Facial, Prosodic, and Lexical Emotional Perception in Unilateral Brain-Damaged Patients

by

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ABSTRACT

FACIAL, PROSODIC, AND LEXICAL EMOTIONAL PERCEPTION IN UNILATERAL BRAIN-DAMAGED PATIENTS

by

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This study examined emotional perception in unilateral brain-damaged subjects. The uniqueness of this project is that emotional perception was evaluated in three communication channels: facial, prosodic, and lexical. Subjects were 11 right brain-damaged (RBD), 10 left brain-damaged (LBD), and 15 normal control (NC) adults. The RBDs and LBDs were included for study if they suffered brain damage as a result of a unilateral CVA. All subjects were native English speakers or were fluent in English by the age of seven. Subjects did not have any history of mental retardation, psychotropic drug treatment, psychiatric disorder, or substance abuse. Subject groups were comparable with regard to age, education, and occupational level. All subjects received a battery of screening, control, and experimental measures. The screening measures were used to ensure a minimum level of cognitive and sensory functioning. Within each channel, nonemotional tasks were employed to control for factors that could influence performance on the experimental emotional tasks. For the facial channel, neutral face recognition was measured. For the prosodic channel, the ability to process intonation contours was assessed. Within the lexical channel, a nonemotional word identification task, a nonemotional word discrimination task, and a nonemotional sentence identification task were used. For the experimental tasks, subjects identified the emotion represented by facial, prosodic, and lexical stimuli. Both identification and discrimination tasks were employed, and positive and negative emotions were used. For the identification tasks, significant group differences occurred, such that RBDs were impaired relative to LBDs and NCs across the three channels, regardless of valence. No subject-group differences were found for the discrimination tasks. Further, when performance on lexical tasks was examined, RBDs were significantly more impaired on emotional than on nonemotional tasks. When correlation coefficients were computed among channels, the magnitude of the correlations was greater for identification than for discrimination tasks, suggesting the possibility of a general emotional processor for identification. Overall, the results of the present study support the right hemisphere hypothesis for emotion. Future studies should include a larger number of subjects so that other factors (e.g., intrahemispheric lesion location) could be examined.

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I. INTRODUCTION

There have been many speculations in the literature proposing potential mechanisms of emotional processing. One of the first studies to suggest a direct link between emotional processing and the right hemisphere was conducted by Mills (1912). He observed that the presence of a unilateral right-sided lesion was associated with a decrease or paralysis of emotional expression, suggesting that emotional processing was localized within the right hemisphere. Later, Papez (1937) described an anatomical pathway within the subcortical limbic system which was intimately involved in emotion. Over the past 25 years, there has been increasing interest in the role of the neocortex in emotional processing. As a result of this research, a number of hypotheses (e.g., right hemisphere and valence) have been proposed in an attempt to explain the relationship between the right cerebral hemisphere and emotion. In most studies, a single channel of communication (facial, prosodic, or lexical) is evaluated in normals or unilaterally brain-damaged patients.

The unique contribution of the present study was to examine facial, prosodic, and lexical emotional perception in unilateral stroke patients and normal controls. Perception tasks which are part of a larger emotion battery (Borod, Welkowitz, & Obler 1992) were used. Subjects with both right and left hemisphere cortical and subcortical lesions were included. The design of this study provided the opportunity to assess the right hemisphere and valence hypotheses in three channels of communication. Although facial, prosodic, and lexical channels have been used to evaluate emotional expression in brain-damaged subjects (Borod, Koff, Lorch, & Nicholas, 1985), to date, there have not been any studies with neurological populations that have attempted to evaluate emotional perception in all three of these channels in the same subjects. Based on the current literature, it was expected that the right hemisphere hypothesis will be operative for all three channels. In addition, it was anticipated that there would be a relationship between communication channels, with impairment in one channel being accompanied by impairment in the others as well.

II. LITERATURE REVIEW

THEORIES OF EMOTIONAL PROCESSING

There are two major neuropsychological theories describing hemispheric specialization for emotional processing: the right hemisphere hypothesis and the valence hypothesis. These theories address the expression and experience of emotion, as well as emotional perception, which is the primary focus of the present review. (For a detailed description of these theories, see Borod [1992].) The right hemisphere hypothesis postulates that the right hemisphere is dominant for both the expression and perception of emotion, regardless of valence. The valence hypothesis, on the other hand, states that the right hemisphere is dominant for negative emotions and the left hemisphere is dominant for positive emotions. A second version of the valence hypothesis (variant hypothesis) suggests that there is a differential specialization for emotional expression, as a function of valence, but right-hemisphere dominance for emotional perception, regardless of valence. The majority of recent studies have been generally supportive of the right hemisphere hypothesis. Whenever possible in the literature review to follow, studies supporting both the right hemisphere and valence hypotheses will be discussed separately as they pertain to emotional perception.

EMOTIONAL PERCEPTION

A number of different methodologies have been employed in the study of emotional perception in both normal and brain-damaged subjects. Tachistoscopic procedures, lateral eye movement (LEMs), chimeric faces, and dichotic listening techniques are based on the notion that an advantage or superiority to one side reflects activation of the contralateral cerebral hemisphere (e.g., a left ear advantage reflects right hemisphere activation). Physiological measures and identification and discrimination tasks have also been used to elucidate the relationship between hemispheric lateralization and emotional processing in the facial, prosodic, and lexical channels. The following sections will provide a brief overview of the relevant findings for each channel for both normal and clinical populations.

Facial Perception

Normal Subjects. In a study examining recognition memory for emotional and non-emotional faces, Suberi and McKeever (1977) found a left visual field advantage (LVF), as measured by a faster reaction time, for the recognition of emotional faces. Ley and Bryden (1979) used cartoon line drawings of male characters each expressing five emotions, ranging from extremely positive to extremely negative (including neutral).

Subjects were required to determine whether a facial expression presented to either visual field matched the target face which was presented centrally. Their findings revealed a significant left visual field superiority across emotions. In a study by Strauss and Moscovitch (1981), male and female subjects were presented pictures of trained male and female posers. Subjects were shown 18 pairs of faces and were asked to identify whether the face and the emotion were the same or different. Again, there was a significant left visual field superiority across emotions. This study differs from the Suberi and McKeever (1977) and Ley and Bryden (1979) studies in that it included both male and female subjects and employed human posers rather than cartoon faces. In addition, while a LVF was observed for both face and emotional perception, the results suggested that the two functions could be dissociated on the basis of overall processing time. The perception of facial emotion took longer than the perception of facial identity. Studies conducted by McKeever and Dixon (1981) and Ladavas, Umilta, and Ricci-Bitti (1980) also found a left visual field advantage for facial emotional perception.

Further evidence supporting the right hemisphere hypothesis comes from studies utilizing the chimeric faces methodology. Levy, Heller, Banich, and Burton (1983) employed facial stimuli in which an emotional hemiface and a neutral hemiface were presented in either original or mirror-reversed orientations. Subjects were asked to decide which chimera in each pair looked happier. The results revealed a left- hemispace bias (i.e., right hemisphere superiority) in which subjects perceived the chimera which was in their left hemispace as happier than the chimera which was in the right hemispace. There a have been a number of subsequent studies in which a left-hemispace bias has also been found (e.g., Levine & Levy, 1986; Borod, Vingiano, & Cytryn,1989).

In general, the data supporting the valence hypothesis of emotional processing have been inconsistent. Reuter-Lorenz and Davidson (1981) presented an emotional and neutral face, simultaneously, to either the left or right visual field. Emotional stimuli consisted of both happy and sad faces. Subjects were required to indicate to which side the emotional face was presented. The results revealed a dissociation between positive and negative emotional faces. That is, subjects responded more quickly to happy faces presented in the right visual field and to sad faces in the left visual field. Further support for the valence hypothesis comes from a study conducted by Reuter-Lorenz, Givist, and Moscovitch (1983) in which subjects reacted more quickly to happy faces presented to the right visual field and sad faces presented to the left visual field. However, a number of studies have failed to support these findings. For example, in a study by Hirschman and Safer (1982), no differential visual field superiorities were found for either positive or negative facial emotion. In addition, Duda and Brown (1984) found a left visual field advantage for happy faces, but no difference for sad faces. Interestingly, there seems to be support for the variant hypothesis (e.g., Borod, 1992; Davidson 1984; Ehrlichman, 1987) which postulates that the right hemisphere is dominant for the perception of all emotion but that there is a differential specialization for the experience and/or expression of emotion. This version of the valence hypothesis seems to explain the inconsistencies and contradictory findings between the various studies.

Brain-damaged Subjects. There have been a number of studies which have evaluated facial emotional perception in brain-damaged populations. DeKosky, Heilman, Bowers, and Valenstein (1980) presented faces or scenes to patients with either right- (RHD) or left-hemisphere disease (LHD) resulting from various etiologies (stroke, tumor). Subjects were required to either identify (i.e., name) an emotion or discriminate (i.e., make a same or different judgement) between two emotions or faces. Overall, patients with right-hemisphere disease performed more poorly than either patients with left-hemisphere disease or normal control subjects on the emotional discrimination task. There was a similar trend for the identification task. In two studies by Etcoff (1984a and

1984b), RHD subjects were found to be impaired relative to LHD subjects on a range of emotional identification and discrimination tasks. Ahern, Schomer, Kleefield, Blume, Cosgrove, Weintraub, and Mesulam (1991) examined emotional facial perception in epilepsy patients undergoing an intracarotid sodium amytal procedure. They found that emotional faces were rated as less intense as compared to baseline when the non-dominant (usually right) hemisphere was suppressed. One particular advantage of this type of study is that it allows for baseline comparisons within the same subjects.

Bowers, Bauer, Coslett, and Heilman (1985) performed a study in which RHD, LHD, and normal control subjects were required to either name or discriminate between a face conveying one of three emotions (happiness, sadness, or anger) or a neutral face. For the identification tasks, subjects had to either choose the emotion from a list or point to the face which portrayed a particular emotion. On the discrimination tasks, subjects were asked to indicate whether the two stimuli depicted the same face or emotion or whether the stimuli depicted a different face or emotion. Overall, RHD subjects were significantly impaired relative to LHD and normal control subjects across tasks. Further, these differences appear to be independent of difficulties with visuoperception or facial processing. Studies by Borod, Martin, Alpert, Brozgold, and Welkowitz (1993) and Cicone, Wapner, and Gardner (1980) also suggest that the facial emotional processing deficits exhibited by right-brain damaged patients are not related to or a function of deficits in either visuospatial processing or in general (nonemotional) facial recognition.

Borod, Koff, Lorch, and Nicholas (1986b) examined perception and expression (posed and spontaneous) of facial emotion in unilateral stroke patients. Subjects were right brain-damaged (RBD), left brain-damaged (LBD), and normal control (NC) right-handed adults. For the perception tasks, subjects were required to identify the emotion being expressed by the poser in each slide. Eight discrete emotions (3 positive--happiness, sexual arousal, and surprise; 5 negative--sadness, fear, anger, disgust, and confusion) and a neutral expression condition were employed. Overall, results indicate that RBDs are more impaired, relative to LBDs or NCs on tasks assessing both emotional expression and perception. There was some evidence from the Borod et al. study (1986b) to support differential hemispheric specialization as a function of valence for both perception and expression. RBDs were impaired for the perception of negative emotions but not for positive emotions. For expression, RBDs were impaired, relative to the LBDs, in all but the posed negative condition.

Psychiatric Populations. While the present study employs only brain-damaged patients, a review of facial perception in psychiatric populations is included because many of the more recent studies illustrate the importance of utilizing appropriate controls for subject groups and task measures when evaluating clinical populations.

