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The Identification of Affective-Prosodic Stimuli by Left- and Right-Hemisphere-Damaged Subjects: All Errors Are Not Created Equal

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Impairments in listening tasks that require subjects to match affective-prosodic speech utterances with appropriate facial expressions have been reported after both left- and right-hemisphere damage. In the present study, both left- and right-hemisphere-damaged patients were found to perform poorly compared to a nondamaged control group on a typical affective-prosodic listening task using four emotional types (happy, sad, angry, surprised). To determine if the two brain-damaged groups were exhibiting a similar pattern of performance with respect to their use of acoustic cues, the 16 stimulus utterances were analyzed acoustically, and the results were incorporated into an analysis of the errors made by the patients. A discriminant function analysis using acoustic cues alone indicated that fundamental frequency (FO) variability, mean FO, and syllable durations most successfully distinguished the four emotional sentence types. A similar analysis that incorporated the misclassifications made by the patients revealed that the left-hemisphere-damaged and right-hemisphere-damaged groups were utilizing these acoustic cues differently. The results of this and other studies suggest that rather than being lateralized to a single cerebral hemisphere in a fashion analogous to language, prosodic processes are made up of multiple skills and functions distributed across cerebral systems.

KEY WORDS: prosody, cerebral dominance, brain damage, speech perception, emotions

Elementary studies of normal intonation in speech are distinguished by their variety. Although there is general agreement on basic elements and fundamental principles for language (e.g., phonemes and words as discrete combinatorial units), no such consensual foundation for a theory of speech prosody exists (Bolinger, 1972; 1986; Crystal, 1969, 1973; Ladd, 1980; Scherer, 1981). It is known that intonation is cued by fundamental frequency, intensity, duration, and voice quality; however, a parsimonious description of normal performance depicting how acoustic-phonetic parameters combine to signal linguistic and affective meanings continues to be elusive (Johnson, Emde, Scherer, & Klinnert, 1986; Lieberman & Michaels, 1962). Similarly, scientific conceptualization of human emotions and moods, which underlie the communication of affective prosodic meanings, is similarly unsettled (Benson, 1984; Papanicolaou, 1991). Thus it is not surprising that the results of studies probing the production and reception of linguistic or affective speech prosody in brain-damaged subjects are disparate and contradictory.

Although disordered expression of emotional prosody has recently been associated with damage to the cerebral hemisphere not specialized for language (Ross & Mesulam, 1979; Tucker, 1981), dysprosodic speech production has also been associated with left-hemisphere damage (Luria, 1966; Monrad-Krohn, 1947), and impaired "melody of speech" has long been included in the diagnostic criteria of Broca's aphasia (Goodglass & Kaplan, 1983). In fact, impaired production of both

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linguistic and affective prosody has been reported after damage to various brain regions, cortical as well as subcortical, and is characteristic of a wide range of dysarthrias (Behrens, 1988; Cancelliere & Kertesz, 1990; Colson, Robin, & Luschei, 1991; Danly & Shapiro, 1982; Danly, Cooper, & Shapiro, 1983; Darley, Aronson, & Brown, 1975; Gandour & Holasuit-Petty, 1988; Kent & Rosenbek, 1982; Luria, 1966; Monrad-Krohn, 1947; Ross, 1980; Ross, Anderson, & Morgan-Fisher, 1989; Shapiro & Danly, 1985; Weniger, 1984).

