007	19.933	.921
	Lower-bound	1.430	1.000	1.430	2.848	.098	2.848	.380
EMOTIONS * GROUP	Sphericity Assumed	1.156	14	8.259E-02	1.151	.312	16.114	.712
	Greenhouse-Geisser	1.156	11.628	9.945E-02	1.151	.320	13.384	.648
	Huynh-Feldt	1.156	14.000	8.259E-02	1.151	.312	16.114	.712
	Lower-bound	1.156	2.000	.578	1.151	.325	2.302	.241
EMOTIONS * GENDER	Sphericity Assumed	.478	7	6.830E-02	.952	.467	6.663	.411
	Greenhouse-Geisser	.478	5.814	8.224E-02	.952	.457	5.534	.369
	Huynh-Feldt	.478	7.000	6.830E-02	.952	.467	6.663	.411
	Lower-bound	.478	1.000	.478	.952	.334	.952	.160
EMOTIONS * GROUP * GENDER	Sphericity Assumed	.906	14	6.472E-02	.902	.557	12.626	.576
	Greenhouse-Geisser	.906	11.628	7.792E-02	.902	.543	10.486	.517
	Huynh-Feldt	.906	14.000	6.472E-02	.902	.557	12.626	.576
	Lower-bound	.906	2.000	.453	.902	.413	1.804	.197
Error(EMOTIONS)	Sphericity Assumed	24.111	336	7.176E-02				
	Greenhouse-Geisser	24.111	279.066	8.640E-02				
	Huynh-Feldt	24.111	336.000	7.176E-02				
	Lower-bound	24.111	48.000	.502				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	1064.277	1	1064.277	1223.259	.000	.962	1223.259	1.000
GROUP	.944	2	.472	.543	.585	.022	1.085	.134
GENDER	.727	1	.727	.835	.365	.017	.835	.146
GROUP * GENDER	.262	2	.131	.150	.861	.006	.301	.072
Error	41.762	48	.870					

a. Computed using alpha = .05

d. Posed Prosodic Expression to Command Task: Rated Intensity:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
EMOTION	Sphericity Assumed	5.030	7	.719	1.053	.394	.022	7.373	.454
	Greenhouse-Geisser	5.030	5.639	.892	1.053	.390	.022	5.940	.400
	Huynh-Feldt	5.030	7.000	.719	1.053	.394	.022	7.373	.454
	Lower-bound	5.030	1.000	5.030	1.053	.310	.022	1.053	.171
EMOTION * NEUT_INT	Sphericity Assumed	7.281	7	1.040	1.525	.158	.031	10.674	.637
	Greenhouse-Geisser	7.281	5.639	1.291	1.525	.174	.031	8.599	.567
	Huynh-Feldt	7.281	7.000	1.040	1.525	.158	.031	10.674	.637
	Lower-bound	7.281	1.000	7.281	1.525	.223	.031	1.525	.227
EMOTION * GENDER	Sphericity Assumed	5.699	7	.814	1.194	.306	.025	8.355	.512
	Greenhouse-Geisser	5.699	5.639	1.011	1.194	.311	.025	6.731	.452
	Huynh-Feldt	5.699	7.000	.814	1.194	.306	.025	8.355	.512
	Lower-bound	5.699	1.000	5.699	1.194	.280	.025	1.194	.188
EMOTION * GROUP	Sphericity Assumed	50.151	14	3.582	5.251	.000	.183	73.519	1.000
	Greenhouse-Geisser	50.151	11.279	4.447	5.251	.000	.183	59.228	1.000
	Huynh-Feldt	50.151	14.000	3.582	5.251	.000	.183	73.519	1.000
	Lower-bound	50.151	2.000	25.076	5.251	.009	.183	10.503	.809
EMOTION * GENDER * GROUP	Sphericity Assumed	10.617	14	.758	1.112	.346	.045	15.563	.693
	Greenhouse-Geisser	10.617	11.279	.941	1.112	.352	.045	12.538	.618
	Huynh-Feldt	10.617	14.000	.758	1.112	.346	.045	15.563	.693
	Lower-bound	10.617	2.000	5.308	1.112	.338	.045	2.223	.234
Error(EMOTION)	Sphericity Assumed	224.428	329	.682					
	Greenhouse-Geisser	224.428	265.047	.847					
	Huynh-Feldt	224.428	329.000	.682					
	Lower-bound	224.428	47.000	4.775					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	109.881	1	109.881	30.421	.000	.393	30.421	1.000
NEUT_INT	61.642	1	61.642	17.066	.000	.266	17.066	.981
GENDER	4.408	1	4.408	1.220	.275	.025	1.220	.191
GROUP	25.132	2	12.566	3.479	.039	.129	6.958	.623
GENDER * GROUP	6.249	2	3.125	.865	.428	.036	1.730	.190
Error	169.764	47	3.612					

a. Computed using alpha = .05

e. Posed Prosodic Expression to Command Task: Accuracy Ratings:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
EMOTION	Sphericity Assumed	5.511	7	.787	11.483	.000	.193	80.382	1.000
	Greenhouse-Geisser	5.511	4.889	1.127	11.483	.000	.193	56.144	1.000
	Huynh-Feldt	5.511	6.078	.907	11.483	.000	.193	69.793	1.000
	Lower-bound	5.511	1.000	5.511	11.483	.001	.193	11.483	.913
EMOTION * GROUP	Sphericity Assumed	1.398	14	9.987E-02	1.457	.125	.057	20.395	.835
	Greenhouse-Geisser	1.398	9.778	.143	1.457	.158	.057	14.245	.717
	Huynh-Feldt	1.398	12.156	.115	1.457	.139	.057	17.708	.790
	Lower-bound	1.398	2.000	.699	1.457	.243	.057	2.914	.296
EMOTION * GENDER	Sphericity Assumed	.276	7	3.949E-02	.576	.775	.012	4.033	.249
	Greenhouse-Geisser	.276	4.889	5.654E-02	.576	.714	.012	2.817	.208
	Huynh-Feldt	.276	6.078	4.549E-02	.576	.752	.012	3.501	.231
	Lower-bound	.276	1.000	.276	.576	.452	.012	.576	.115
EMOTION * GROUP * GENDER	Sphericity Assumed	.489	14	3.493E-02	.510	.927	.021	7.134	.319
	Greenhouse-Geisser	.489	9.778	5.002E-02	.510	.879	.021	4.983	.260
	Huynh-Feldt	.489	12.156	4.024E-02	.510	.910	.021	6.194	.294
	Lower-bound	.489	2.000	.245	.510	.604	.021	1.019	.129
Error(EMOTION)	Sphericity Assumed	23.035	336	6.856E-02					
	Greenhouse-Geisser	23.035	234.683	9.815E-02					
	Huynh-Feldt	23.035	291.734	7.896E-02					
	Lower-bound	23.035	48.000	.480					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	23.781	1	23.781	275.988	.000	.852	275.988	1.000
GROUP	.430	2	.215	2.495	.093	.094	4.990	.477
GENDER	7.539E-02	1	7.539E-02	.875	.354	.018	.875	.150
GROUP * GENDER	.124	2	6.202E-02	.720	.492	.029	1.440	.165
Error	4.136	48	8.617E-02					