Dougherty, Bartlett, and Izard (1974) compared the performances of schizophrenics (SZs) and a normal control group. Subjects were presented photographs of faces exhibiting one of eight different emotions. They were required to name the emotion being portrayed. Schizophrenics performed less accurately (particularly on negative emotions) than the normal controls. In a study by Muzekari and Bates (1977), subjects were shown posed facial expressions and videotaped scenes depicting various emotions (e.g., happiness, anger) and were asked to name and to choose the emotion being portrayed. The results revealed that chronic schizophrenics (SZs) were significantly less accurate in identifying the emotion on both the facial and videotaped tasks. Further, statistical differences (i.e., SZs impaired relative to normals) were found for the six negative facial expressions but not for the two positive ones. In a cross-sectional study of hospitalized SZs (Walker, Marwit, & Emory, 1980), patients were impaired relative to normals on a facial emotional recognition task which involved 8 discrete emotions (3 positive and 5 negative). This performance difference was observed across all three age groups (child, adolescent, and adult). However, no significant differences as a function of valence, were seen.

There are also a number of studies which have compared the performance of schizophrenics to that of other psychiatric groups, particularly depressed patients. Overall, the findings have generally shown that schizophrenics are more impaired on emotional perception tasks than depressed or normal subjects. In a study by Feinberg, Rifkin, Schaffer, and Walker (1986), schizophrenic and depressed patients were compared to normal subjects on four tasks assessing facial discrimination (i.e., facial identity matching) and emotional recognition and labelling. Schizophrenic (SZs) patients performed significantly more poorly than normals on all tasks and more poorly than the depressed patients on the emotion tasks. The depressed patients were impaired, relative to normals, only on the emotion labelling task. These data suggest that schizophrenics are impaired on various aspects of emotional perception. Walker, McGuire, and Bettes (1984) examined facial recognition and identification in both schizophrenic and affective disorder (schizoaffective disorder [depressed type] and major depression). Their battery consisted of four tasks: facial discrimination, emotion discrimination, emotion labelling, and a multiple-choice emotion test. SZs were impaired, relative to normals, on all tasks, except for facial discrimination. The overall performance of the affective disorder patients was better than the performance of the SZs but worse than the normals. In another study, using a psychiatric control group, Zuroff and Colussy (1986) examined whether schizophrenics have difficulty with the perception of both positive and negative emotions. They found that both SZs and depressed patients were impaired, relative to normals, on all tasks. In addition, there were no significant differences between the performance of the SZs and the depressed patients, regardless of valence (e.g., Davidson, 1984).

A few studies have examined emotional processing in neurological and psychiatric populations. Borod, Welkowitz, Alpert, Brozgold, Martin, Peselow, and Diller (1990) compared the performance of schizophrenic, unipolar depressed, right brain-damaged (RBD), and Parkinson's Disease (PD) patients with normal control subjects on a battery of emotional processing tasks. The battery included perception (identification and discrimination) and expression tasks, using positive and negative emotions, and assessed performance in both the facial and prosodic channels. Overall, SZs were the most impaired of the patient groups on both perception and expression tasks. RBDs were also impaired, relative to normals on most tasks. For perception, no difference in accuracy was observed between SZs and RBDs for either the identification or discrimination task in the facial or vocal channel. Parkinson's patients were intermediate, while depressed and normals subjects were the most accurate. For facial expression, the SZs were the least accurate and produced the least intense emotions. RBDs and PDs were intermediate. For vocal expression, SZs and RBDs were the most impaired while PDs and depressed patients were intermediate. The overall results of this study are consistent with a preliminary study by Borod, Alpert, Brozgold, Martin, Welkowitz, Diller, Peselow, Angrist, and Lieberman (1989). With regards to valence, positive emotions were identified and discriminated more accurately than negative emotions for the facial channel only. RBDs and SZs exhibited a deficit in the expression of positive, relative to negative, emotions. The findings for valence in the emotional expression mode are consistent with earlier work by Borod et al. (1986b) but are in contrast to the literature in general, which has found no systematic deficits as a function for valence. (For review see Borod, 1993.)

Borod, Martin, Alpert, Brozgold, and Welkowitz (1993) examined facial emotional perception in SZs, RBDs, and normal controls. Subjects were given both an identification and a discrimination task which included positive and negative emotions. In addition, tasks controlling for visuospatial (Visual Matrices Test) and nonemotional facial (Benton Facial Recognition) processing were administered. Overall, SZs and RBDs performed significantly poorer than normal controls, but not different from each other, on the emotional perception tasks. Further, RBDs and SZs were also impaired on the Visual Matrices and Facial Recognition Test. When statistical controls were employed through covariate analysis, the group differences on the identification task remained but the differences for the discrimination task did not. For valence, negative emotional stimuli were less accurately identified than positive stimuli. No differences between groups were seen for positive emotions. These findings are basically consistent with the valence theory of emotional processing. This study underscores the importance of utilizing appropriate control measures and lends additional support for the notion of right hemisphere dysfunction in schizophrenia.

<u>Prosodic Perception</u>

Normal Subjects. Haggard and Parkinson (1971) conducted a study in which subjects were presented emotionally-intoned sentences in a dichotic listening paradigm. They obtained a left ear advantage (LEA) for the recognition of emotional intonation and no advantage for the recognition of words in the sentences. Ley and Bryden (1982) paired emotionally-intoned sentences (happy, angry, sad) with monotone sentences. They found a LEA for the emotional sentences and a right ear advantage for the nonemotional sentences. Taken together, these studies support the concept of right hemisphere superiority for the perception of prosodic emotion and left hemisphere dominance for nonemotional linguistic processing. More recent studies by Morais and Ladavas (1987) and Herrero and Hillix (1990) also found a left ear advantage for prosodic emotional stimuli.

Brain-Damaged Subjects. Heilman, Scholes, and Watson (1975) examined the ability of right and left hemisphere patients with temporoparietal lesions to comprehend affective speech. Subjects were presented tape recorded sentences and ask to indicate, by pointing to the appropriate line drawing, either the content of the sentence or the emotional tone (i.e., happy, sad, angry, indifferent). Overall, patients with right hemisphere disease (RHD) performed significantly more poorly on the emotional sentences than either the left hemisphere group or the normal controls. No group differences were observed for the content identification task. In a similar vein, Tucker, Watson, and Heilman (1977) presented subjects with right parietal disease and neglect, conduction aphasics with left hemisphere lesions, and normal subjects tasks which required identification and discrimination of emotionally-intoned sentences. Again, patients with right hemisphere disease (RHD) performed significantly worse than either the patients with left hemisphere disease or normals on both the identification and discrimination tasks. Heilman, Bowers, Speedie, and Coslett (1984) found that RHD patients showed decreased comprehension, relative to left hemisphere disease patients on emotional prosody tasks. In addition, both patient groups were impaired on a nonemotional prosody task, relative to normals. No group differences were observed as a function of valence. In a separate study using the Tucker et al. tasks (1977), Borod et al. (1990) found that RHD patients were impaired for identification, but not discrimination, relative to normals.

Based on clinical observation, Ross (1981; Ross & Mesulam, 1979) describes a group of disorders termed the aprosodias. These disorders of prosody are classified using terms similar to those found in the aphasia literature (e.g., motor, sensory, global, transcortical motor, etc.) and are defined by functional and anatomic parameters (i.e., an anterior-posterior emotional prosody circuit). Prosody refers to those aspects of speech that convey emotion (e.g., melody, intonation, stresses) (Ross, 1985; Borod, 1993). Gorelick and Ross (1987) evaluated right hemispheric stroke patients for aprosodia, using bedside techniques developed by Ross (1981). Four categories of affective language functioning were assessed: spontaneous affective-prosody and gesture, affective-prosodic repetition, affective prosodic comprehension, and comprehension of emotional gesturing. Based on the patterns of performance on these categories, subjects were assigned to one of the aprosodia subtypes defined by Ross (1981). CT scans were analyzed and functional-anatomic correlations were described. Similarly, in a study by Borod et al. (1990), RBDs were impaired, relative to normals, in the accuracy and intensity with which they produced prosodic emotional expressions. These studies suggest that aprosodia is relatively common and easy to diagnose. In addition, subtypes of this disorder are analogous to distinctions seen in aphasia and can be distinguished on the basis of anatomic lesion location and symptomatology.

Other studies have been generally less supportive of the concept of right hemisphere dominance for the perception of emotional prosody. Denes, Caldognetto, Semenza, Vagges, and Zettin (1984) presented right- and left-brain damaged patients discrimination and identification tasks using five basic emotions (happiness, sadness, fear, anger, and disgust). The brain-damaged subjects were divided into four groups based on side of lesion (right vs. left) and intrahemispheric lesion location (anterior vs. posterior). Results suggest that while right-brain damaged patients were impaired, relative to left-brain damaged patients and normals on a discrimination task, there were no significant differences (i.e., all were impaired) on the identification task between the RBDs and the left posterior patients. Van Lanckner and Sidtis (1992) also failed to find a difference in the level of performance between right and left hemisphere patients. Tompkins and Flowers (1985) performed a study in which right and left stroke patients were tested on prosodic tasks of increasing difficulty. While the results supported right hemisphere dominance for emotional perception, there was an effect of task difficulty. RBDs were significantly impaired, relative to LBDs and normals for the two simplest tasks. However, both patient groups performed more poorly than normal on the two most difficult tasks. These findings indicate the importance of task difficulty as a factor in studies assessing hemispheric specialization and may explain some of the contradictory findings in the literature.

Finally, Cancelliere and Kertesz (1990) examined emotional prosodic expression and comprehension in right and left hemisphere stroke patients. Subjects were given a battery of tasks and were assigned to an aprosodic subgroup based on their test scores. Lesion data was also compared using an objective CT tracing technique. Results indicated that the basal ganglia were the structures most frequently associated with aprosodia. In addition, the anterior temporal lobe, insula, and perisylvian region were also frequently affected. These findings are not consistent with earlier reports in the literature (Ross, 1981) stressing the role of an anterior-posterior circuit in emotional prosodic processing. This discrepancy may be due to more refined lesion analysis techniques in the Cancelliere and Kertesz (1990) study.

Lexical Perception

Normal Subjects. By lexical, one refers to the verbal content of emotional speech or written materials. Graves, Landis, and Goodglass (1981) conducted a study in which male and female volunteers were tested using a tachistoscopic presentation of emotional and nonemotional words. Male subjects processed emotional words more accurately in the left visual field (reflecting right hemisphere involvement) than nonemotional words. However, in a similar study by Strauss (1983), both emotional and nonemotional words were recognized more accurately when presented to the right visual field (reflecting left hemisphere activation) than when presented to the left visual field. These results contradict the findings of Graves et al. (1981) which implicated the right hemisphere in the processing of emotional words. In a review of the more recent literature (Borod, Bloom & Haywood, 1995), the findings for normals continue to be equivocal.

Brain-Damaged Subjects. Wechsler (1973) found that RBD patients were significantly impaired, relative to LBDs and normals in their ability to recall emotionally-laden text. No differences were observed between the patient groups when the content of the narratives was neutral. Landis, Graves, and Goodglass (1982) examined aphasics' ability to read and write emotional and nonemotional words. Overall, the aphasics performed more accurately when processing the emotional words than when reading or writing the nonemotional words. This suggests that the intact right hemisphere is involved in these tasks. Semenza, Pasini, Zettin, Tonin, and Portolan conducted a study in which right and left hemisphere patients were shown to differ in their performance on a task of hierarchical clustering. RBDs treated emotional, but not nonemotional words, differently than did LBDs and NCs.