The variety and inconsistency of results on receptive abilities for prosodic cues are equally troubling. Several studies have reported that patients with right-hemisphere damage were impaired in the recognition of affective prosody compared to nondamaged control subjects (Borod et al., 1990; Edmonson, Ross, Chan, & Seibert, 1987; Gorelick & Ross, 1987; Hughes, Chau, & Su, 1983; Weintraub, Mesulam, & Kramer, 1981), whereas one study found no differences between these groups (Bradvik et al., 1990). However, the relative contribution of the two hemispheres cannot be determined from any of these studies as the effect of left-hemisphere damage on prosodic performance was not examined. Other studies comparing unilaterally damaged groups have found relatively less impairment in patients with left-hemisphere damage than those with right-hemisphere damage (Bowers, Coslett, Bauer, Speedie, & Heilman, 1987; Ehlers & Dalby, 1987; Heilman, Bowers, Speedie, & Coslett, 1984; Heilman, Scholes, & Watson, 1975; Tompkins & Mateer, 1985; Tucker, Watson, & Heilman, 1977), but still others reported that the two unilaterally damaged groups performed similarly on many of these tasks (Cancelliere & Kertesz, 1990; Schlanger, Schlanger, & Gerstmann, 1976; Seron, Van Der Kaa, Vanderlinden, Remits, & Feyereisen, 1982; Tompkins & Flowers, 1985; 1987; Weniger, 1984). In contrast to studies in which patients with left- and right-hemisphere damage were compared directly, Ross, Anderson, and Morgan-Fisher (1989) reported prosodic deficits in 2 patients with left-hemisphere damage. Without presenting any evidence regarding the incidence of such deficits after left-hemisphere damage, they asserted that these patients represented unusual instances of "crossed aprosodia." A role for the basal ganglia in affective-prosodic recognition has also been proposed (Blonder, Gur, & Gur, 1989; Cancelliere & Hausdorf, 1988; Scott, Caird, & Williams, 1984; Speedie, Brake, Folstein, Bowers, & Heilman, 1990).

With respect to affective prosody, the question of brain organization may be further complicated by differences that are due to affective type. It has been suggested that the left and right hemispheres process negative and positive emotions differently (Bear, 1983; Gainotti, 1972; 1983; Sackeim et al., 1982; Sackeim, Putz, Vingian, Coleman, & McElhiney, 1988). Although most of the evidence used to support such claims comes from clinical observation and visual recognition studies, in the domain of receptive prosody, Schlanger, Schlanger, and Gerstman (1976) found a bias against sentences spoken with happy but not angry or sad intonations in both left- and right-hemisphere-damaged groups, whereas Seron et al. (1982) and Borod et al. (1990) found no bias toward negative or positive responses.

The complexity involved in establishing predictable and reliable normal patterns in production of prosodic cues mentioned above, as well as the conflicting clinical evidence for either of the two cerebral hemispheres as the primary source of prosodic ability, casts doubt on claims for hemispheric specialization for prosody of the linguistic or affective variety. The present study was carried out to determine (a) if unilateral hemispheric damage would result in a selective deficit in affective prosody after damage to one side but not to the other, and (b) if the performance of patients in the two groups could contribute some insight into sources of the variability in the literature on receptive prosody after brain damage.

Method

Subjects

Twenty-four patients with left-hemisphere-damage with a mean age of 56.8 ± 11.8 years (range 30–80) and 13 patients with right hemisphere damage, mean age 56.4 ± 13.6 years (range 34–82) were tested, along with 37 nondamaged control subjects, mean age 55.8 ± 17.8 years (range 32–80). Clinical and control subjects ranged in education level from 10th grade to postgraduate education. The control subjects consisted of family members of the study patients, other hospital patients without neurologic disease, and recruits from retirement homes located in the community served by the hospital so that they had a similar educational and socioeconomic background as the study patients.

All patients with left-hemisphere-damage received standard speech-language evaluation and treatment by a qualified speech-language pathologist, and all were aphasic: 14 patients were diagnosed as having a nonfluent aphasia, 3 had fluent aphasia, 2 were anomic, 1 had conduction aphasia, and 4 were globally aphasic. In the left-hemisphere-damaged group, 4 were female and 20 were male, and all but one were right-handed. In the right-hemisphere-damaged group, all patients were right-handed, and 2 of the 13 were female.

Patients in both groups had single, unilateral lesions resulting from a cerebral vascular accident. The presence and site of brain lesions were established from neurological history and examination and by neuroradiological investigation. Computerized tomographic (CT) scans were available for 25 of the patients (13 and 11 in the left- and right-hemisphere groups respectfully). All of the CT scans inspected revealed a unilateral lesion except for two scans in the right-hemisphere group, which were normal; these patients, as well as the two patients in that group for whom a CT scan was not available, were hemiplegic on the left side. Only patients for whom clinical data converged to indicate unequivocally a unilateral lesion were included in the study.