a. Computed using alpha = .05

f. Prosodic Perception: Identification:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
EMOTIONS	Sphericity Assumed	4.794	7	.685	8.603	.000	.152	60.220	1.000
	Greenhouse-Geisser	4.794	6.122	.783	8.603	.000	.152	52.666	1.000
	Huynh-Feldt	4.794	7.000	.685	8.603	.000	.152	60.220	1.000
	Lower-bound	4.794	1.000	4.794	8.603	.005	.152	8.603	.820
EMOTIONS * GROUP	Sphericity Assumed	.515	14	3.679E-02	.462	.952	.019	6.471	.288
	Greenhouse-Geisser	.515	12.244	4.207E-02	.462	.938	.019	5.659	.267
	Huynh-Feldt	.515	14.000	3.679E-02	.462	.952	.019	6.471	.288
	Lower-bound	.515	2.000	.258	.462	.633	.019	.924	.121
EMOTIONS * GENDEF	Sphericity Assumed	.779	7	.111	1.398	.205	.028	9.783	.592
	Greenhouse-Geisser	.779	6.122	.127	1.398	.214	.028	8.556	.549
	Huynh-Feldt	.779	7.000	.111	1.398	.205	.028	9.783	.592
	Lower-bound	.779	1.000	.779	1.398	.243	.028	1.398	.212
EMOTIONS * GROUP * GENDER	Sphericity Assumed	.481	14	3.437E-02	.432	.964	.018	6.045	.268
	Greenhouse-Geisser	.481	12.244	3.930E-02	.432	.952	.018	5.286	.249
	Huynh-Feldt	.481	14.000	3.437E-02	.432	.964	.018	6.045	.268
	Lower-bound	.481	2.000	.241	.432	.652	.018	.864	.116
Error(EMOTIONS)	Sphericity Assumed	26.747	336	7.960E-02					
	Greenhouse-Geisser	26.747	293.850	9.102E-02					
	Huynh-Feldt	26.747	336.000	7.960E-02					
	Lower-bound	26.747	48.000	.557					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	71.885	1	71.885	237.089	.000	.832	237.089	1.000
GROUP	.410	2	.205	.676	.513	.027	1.353	.157
GENDER	.599	1	.599	1.976	.166	.040	1.976	.281
GROUP * GENDER	1.125	2	.562	1.855	.168	.072	3.710	.368
Error	14.554	48	.303					

a. Computed using alpha = .05

g. Prosodic Perception: Discrimination:

Tests of Between-Subjects Effects

Dependent Variable: Total Discrimination Accuracy %

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Corrected Model	3.448E-02 ^b	5	6.897E-03	2.059	.087	.177	10.296	.634
Intercept	44.123	1	44.123	13174.327	.000	.996	13174.327	1.000
GENDER	1.456E-02	1	1.456E-02	4.348	.042	.083	4.348	.533
GROUP	7.709E-03	2	3.854E-03	1.151	.325	.046	2.302	.241
GENDER * GROUP	1.604E-02	2	8.018E-03	2.394	.102	.091	4.788	.460
Error	.161	48	3.349E-03					
Total	47.064	54						
Corrected Total	.195	53						

a. Computed using alpha = .05

b. R Squared = .177 (Adjusted R Squared = .091)

2. Group (2) x Gender (2) x Valence (2)

a. Posed Prosodic Expression to Command Task: F₀ Mean Semitone Difference score:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a	
VALENCE	Sphericity Assumed	169.567	1	169.567	35.854	.000	.428	35.854	1.000
	Greenhouse-Geisser	169.567	1.000	169.567	35.854	.000	.428	35.854	1.000
	Huynh-Feldt	169.567	1.000	169.567	35.854	.000	.428	35.854	1.000
	Lower-bound	169.567	1.000	169.567	35.854	.000	.428	35.854	1.000
VALENCE * GROUP	Sphericity Assumed	18.809	2	9.404	1.989	.148	.077	3.977	.391
	Greenhouse-Geisser	18.809	2.000	9.404	1.989	.148	.077	3.977	.391
	Huynh-Feldt	18.809	2.000	9.404	1.989	.148	.077	3.977	.391
	Lower-bound	18.809	2.000	9.404	1.989	.148	.077	3.977	.391
VALENCE * GENDER	Sphericity Assumed	18.780	1	18.780	3.971	.052	.076	3.971	.497
	Greenhouse-Geisser	18.780	1.000	18.780	3.971	.052	.076	3.971	.497
	Huynh-Feldt	18.780	1.000	18.780	3.971	.052	.076	3.971	.497
	Lower-bound	18.780	1.000	18.780	3.971	.052	.076	3.971	.497
VALENCE * GROUP * GENDER	Sphericity Assumed	3.429	2	1.714	.363	.698	.015	.725	.105
	Greenhouse-Geisser	3.429	2.000	1.714	.363	.698	.015	.725	.105
	Huynh-Feldt	3.429	2.000	1.714	.363	.698	.015	.725	.105
	Lower-bound	3.429	2.000	1.714	.363	.698	.015	.725	.105
Error(VALENCE)	Sphericity Assumed	227.007	48	4.729					
	Greenhouse-Geisser	227.007	48.000	4.729					
	Huynh-Feldt	227.007	48.000	4.729					
	Lower-bound	227.007	48.000	4.729					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	760.076	1	760.076	71.566	.000	.599	71.566	1.000
GROUP	2.038	2	1.019	.096	.909	.004	.192	.064
GENDER	4.221	1	4.221	.397	.531	.008	.397	.095
GROUP * GENDER	71.977	2	35.989	3.389	.042	.124	6.777	.611
Error	509.789	48	10.621					

a. Computed using alpha = .05

b. Posed Prosodic Expression to Command Task: F₀ Standard Deviation Semitone Difference score:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
VALENCE	Sphericity Assumed	17.148	1	17.148	7.165	.010	.130	.746
	Greenhouse-Geisser	17.148	1.000	17.148	7.165	.010	.130	.746
	Huynh-Feldt	17.148	1.000	17.148	7.165	.010	.130	.746
	Lower-bound	17.148	1.000	17.148	7.165	.010	.130	.746
VALENCE * GROUP	Sphericity Assumed	.195	2	9.739E-02	.041	.960	.002	.056
	Greenhouse-Geisser	.195	2.000	9.739E-02	.041	.960	.002	.056
	Huynh-Feldt	.195	2.000	9.739E-02	.041	.960	.002	.056
	Lower-bound	.195	2.000	9.739E-02	.041	.960	.002	.056
VALENCE * GENDER	Sphericity Assumed	.588	1	.588	.246	.622	.005	.077
	Greenhouse-Geisser	.588	1.000	.588	.246	.622	.005	.077
	Huynh-Feldt	.588	1.000	.588	.246	.622	.005	.077
	Lower-bound	.588	1.000	.588	.246	.622	.005	.077
VALENCE * GROUP * GENDER	Sphericity Assumed	2.803	2	1.401	.586	.561	.024	.142
	Greenhouse-Geisser	2.803	2.000	1.401	.586	.561	.024	.142
	Huynh-Feldt	2.803	2.000	1.401	.586	.561	.024	.142
	Lower-bound	2.803	2.000	1.401	.586	.561	.024	.142
Error(VALENCE)	Sphericity Assumed	114.883	48	2.393				
	Greenhouse-Geisser	114.883	48.000	2.393				
	Huynh-Feldt	114.883	48.000	2.393				
	Lower-bound	114.883	48.000	2.393				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	118.325	1	118.325	20.612	.000	.300	20.612	.994
GROUP	3.971	2	1.985	.346	.709	.014	.692	.102
GENDER	5.443E-03	1	5.443E-03	.001	.976	.000	.001	.050
GROUP * GENDER	2.681	2	1.340	.233	.793	.010	.467	.085
Error	275.546	48	5.741					