In a recent study by Borod, Andelman, Obler, Tweedy, and Welkowitz

(1992), the performance of right and left hemisphere stroke patients was compared, using lexical emotional and nonemotional tasks. The emotion tasks were word-cluster identification, where subjects were required to choose which emotion was best represented by a group of three words, sentence identification, and word discrimination. Each task included three positive (happiness, interest, and pleasant surprise) and four negative (sadness, fear, anger, and disgust) emotions. Three nonemotional control tasks (word-cluster identification, word discrimination, and sentence identification) were also employed. These tasks were based on the category "Characteristics of People" and were divided into three positive (beauty, strength, intelligence), three negative (fatness, weakness, stupidity), and one neutral (hair color) category. Overall, right hemisphere stroke patients were impaired, relative to left hemisphere stroke patients and normal controls, on the emotional tasks. Further analysis of the data with regards to valence, did not produce any difference between groups. Taken together, these findings lend support to the right hemisphere hypothesis.

.Conclusions

Overall, data from normal, brain-damaged, and psychiatric groups seem to be most supportive of the right hemisphere hypothesis, regardless of channel of communication. There is, however, some support for the valence hypothesis, particularly the variant corollary of this hypothesis. Further research, using multiple channels and processing modes is necessary to more clearly elucidate these hypotheses.

III. PURPOSE AND HYPOTHESES

The overall purpose of this study is to evaluate emotional perception in unilateral brain-damaged patients in the facial, prosodic, and lexical channel of communication. The specific purposes and hypotheses of the present study are:

1. To test two hypotheses regarding hemispheric specialization of emotion:

the right hemisphere hypothesis which states that the right hemisphere is dominant for all emotional processing and the valence hypothesis which states that the right hemisphere is dominant for negative emotions and the left hemisphere is dominant for positive emotions. It is hypothesized that the right brain-damaged patients will be impaired, relative to left brain-damaged patients and normal controls, for the perception of emotions of both valences.

2. To examine the relationship among communication channels: This study will attempt to evaluate whether facial, prosodic, and lexical channels are independent systems or are part of an interrelated system. It is hypothesized that there will be a relationship between the channels such that impairment in one channel will be associated with impairment in the other channels.

IV. METHODS

Subjects

Subjects were 11 right brain-damaged (RBD), 10 left brain-damaged (LBD), and 15 normal controls, between 34 and 81 years of age. All subjects, except for one RBD, were right-handed by self-report (as measured by the Coren, Porac, & Duncan [1979] lateral preference inventory) and had no history of being converted from left-handedness. To ensure that the left-hander did not differ from the RBDs in this study, this subject's performance was compared to that of the other RBDs on all emotion variables. Her performance was found to be consistent with the RBD group. If her brain laterality was crossed for emotion, then one would expect her data to be similar to the performance of the LBDs, rather than the performance of the other RBDs. All subjects were native speakers of English or spoke fluent English by the age of seven. Subjects did not have any history of mental retardation, psychotropic drug treatment, psychiatric disorder, or alcohol or drug abuse. Normal control subjects had no history of neurological disease. Educational history (i.e., number of years completed) and occupational status (Hollingshead, 1977) were recorded for all subjects. (See Tables 1-3 for demographic data for each subject.). To ensure that the subject groups were comparable with regard to age, education, and occupational status, three separate one-way analyses of variance were conducted (ANOVAs). As can be seen in Table 4, there were no significant differences between the groups on any of these demographic variables. In addition, the number of male and female subjects did not differ significantly among the groups.

RBDs and LBDs were included for study if they suffered brain damage as a result of a unilateral cerebrovascular accident (CVA). Exact lesion location was confirmed by CT-scan for all brain-damaged subjects, except for one RBD. In this case, side of lesion was confirmed by a clinical neurological examination. All CT-scan information was based on a radiology report. See Tables 1 and 2 for lesion location information for RBDs and LBDs, respectively. Brain-damaged subjects did not have any history of premorbid neurological disease (e.g., epilepsy).

Table 1. **Characteristics of Right Brain-Damaged Subjects**

SUBJECT	GENDER	AGE	EDUCATION (Years)	OCCUPATION*	LESION LOCATION
1.	male	56	16	7	frontal lobe
2.	male	78	12	6	globus pallidus & putamen
3.	male	77	12	5	occipital lobe
4.	male	71	17	9	frontal & parietal lobes, putamen
5.	female	67	12	7	corona radiata & internal capsule
6.	female	50	16	5	frontal lobe
7.	male	63	14	4	frontal lobe, basal ganglia, & periventricular white matter
8.	female	70	10	6	right CVA by diagnosis
9.	male	81	19	9	frontal lobe, amygdala, & hippocampus
10.	female	50	12	3	parietal lobe
11.	male	75	14	5	corona radiata

*Hollingshead Occupational Rating Scale, Range 1 (never worked) to 9 (major professional).

Table 2.

Characteristics of Left Brain-Damaged Subjects

SUBJECT	GENDER	AGE	EDUCATION (Years)	OCCUPATION*	Language Rating**	LESION LOCATION
1.	female	63	16	5	1	basal ganglia
2.	male	72	13	7	1	occipital lobe
3.	male	71	18	7	2	frontal, temporal, & parietal lobes; external capsule
4.	female	34	16	8	2	anterior cortical
5.	male	64	10	6	1	temporal & occipital lobes, posterior internal capsule
6.	male	61	19	9	1	thalamus & posterior internal capsule
7.	male	65	16	8	1	corona radiata
8.	female	54	12	2	2	corona radiata
9.	male	78	16	8	2	frontal & parietal lobes
10.	male	70	20	9	2	frontal, temporal, & parietal lobes

*Hollingshead Occupational Rating Scale, Range from 1 (never worked) to 9 (major professional).
**1=No language deficits seen; 2=Language deficits observed.

Table 3. **Characteristics of Normal Subjects**

SUBJECT	GENDER	AGE	EDUCATION (Years)	OCCUPATION*
1.	male	49	16	9
2.	female	64	16	7
3.	male	56	16	9
4.	male	69	18	7
5.	male	65	12	6
6.	male	52	16	8
7.	male	76	20	9
8.	male	71	18	7
9.	male	75	16	9
10.	male	73	16	7
11.	female	72	14	7
12.	female	74	13	6
13.	male	65	12	7
14.	female	62	12	8
15.	female	49	14	6

*Hollingshead Occupational Rating Scale, Range 1 (never worked) to 9 (major professional).

Table 4.

Demographic Variables for Each Subject Group

Variable	Measure	RBDS (N=11) M(SD)	LBDS (N=12) M(SD)	NCS (N=15) M(SD)	Statistic (F-Test or χ^2)	p-Value
Age	Years	67.09 (11.05)	63.20 (12.25)	64.80 (9.40)	0.35	.707
Education	Years	14.00 (2.72)	15.60 (3.13)	15.27 (2.40)	1.06	.358
Occupation	9-point Scale*	6.00 (1.90)	6.90 (2.13)	7.47 (1.13)	2.38	.108
Gender	M/F Ratio	7/4	7/3	10/5	0.62	.970

*Hollingshead Occupational Rating Scale, 1977.

Patient groups were tested at least two months post onset (MPO) of stroke. Median MPO was 21.00 months for the RBDs and 12.50 months for the LBDs while the mean MPO was 54.09 (S.D.= 75.43) and 21.90 (S.D.= 30.22) months for the RBDs and LBDs, respectively. Statistical analysis did not reveal any significant differences between the groups for either the median MPO (Mann Whitney U; p=.458) or mean MPO (F=1.30; df=13, 38; p=.214). Although the total number of subjects in each category is small, the groups are relatively well-matched in terms of the presence of cortical, subcortical, or mixed lesions (i.e., lesions affecting both cortical and subcortical structures). See Table 4a. Each LBD was assigned a language rating of "1" if there was no evidence of language deficits either at the time of stroke or at the time of testing or a rating of "2" if there were language deficits present at any point (see Table 2). A language deficit was defined as an impairment in expressive and/or receptive language functioning which was present at some point since the onset of stroke. Information concerning the presence or absence of language deficits was generally found in the subjects' medical charts. At the time of testing, only 2 out of the 5 LBDs with language deficits had an aphasia diagnosis (1 fluent, 1 nonfluent). The three remaining LBDs had some evidence, either from their medical charts and/or from clinical observation, of mild language disturbances (predominantly mild word-finding difficulties). This language deficit measure was used in some of the analyses to follow. (See page72).

All subjects were reimbursed for their time and transportation costs.

Further, ambulette service was provided for any brain-damaged subject who needed it. Brain-damaged subjects were recruited primarily from the Neurology Service (inpatient and outpatient) of Mount Sinai Medical Center and one of its affiliates, the Bronx VA Medical Center. In addition, subjects were recruited via ads in area newspapers, as well as via flyers distributed to local stroke clubs and senior citizen centers. All testing was conducted at Mount Sinai Medical Center. Subjects were required to sign informed consent forms prior to the start of the first testing session. Total testing time was approximately six hours for normal controls and eight hours for brain-damaged subjects. Most testing sessions lasted for about two hours and were scheduled, whenever possible, within a reasonable proximity to each other (e.g., a week to 10 days apart). All subjects received a battery of tests (Borod, Welkowitz, and Obler, 1992) which included screening, control, and experimental measures, as part of a larger NIH-funded research project.

Table 4a. Number of Cortical, Subcortical, and Mixed Lesion Levels, by Group

	Cortical	Subcortical	Mixed[1]	Unknown
RBDs	4	3	3	1
LBDs	4	4	2	0

[1]Mixed=cortical and subcortical lesions present

Screening Measures

All subjects underwent a series of screening procedures to insure a minimum level of sensory and cognitive functioning. Screening tasks included: (1) the Schedule for Affective Disorders and Schizophrenia-Lifetime Version (SADS-L) (Endicott & Spitzer, 1978) to screen for psychiatric history; (2) the Commands, Complex Ideational Material, and Reading Sentences and Paragraphs subtests of the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983) to screen for auditory comprehension and reading comprehension deficits, respectively; (3) Attention and Memory subtests of the Mattis Dementia Rating Scale (Mattis, 1988) to screen for basic attention and memory capacity; (4) Benton Visual Form Discrimination Test (Benton, deS. Hamsher, Varney, & Spreen, 1983) to screen for deficits in basic visual perception; (5) Pure Tone Threshold (Beltone Owner's Manual, 1987) to screen for significant hearing loss; (6) Phoneme Discrimination (Benton et al., 1983) to assess auditory discrimination ability; and (7) Information subtest (for NCs and RBDs) and the Block Design subtest (for NCs and LBDs) from the Weschler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981) to assess premorbid functioning. The cutoff scores utilized in this study are based on previous research of this type in Dr. Borod's laboratory, and are generally one to two standard deviations below the normal mean. See Table 5.

Control Measures

All subjects received **control tasks** that controlled for factors that can potentially confound performance on the various experimental tasks. Since subjects were tested in three different channels (i.e., facial, prosodic, and lexical) appropriate control tasks were employed for each channel. Within the facial channel, the Facial Recognition Test (Benton et al., 1983) and the Visual Matrices Test (Borod, et al., 1993) were used to control for nonemotional facial recognition and visuospatial perception, respectively. Within the prosodic channel, a task requiring the identification of nonsense syllables (Intonation Contours-Perception) was used to control for difficulty processing intonation contours. Within the lexical channel, analogous nonemotional lexical control tasks (Borod, Welkowitz, Obler, Whalen, Erhan, & Grunwald, 1992) were used. These tasks included a Word Identification Task, a Sentence Identification Task, and a Word Discrimination Task. In the identification tasks, subjects were required to choose which category a cluster of three words (for Word Identification) or a sentence (for Sentence Identification) best represents. For Word Discrimination, subjects were required to indicate whether two words come from the same category or a different category. There are eight categories classified as "Characteristics of People": personality, hair type, voice type, vision, complexion, body type, teeth, and intelligence. For all lexical tasks, stimulus items are presented in booklet form (i.e., with words or sentences centered on an 8-1/2" x 11" sheet of white paper). Categories were listed in a vertical array on an 8-1/2" x 11" card placed in front of the subject. For the Word Discrimination Task, an additional card with the words "SAME" and "DIFFERENT" was also placed near the subject. All subjects were given verbal and nonverbal cancellation tasks (Diller, Ben-Yishay, Goodkin, Gordon, & Weinberg, 1974) to control for neglect and the Beck Depression Inventory (Beck, 1967) to control for post-stroke depression.