Patients were tested on the protocols described below when medically stable following the cerebral insult, with a median in the left-hemisphere-damaged group of 19.5 months post-onset (mean = 24.5, range 1–144), and a median in the right-hemisphere-damaged group of 6 months post-onset (mean = 28.8, range 1–180). Only those patients who performed successfully on the practice portion of the test protocol were allowed to continue. Informed consent was obtained from all subjects.

Stimuli

Five sentence types with emotionally neutral meanings were selected (e.g., "Lizzie is petting her cat"; "Johnnie is walking his dog"). Each sentence contained 7 syllables. The utterances were spoken by a professional actress who was instructed to say the sentences as naturally as possible with four different emotional intonations—sad, angry, happy, or surprised. Sixteen test stimuli were generated.

This stimulus set was used to elicit linguistic and affective judgments. For the linguistic task, patients were presented with four line drawings of scenes representing the linguistic meaning of the stimuli; for the affective task, patients were presented with line drawings of a happy, sad, angry, or surprised face, with the written word for each emotion below the face. The affective condition began with tape-recorded instructions in the voice of the actress as follows: "Sometimes I feel sad, sometimes happy, sometimes angry, sometimes surprised; and then when I talk, I sound just how I feel. Listen to me talk now, and point to the picture that shows how I feel." The subject had an opportunity to become accustomed to the speaker's voice while hearing the instructions. For the linguistic condition, the instructions, given on tape by the same speaker, stated, "Now listen to me talk, and point to the picture that shows what the sentence means."

Both linguistic and affective conditions were preceded by four practice items, which were reiterated by the examiner until it was clear that the task was understood. Thus, each patient heard four practice items and 16 test items for each condition. When a clear pointing response was elicited, the examiner entered the response onto a separate answer sheet. The order of the tasks (linguistic/affective) was alternated with each subject.

Acoustic Analysis

Each sentence was band-pass filtered (.08–9.5 kHz; Krohn-Hite model 3550), and digitized at a sampling rate of 20 kHz using the Barus Laboratories Interactive Speech System (BLISS) (Mertus, 1984) running on a Digital Equipment Corporation 11/83 microcomputer. Using the waveform editor, the duration of each sentence was measured, and the syllable boundaries and durations were identified. An autocorrelation fundamental frequency (FO) extraction was performed (Mertus, 1985) for each sentence, as was a root-mean-squared determination of relative amplitude. Using the time values for the syllable boundaries, duration, mean FO, and mean amplitude were determined at the syllable level for each sentence. Using the syllable values, both a mean and standard deviation value were derived for duration, FO, and amplitude, resulting in six acoustic parameters for each sentence. These variables provided a basic description of sentence prosody that was consistent with other acoustic studies.

Statistical Analysis

The results of the comprehension test were analyzed using several mixed-design analyses of variance (ANOVAs). Group membership served as a between-subjects factor, whereas task and affect type served as within-subjects factors in analyses of accuracy and errors on the linguistic and affective judgments.

The acoustic measures were subjected to several discriminant analyses using the DSCRIMINANT procedure in SPSS/PC+ (Norusis/SPSS Inc, 1988). In this procedure the MINRESID method, which is a stepwise analysis based on minimizing the sum of unexplained variation between groups, was used. The first discriminant analysis examined the degree to which acoustic cues could differentiate the four affective types by using the six acoustic cues as independent variables to predict the intended affective categories of the 16 sentences. Two subsequent discriminant analyses examined the relationships between misclassifications made by the two patient groups and the acoustic descriptions of the sentences by using the six acoustic cues as independent variables to predict the misclassifications of each of the two patient groups. These analyses applied the initial discriminant analysis to error data, in which each stimulus had been reclassified according to the most frequent affective misclassification made by the left- and right-hemisphere-damaged groups, respectively, rather than by each sentence's intended affective category.