a. Computed using alpha = .05

c. Posed Prosodic to Expression Task: Duration:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
VALENCE	Sphericity Assumed	.271	1	.271	13.302	.001	.221	13.302	.946
	Greenhouse-Geisser	.271	1.000	.271	13.302	.001	.221	13.302	.946
	Huynh-Feldt	.271	1.000	.271	13.302	.001	.221	13.302	.946
	Lower-bound	.271	1.000	.271	13.302	.001	.221	13.302	.946
VALENCE * GENDER	Sphericity Assumed	2.516E-02	1	2.516E-02	1.233	.272	.026	1.233	.193
	Greenhouse-Geisser	2.516E-02	1.000	2.516E-02	1.233	.272	.026	1.233	.193
	Huynh-Feldt	2.516E-02	1.000	2.516E-02	1.233	.272	.026	1.233	.193
	Lower-bound	2.516E-02	1.000	2.516E-02	1.233	.272	.026	1.233	.193
VALENCE * GROUP	Sphericity Assumed	6.386E-02	2	3.193E-02	1.565	.220	.062	3.131	.316
	Greenhouse-Geisser	6.386E-02	2.000	3.193E-02	1.565	.220	.062	3.131	.316
	Huynh-Feldt	6.386E-02	2.000	3.193E-02	1.565	.220	.062	3.131	.316
	Lower-bound	6.386E-02	2.000	3.193E-02	1.565	.220	.062	3.131	.316
VALENCE * GENDER * GROUP	Sphericity Assumed	5.538E-02	2	2.769E-02	1.358	.267	.055	2.715	.278
	Greenhouse-Geisser	5.538E-02	2.000	2.769E-02	1.358	.267	.055	2.715	.278
	Huynh-Feldt	5.538E-02	2.000	2.769E-02	1.358	.267	.055	2.715	.278
	Lower-bound	5.538E-02	2.000	2.769E-02	1.358	.267	.055	2.715	.278
Error(VALENCE)	Sphericity Assumed	.959	47	2.040E-02					
	Greenhouse-Geisser	.959	47.000	2.040E-02					
	Huynh-Feldt	.959	47.000	2.040E-02					
	Lower-bound	.959	47.000	2.040E-02					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	255.191	1	255.191	1202.231	.000	.962	1202.231	1.000
GENDER	.290	1	.290	1.367	.248	.028	1.367	.209
GROUP	.244	2	.122	.575	.567	.024	1.150	.140
GENDER * GROUP	5.524E-02	2	2.762E-02	.130	.878	.006	.260	.069
Error	9.976	47	.212					

a. Computed using alpha = .05

d. Posed Prosodic to Expression Task: Intensity Ratings:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
VALENCE	Sphericity Assumed	.460	1	.460	2.585	.115	.052	2.585	.350
	Greenhouse-Geisser	.460	1.000	.460	2.585	.115	.052	2.585	.350
	Huynh-Feldt	.460	1.000	.460	2.585	.115	.052	2.585	.350
	Lower-bound	.460	1.000	.460	2.585	.115	.052	2.585	.350
VALENCE * NEUT_INT	Sphericity Assumed	.243	1	.243	1.366	.248	.028	1.366	.208
	Greenhouse-Geisser	.243	1.000	.243	1.366	.248	.028	1.366	.208
	Huynh-Feldt	.243	1.000	.243	1.366	.248	.028	1.366	.208
	Lower-bound	.243	1.000	.243	1.366	.248	.028	1.366	.208
VALENCE * GENDER	Sphericity Assumed	.555	1	.555	3.123	.084	.062	3.123	.410
	Greenhouse-Geisser	.555	1.000	.555	3.123	.084	.062	3.123	.410
	Huynh-Feldt	.555	1.000	.555	3.123	.084	.062	3.123	.410
	Lower-bound	.555	1.000	.555	3.123	.084	.062	3.123	.410
VALENCE * GROUP	Sphericity Assumed	2.072	2	1.036	5.825	.005	.199	11.651	.850
	Greenhouse-Geisser	2.072	2.000	1.036	5.825	.005	.199	11.651	.850
	Huynh-Feldt	2.072	2.000	1.036	5.825	.005	.199	11.651	.850
	Lower-bound	2.072	2.000	1.036	5.825	.005	.199	11.651	.850
VALENCE * GENDER * GROUP	Sphericity Assumed	.414	2	.207	1.165	.321	.047	2.329	.243
	Greenhouse-Geisser	.414	2.000	.207	1.165	.321	.047	2.329	.243
	Huynh-Feldt	.414	2.000	.207	1.165	.321	.047	2.329	.243
	Lower-bound	.414	2.000	.207	1.165	.321	.047	2.329	.243
Error(VALENCE)	Sphericity Assumed	8.357	47	.178					
	Greenhouse-Geisser	8.357	47.000	.178					
	Huynh-Feldt	8.357	47.000	.178					
	Lower-bound	8.357	47.000	.178					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	57.002	1	57.002	70.804	.000	.601	70.804	1.000
NEUT_INT	3.921	1	3.921	4.870	.032	.094	4.870	.580
GENDER	1.800	1	1.800	2.236	.141	.045	2.236	.311
GROUP	3.841	2	1.921	2.386	.103	.092	4.771	.458
GENDER * GROUP	6.025	2	3.013	3.742	.031	.137	7.484	.657
Error	37.838	47	.805					

a. Computed using alpha = .05

e. Posed Prosodic to Expression Task: Accuracy Ratings:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
VALENCE	Sphericity Assumed	4.248E-03	1	4.248E-03	.250	.619	.005	.250	.078
	Greenhouse-Geisser	4.248E-03	1.000	4.248E-03	.250	.619	.005	.250	.078
	Huynh-Feldt	4.248E-03	1.000	4.248E-03	.250	.619	.005	.250	.078
	Lower-bound	4.248E-03	1.000	4.248E-03	.250	.619	.005	.250	.078
VALENCE * GROUP	Sphericity Assumed	.195	2	9.742E-02	5.738	.006	.193	11.477	.845
	Greenhouse-Geisser	.195	2.000	9.742E-02	5.738	.006	.193	11.477	.845
	Huynh-Feldt	.195	2.000	9.742E-02	5.738	.006	.193	11.477	.845
	Lower-bound	.195	2.000	9.742E-02	5.738	.006	.193	11.477	.845
VALENCE * GENDER	Sphericity Assumed	2.488E-02	1	2.488E-02	1.465	.232	.030	1.465	.220
	Greenhouse-Geisser	2.488E-02	1.000	2.488E-02	1.465	.232	.030	1.465	.220
	Huynh-Feldt	2.488E-02	1.000	2.488E-02	1.465	.232	.030	1.465	.220
	Lower-bound	2.488E-02	1.000	2.488E-02	1.465	.232	.030	1.465	.220
VALENCE * GROUP * GENDER	Sphericity Assumed	9.067E-03	2	4.534E-03	.267	.767	.011	.534	.090
	Greenhouse-Geisser	9.067E-03	2.000	4.534E-03	.267	.767	.011	.534	.090
	Huynh-Feldt	9.067E-03	2.000	4.534E-03	.267	.767	.011	.534	.090
	Lower-bound	9.067E-03	2.000	4.534E-03	.267	.767	.011	.534	.090
Error(VALENCE)	Sphericity Assumed	.815	48	1.698E-02					
	Greenhouse-Geisser	.815	48.000	1.698E-02					
	Huynh-Feldt	.815	48.000	1.698E-02					
	Lower-bound	.815	48.000	1.698E-02					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	5.866	1	5.866	279.512	.000	.853	279.512	1.000
GROUP	9.638E-02	2	4.819E-02	2.296	.112	.087	4.593	.444
GENDER	3.128E-02	1	3.128E-02	1.490	.228	.030	1.490	.223
GROUP * GENDER	3.216E-02	2	1.608E-02	.766	.470	.031	1.533	.173
Error	1.007	48	2.099E-02					