Table 5. *Cognitive Screening Variables*

Variable	Measure	Cutoff Score	Range	RBDs Mean (S.D.)	LBDs Mean (S.D.)	NCs Mean (S.D.)
Auditory Comprehension	1. Commands[1]	3/6 points on items 1-3	0-15	15.00 (0.00)	14.90 (0.32)	14.93 (0.26)
	2 .C.I.M.[2]	4/6 points on items 1-6.	0-12	11.10 (0.94)	10.33 (1.66)	11.13 (1.06)
Reading Comprehension	Read. Sentences & Paragraphs	5/10	0-10	9.64 (0.67)	9.33 (1.00)	9.93 (0.26)
General Intelligence	Information or Block Design[3]	7 ACSS	0-19	10.91 (2.42)	9.50 (3.34)	12.40[4] (3.16)
Basic Attention	MDRS Attention Subtest[5]	34/37	0-37	35.36 (1.03)	35.67 (2.00)	36.40 (0.91)
Basic Memory	MDRS Memory Subtest	22/25	0-25	24.09 (1.04)	23.33 (3.08)	24.13 (0.99)
Basic Visual Perception	BVFD[6]	26/32	0-32	27.64 (4.20)	28.90 (3.45)	29.93 (2.12)
Auditory Perception	BPD[7]	19/30	0-30	26.45 (2.11)	27.20 (1.13)	27.13 (2.46)
Pure Tone Threshold	1. 500HZ	≤40dB[8]		22.73 11.26)	17.75 (4.63)	24.50 (7.21)
	2. 1000HZ	≤40dB		20.45 11.77)	13.75 (6.48)	18.50 (8.80)
	3. 2000HZ	≤40dB		25.45 17.99)	15.30 (9.45)	16.53 10.84)

[1]BDAE Commands Subtest
[2]BDAE Complex Ideational Materials Subtest
[3]Age-Corrected Scaled Score (ACSS) for the WAIS-R Subtests
[4]Mean of Information and Block Design Age-Corrected Scaled Scores
[5]Mattis Dementia Rating Scale
[6]Benton Visual Form Discrimination Test
[7]Benton Phoneme Discrimination
[8]Mean of right +left ear is less than or equal to 40dB for each frequency

Experimental Tasks

All subjects completed seven experimental emotional perception tasks. Subjects were given identification and discrimination tasks in each of three communication channels: facial, prosodic, and lexical. For the lexical channel, there were both a word identification task and a sentence identification task, but only one discrimination task (i.e., word discrimination). There were two equivalent forms of each discrimination task (56 total pairs, 28 different trial and 28 same trials) and two random orders for the identification task.

For the facial channel, subjects completed a Facial Identification Task and a Facial Discrimination Task. Facial stimuli consisted of Ekman and Friesen (1976) slides depicting happiness, sadness, disgust, fear, and anger, in addition to new ones (Borod, Erhan, Welkowitz, Obler, Whalen, & Grunwald, 1994) expressing pleasant surprise, unpleasant surprise, and interest. For identification, slides were presented to subjects (via a Caramate), and subjects were asked to identify the emotion being portrayed. Subjects named or pointed to one of the eight emotions which were presented in a vertical array on an 8-1/2" x 11" card. There were three positive (happy, pleasant surprise, and interest) and five negative (sadness, disgust, fear, anger, and unpleasant surprise) emotions. The Facial Identification task contained 32 items (8 emotions x 4 presentations) (16 male and 16 female posers, equally distributed across emotions). Subjects were given two practice trials and the examiner either read the list of emotions to the subject or had the subject read the list aloud prior to the first practice trial. For discrimination, two slides of different posers with the same or different emotional expression were presented on a Caramate slide projector. Subjects indicated whether two expressions were the same or different either orally or by pointing to printed on a response card. For each pair, slides were presented for 5 seconds with an interstimulus interval of 1 second. There were 28 trials on this task and three practice trials.

For the prosodic channel, subjects completed a Prosodic Identification Task and a Prosodic Discrimination Task. Prosodic stimuli were composed of neutral sentences spoken by actors and actresses in eight emotional tones of voice. For identification, subjects were presented 24 (and two practice) emotionally-intoned neutral sentences and asked to identify the emotion being expressed in each from the choices presented on the response card. An equal number of male and female voices were presented, and each emotion occurred three times. For discrimination, two sentences spoken by the same actor or actress were presented via audiotape, and subjects were required to respond "same" or "different". The task contained 28 test trials and three practice trials.

For the lexical channel, subjects received a Word Identification, a Sentence Identification, and a Word Discrimination Task. The lexical stimuli consisted of words and sentences rated for category accuracy and emotionality by normal raters. Items which had an accuracy of greater than 50% and emotionality of greater than 2.5 (on a six-point scale) [0-5, from "not at all emotional" to "extremely emotional"]) were used. For word identification, subjects were presented 3-word clusters and asked to identify the emotion best represented by all three words. There were 24 test trials and two practice items. For sentence identification, 24 different 7-word sentences were presented in the center of an 8-1/2" x 11" sheet of white paper. Subjects were required to indicate which emotion was best represented by the sentence. There were 24 trials and two practice items. For word discrimination, two words printed one above the other, representing either the same or a different emotion, were shown to each subject. There were 28 test items and three practice trials.

The experimental tasks were presented in one of four random orders, equally distributed across the three subject groups. Screening and control measures were completed prior to the administration of the experimental tasks and were presented in a fixed order for all subjects. RBDs, LBDs, and NC were given subject identification numbers, and subject confidentiality was respected.

V. RESULTS

Overall, the statistical analyses included three major components. First, repeated-measures analyses of variance (ANOVAs) were used to test the right hemisphere versus the valence hypothesis and to compare emotional and nonemotional lexical perception tasks. The Newman-Keuls multiple comparison post-hoc procedure was used to evaluate all significant main effects and interactions. Second, the performance of the three subject groups on the control tasks was compared using one-way ANOVAs. When significant group differences were found, correlations were then computed between the control task and its appropriate experimental measure(s). If the number of significant correlations between the control and experimental tasks was more than would be expected by chance, the control measure was then used as a covariate in an analysis of covariance (ANCOVA) for the relevant experimental task to test the hypotheses described above. Third, correlation coefficients were computed in order to evaluate the interrelationships among the facial, prosodic, and lexical channels of communication.

In order to compare subject performance, total correct scores were converted to percent correct for each of the seven experimental tasks and the three nonemotional lexical control tasks. It was necessary to use a percent correct measure because the number of items differed among the tasks. For valence, separate percent correct scores were calculated for positive (total number of correct positive items /total number of positive items) and negative items (total number of negative items correct/ total number of items) for both identification and discrimination tasks. In addition, for the discrimination tasks, percent correct scores were calculated for mixed items (total number of mixed items correct/total number of mixed items). Mixed items were those in which one item in a pair was positive and the other item was negative.

A. Analyses of Variance

Test of the Right Hemisphere versus the Valence Hypothesis

In order to compare the right hemisphere to the valence hypothesis, three Group (3) X Channel (3) X Valence (2) or (3) repeated-measures ANOVAs were conducted, two with identification tasks and one with the discrimination tasks. The Facial Identification and the Prosodic Identification tasks were used in both identification ANOVAs. In one of these ANOVAs, Word Identification (WID) was used for the lexical channel task while, in the other ANOVA, Sentence Identification (SID) was used for the lexical channel. For the discrimination ANOVA, the Facial Discrimination, Prosodic Discrimination, and Lexical Word Discrimination (WDIS) tasks were used.

Identification Tasks with "Words" for the Lexical Task. For the WID ANOVA, there was a significant main effect of Group ($p=.002$). Table 6 displays the ANOVA summary table and Table 7 presents the means of the main effects for this analysis. Newman-Keuls post-hoc analyses revealed that RBDs were significantly impaired relative to the NCs and LBDs. LBDs and NCs did not differ significantly from each other. There was also a main effect of Channel ($p<.001$), such that performance on the prosodic identification task was significantly worse than on the facial or lexical word identification tasks; the lexical and facial tasks were not significantly different from each other.

A significant interaction between Channel and Valence ($p=.009$) (see Figure 1) was also observed. In the case of negative emotions, performance in both the facial and prosodic channels was significantly reduced as compared to the lexical channel. For positive emotions, the prosodic channel was perceived significantly less accurately than either the facial or lexical channels.

Table 6. Summary Table for the Group X Channel X Valence ANOVA with WID

Variable	DF	F-Test	P-Value
Group	2,33	7.53	.002**
Channel	2,66	66.67	.000**
Valence	1,33	0.22	.643
Group X Channel	4,66	0.43	.790
Group X Valence	2,33	0.60	.556
Channel X Valence	2,66	5.02	.009**
Group X Channel X Valence	4,66	1.11	.358

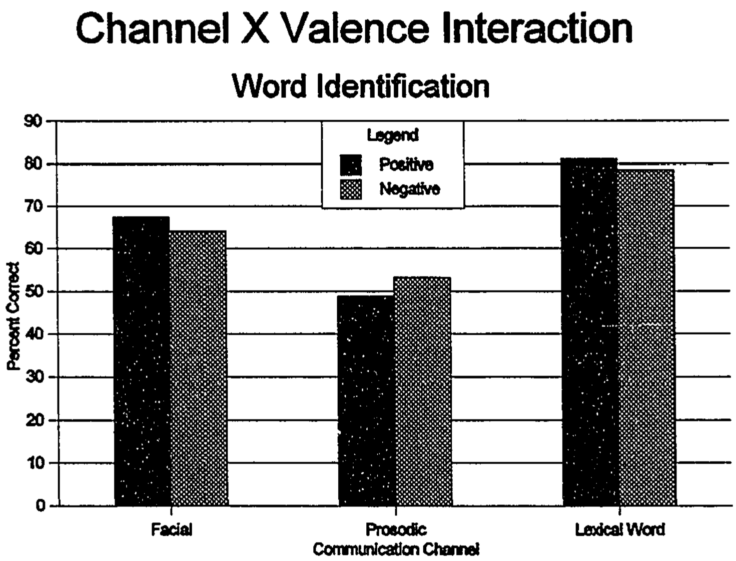
*$p\leq.05$
**$p\leq.01$
***$p\leq.001$

Table 7. Means of Main Effects for the WID ANOVA

Main Effect	Level	Mean*	S.D.
Group	RBDs	54.61	18.27
	LBDs	68.19	15.82
	NCs	71.96	20.39
Channel	Facial	65.05	13.38
	Prosodic	49.08	17.13
	Lexical (WID)	79.83	17.16
Valence	Positive	64.48	24.80
	Negative	65.36	19.99

*Percent Correct

Figure 1.



Identification Tasks With "Sentences" for the Lexical Task. A second Group (3) X Channel (3) X Valence (2) repeated-measures ANOVA was conducted using the Lexical Sentence Identification (SID) Task. There was a significant main effect of Group ($p=.002$). Tables 8 and 9 display the ANOVA summary table and the mean of the main effects for this analysis, respectively. Using post hoc tests, RBDs were significantly impaired relative to LBDs and NCs. LBDs and NCs did not differ significantly from each other. In addition, there was a significant main effect of Channel ($p<.001$) such that overall performance in the prosodic channel was significantly poorer than in the facial or lexical channel across subjects. There was also a significant interaction between Channel and Valence ($p=.025$) (see Figure 2). For both positive and negative items, performance in the prosodic channel was significantly lower than for either the facial or lexical channels. The lexical sentence and facial tasks were not significantly different from each other for items of either valence.