Results

Comprehension Task

The left- and right-brain-damaged groups performed at comparable levels on the affective and linguistic tasks. Results for each group are shown in Table 1. A mixed-design ANOVA revealed a main effect of task that showed that both brain-damaged groups performed significantly better on the linguistic task than on the affective task [$F(1,35) = 16.26$, $p < 0.001$]. There was no main effect of group in this analysis. Although the right-hemisphere-damaged group performed better on the linguistic task than the left-hemisphere-damaged group, as would be expected, this difference was not statistically significant and there was no significant interaction between group and task. Both clinical groups were less accurate than control subjects on both the affective task [$F(2,71) = 9.77$, $p < 0.0001$] and the linguistic task. A statistical comparison was not done for the linguistic task because of the obvious ceiling effect in the control group.

Performance scores on individual emotions were also examined. The two brain-damaged groups did not differ in how accurately they identified sad, happy, angry, or sur-

TABLE 1. Means and standard deviations for the three experimental groups on the linguistic and affective tasks. Values represent the mean number correct on the 16 item tests.

	Task	
	Linguistic	**Affective**
Right hemisphere damage (n = 13)	14.46 ± 2.47	10.92 ± 3.04
Left hemisphere damage (n = 24)	12.00 ± 4.17	10.25 ± 3.44
Normal controls (n = 37)	16.00 ± 0.00	13.73 ± 3.06

TABLE 2. Group means ± one standard deviation for the syllable means (MEAN) and syllable-to-syllable variability (VAR) of the acoustic measures for the four affective sentence types. Fundamental frequency (FO) is presented in Hz, duration is presented in msec, and amplitude is presented in arbitrary root-mean-squared units.

	FO		DURATION		AMPLITUDE	
	MEAN	VAR	MEAN	VAR	MEAN	VAR
Sad	181 ± 7	14 ± 3	258 ± 16	141 ± 42	4,017 ± 890	1,736 ± 316
Angry	131 ± 9	18 ± 4	251 ± 18	132 ± 38	4,305 ± 1,804	2,298 ± 1,765
Happy	196 ± 26	39 ± 12	237 ± 19	151 ± 62	4,740 ± 3,092	2,625 ± 1,587
Surprised	288 ± 58	83 ± 17	220 ± 29	129 ± 29	4,093 ± 238	2,229 ± 223

prised emotions. To further determine whether either group tended to confuse negative (sad, angry) and positive (happy, surprised) emotions, such errors made by the two groups were compared. These analyses revealed that right-hemisphere-damaged patients were significantly more likely than left-hemisphere-damaged patients to erroneously label negative emotions (sad or angry) as positive (happy or surprised). The right-hemisphere-damaged group mislabeled negative emotions as positive 40.4% of the time (of a total of 72 errors), compared to the left-hemisphere-damaged group who did so 18.5% of the time (of a total of 136 errors) [$F(1,32) = 9.69$, $p < 0.01$].

Acoustic Analysis

Summary measures for the acoustic variables are presented for each affect type in Table 2. For each sentence, syllable means and syllable-to-syllable variability were determined for FO, duration, and amplitude, and then means and standard deviations for those measures were calculated across the sentences in each affective category. The syllable means and variability measures of each type of acoustic measure were significantly correlated with each other (FO: $r = 0.77$, $p < 0.001$; duration: $r = 0.69$, $p < 0.01$; amplitude: $r = 0.88$, $p < 0.01$), but there were no significant correlations between the different types of acoustic measure. Although correlated, both mean and variability measures were used in the discriminant function analyses since there was no a priori reason to assume that brain damage would have a comparable impact on the ability to process and retain both types of information about the sentences. A series of one-way ANOVAs demonstrated significant differences across affective categories for only FO means [$F(3,12) = 16.38$, $p < 0.0003$] and FO variability [$F(3,12) = 36.30$, $p < 0.0001$].