a. Computed using alpha = .05

f. Prosodic Perception: Identification:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
VALENCE	Sphericity Assumed	.172	1	.172	5.555	.023	.104	5.555	.637
	Greenhouse-Geisser	.172	1.000	.172	5.555	.023	.104	5.555	.637
	Huynh-Feldt	.172	1.000	.172	5.555	.023	.104	5.555	.637
	Lower-bound	.172	1.000	.172	5.555	.023	.104	5.555	.637
VALENCE * GENDER	Sphericity Assumed	3.251E-03	1	3.251E-03	.105	.747	.002	.105	.062
	Greenhouse-Geisser	3.251E-03	1.000	3.251E-03	.105	.747	.002	.105	.062
	Huynh-Feldt	3.251E-03	1.000	3.251E-03	.105	.747	.002	.105	.062
	Lower-bound	3.251E-03	1.000	3.251E-03	.105	.747	.002	.105	.062
VALENCE * GROUP	Sphericity Assumed	3.099E-02	2	1.549E-02	.501	.609	.020	1.003	.128
	Greenhouse-Geisser	3.099E-02	2.000	1.549E-02	.501	.609	.020	1.003	.128
	Huynh-Feldt	3.099E-02	2.000	1.549E-02	.501	.609	.020	1.003	.128
	Lower-bound	3.099E-02	2.000	1.549E-02	.501	.609	.020	1.003	.128
VALENCE * GENDER * GROUP	Sphericity Assumed	2.940E-02	2	1.470E-02	.476	.624	.019	.951	.123
	Greenhouse-Geisser	2.940E-02	2.000	1.470E-02	.476	.624	.019	.951	.123
	Huynh-Feldt	2.940E-02	2.000	1.470E-02	.476	.624	.019	.951	.123
	Lower-bound	2.940E-02	2.000	1.470E-02	.476	.624	.019	.951	.123
Error(VALENCE)	Sphericity Assumed	1.484	48	3.091E-02					
	Greenhouse-Geisser	1.484	48.000	3.091E-02					
	Huynh-Feldt	1.484	48.000	3.091E-02					
	Lower-bound	1.484	48.000	3.091E-02					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	17.104	1	17.104	236.414	.000	.831	236.414	1.000
GENDER	.161	1	.161	2.226	.142	.044	2.226	.310
GROUP	7.825E-02	2	3.912E-02	.541	.586	.022	1.082	.134
GENDER * GROUP	.302	2	.151	2.085	.135	.080	4.170	.408
Error	3.473	48	7.235E-02					

a. Computed using alpha = .05

g. Prosodic Perception: Discrimination:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
VALENCE	Sphericity Assumed	.114	2	5.675E-02	8.186	.001	.146
	Greenhouse-Geisser	.114	1.320	8.597E-02	8.186	.003	.146
	Huynh-Feldt	.114	1.484	7.646E-02	8.186	.002	.146
	Lower-bound	.114	1.000	.114	8.186	.006	.146
VALENCE * GENDER	Sphericity Assumed	5.935E-03	2	2.967E-03	.428	.653	.009
	Greenhouse-Geisser	5.935E-03	1.320	4.495E-03	.428	.570	.009
	Huynh-Feldt	5.935E-03	1.484	3.998E-03	.428	.594	.009
	Lower-bound	5.935E-03	1.000	5.935E-03	.428	.516	.009
VALENCE * GROUP	Sphericity Assumed	5.691E-02	4	1.423E-02	2.052	.093	.079
	Greenhouse-Geisser	5.691E-02	2.641	2.155E-02	2.052	.123	.079
	Huynh-Feldt	5.691E-02	2.969	1.917E-02	2.052	.115	.079
	Lower-bound	5.691E-02	2.000	2.846E-02	2.052	.140	.079
VALENCE * GENDER * GROUP	Sphericity Assumed	9.099E-03	4	2.275E-03	.328	.858	.013
	Greenhouse-Geisser	9.099E-03	2.641	3.446E-03	.328	.780	.013
	Huynh-Feldt	9.099E-03	2.969	3.065E-03	.328	.803	.013
	Lower-bound	9.099E-03	2.000	4.550E-03	.328	.722	.013
Error(VALENCE)	Sphericity Assumed	.666	96	6.933E-03			
	Greenhouse-Geisser	.666	63.373	1.050E-02			
	Huynh-Feldt	.666	71.254	9.341E-03			
	Lower-bound	.666	48.000	1.387E-02			

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Intercept	131.093	1	131.093	10062.868	.000	.995
GENDER	5.064E-02	1	5.064E-02	3.887	.054	.075
GROUP	3.245E-02	2	1.623E-02	1.246	.297	.049
GENDER * GROUP	6.130E-02	2	3.065E-02	2.353	.106	.089
Error	.625	48	1.303E-02			

3. Group (3) x Gender (2) x Motoric Direction (2)

a. Posed Prosodic Expression to Command Task: F₀ Mean Semitone Difference Scores

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a	
MOTORIC	Sphericity Assumed	95.950	1	95.950	37.959	.000	.442	37.959	1.000
	Greenhouse-Geisser	95.950	1.000	95.950	37.959	.000	.442	37.959	1.000
	Huynh-Feldt	95.950	1.000	95.950	37.959	.000	.442	37.959	1.000
	Lower-bound	95.950	1.000	95.950	37.959	.000	.442	37.959	1.000
MOTORIC * GROUP	Sphericity Assumed	15.059	2	7.530	2.979	.060	.110	5.958	.553
	Greenhouse-Geisser	15.059	2.000	7.530	2.979	.060	.110	5.958	.553
	Huynh-Feldt	15.059	2.000	7.530	2.979	.060	.110	5.958	.553
	Lower-bound	15.059	2.000	7.530	2.979	.060	.110	5.958	.553
MOTORIC * GENDER	Sphericity Assumed	10.411	1	10.411	4.119	.048	.079	4.119	.512
	Greenhouse-Geisser	10.411	1.000	10.411	4.119	.048	.079	4.119	.512
	Huynh-Feldt	10.411	1.000	10.411	4.119	.048	.079	4.119	.512
	Lower-bound	10.411	1.000	10.411	4.119	.048	.079	4.119	.512
MOTORIC * GROUP * GENDER	Sphericity Assumed	.731	2	.365	.145	.866	.006	.289	.071
	Greenhouse-Geisser	.731	2.000	.365	.145	.866	.006	.289	.071
	Huynh-Feldt	.731	2.000	.365	.145	.866	.006	.289	.071
	Lower-bound	.731	2.000	.365	.145	.866	.006	.289	.071
Error(MOTORIC)	Sphericity Assumed	121.331	48	2.528					
	Greenhouse-Geisser	121.331	48.000	2.528					
	Huynh-Feldt	121.331	48.000	2.528					
	Lower-bound	121.331	48.000	2.528					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	385.624	1	385.624	49.170	.000	.506	49.170	1.000
GROUP	8.441	2	4.220	.538	.587	.022	1.076	.134
GENDER	.569	1	.569	.073	.789	.002	.073	.058
GROUP * GENDER	58.379	2	29.190	3.722	.031	.134	7.444	.655
Error	376.448	48	7.843					

a. Computed using alpha = .05

b. Posed Prosodic Expression to Command Task: F₀ Standard Deviation Semitone Difference Scores:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
MOTORIC	Sphericity Assumed	16.974	1	16.974	10.262	.002	.176	10.262	.881
	Greenhouse-Geisser	16.974	1.000	16.974	10.262	.002	.176	10.262	.881
	Huynh-Feldt	16.974	1.000	16.974	10.262	.002	.176	10.262	.881
	Lower-bound	16.974	1.000	16.974	10.262	.002	.176	10.262	.881
MOTORIC * GROUP	Sphericity Assumed	.611	2	.306	.185	.832	.008	.370	.077
	Greenhouse-Geisser	.611	2.000	.306	.185	.832	.008	.370	.077
	Huynh-Feldt	.611	2.000	.306	.185	.832	.008	.370	.077
	Lower-bound	.611	2.000	.306	.185	.832	.008	.370	.077
MOTORIC * GENDER	Sphericity Assumed	1.388E-02	1	1.388E-02	.008	.927	.000	.008	.051
	Greenhouse-Geisser	1.388E-02	1.000	1.388E-02	.008	.927	.000	.008	.051
	Huynh-Feldt	1.388E-02	1.000	1.388E-02	.008	.927	.000	.008	.051
	Lower-bound	1.388E-02	1.000	1.388E-02	.008	.927	.000	.008	.051
MOTORIC * GROUP * GENDER	Sphericity Assumed	6.065	2	3.033	1.833	.171	.071	3.667	.364
	Greenhouse-Geisser	6.065	2.000	3.033	1.833	.171	.071	3.667	.364
	Huynh-Feldt	6.065	2.000	3.033	1.833	.171	.071	3.667	.364
	Lower-bound	6.065	2.000	3.033	1.833	.171	.071	3.667	.364
Error(MOTORIC)	Sphericity Assumed	79.396	48	1.654					
	Greenhouse-Geisser	79.396	48.000	1.654					
	Huynh-Feldt	79.396	48.000	1.654					
	Lower-bound	79.396	48.000	1.654					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	89.970	1	89.970	18.262	.000	.276	18.262	.987
GROUP	8.468	2	4.234	.859	.430	.035	1.719	.189
GENDER	.245	1	.245	.050	.824	.001	.050	.055
GROUP * GENDER	13.360	2	6.680	1.356	.267	.053	2.712	.278
Error	236.480	48	4.927					