Table 8. Summary Table for the Group X Channel X Valence ANOVA with SID

Variable	DF	F-Test	P-Value
Group	2,33	7.77	.002**
Channel	2,66	40.70	.000***
Valence	1,33	1.54	.223
Group X Channel	4,66	0.58	.670
Group X Valence	2,33	0.25	.784
Channel X Valence	2,66	3.90	.025*
Group X Channel X Valence	4,66	1.14	.343

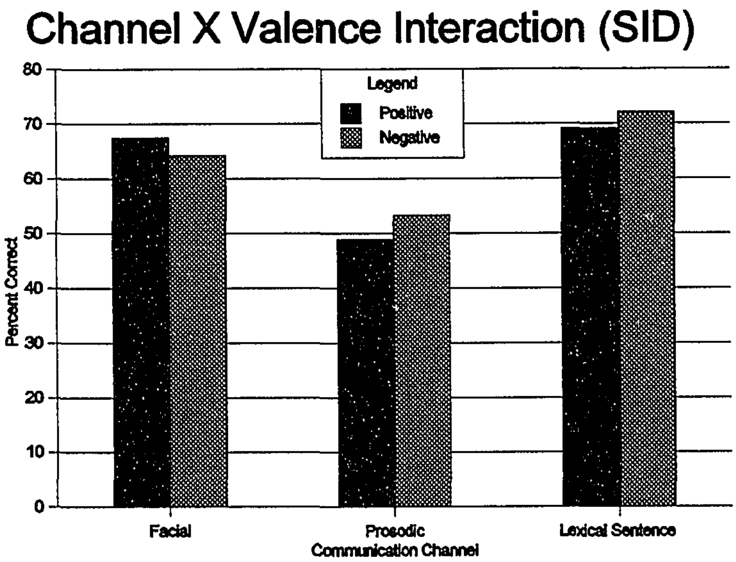
*p≤.05
**p≤.01
***p≤.001

Table 9. Means of Main Effects For SID

Main Effect	Level	Mean*	S.D.
Group	RBDs	51.35	16.27
	LBDs	65.48	13.59
	NCs	68.75	19.02
Channel	Facial	65.85	13.38
	Prosodic	49.09	17.13
	Lexical (SID)	70.65	17.77
Valence	Positive	56.34	21.92
	Negative	63.23	19.74

*Percent Correct

Figure 2.



Discrimination Tasks. A third Group (3) X Channel (3) X Valence (3) repeated-measures ANOVA was conducted using the discrimination tasks. (See page 32 for a description of positive, negative, and mixed valence items). Overall, there was a significant main effect of Channel ($p<.001$). See Table 10 for the ANOVA summary table and Table 11 for the means of the main effects. While subject performance on both facial and lexical word discrimination was lower than on prosodic discrimination, these differences did not reach significance when tested on a post-hoc basis. In addition, there was a significant Channel X Valence interaction ($p<.001$). (See Figure 3.) Post-hoc analyses revealed that subjects were significantly more accurate in discriminating both positive and negative prosodic items than they were for any of the other items. Positive and negative prosodic items did not differ significantly from each other.

There was also a significant Group X Channel X Valence interaction ($p=.043$). (See Figure 4.) Within the facial channel, post-hoc analyses did not reveal any significant differences among the subject groups or among the valences. For the prosodic channel, no significant group differences were seen for positive, negative, or mixed items. However, there were two significant valence findings for the group analyses. First, RBDs were significantly more accurate on positive prosodic items than on mixed items. Second, LBDs were significantly more accurate on both positive and negative items than on mixed items. NCs did not show any valence differences for prosodic items. Within the lexical channel, there were no significant group differences for individual valence categories. However, there were valence differences for individual groups. RBDs performed significantly better on mixed valence lexical items than on either positive or negative items. LBDs were significantly better on mixed than on positive, but not negative, items. The NCs did not show any significant differences.

Table 10. Summary Table for the Group X Channel X Valence ANOVA for Discrimination

Variable	DF	F-Test	P-Value
Group	2,33	1.13	.334
Channel	2,66	12.09	.000***
Valence	1,33	0.66	.520
Group X Channel	4,66	0.13	.973
Group X Valence	2,33	1.18	.326
Channel X Valence	2,66	8.60	.000***
Group X Channel X Valence	4,66	2.07	.043*

*$p \leq .05$
**$p \leq .01$
***$p \leq .001$

Table 11. Means of Main Effects for the Discrimination Tasks

Main Effect	Level	Mean*	S.D.
Group	RBDs	82.03	11.78
	LBDs	85.07	9.97
	NCs	86.51	10.67
Channel	Facial	82.65	8.69
	Prosodic	90.02	9.90
	Lexical (WDIS)	80.94	11.72
Valence	Positive	84.11	15.62
	Negative	83.91	14.03
	Mixed	85.58	17.68

*Percent Correct

Figure 3.

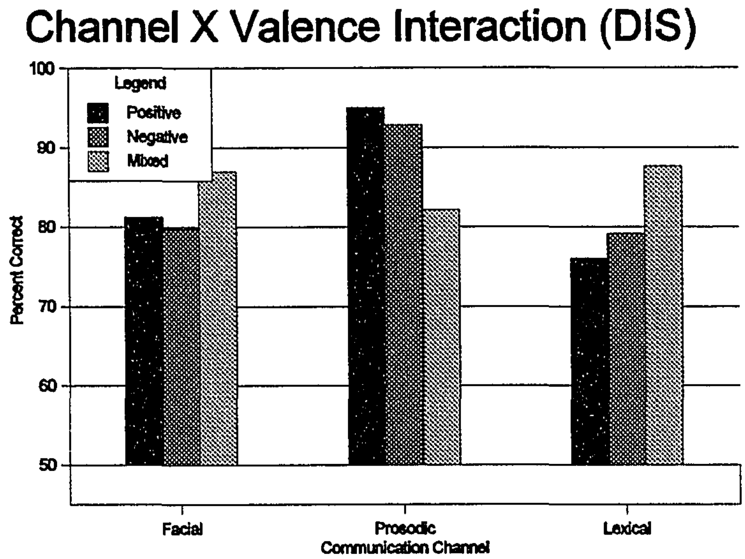
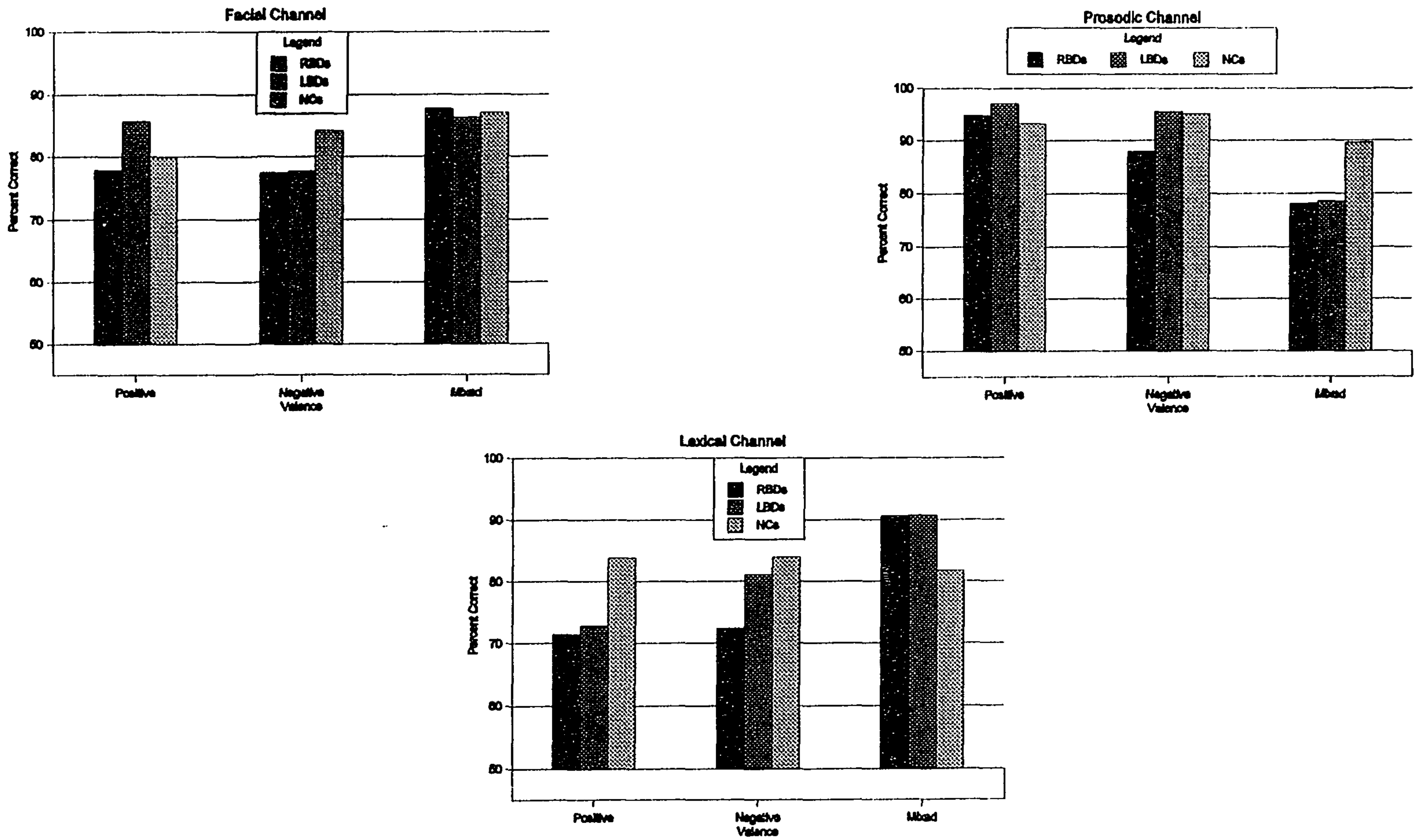

Channel X Valence Interaction (DIS)
Legend
Positive
Negative
Mixed
Percent Correct
100
90
80
70
60
50
Facial
Prosodic
Lexical
Communication Channel

Figure 4. Group X Channel X Valence Interaction



Summary. The overall results of the identification analyses demonstrate a consistent difference between the RBDs and both the LBDs and NCs. In general, RBDs were impaired relative to the other two groups while the LBDs did not consistently differ from the normals. In terms of communication channel, the prosodic channel yielded the lowest percent correct scores for identification tasks. For discrimination, however, subjects performed best on the prosodic discrimination task.

Comparison of Emotional to Nonemotional Lexical Perception

In order to compare the performance of the subject groups on emotional and nonemotional lexical tasks, a Group (3) X Condition (2) X Task (3) repeated-measures ANOVA was conducted, using the total percent correct score for each task. Condition was either emotional or nonemotional, and the Tasks were Word Identification, Word Discrimination, and Sentence Identification. Overall, there was a significant main effect of Group (p=.009). (See Table 12.) Post-hoc pairwise comparisons indicated that RBDs were significantly less accurate than NCs or LBDs. LBDs and NCs did not differ significantly from each other. (See Table 13.)

There was also a significant main effect of Task. Post-hoc analyses revealed that subjects performed significantly more poorly on Sentence Identification than on Word Identification. However, Word Discrimination did not differ significantly from either of the other two tasks. In addition, there was a significant 2-way interaction involving Condition and Task. For the Condition X

Task interaction (p<.001) (see Figure 5), post-hoc analyses indicated that subjects did significantly better on Nonemotional Word Identification than on any other task.