In order to determine how affect was conveyed in the sentences used in this study, a discriminant analysis was performed to examine how these acoustic measures predicted the intended affective categories. The first function described by this analysis accounted for 97% of the variance. Examination of the pooled-within-groups correlation between the acoustic measures and the first canonical discriminant function scores indicated that FO variability had the highest correlation ($r = 0.62$). The discrimination scores for this function differed significantly by group [$F(3,12) = 53.54$, $p < 0.0001$]. In a second function, which accounted for 1.7% of the variance, mean FO had the largest pooled-within-groups correlation with the canonical discriminant function score ($r = 0.83$). The discrimination scores for this function also differed significantly by group [$F(3,12) = 30.37$, $p < 0.0001$]. In a third function, which accounted for 1.3% of the variance, duration variability had the largest pooled-within-group correlation with the canonical discriminant function score ($r = 0.37$). The discrimination scores for this function differed significantly by group as well [$F(3,12) = 11.28$, $p < 0.001$]. To depict the way in which the discrimination scores for the first two functions separated the affective sentence categories, each sentence is plotted as a function of these scores in Figure 1. Using these discrimination scores, there is a reasonable separation of sentences by affective category based on these two functions. The surprised and happy sentences were generally well separated from the remaining sentences on both functions one and two, whereas sad and angry were distinguished from each other primarily by function two.

Error Analysis

To determine whether unilateral brain damage produced a systematic misuse of acoustic cues, the errors produced by the patients were incorporated into additional discriminant analyses. The left-hemisphere-damaged and right-hemisphere-damaged groups were analyzed separately. For each group, each stimulus sentence was classified according to its

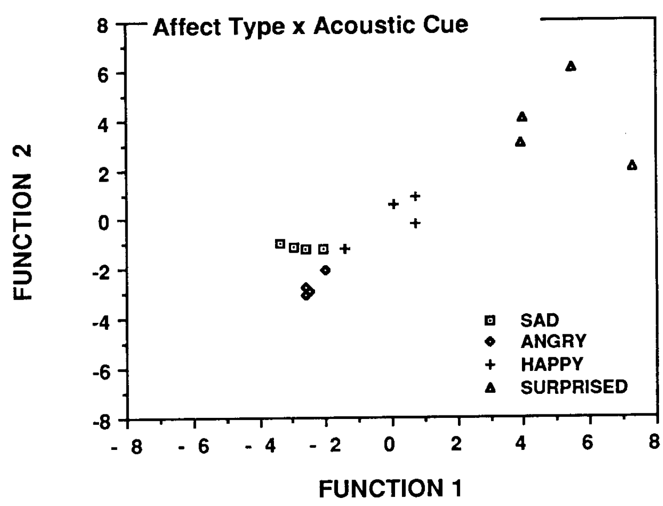

FIGURE 1. The results of the discriminant analysis predicting intended affect using six acoustic parameters. Each sentence is plotted using its discrimination scores for the first two discriminant functions. In this analysis, function one was most highly correlated with FO variability, while function two was most highly correlated with mean FO.

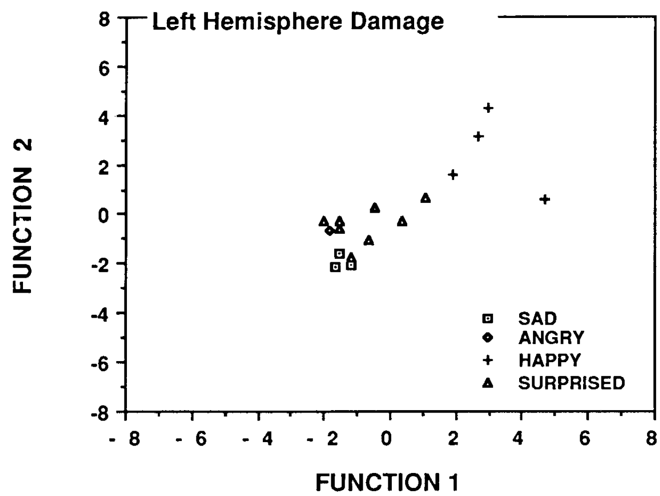

FIGURE 2. The results of the discriminant analysis predicting misclassifications made by the right-hemisphere-damaged group using six acoustic parameters. Each sentence is plotted using its discrimination scores for the first two discriminant functions. *Sad* was not the most frequent affective misclassification made by this group for any of the sentences, so it is not represented in this plot. In this analysis, function one was most highly correlated with syllable duration variability, while function two was most highly correlated with FO variability.