a. Computed using alpha = .05

c. Posed Prosodic Expression to Command Task: Duration:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
MOTORIC	Sphericity Assumed	.164	1	.164	4.930	.031	.093	4.930	.585
	Greenhouse-Geisser	.164	1.000	.164	4.930	.031	.093	4.930	.585
	Huynh-Feldt	.164	1.000	.164	4.930	.031	.093	4.930	.585
	Lower-bound	.164	1.000	.164	4.930	.031	.093	4.930	.585
MOTORIC * GROUP	Sphericity Assumed	.100	2	5.006E-02	1.509	.231	.059	3.018	.306
	Greenhouse-Geisser	.100	2.000	5.006E-02	1.509	.231	.059	3.018	.306
	Huynh-Feldt	.100	2.000	5.006E-02	1.509	.231	.059	3.018	.306
	Lower-bound	.100	2.000	5.006E-02	1.509	.231	.059	3.018	.306
MOTORIC * GENDER	Sphericity Assumed	5.320E-02	1	5.320E-02	1.604	.211	.032	1.604	.237
	Greenhouse-Geisser	5.320E-02	1.000	5.320E-02	1.604	.211	.032	1.604	.237
	Huynh-Feldt	5.320E-02	1.000	5.320E-02	1.604	.211	.032	1.604	.237
	Lower-bound	5.320E-02	1.000	5.320E-02	1.604	.211	.032	1.604	.237
MOTORIC * GROUP * GENDER	Sphericity Assumed	2.240E-02	2	1.120E-02	.338	.715	.014	.675	.101
	Greenhouse-Geisser	2.240E-02	2.000	1.120E-02	.338	.715	.014	.675	.101
	Huynh-Feldt	2.240E-02	2.000	1.120E-02	.338	.715	.014	.675	.101
	Lower-bound	2.240E-02	2.000	1.120E-02	.338	.715	.014	.675	.101
Error(MOTORIC)	Sphericity Assumed	1.592	48	3.317E-02					
	Greenhouse-Geisser	1.592	48.000	3.317E-02					
	Huynh-Feldt	1.592	48.000	3.317E-02					
	Lower-bound	1.592	48.000	3.317E-02					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	269.365	1	269.365	1196.421	.000	.961	1196.421	1.000
GROUP	.145	2	7.231E-02	.321	.727	.013	.642	.098
GENDER	.126	1	.126	.562	.457	.012	.562	.114
GROUP * GENDER	1.362E-02	2	6.808E-03	.030	.970	.001	.060	.054
Error	10.807	48	.225					

a. Computed using alpha = .05

d. Posed Prosodic Expression to Command Task: Intensity Ratings

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
MOTORIC	Sphericity Assumed	.803	1	.803	3.675	.061	.073	3.675	.467
	Greenhouse-Geisser	.803	1.000	.803	3.675	.061	.073	3.675	.467
	Huynh-Feldt	.803	1.000	.803	3.675	.061	.073	3.675	.467
	Lower-bound	.803	1.000	.803	3.675	.061	.073	3.675	.467
MOTORIC * NEUT_INT	Sphericity Assumed	5.405E-02	1	5.405E-02	.247	.621	.005	.247	.078
	Greenhouse-Geisser	5.405E-02	1.000	5.405E-02	.247	.621	.005	.247	.078
	Huynh-Feldt	5.405E-02	1.000	5.405E-02	.247	.621	.005	.247	.078
	Lower-bound	5.405E-02	1.000	5.405E-02	.247	.621	.005	.247	.078
MOTORIC * GENDER	Sphericity Assumed	.326	1	.326	1.493	.228	.031	1.493	.224
	Greenhouse-Geisser	.326	1.000	.326	1.493	.228	.031	1.493	.224
	Huynh-Feldt	.326	1.000	.326	1.493	.228	.031	1.493	.224
	Lower-bound	.326	1.000	.326	1.493	.228	.031	1.493	.224
MOTORIC * GROUP	Sphericity Assumed	1.544	2	.772	3.532	.037	.131	7.063	.630
	Greenhouse-Geisser	1.544	2.000	.772	3.532	.037	.131	7.063	.630
	Huynh-Feldt	1.544	2.000	.772	3.532	.037	.131	7.063	.630
	Lower-bound	1.544	2.000	.772	3.532	.037	.131	7.063	.630
MOTORIC * GENDER * GROUP	Sphericity Assumed	1.123	2	.561	2.568	.087	.099	5.135	.488
	Greenhouse-Geisser	1.123	2.000	.561	2.568	.087	.099	5.135	.488
	Huynh-Feldt	1.123	2.000	.561	2.568	.087	.099	5.135	.488
	Lower-bound	1.123	2.000	.561	2.568	.087	.099	5.135	.488
Error(MOTORIC)	Sphericity Assumed	10.273	47	.219					
	Greenhouse-Geisser	10.273	47.000	.219					
	Huynh-Feldt	10.273	47.000	.219					
	Lower-bound	10.273	47.000	.219					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	23.604	1	23.604	20.875	.000	.308	20.875	.994
NEUT_INT	17.837	1	17.837	15.774	.000	.251	15.774	.973
GENDER	.555	1	.555	.491	.487	.010	.491	.106
GROUP	5.548	2	2.774	2.453	.097	.095	4.906	.469
GENDER * GROUP	3.425	2	1.713	1.515	.230	.061	3.029	.306
Error	53.145	47	1.131					

a. Computed using alpha = .05

e. Posed Prosodic Expression to Command Task: Accuracy Ratings:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
MOTORIC	Sphericity Assumed	3.532E-02	1	3.532E-02	1.475	.230	.030	.222
	Greenhouse-Geisser	3.532E-02	1.000	3.532E-02	1.475	.230	1.475	.222
	Huynh-Feldt	3.532E-02	1.000	3.532E-02	1.475	.230	1.475	.222
	Lower-bound	3.532E-02	1.000	3.532E-02	1.475	.230	1.475	.222
MOTORIC * GROUP	Sphericity Assumed	.114	2	5.680E-02	2.372	.104	.090	.457
	Greenhouse-Geisser	.114	2.000	5.680E-02	2.372	.104	4.744	.457
	Huynh-Feldt	.114	2.000	5.680E-02	2.372	.104	4.744	.457
	Lower-bound	.114	2.000	5.680E-02	2.372	.104	4.744	.457
MOTORIC * GENDER	Sphericity Assumed	4.549E-03	1	4.549E-03	.190	.665	.004	.071
	Greenhouse-Geisser	4.549E-03	1.000	4.549E-03	.190	.665	.190	.071
	Huynh-Feldt	4.549E-03	1.000	4.549E-03	.190	.665	.190	.071
	Lower-bound	4.549E-03	1.000	4.549E-03	.190	.665	.190	.071
MOTORIC * GROUP * GENDER	Sphericity Assumed	1.533E-02	2	7.664E-03	.320	.728	.013	.098
	Greenhouse-Geisser	1.533E-02	2.000	7.664E-03	.320	.728	.640	.098
	Huynh-Feldt	1.533E-02	2.000	7.664E-03	.320	.728	.640	.098
	Lower-bound	1.533E-02	2.000	7.664E-03	.320	.728	.640	.098
Error(MOTORIC)	Sphericity Assumed	1.149	48	2.395E-02				
	Greenhouse-Geisser	1.149	48.000	2.395E-02				
	Huynh-Feldt	1.149	48.000	2.395E-02				
	Lower-bound	1.149	48.000	2.395E-02				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	5.218	1	5.218	387.626	.000	.890	387.626	1.000
GROUP	.319	2	.159	11.846	.000	.330	23.692	.992
GENDER	1.333E-02	1	1.333E-02	.990	.325	.020	.990	.164
GROUP * GENDER	5.509E-04	2	2.754E-04	.020	.980	.001	.041	.053
Error	.646	48	1.346E-02					