There were two significant interactions involving Group. First, there was a Group X Condition interaction (p=.043) (see Figure 6). Second, there was a significant Group X Condition X Task interaction (p=.051). (See Figure 7.) Based on a priori predictions concerning Group and Condition, a series of post-hoc analyses were conducted which tested group differences (i.e.,, RBDs vs. LBDs, RBDs vs. NCs, and LBDs vs. NCs) within a condition and condition differences (i.e., emotional vs. nonemotional) within a group.

First, post-hoc analyses were conducted on the Group X Condition interaction. For the group comparisons, RBDs were significantly impaired relative to LBDs and NCs within the emotional condition. There were no significant group differences within the nonemotional condition. For the condition comparisons, no significant findings were observed for any of the groups.

In order to elucidate the Group X Condition X Task interaction, the series of post-hoc analyses described above were repeated separately for each task. For Sentence Identification (SID), RBDs performed significantly more poorly on emotional SID than either LBDs or NCs. No significant group differences were seen for nonemotional SID. RBDs were significantly less accurate on emotional SID than on nonemotional SID; no condition differences emerged for the other two groups. For Word Identification (WID), RBDs were significantly impaired relative to LBDs and NCs on emotional WID. RBDs were significantly less accurate on nonemotional WID than NCs; no other group differences emerged. RBDs performed significantly more poorly on emotional than nonemotional WID. No significant condition differences were seen for the LBDs or NCs. There were no significant findings between conditions or among groups for Word Discrimination.

Table 12. Summary Table for the Group X Condition X Task ANOVA

Variable	DF	F-Test	P-Value
Group	2,33	5.39	.009**
Condition	1,33	3.23	.081
Task	2,66	23.17	.000***
Group X Condition	2,33	3.46	.043*
Group X Task	4,66	1.59	.188
Condition X Task	2,66	9.26	.000***
Group X Condition X Task	4,66	2.50	.051*

*$p \leq .05$
**$p \leq .01$
***$p \leq .001$

Table 13. Means of Main Effects of Group X Condition X Task ANOVA

Main Effect	Level	Mean*	S.D.
Group	RBDs	71.80	16.73
	LBDs	80.37	12.42
	NCs	83.45	14.60
Condition	Emotional	77.08	16.18
	Nonemotional	79.99	14.33
Task	Word ID	84.31	15.35
	Word Dis	78.56	12.34
	Sentence ID	72.74	15.73

*Percent Correct

Figure 5.

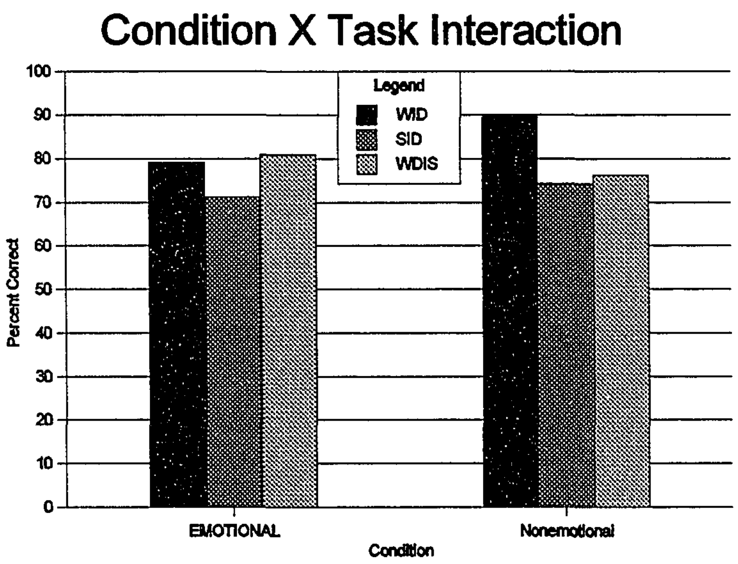


Figure 6.

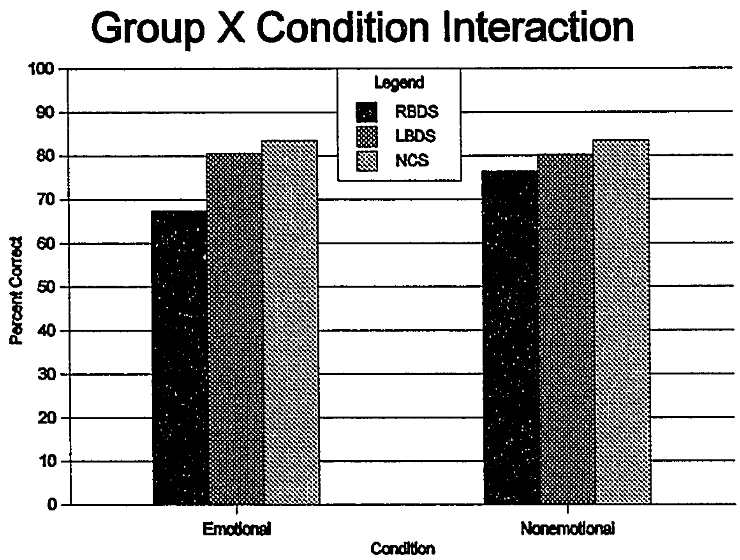
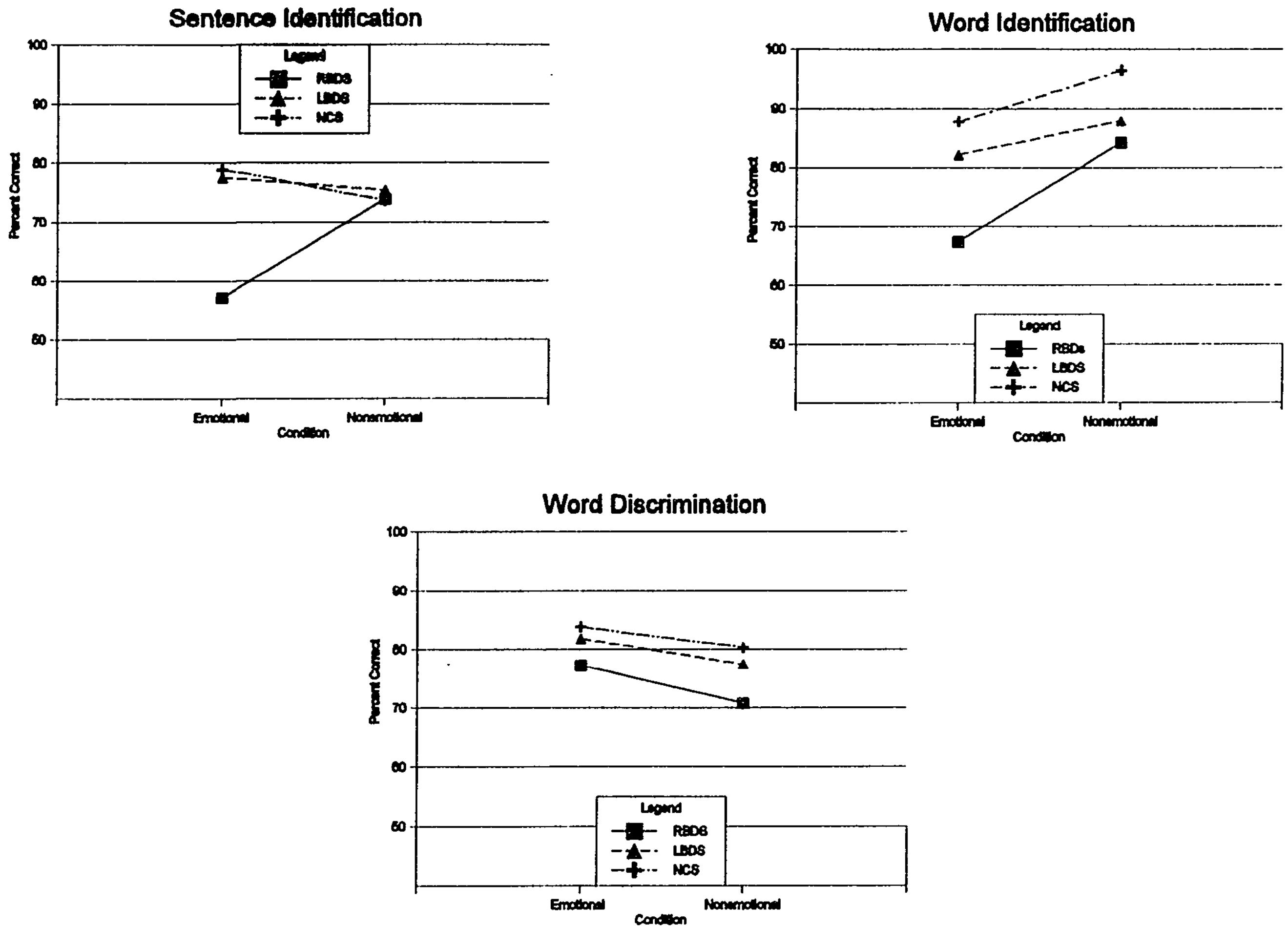

Group X Condition Interaction
Legend
RBDS
LBDS
NCS
Percent Correct
100
90
80
70
60
50
40
30
20
10
0
Emotional
Nonemotional
Condition

Figure 7. Group X Condition X Task Interaction



B. Effect of the Nonemotional Control Tasks on Experimental Emotional Tasks

Group Comparisons. To compare the performance of the three subject groups on the facial, prosodic, and lexical control tasks, a series of one-way ANOVAs was conducted. As can be seen in Table 14, there were significant group differences on three of these control tasks, one in each communication channel. For Facial Recognition (p=.007), post-hoc Newman-Keuls tests revealed that both RBDs and LBDs, while not different from each other, were significantly impaired relative to NCs. In the prosodic channel, the groups differed on Intonation Contours (p=.036). Post-hoc tests revealed that RBDs performed significantly more poorly than the LBDs or NCs, who did not differ from each other. For Nonemotional Word Identification (p=.015), post-hoc analyses indicated that RBDs were significantly impaired relative to the other groups, while LBDs and NCs did not differ from each other.

Correlations. In light of these significant findings, the three control tasks described above were correlated with positive and negative percent correct scores for their respective tasks: Facial Identification (FID) and Facial Discrimination (FDIS) with Facial Recognition, Prosodic Identification (PID) and Prosodic Discrimination (PDIS) with Intonation Contours, and Word Identification(WID) with Nonemotional Word Identification. Positive, negative, and mixed valence scores were used because valence was a factor in the analyses conducted above. The significant correlations for these measures are displayed in Tables 15 (positive percent correct), 16 (negative percent correct), and 16a (mixed valence percent correct). For the facial tasks, there were 2 significant correlations out of 6 for Facial Identification and 0 out of 9 for Facial Discrimination. There were no significant correlations (out of 6) for Prosodic Identification and 2 out of 9 for Prosodic Discrimination. For Word Identification, there were 2 significant correlation out of 6. Because there were more significant correlations than would be expected by chance for FID, PDIS and for lexical WID, analyses of covariance (ANCOVAs) were conducted for each of these variables with each one's appropriate control task as a covariate.