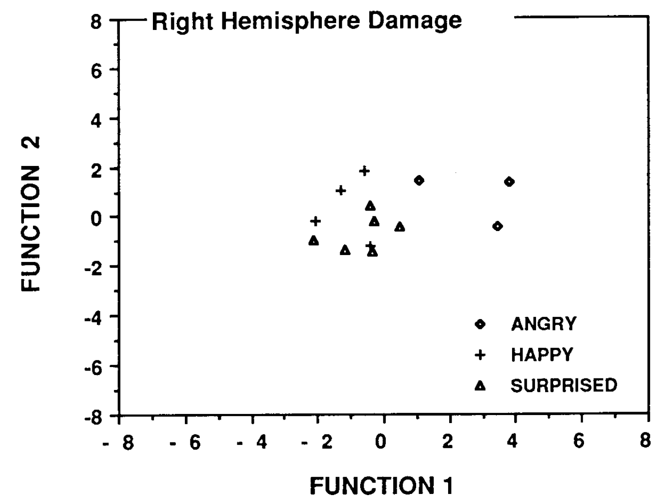

FIGURE 3. The results of the discriminant analysis predicting misclassifications made by the left-hemisphere-damaged group using six acoustic parameters. Each sentence is plotted using its discrimination scores for the first two discriminant functions. In this analysis, function one was most highly correlated with FO variability, while function two was most highly correlated with mean FO.

most frequent affective misclassification. Such misclassifications accounted for 63% of the errors of the left-hemisphere group. For the right-hemisphere group, such misclassifications accounted for 67% of the errors, but there were three stimuli for which there were two equally frequent misclassifications: two ties between happy and surprised, one tie between sad and happy. These three stimuli were excluded from the discriminant analysis of the right-hemisphere group's errors since they could not be unambiguously assigned to a single group. A discriminant analysis was then repeated to determine which acoustic cues, if any, predicted these errors for each patient group.

For the right-hemisphere-damaged group, the first function described by this analysis accounted for 92% of the variance. Examination of the pooled-within-groups correlations indicated that syllable duration variability was most highly correlated with the canonical discriminant function score (r = 0.46). The discrimination scores for this function differed significantly by group, that is, error category [$F(2,10) = 15.19$, $p < 0.001$]. Function two, which accounted for 8% of the variance, yielded canonical discriminant function scores that were most highly correlated with FO variability ($r = 0.92$). The discrimination scores for this function approached a significant difference by group [$F(2,10) = 3.70$, $p = 0.06$]. The way in which the discrimination scores for these functions separated the affective misclassifications of the right-hemisphere-damaged group is represented in Figure 2, in which each sentence is plotted as a function of these scores. In this case, the affective misclassifications are not as well characterized by the discriminant functions as were the intended affective categories in the previous analysis. Consistent with this lack of separation, none of the acoustic measures differed significantly as a function of these error groupings.

In the comparable analysis of the errors made by the left-hemisphere-damaged group, the first function accounted for 98% of the variance. The pooled-within-groups correlation was highest between the canonical discriminant function score and FO variability ($r = 0.79$). The discrimination scores for this function differed significantly by group [$F(3,12) = 17.18$, $p < 0.0001$]. The second function, which accounted for less than 2% of the variance, yielded canonical discriminant function scores that were most highly correlated with mean FO ($r = 0.75$). The discrimination scores for this function also differed significantly by group [$F(3,12) = 11.92$, $p < 0.001$]. The way in which the discrimination scores for these functions separated the affective misclassifications of the left-hemisphere-damaged group is presented in Figure 3. In this case, there is a better separation of affective misclassifications than seen in the right-hemisphere-damaged group. As in the previous comparison of sentences by intended affective category described above in the acoustic analysis section, FO means [$F(3,12) = 16.38$, $p < 0.0003$] and FO variability [$F(3,12) = 36.30$, $p < 0.0001$] differed significantly as a function of these error groupings.