a. Computed using alpha = .05

f. Prosodic Perception: Identification:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
MOTORIC	Sphericity Assumed	4.064E-02	1	4.064E-02	1.337	.253	.027	1.337	.205
	Greenhouse-Geisser	4.064E-02	1.000	4.064E-02	1.337	.253	.027	1.337	.205
	Huynh-Feldt	4.064E-02	1.000	4.064E-02	1.337	.253	.027	1.337	.205
	Lower-bound	4.064E-02	1.000	4.064E-02	1.337	.253	.027	1.337	.205
MOTORIC * GROUP	Sphericity Assumed	3.287E-02	2	1.644E-02	.541	.586	.022	1.081	.134
	Greenhouse-Geisser	3.287E-02	2.000	1.644E-02	.541	.586	.022	1.081	.134
	Huynh-Feldt	3.287E-02	2.000	1.644E-02	.541	.586	.022	1.081	.134
	Lower-bound	3.287E-02	2.000	1.644E-02	.541	.586	.022	1.081	.134
MOTORIC * GENDER	Sphericity Assumed	2.089E-02	1	2.089E-02	.687	.411	.014	.687	.128
	Greenhouse-Geisser	2.089E-02	1.000	2.089E-02	.687	.411	.014	.687	.128
	Huynh-Feldt	2.089E-02	1.000	2.089E-02	.687	.411	.014	.687	.128
	Lower-bound	2.089E-02	1.000	2.089E-02	.687	.411	.014	.687	.128
MOTORIC * GROUP * GENDER	Sphericity Assumed	3.002E-02	2	1.501E-02	.494	.613	.020	.987	.126
	Greenhouse-Geisser	3.002E-02	2.000	1.501E-02	.494	.613	.020	.987	.126
	Huynh-Feldt	3.002E-02	2.000	1.501E-02	.494	.613	.020	.987	.126
	Lower-bound	3.002E-02	2.000	1.501E-02	.494	.613	.020	.987	.126
Error(MOTORIC)	Sphericity Assumed	1.459	48	3.040E-02					
	Greenhouse-Geisser	1.459	48.000	3.040E-02					
	Huynh-Feldt	1.459	48.000	3.040E-02					
	Lower-bound	1.459	48.000	3.040E-02					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	19.252	1	19.252	212.059	.000	.815	212.059	1.000
GROUP	.114	2	5.677E-02	.625	.539	.025	1.251	.148
GENDER	.183	1	.183	2.021	.162	.040	2.021	.286
GROUP * GENDER	.322	2	.161	1.771	.181	.069	3.543	.353
Error	4.358	48	9.079E-02					

a. Computed using alpha = .05

4. Group (3) x Gender (2) x Arousal Level (2)

a. Posed Prosodic Expression to Command Task: F₀ Mean Semitone Difference Scores:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
AROUSAL	Sphericity Assumed	16.973	1	16.973	12.210	.001	.203	12.210	.928
	Greenhouse-Geisser	16.973	1.000	16.973	12.210	.001	.203	12.210	.928
	Huynh-Feldt	16.973	1.000	16.973	12.210	.001	.203	12.210	.928
	Lower-bound	16.973	1.000	16.973	12.210	.001	.203	12.210	.928
AROUSAL * GROUP	Sphericity Assumed	7.191	2	3.595	2.587	.086	.097	5.173	.492
	Greenhouse-Geisser	7.191	2.000	3.595	2.587	.086	.097	5.173	.492
	Huynh-Feldt	7.191	2.000	3.595	2.587	.086	.097	5.173	.492
	Lower-bound	7.191	2.000	3.595	2.587	.086	.097	5.173	.492
AROUSAL * GENDER	Sphericity Assumed	7.576	1	7.576	5.450	.024	.102	5.450	.628
	Greenhouse-Geisser	7.576	1.000	7.576	5.450	.024	.102	5.450	.628
	Huynh-Feldt	7.576	1.000	7.576	5.450	.024	.102	5.450	.628
	Lower-bound	7.576	1.000	7.576	5.450	.024	.102	5.450	.628
AROUSAL * GROUP * GENDER	Sphericity Assumed	6.097E-02	2	3.048E-02	.022	.978	.001	.044	.053
	Greenhouse-Geisser	6.097E-02	2.000	3.048E-02	.022	.978	.001	.044	.053
	Huynh-Feldt	6.097E-02	2.000	3.048E-02	.022	.978	.001	.044	.053
	Lower-bound	6.097E-02	2.000	3.048E-02	.022	.978	.001	.044	.053
Error(AROUSAL)	Sphericity Assumed	66.721	48	1.390					
	Greenhouse-Geisser	66.721	48.000	1.390					
	Huynh-Feldt	66.721	48.000	1.390					
	Lower-bound	66.721	48.000	1.390					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	383.327	1	383.327	50.520	.000	.513	50.520	1.000
GROUP	6.475	2	3.238	.427	.655	.017	.853	.115
GENDER	.977	1	.977	.129	.721	.003	.129	.064
GROUP * GENDER	47.823	2	23.912	3.151	.052	.116	6.303	.578
Error	364.209	48	7.588					

a. Computed using alpha = .05

b. Posed Prosodic Expression to Command Task: F_0 Standard Deviation
Semitone Difference Scores:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
AROUSAL	Sphericity Assumed	21.156	1	21.156	4.402	.041	.084	4.402	.538
	Greenhouse-Geisser	21.156	1.000	21.156	4.402	.041	.084	4.402	.538
	Huynh-Feldt	21.156	1.000	21.156	4.402	.041	.084	4.402	.538
	Lower-bound	21.156	1.000	21.156	4.402	.041	.084	4.402	.538
AROUSAL * GROUP	Sphericity Assumed	3.342	2	1.671	.348	.708	.014	.695	.103
	Greenhouse-Geisser	3.342	2.000	1.671	.348	.708	.014	.695	.103
	Huynh-Feldt	3.342	2.000	1.671	.348	.708	.014	.695	.103
	Lower-bound	3.342	2.000	1.671	.348	.708	.014	.695	.103
AROUSAL * GENDER	Sphericity Assumed	1.240	1	1.240	.258	.614	.005	.258	.079
	Greenhouse-Geisser	1.240	1.000	1.240	.258	.614	.005	.258	.079
	Huynh-Feldt	1.240	1.000	1.240	.258	.614	.005	.258	.079
	Lower-bound	1.240	1.000	1.240	.258	.614	.005	.258	.079
AROUSAL * GROUP * GENDER	Sphericity Assumed	19.232	2	9.616	2.001	.146	.077	4.002	.393
	Greenhouse-Geisser	19.232	2.000	9.616	2.001	.146	.077	4.002	.393
	Huynh-Feldt	19.232	2.000	9.616	2.001	.146	.077	4.002	.393
	Lower-bound	19.232	2.000	9.616	2.001	.146	.077	4.002	.393
Error(AROUSAL)	Sphericity Assumed	230.662	48	4.805					
	Greenhouse-Geisser	230.662	48.000	4.805					
	Huynh-Feldt	230.662	48.000	4.805					
	Lower-bound	230.662	48.000	4.805					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	69.814	1	69.814	13.625	.001	.221	13.625	.951
GROUP	2.212	2	1.106	.216	.807	.009	.432	.082
GENDER	2.233E-02	1	2.233E-02	.004	.948	.000	.004	.050
GROUP * GENDER	.696	2	.348	.068	.934	.003	.136	.060
Error	245.944	48	5.124					