Table14. Performance of the Subject Groups on Nonemotional Control Tasks

Category Controlled For:	Variable	Range	Measure	RBDs	LBDs	NCs	F-Test	p-Value
Facial Emotion	**Face Perception**	0-54	BFRT[1]	44.45 (3.83)	44.01 (4.56)	49.33 (4.70)	5.74	.007
	Visual Perception	0-24	Visual Matrices	22.64 (1.21)	23.20 (0.79)	23.07 (1.53)	0.59	.561
Prosodic Emotion	Auditory Perception	0-24	Intonation Contours	18.00 (4.02)	21.30 (2.75)	21.29 (3.07)	3.70	.035*
Lexical Emotion	Lexical Perception	0-24	Word ID	84.25 (11.88)	87.92 (13.95)	96.39 (4.69)	4.82	.015*
		0-24	Sentence ID	73.85 (9.33)	75.42 (16.37)	73.61 (14.91)	0.06	.947
		0-28	Word Discrim	70.78 (12.56)	77.50 (10.38)	80.24 (13.35)	1.89	.166
Inattention	Left Neglect--Letter	-1 to +1	L-R[2] / L+R	-.13 (0.49)	.03 (0.48)	-.05 (0.54)	0.23	.794
	--Form			-.03 (0.72)	.38 (0.46)	-.05 (0.61)	1.67	.205
Psychiatric Status	Depression	0-39	BDI[3]	2.64 (2.16)	2.50 (2.68)	1.67 (2.02)	0.71	.498

[1]Benton Facial Recognition Test
**P≤.01; *p≤.05
[2]Error Ratio
[3]Beck Depression Inventory

Table 15. Significant Pearson Product-Moment Correlation Coefficients for **Positive** Experimental Items (Percent Accuracy) versus Control Tasks Separately for Channel and for Each Subject Group

	RBDs		LBDs		NCs	
Control Task	Face ID	Face Discrim	Face ID	Face Discrim	Face ID	Face Discrim
1. Facial Channel						
Facial Recognition	.70*	.27	-.04	.45	.13	-.18
2. Prosodic Channel						
	Prosodic ID	Prosodic Discrim	Prosodic ID	Prosodic Discrim	Prosodic ID	Prosodic Discrim
Intonation Contours	.02	.00	.00	.92***	.38	.29
3. Lexical Channel						
	Word ID		Word ID		Word ID	
Nonemotional Word ID	.36		.82**		.15	

*p≤.05 **p≤.01; ***p≤.001

Table 16. Significant Pearson Product-Moment Correlation Coefficients for **Negative** Experimental Items (Percent Accuracy) versus Control Tasks, Separately for Each Channel and for Each Subject Group

Control Task	RBDs Face ID	RBDs Face Discrim	LBDs Face ID	LBDs Face Discrim	NCs Face ID	NCs Face Discrim
1. Facial Channel						
Facial Recognition	.44	.06	.28	.04	.51***	.20
2. Prosodic Channel	**Prosodic ID**	**Prosodic Discrim**	**Prosodic ID**	**Prosodic Discrim**	**Prosodic ID**	**Prosodic Discrim**
Intonation Contours	.30	.43	-.13	.53	.19	.28
3. Lexical Channel	Word ID		Word ID		Word ID	
Nonemotional Word ID	.49		.65*		.06	

*p≤.05; **p≤.01; ***p≤.001

Table 16a. Significant Pearson Product-Moment Correlation Coefficients for Mixed Experimental Items (Percent Accuracy) versus Control Tasks Separately for Each Channel and for Each Subject Group

Control Task	RBDs Face Discrim	LBDs Face Discrim	NCs Face Discrim
1. Facial Channel			
Facial Recognition	.32	.24	.05
2. Prosodic Channel	Prosodic Discrim	Prosodic Discrim	Prosodic Discrim
Intonation Contours	.73**	.23	.25

*p≤.05; **p≤.01; ***p≤.001

Analyses of Covariance In light of the significant correlations between the control tasks and the experimental tasks, a series of covariate analyses were conducted: Group (3) X Valence (2) repeated measures ANCOVAs were performed, pairing the control task with its experimental task. For Facial Recognition, the ANCOVA for Facial Identification yielded a significant main effect for Group (f=6.10; df=2,32; p=.006). Post-hoc tests revealed that the RBDs (adjusted mean=80.59) were significantly impaired relative to both the LBDs (adjusted mean=100.32) and NCs (adjusted mean=98.44). LBDs were not significantly different from NCs. For Intonation Contours, the ANCOVA for Prosodic Discrimination did not yield any significant effect of Group (F=.35; df=2,31; p=.710). There were, however, similar findings for Valence (F=10.78; df=2,64; p=<.001) and Channel X Valence (F=2.50; df=4,64; p=.051) as described in the original ANOVA above (see page 37). Finally, for Nonemotional Word ID, the ANCOVA for Emotional Word Identification produced a trend for Group (F=2.92; df=2,32; p=.068). With post-hoc analysis, RBDs (adjusted mean=100.80) were found to be significantly different from NCs (adjusted mean=117.43). LBDs (adjusted mean=120.43) did not differ significantly from either of the other groups. Thus, in general, utilizing these nonemotional control tasks did not substantially alter the group findings reported above.

C. <u>The Relationship Among Communication Channels</u>

In order to investigate the relationship among the facial, prosodic, and lexical channels of emotion, separate intercorrelation (Pearson Product-Moment Correlations) matrices were computed for total scores, positive valence scores, negative valence scores, and mixed valence scores, separately for identification and discrimination tasks.

<u>Total Scores.</u> Table 17 displays the correlation coefficients for identification and discrimination total scores by Group. As can be seen, the NCs show relatively strong significant correlations among all of the identification tasks (5/5 correlations). However, they exhibited only one (out of 3) significant correlation for discrimination (between face and prosody). LBDs, on the other hand, showed the exact opposite pattern. There were three (out of 3) significant correlations for discrimination but only one (out of 5) for identification (between word and face). For the RBDs, there were no significant correlations among any of the tasks for either identification or discrimination.

<u>Valence Scores.</u> Correlations were computed for positive, negative, and mixed percent correct scores for both identification and discrimination tasks. For <u>identification</u>, NCs had the greatest number of significant correlations (7 out of 10). LBDs exhibited 3 (out of 10) significant correlations, and RBDs had only 1 (out of 10). See Table 18. For <u>discrimination</u>, there were relatively few significant correlations: 2 (out of 9) for NCs, 1 (out of 9) for LBDs, and 2 (out of 9) for RBDs. See Table 19.

Summary. There were a few consistent findings for the communication channel correlations. In general, for Normal Controls there were a greater number of significant correlations than for either the LBDs (who were intermediate) or the RBDs (who had very few such findings). Second, there was a higher percentage of significant correlations (nearly twice as many) for identification tasks (36.7%) than for discrimination tasks (18.5%).

Table 17. Correlation Coefficients Among the Communication Channels for Identification and Discrimination Total Score Variables

	RBDS				LBDS				NCS			
IDENT	FID	PID	WID	SID	FID	PID	WID	SID	FID	PID	WID	SID
FID		.57	.47	.37		-.21	.76**	.28		.57*	.82***	.68**
PID			.38	.59			-.29	.33			.73**	.78***

	RBDS			LBDS			NCS		
DISCRIM	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS
FDIS		-.05	.09		.63*	.62*		.52*	.31
PDIS			.28			.80**			.39

*p≤ .05; **p≤ .01; ***p≤ .001

Table 18. Correlation Coefficients Among the Communication Channels for Positive and Negative Identification Items

	RBDS				LBDS				NCS			
POSITIVE	FID	PID	WID	SID	FID	PID	WID	SID	FID	PID	WID	SID
FID		.11	.23	.25		.02	.72*	-.08		.05	.000	-.03
PID			-.29	.28			-.12	.49			.66**	.63*
NEGATIVE	FID	PID	WID	SID	FID	PID	WID	SID	FID	PID	WID	SID
FID		.77**	.52	.48		-.16	.75*	.67*		.61*	.75***	.75***
PID			.47	.51			-.33	-.27			.66**	.73**

*p≤ .05; **p≤ .01; ***p≤ .001

Table 19. Correlation Coefficients Among Communication Channels for Positive and Negative Discrimination Items

	RBDs			LBDs			NCs		
POSITIVE	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS
FDIS		-.03	.20		.56	.07		.13	-.10
PDIS			-.40			-.18			-.29
NEGATIVE	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS
FDIS		-.66*	-.30		.002	.35		-.43	.69**
PDIS			.22			.66*			.67**
MIXED	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS	FDIS	PDIS	WDIS
FDIS		.77**	-.20		.38	.25		.28	.14
PDIS			-.46			-.09			.05

*P≤.05;**p≤.01

VI. DISCUSSION

Right Hemisphere versus Valence Hypothesis

One of the major goals of this study was to evaluate the right hemisphere hypothesis versus the valence hypothesis using three different communication channels. Overall, there is strong support for right hemisphere dominance in emotional perception. Evidence for the right hemisphere theory comes from the finding of significant main effects of Group but no significant Group X Valence interactions. These results were seen for the identification tasks, whether Word Identification or Sentence Identification was included. In these analyses, RBDs were significantly impaired (less accurate) relative to NCs and LBDs. The LBDs and NCs did not differ significantly from each other. This study is consistent with a large number of studies in the emotion literature which have also found right hemisphere dominance for emotional perception rather than differential specialization as a function of valence (e.g., Borod, et al., 1992; Bowers, et al., 1985; Heilman, et al., 1984). However, this is the first study to include facial, prosodic, and lexical communication channels to study emotional perception. In a related study on emotional perception, Benowitz, Bear, Rosenthal, Mesulam, Zaidel, and Sperry (1983) used three nonverbal channels of communication: facial expression, body movement, and vocal intonation. Overall, their results suggest that nonverbal emotional communication is dependent upon right hemisphere functioning. In addition, the perception of facial expression was the most impaired of the three measures for RBDs.

When a Group X Channel X Valence ANOVA was performed in the current study with the discrimination tasks, no significant main effect of Group was observed. There are at least two possible explanations for the lack of significant findings. First, it may be that the discrimination tasks are less difficult than the identification tasks. As a result, brain-damaged subjects who are cognitively-intact enough to participate in the study will then perform at a level comparable to the normal controls. Another explanation is that the discrimination process is activating perceptual systems rather than emotional systems. In other words, the task is performed as a perceptual matching task rather than as an emotional discrimination task (e.g., Borod et al., 1993). Of interest, is the fact that there were very few significant intrachannel correlations (only 3 significant correlations out of 24) for valence scores for identification versus valence scores for discrimination for each channel for each subject group). This lack of relationship further underscores the separateness of the discrimination process tapped in this study as compared to the identification process.

There was a significant Group X Channel X Valence interaction for the discrimination tasks. Overall, there were no significant group or valence differences within the facial channel. However, for the prosodic channel, RBDs were significantly more impaired on mixed valence items than on positive items, while LBDs were significantly more impaired on mixed than on either positive or negative items. In contrast, for the lexical channel, RBDs were significantly less accurate on positive or negative items relative to mixed valence items. LBDs were significantly less accurate on mixed valence lexical items than on either positive or negative items. NCs did not exhibit any significant differences as a function of valence. It should be noted that when this analysis was conducted without the mixed valence items, no significant main effect of Group or significant interactions involving Group were seen. It appears as if the Group X Channel X Valence interaction is primarily the result of the varied performance of the brain-damaged groups on the mixed items.

For both the identification and discrimination analyses, a consistent main effect of Channel was observed. For identification, subjects performed significantly worse on Prosodic Identification than on either Facial, Lexical Word, or Lexical Sentence Identification. For the discrimination tasks, however, the opposite pattern was seen. That is, all subject groups performed significantly better on Prosodic Discrimination than on the Facial or Lexical Word Discrimination tasks. These findings may be due to factors associated with the prosodic tasks themselves rather than the result of a difference in the manner in which prosodic emotion is perceived or processed. It appears as if the Prosodic Identification task may be inherently more difficult than the other two identification tasks. While they may be able to distinguish fear from happiness or even anger, it seems much more difficult to distinguish fear from disgust or unpleasant surprise. One possible way to determine if this is the case, would be to do an item/error analysis in order to assess the exact nature of the errors made by the subjects. Prosodic Discrimination, on the other hand, appears to be quite simple for the majority of the subjects. One reason for this could be the fact that for "Same" items, the emotionally-intoned sentence is said by the same actor or actress. For "Different" items, a different actor or actress is used. It may be that the subjects are performing a simple perceptual matching task rather than discriminating discrete emotions. That is, the subjects may be judging the voices as "same" or "different" rather than judging whether the emotion being conveyed by the voice is the same or different. One way to assess this would be to add a second discrimination task (or add a few items to the current one) where both "Same" and "Different" items are intoned by both the same and a different actor. An item analysis could then be performed and the different presentations (e.g., same emotion--same voice, different emotion--same voice) compared.