Discussion

Affective-prosodic stimuli found to be recognized equally poorly by left- and right-hemisphere-damaged patients were analyzed to determine the key acoustic cues distinguishing the affective types. The results of the acoustic analysis indicated that fundamental frequency variability was the major cue in distinguishing between affective categories in this stimulus set. These results are in agreement with previous acoustic studies of intonation that demonstrated the importance of fundamental frequency means and changes in signalling affective meanings (Fairbanks, 1940; Lieberman & Michaels, 1962; Williams & Stevens, 1969, 1972). Analysis of the patients' errors further revealed that the right-hemisphere-damaged patients did not appear to be making use of fundamental frequency variability, but rather relied on duration cues to make their affective classifications. In contrast, the left-hemisphere-damaged subjects did appear to make use of fundamental frequency information, but performed poorly nonetheless. Performance by both patient groups was impaired, but for each group, performance was based on a reliance on a different subset of the acoustic cues normally used in the perception of prosody.

What are these cues, and how are they used (or misused) after unilateral brain damage? One of the most important cues to prosody comes from the ability to extract pitch information from the utterance. Previous studies in nondamaged (Sidtis, 1980; 1982; Wolf, 1977) and brain-damaged subjects (Robin, Tranel, & Damasio, 1990; Sidtis, 1984, 1988; Sidtis & Volpe, 1988; Sidtis, Sadler, & Nass, 1989; Zatorre, 1988) have shown that the right hemisphere has an advantage over the left in extracting pitch information from complex auditory stimuli. Whereas this advantage has been related to possible hemispheric differences in musical function, the specialized process reflected in the asymmetry likely plays a role in some forms of receptive dysprosody as well (Sidtis & Feldmann, 1990). Consistent with this notion, the error analysis of the right-hemisphere-damaged patients' performance in this study suggests that this group was not using information about pitch change (fundamental frequency variability) normally. However, the fact that the left-hemisphere-damaged patients also performed poorly despite having information about pitch change available to them suggests that such information is not sufficient for the normal perception of affective prosody.

Another class of cues to prosody are provided by temporal information, which is generally thought to be processed in brain regions separate from those involved in complex-pitch discrimination (Robin, Tranel, & Damasio, 1990). Rapidly changing temporal cues have been strongly associated with left-hemisphere auditory function (Halperin, Nachshon, & Carmon, 1973; Schwartz & Tallal, 1980), and timing problems have been shown to play a primary role in the deficits of patients with Broca's aphasia (Danly & Shapiro, 1982; Gandour, Holasuit-Petty, & Dardarananda, 1989). Furthermore, durational characteristics are known to distinguish meanings via speech prosody (Fairbanks & Hoaglin, 1941; Van Lancker, Canter, & Terbeek, 1981). The error analysis in the present study suggested that both patient groups used timing information in the form of syllable duration variability, and that timing was the principal cue used by the right-hemisphere-damaged (left hemisphere intact) group for affective prosody judgments.

Although analysis of the errors produced by left- and right-hemisphere-damaged patients yielded results that are consistent with demonstrated properties of auditory function in each hemisphere, these findings chiefly reinforce the point that prosody, affective or otherwise, is a complex communicative act that requires the successful integration of multiple cues.

The greater tendency for right-hemisphere-damaged patients to select positive-emotion responses for negative-emotion target utterances is consistent with many previous reports (Bear, 1983; Gainotti, 1972; 1983; Sackeim et al., 1982; Sackeim, Putz, Vingiano, Coleman, & McElhiney, 1988). However, this effect in our study may also be explained by the misuse of specific cues. The discriminant analysis using acoustic cues to classify sentences by intended affect showed that angry and sad (negative emotions) utterances were distinguished from happy and surprised (positive emotions) utterances primarily in terms of fundamental frequency variability, the acoustic cue poorly utilized by the right-hemisphere-damaged group.