a. Computed using alpha = .05

c. Posed Prosodic Expression to Command Task: Duration:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
AROUSAL	Sphericity Assumed	.314	1	.314	10.327	.002	.177	10.327	.883
	Greenhouse-Geisser	.314	1.000	.314	10.327	.002	.177	10.327	.883
	Huynh-Feldt	.314	1.000	.314	10.327	.002	.177	10.327	.883
	Lower-bound	.314	1.000	.314	10.327	.002	.177	10.327	.883
AROUSAL * GENDER	Sphericity Assumed	6.504E-03	1	6.504E-03	.214	.646	.004	.214	.074
	Greenhouse-Geisser	6.504E-03	1.000	6.504E-03	.214	.646	.004	.214	.074
	Huynh-Feldt	6.504E-03	1.000	6.504E-03	.214	.646	.004	.214	.074
	Lower-bound	6.504E-03	1.000	6.504E-03	.214	.646	.004	.214	.074
AROUSAL * GROUP	Sphericity Assumed	.107	2	5.344E-02	1.758	.183	.068	3.515	.350
	Greenhouse-Geisser	.107	2.000	5.344E-02	1.758	.183	.068	3.515	.350
	Huynh-Feldt	.107	2.000	5.344E-02	1.758	.183	.068	3.515	.350
	Lower-bound	.107	2.000	5.344E-02	1.758	.183	.068	3.515	.350
AROUSAL * GENDER * GROUP	Sphericity Assumed	3.120E-02	2	1.560E-02	.513	.602	.021	1.026	.130
	Greenhouse-Geisser	3.120E-02	2.000	1.560E-02	.513	.602	.021	1.026	.130
	Huynh-Feldt	3.120E-02	2.000	1.560E-02	.513	.602	.021	1.026	.130
	Lower-bound	3.120E-02	2.000	1.560E-02	.513	.602	.021	1.026	.130
Error(AROUSAL)	Sphericity Assumed	1.459	48	3.041E-02					
	Greenhouse-Geisser	1.459	48.000	3.041E-02					
	Huynh-Feldt	1.459	48.000	3.041E-02					
	Lower-bound	1.459	48.000	3.041E-02					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	264.404	1	264.404	1224.782	.000	.962	1224.782	1.000
GENDER	.103	1	.103	.475	.494	.010	.475	.104
GROUP	9.334E-02	2	4.667E-02	.216	.806	.009	.432	.082
GENDER * GROUP	.116	2	5.812E-02	.269	.765	.011	.538	.090
Error	10.362	48	.216					

a. Computed using alpha = .05

d. Posed Prosodic Expression to Command Task: Intensity Ratings:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
AROUSAL	Sphericity Assumed	3.979E-05	1	3.979E-05	.000	.990	.000	.000	.050
	Greenhouse-Geisser	3.979E-05	1.000	3.979E-05	.000	.990	.000	.000	.050
	Huynh-Feldt	3.979E-05	1.000	3.979E-05	.000	.990	.000	.000	.050
	Lower-bound	3.979E-05	1.000	3.979E-05	.000	.990	.000	.000	.050
AROUSAL * NEUT_INT	Sphericity Assumed	.149	1	.149	.586	.448	.012	.586	.116
	Greenhouse-Geisser	.149	1.000	.149	.586	.448	.012	.586	.116
	Huynh-Feldt	.149	1.000	.149	.586	.448	.012	.586	.116
	Lower-bound	.149	1.000	.149	.586	.448	.012	.586	.116
AROUSAL * GENDER	Sphericity Assumed	1.264E-03	1	1.264E-03	.005	.944	.000	.005	.051
	Greenhouse-Geisser	1.264E-03	1.000	1.264E-03	.005	.944	.000	.005	.051
	Huynh-Feldt	1.264E-03	1.000	1.264E-03	.005	.944	.000	.005	.051
	Lower-bound	1.264E-03	1.000	1.264E-03	.005	.944	.000	.005	.051
AROUSAL * GROUP	Sphericity Assumed	6.556	2	3.278	12.853	.000	.354	25.706	.995
	Greenhouse-Geisser	6.556	2.000	3.278	12.853	.000	.354	25.706	.995
	Huynh-Feldt	6.556	2.000	3.278	12.853	.000	.354	25.706	.995
	Lower-bound	6.556	2.000	3.278	12.853	.000	.354	25.706	.995
AROUSAL * GENDER * GROUP	Sphericity Assumed	7.845E-02	2	3.923E-02	.154	.858	.007	.308	.072
	Greenhouse-Geisser	7.845E-02	2.000	3.923E-02	.154	.858	.007	.308	.072
	Huynh-Feldt	7.845E-02	2.000	3.923E-02	.154	.858	.007	.308	.072
	Lower-bound	7.845E-02	2.000	3.923E-02	.154	.858	.007	.308	.072
Error(AROUSAL)	Sphericity Assumed	11.987	47	.255					
	Greenhouse-Geisser	11.987	47.000	.255					
	Huynh-Feldt	11.987	47.000	.255					
	Lower-bound	11.987	47.000	.255					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	25.481	1	25.481	28.285	.000	.376	28.285	.999
NEUT_INT	15.112	1	15.112	16.775	.000	.263	16.775	.980
GENDER	2.542	1	2.542	2.822	.100	.057	2.822	.377
GROUP	6.359	2	3.180	3.530	.037	.131	7.059	.629
GENDER * GROUP	.791	2	.396	.439	.647	.018	.878	.117
Error	42.341	47	.901					

a. Computed using alpha = .05

e. Posed Prosodic Expression to Command Task: Accuracy Ratings:

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
AROUSAL	Sphericity Assumed	7.982E-02	1	7.982E-02	2.972	.091	.058	.394
	Greenhouse-Geisser	7.982E-02	1.000	7.982E-02	2.972	.091	2.972	.394
	Huynh-Feldt	7.982E-02	1.000	7.982E-02	2.972	.091	2.972	.394
	Lower-bound	7.982E-02	1.000	7.982E-02	2.972	.091	2.972	.394
AROUSAL * GROUP	Sphericity Assumed	2.433E-02	2	1.216E-02	.453	.638	.019	.120
	Greenhouse-Geisser	2.433E-02	2.000	1.216E-02	.453	.638	.019	.120
	Huynh-Feldt	2.433E-02	2.000	1.216E-02	.453	.638	.019	.120
	Lower-bound	2.433E-02	2.000	1.216E-02	.453	.638	.019	.120
AROUSAL * GENDER	Sphericity Assumed	1.079E-02	1	1.079E-02	.402	.529	.008	.095
	Greenhouse-Geisser	1.079E-02	1.000	1.079E-02	.402	.529	.008	.095
	Huynh-Feldt	1.079E-02	1.000	1.079E-02	.402	.529	.008	.095
	Lower-bound	1.079E-02	1.000	1.079E-02	.402	.529	.008	.095
AROUSAL * GROUP * GENDER	Sphericity Assumed	1.209E-02	2	6.046E-03	.225	.799	.009	.083
	Greenhouse-Geisser	1.209E-02	2.000	6.046E-03	.225	.799	.009	.083
	Huynh-Feldt	1.209E-02	2.000	6.046E-03	.225	.799	.009	.083
	Lower-bound	1.209E-02	2.000	6.046E-03	.225	.799	.009	.083
Error(AROUSAL)	Sphericity Assumed	1.289	48	2.686E-02				
	Greenhouse-Geisser	1.289	48.000	2.686E-02				
	Huynh-Feldt	1.289	48.000	2.686E-02				
	Lower-bound	1.289	48.000	2.686E-02				