There was a significant interaction between Channel and Valence for identification tasks. In the Word Identification 3-way ANOVA, negative emotions presented in either facial or prosodic channels were significantly less accurately perceived than were negative emotions presented in the lexical channel. For positive emotions, prosodic items were significantly less accurately perceived than were either facial or lexical items. One reason for differences between the perception of positive and negative facial emotions may be that positive facial expressions are easier to identify than negative expressions.

There may be subtler differences in the facial expressions of fear and unpleasant surprise as compared to happiness and interest or even pleasant surprise. In the Sentence Identification ANOVA, facial and lexical emotions were more accurately perceived than were prosodic emotions for both positive and negative items. This may due to the greater difficulty of the prosodic task in general.

When ANCOVAs were performed separately for Facial Identification, Prosodic Discrimination, and Word Identification, a significant main effect for Group was obtained for Facial Identification. Post-hoc tests indicated that RBDs were significantly impaired relative to both LBDs and NCs. Although there was only a trend for Word Identification, post hoc analyses revealed that RBDs were significantly more impaired than NCs. The finding for the facial channel in the presence of a control for neutral face recognition indicates that the results obtained are most probably due to emotional processing deficits rather than to a more general deficit in face recognition. This finding is in agreement with several studies in the literature (e.g., Borod et al., 1993; Bowers et al., 1985; Cicone et al., 1980) that also suggest that facial emotion deficits are independent of neutral face recognition (or visual perception) in brain-damaged patients. The presence of a significant post-hoc group difference between RBDs and NCs and post-hoc group difference (albeit not significant) between RBDs and LBDs for Word Identification when covaried with the appropriate nonemotional control task suggests that this lexical emotional deficit exhibited by

RBDs might be due to difficulties with emotional processing rather than to linguistic factors.

Emotional versus Nonemotional Lexical Perception

In order to further assess the impact of linguistic factors on lexical emotional processing, a Group X Condition X Task ANOVA was conducted. There was a significant main effect of Group such that RBDs were impaired relative to the other two groups. More importantly, there was a significant Group X Condition interaction. RBDs were impaired relative to LBDs and NCs within the emotional condition. However, no group differences were seen in the nonemotional condition. This is precisely what one would expect if the differences were due to emotion deficits rather than to linguistic factors. These results are similar to those obtained by Borod et al. (1992) where significant Group X Condition interactions were obtained for measures of lexical emotional identification and discrimination. As in the current study, the RBDs showed more deficits in the emotional than in the nonemotional condition, relative to the LBDs and NCs. Taken together, these findings and the results from the ANCOVAs in the current study suggest that emotional and linguistic factors that comprise the lexical emotional tasks in this study probably operate independently.

Communication Channel

There are a number of studies that have found a relationship between channels of emotional communication. Some of these studies have found significant relationships between the facial and prosodic channel (Borod et al., 1990; Borod, et al., 1985) for brain-damaged and normal subjects. Borod et al. (1985) examined the relationship between face, prosody, and speech content channels in spontaneous emotional expression. While face and prosody were substantially correlated with each other among brain-damaged patients, speech content did not correlate significantly with the other channels. In Benowitz et al. (1983), however, among brain-damaged patients with preserved left hemisphere functioning, face perception was not positively correlated with perception scores for vocal intonation or body movements.

In the present study, correlation coefficients were computed between the facial, prosodic, and lexical channels of emotional perception. Several interesting findings emerged. For identification tasks, NCs exhibited significant correlations (100% for total scores, 70% for valence scores) among the three communication channels. LBDs had fewer significant correlations (20% for total scores, 30% for valence scores) whereas RBDs showed virtually no significant relationships (0% for total scores, 10% for valence scores). On the other hand, for discrimination, there were fewer significant correlations overall, and the group-related patterns were not systematic. It should be noted that the number of subjects in each group is small and that these patterns of results should be interpreted with caution.

For identification, while the results for NCs are consistent with earlier reports in the literature, the findings for BDs are not (but see Bowers, Bauer, & Heilman, 1993). The presence of significant correlations for identification tasks among all channels for normals suggests that there may be a central processor for emotion identification that is independent of channel (e.g., Borod, 1992; Semenza, et al., 1986). While the lack of significant correlations for the BD groups seems to suggest that there is a single processor for each channel, the identification correlations obtained were all positive and of substantial magnitude. Again, In light of the small number of subjects per patient group, these findings should be interpreted with caution. A larger number of subjects, particularly brain-damaged subjects, would be necessary to confirm this pattern of results. Finally, the presence of fewer significant correlations for discrimination may reflect the underlying perceptual or even sensory components of these tasks. Such systems are separately and independently represented within the brain and may not necessarily show any relationship to each other.

Exploratory Issues

Finally, a number of exploratory analyses were undertaken to investigate the effect that certain factors (e.g., language deficits) had on the experimental variables under study. Some of these factors (e.g., lesion level) were discussed a priori but due to small N's, were not included in the primary analyses. Factors raised in the following discussion reflect both patient issues and general subject issues.

Lesion Level. The brain-damaged subjects were classified into three groups according to lesion level. Cortical subjects had lesions which affected only the cerebral cortex. Subcortical subjects had lesions which were confined to subcortical structures. Mixed-level subjects had lesions which involved both cortical and subcortical regions. Three Group (2) X Lesion Level (3) X Channel (3) X Valence (2) or (3) repeated- measures ANOVAs were conducted separately using Lexical Word ID (WID), Sentence ID (SID), and Word Discrimination (WDIS).

The results of the lesion level analyses are similar to those seen for the Group X Channel X Valence ANOVAs reported above. There were similar main effects for Group and Channel for the Identification tasks and a main effect for Channel for the Discrimination tasks. However, there were no significant main effects for lesion level or any significant interactions involving level of lesion and side of lesion. Similarly, no significant main effect of lesion level or Group X Level interactions were found when a Group (2) X Level (3) X Condition (2) X Task (3) ANOVA was performed for the lexical channel.

There is evidence from animal studies that subcortical structures play a role in the perception of emotion (e.g., fear conditioning; LeDoux, Ruggerio, & Reis [1985], cited in Gainotti, Caltagirone, & Zoccolotti [1993]) . Allman and

Brothers (1994) describe a case study by Adolphs, Tranel, Damasio, and Damasio (1994) in a which a patient with bilateral damage (destruction) of the amygdala was unable to identify the facial expression of fear. Taken together, the results of these studies and the current findings suggest that the subcortex is involved in emotional perception.

Language Deficits. In order to evaluate any potential impact of language deficits on the variables under study, all LBDs were classified according to whether or not language deficits were present. The "no deficit" group did not have known history of language problems either at the time of testing or at the time of the stroke. The "deficits present" group had a history of language disturbances or a diagnosable aphasia either at the time of stroke or at the time of testing. It should be noted that although half of the LBDs had language deficits at some point, only 2 out of 5 had an aphasia diagnosis (i.e., 1 fluent, 1 nonfluent) both while hospitalized and at the time of testing. A Language Group (2) X Condition (2) X Task (3) ANOVA was performed but did not yield a significant main effect for Language Group or significant Language Group interactions. In addition, three separate Language Group (2) X Channel (3) X Valence (2) or (3) ANOVAs were conducted using Word Identification, Sentence Identification, and Word Discrimination, respectively. Overall, none of the analyses yielded any significant main effects or interactions for the Language Group variable.

Months Post Onset. Although there were no significant differences between the brain-damaged groups for either the mean months post onset (MPO) or median MPO, on an exploratory basis, correlation coefficients were computed for each group separately and for all BDs together for both total scores and valence scores. There were only 2 (out of 72) significant correlations, which is less than would be expected by chance. Despite the wide range of MPO within and between subject groups, this variable had minimal impact on emotional task performance in this study. It should be noted that, as a group, the LBDs had a shorter MPO, suggesting that they were in an earlier stage of recovery than the RBDs. Based on this information, one would expect the LBDs to be more impaired, relative to the RBDs who had more time for recovery of function to occur. This, however, was not the case. The LBDs performed better than the RBDs on the tasks under study.

Unilateral Neglect. Although some studies have reported an association between unilateral neglect and emotional deficits in right brain-damaged patients (e.g., Gainotti, 1972; Ruckdeschel-Hibbard, Gordon, & Diller, 1984), others have failed to find significant relationships for emotional perception (Borod et al., 1992), expression (Borod, Koff, Lorch, & Nicholas, 1986a), or experience (Borod, Rorie, Haywood, Andelman, Obler, Welkowitz, Bloom, & Tweedy, 1995). In the current study, a left neglect ratio was calculated for each cancellation task (letters and geometric forms) separately and then correlated with total scores and valence scores for each experimental task for the RBDs. Overall, there were only 3 significant correlations out of a possible 34, indicating that this variable did not have any major impact on the results of this study.

Gender. In light of the unequal number of males and females in the three subject groups and findings in the literature of differences in emotional processing for men and women (e.g., Ladavas et al., 1980; La France & Banaji, 1992; Strauss & Moscovitch, 1981), three Group (3) X Gender (2) X Channel (3) X Valence (2) or (3) ANOVAs were conducted for identification and discrimination tasks. Overall, there were no significant main effects of Gender or significant Gender interactions for any of these analyses. A Group (3) X Gender (2) X Condition (2) X Task (3) ANOVA was performed on the total scores for the lexical channel. Again, no significant main effect or interactions for Gender emerged.

Beck Depression Inventory. Scores on the Beck Depression Inventory (BDI) were correlated for each subject group, separately for total scores and for positive, negative, and mixed valence percent correct scores. Overall, there was 2 out 10 significant correlations for RBDs, 0 out of 10 for LBDs, and 3 out of 10 for NCs. As one might expect, among the four significant correlations for valence, all four occurred for negative items. In light of the number of significant correlations (i.e., more than would be expected by chance), all major analyses were conducted again, using BDI as a covariate. Overall, the pattern of results remained essentially the same as above for the identification analyses, the discrimination analysis, and for the emotional versus nonemotional lexical task analysis. While this variable may not have had a major impact in the present study, it may be an important variable in future studies with this database if differences emerge between positive and negative emotions.

Conclusions

In summary, in this study facial, prosodic, and lexical emotional perception in right- and left-brain-damaged subjects and normal controls were compared. The unique contribution of this study to the literature lies in the fact that three channels of communication were systematically compared in the same group of subjects. Overall, the results of the present study support the right hemisphere hypothesis. In addition, there is evidence of a single emotional processor involved in emotional perception across the various communication channels. Finally, the fact that RBDs were impaired on lexical emotional tasks relative to nonemotional lexical tasks provides additional evidence that these tasks reflect emotional rather than linguistic factors.

Although the subject groups were well-matched in terms of salient demographic variables, future research should include larger numbers of subjects. In this way, analyses can be conducted for factors such as lesion level and language deficit/aphasia type. An attempt was made to investigate the effect of lesion site (i.e., anterior vs posterior) on the experimental variables under study. Unfortunately, however, the number of subjects in each group was too small to permit such analyses. Future studies should include larger sample sizes to examine the impact of intrahemispheric (e.g., caudality) factors on these tasks.

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