Whereas the cerebral hemispheres may well differ in type or degree of affective processing or emotional experience, a clearer understanding of such differences awaits a better characterization of the perceptual cues that signal affective intent. Together with the results of other studies that have documented specific perceptual deficits after unilateral brain damage, this study suggests that receptive dysprosody can be accounted for at the level of perceptual deficit without invoking additional deficits in affective or cognitive processing. Other questions about how the ability to categorize experimental prosodic stimuli is related to the ability to perceive them in natural settings remain to be answered. A dissociation between performance on a typical affective comprehension test and presumed competence in affective prosody was demonstrated by Van Lancker, Cornelius, and Kreiman (1989). Whereas children younger than 8 years of age surely can use and understand affective prosody in everyday situations, they were unable to perform accurately the affective categorization task used in the present study although competent in the linguistic task. Based on the children's poor performance on this task alone, it would be unwise to infer anything about their ability to recognize affective meanings in spoken language outside of this experimental setting.

With respect to expressive dysprosody, questions about the relative contributions of motor control and affective processing also exist. It has been shown that the impaired control of vocal pitch in a patient with a severe expressive dysprosody after a right-hemisphere lesion could be demonstrated in simple vowel production as well (Sidtis, 1984). The deficit was present without having the patient produce utterances that required interrogative inflection or affective intonation. At present, then, the dysprosodies are more suitably placed in the domains of perceptual deficits and dysarthria than in the domain of language.

The fact that both left-hemisphere-damaged and right-hemisphere-damaged groups reported in this study performed at comparable levels, apparently using different sets of acoustic cues, further reinforces the notion that prosody is a multifaceted process (Kent & Rosenbek, 1982; Lieberman & Michaels, 1962; Ryalls, 1988). Accordingly, models of brain-behavior relationships attributing linguistic prosody to left-hemisphere function and affective prosody to right-hemisphere functioning require revision (Van Lancker, 1980). The lack of a systematic understanding of the ways in which various types of brain injury can produce disorders involving the components of normal prosody has probably contributed to the periodic discovery of putatively new syndromes (Heilman, Scholes, & Watson, 1975; Luria, 1966; Monrad-Krohn, 1947; Ross, 1980) that have served to obscure rather than clarify the underlying processes. Simplistic analogies with the neurological organization of language using such terms as "the aprosodias," "crossed aprosodia," or "anomalous dominance" (Ross, Anderson, & Morgan-Fischer, 1989) are unwarranted. Deficits in prosody do not follow the reliable pattern of brain organization seen for speech and language, and a hemispheric specialization for any type of prosody is far from established.

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Appendix

Emotional Sentences

1. happy- - - - - - - - - - - -Johnnie is walking his dog.
2. angry - - - - - - - - - - - -Johnnie is petting his dog.
3. sad - - - - - - - - - - - - -Johnnie is walking his cat.
4. surprised - - - - - - - - -Johnnie is petting his cat.
5. sad - - - - - - - - - - - - -Lizzie is walking her dog.
6. angry - - - - - - - - - - - -Lizzie is petting her dog.
7. surprised - - - - - - - - -Lissie is walking her cat.
8. happy- - - - - - - - - - - -Lizzie is petting her cat.
9. surprised - - - - - - - - -Johnnie is walking his dog.
10. sad - - - - - - - - - - - - -Johnnie is petting his dog.
11. angry - - - - - - - - - - - -Johnnie is walking his cat.
12. happy- - - - - - - - - - - -Johnnie is petting his cat.
13. angry - - - - - - - - - - - -Lizzie is walking her dog.
14. sad - - - - - - - - - - - - -Lizzie is petting her dog.
15. happy- - - - - - - - - - - -Lizzie is walking her cat.
16. surprised - - - - - - - - -Lizzie is petting her cat.