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	6.121	1	6.121	323.147	.000	.871	323.147	1.000
GROUP	.359	2	.180	9.480	.000	.283	18.959	.973
GENDER	7.112E-03	1	7.112E-03	.375	.543	.008	.375	.092
GROUP * GENDER	6.617E-02	2	3.309E-02	1.747	.185	.068	3.493	.348
Error	.909	48	1.894E-02					

a. Computed using alpha = .05

f. Prosodic Perception: Identification

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
AROUSAL	Sphericity Assumed	2.366E-02	1	2.366E-02	1.151	.289	.023	1.151	.183
	Greenhouse-Geisser	2.366E-02	1.000	2.366E-02	1.151	.289	.023	1.151	.183
	Huynh-Feldt	2.366E-02	1.000	2.366E-02	1.151	.289	.023	1.151	.183
	Lower-bound	2.366E-02	1.000	2.366E-02	1.151	.289	.023	1.151	.183
AROUSAL * GENDER	Sphericity Assumed	3.827E-02	1	3.827E-02	1.862	.179	.037	1.862	.267
	Greenhouse-Geisser	3.827E-02	1.000	3.827E-02	1.862	.179	.037	1.862	.267
	Huynh-Feldt	3.827E-02	1.000	3.827E-02	1.862	.179	.037	1.862	.267
	Lower-bound	3.827E-02	1.000	3.827E-02	1.862	.179	.037	1.862	.267
AROUSAL * GROUP	Sphericity Assumed	2.331E-02	2	1.166E-02	.567	.571	.023	1.134	.139
	Greenhouse-Geisser	2.331E-02	2.000	1.166E-02	.567	.571	.023	1.134	.139
	Huynh-Feldt	2.331E-02	2.000	1.166E-02	.567	.571	.023	1.134	.139
	Lower-bound	2.331E-02	2.000	1.166E-02	.567	.571	.023	1.134	.139
AROUSAL * GENDER * GROUP	Sphericity Assumed	2.376E-03	2	1.188E-03	.058	.944	.002	.116	.058
	Greenhouse-Geisser	2.376E-03	2.000	1.188E-03	.058	.944	.002	.116	.058
	Huynh-Feldt	2.376E-03	2.000	1.188E-03	.058	.944	.002	.116	.058
	Lower-bound	2.376E-03	2.000	1.188E-03	.058	.944	.002	.116	.058
Error(AROUSAL)	Sphericity Assumed	.986	48	2.055E-02					
	Greenhouse-Geisser	.986	48.000	2.055E-02					
	Huynh-Feldt	.986	48.000	2.055E-02					
	Lower-bound	.986	48.000	2.055E-02					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared	Noncent. Parameter	Observed Power ^a
Intercept	20.779	1	20.779	235.174	.000	.830	235.174	1.000
GENDER	9.300E-02	1	9.300E-02	1.053	.310	.021	1.053	.171
GROUP	6.910E-02	2	3.455E-02	.391	.679	.016	.782	.109
GENDER * GROUP	.228	2	.114	1.291	.284	.051	2.583	.266
Error	4.241	48	8.836E-02					

a. Computed using alpha = .05

Appendix B.

Correlation Tables for all Inter-Relationship Comparisons

A. Intensity Ratings VS. F₀ Mean Semitone Difference Scores

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	-.101	.035	-.007	.063	.250	.087	.246	-.318
LBD	.549*	-.137	.635**	.753**	.453	.492*	.346	.411
NC	.763**	.275	.434	.331	.196	.147	.462	.298
ALL	.515**	.113	.345*	.383**	.298*	.289*	.374**	.088
MEN	.598**	.175	.312	.357*	.333	.319	.573**	-.012
WOM.	.368	.022	.397	.360	.237	.255	-.043	.275
BD	.342*	-.052	.300	.291	.348*	.346*	.294	-.007

Note: * = p is significant at .05 level; ** = p < .001

B. Intensity Ratings Vs. F₀ Standard Deviation Semitone Difference Scores

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	-.370	-.408	-.249	.180	-.140	-.446	-.258	-.442
LBD	.191	-.055	.739**	-.477	.424	.230	.328	.493*
NC	-.302	-.028	-.354	.212	.322	.438	-.254	.543*
ALL	-.163	-.232	-.009	-.110	.211	-.042	-.087	.168
MEN	-.244	-.346*	-.136	-.101	.175	.013	-.186	.001
WOM.	.000	.071	.230	-.092	.308	-.124	.321	.507*
BD	-.044	-.255	.165	-.257	.158	-.171	.036	-.037

Note: * = p is significant at .05 level; ** = p < .001

C. Intensity Ratings vs. Duration (seconds)

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	.054	.238	-.271	-.307	.170	.349	.026	.153
LBD	.432	.121	-.018	.159	.414	.334	.461	.290
NC	.198	-.350	.063	.255	.327	-.069	-.190	.077
ALL	.245	-.113	-.104	.276*	.307*	.212	.111	.140
MEN	.092	.039	-.060	-.060	.327	.311	-.106	.004
WOM.	.360	-.353	.330	.041	.270	.053	.504*	.446*
BD	.297	.375*	-.140	.051	.303	.329	.218	.163

Note: * = p is significant at .05 level; ** = p < .001

D. Accuracy Ratings vs. F₀ Mean Semitone Difference Scores

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	.105	-.214	-.275	-.489*	.094	-.157	.223	-.405
LBD	-.199	-.137	.077	-.453	.362	-.013	-.583*	-.350
NC	-.348	-.166	-.411	-.172	.297	.208	.027	.377
ALL	-.123	.059	-.229	-.329*	.224	-.010	.053	-.055
MEN	-.300	-.071	-.269	-.502**	.296	-.123	.084	-.102
WOM.	.260	-.063	-.172	-.082	.133	.285	-.024	-.002
BD	-.037	-.153	-.124	-.328	.195	-.132	.033	-.357*

Note: * = p is significant at .05 level; ** = p < .001

E. Accuracy Ratings vs. F₀ Standard Deviation Semitone Difference Scores

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	-.058	.151	-.178	-.082	.038	.150	.188	-.274
LBD	-.002	.264	.154	.388	.266	-.104	-.033	-.100
NC	.102	.276	.164	-.349	.138	-.299	-.321	.488*
ALL	.102	.146	.000	-.083	.156	-.031	-.093	.095
MEN	-.031	.084	-.059	.015	.230	-.145	-.135	-.033
WOM.	.404	.320	.068	-.311	.026	.127	.059	.283
BD	-.019	.161	-.081	.102	.170	.092	.104	-.204

Note: * = p is significant at .05 level; ** = p < .001

F. Accuracy Ratings vs. Duration (seconds)

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	-.004	-.588*	.034	.024	-.109	-.129	-.110	.133
LBD	-.284	-.040	-.271	.187	.137	.011	-.326	-.313
NC	-.128	.210	-.034	-.252	.300	-.204	-.115	.019
ALL	-.167	-.032	-.122	.008	.080	-.098	-.114	-.002
MEN	-.061	-.118	-.015	.089	-.009	.050	-.065	.022
WOM.	-.325	.098	-.273	-.150	.017	.074	-.212	-.071
BD	-.242	-.066	-.150	.034	.007	-.071	-.147	-.019

Note: * = p is significant at .05 level; ** = p < .001

G. Accuracy Ratings vs. Comprehension Identification Accuracy

	Happy	PS	Interest	Sad	Disgust	Fear	Anger	UPS
RBD	-.067	-.009	-.495*	.065	-.228	.026	-.195	.178
LBD	-.325	-.101	-.045	.518*	-.342	.162	-.147	.507*
NC	.275	.037	.109	.391	-.125	.014	-.492*	.220
ALL	-.020	.058	-.053	.218	.024	.028	-.157	.226
MEN	.291	-.001	.023	.327	.020	-.030	-.238	.327
WOM.	-.370	.164	-.084	-.019	.064	.130	.084	.176
BD	-.081	.011	-.153	.045	.044	-.080	.026	.211

Note: * = p is significant at .05 level; ** = p < .001

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