Resolution of Ambiguous Emotional Messages: Age, Gender, and Brain Lesion Effects

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The two cerebral hemispheres are not functionally symmetrical, and it is generally agreed (Ross, 1988) that the right hemisphere processes paralinguistic components of communication (facial expression, intonation, etc.) but the left hemisphere interprets linguistic aspects. This conceptualization of hemispheric processing, however, has not been consistently demonstrated in the study of emotion, although there is substantial evidence that the right hemisphere is responsible for affective processing (Silberman & Weingartner, 1986). Schlanger, Schlanger, and Gerstman (1976) found no significant differences between aphasic and right-hemisphere-damaged subjects in the perception of 60 emotionally intoned sentences. DeKosky, Heilman, Bowers, and Valenstein (1980) reported that patients with right sided non-parietal lesions without neglect were identical to left-lesioned subjects in their ability to recognize emotional tone or content of sentences. Cancelliere and Kertesz (1990) reported no significant differences on tests of elicitation, repetition and identification of emotional prosody and the identification of emotional situations by left- and right-brain-damaged subjects.

Some evidence suggests that right hemisphere dominance for emotional processing depends on task complexity. Tompkins and Flowers (1985) found that the right hemisphere is primarily involved in the reception and recognition of emotional stimuli, but increased cognitive demand results in a shift in emphasis from the right hemisphere to both hemispheres. Silberman and Weingartner (1986) concluded that both hemispheres may have strategies for decoding emotional stimuli, but an intact right hemisphere is needed to mediate *felt* emotional responses.

In this study we explored hemispheric processing of congruous and ambiguous emotional messages in right- and left-brain-damaged subjects. We predicted that short messages with linguistic and paralinguistic components of emotion coded unambiguously would produce few errors in unilaterally brain damaged subjects because they could utilize the residual abilities of the unimpaired hemisphere to interpret the emotion. We also hypothesized that presenting more cognitively demanding tasks in which the emotion of the message's linguistic and paralinguistic components did not agree would generate more errors and a predictable reliance of the right-brain-damaged subjects on the verbal cues and the left-brain-damaged subjects on the paralinguistic cues. Finally, we predicted that closed-head-brain-trauma subjects would produce more errors than the unilateral brain damaged subjects and that there would be no dominant form of response to paralinguistic or linguistic components of the message. The diffuse bihemispheric characteristics of the brain damage would not leave an unimpaired hemisphere available for processing. Previous studies have shown that brain trauma patients demonstrate deficits in processing emotion (Jackson & Moffat, 1987; Mammucari et al., 1988) and in interpreting ambiguous information that is a major feature of humor (Braun, Lussier, Baribeau & Ethier, 1989).

We were also concerned with two methodological issues: First, there is evidence that there are age (Faix & Hough, 1990) and gender (Rotter & Rotter, 1988) effects in the processing of emotion. We therefore decided to include a group of neurologically normal adults equally balanced by gender across the adult lifespan to serve as a reference for examining hemispheric site of lesion effects. Second, many studies of emotion are based on static facial images or present only part of the typically available information for processing emotion (see Silberman & Weingartner, 1986, for a review). We decided to address this issue by including dynamic stimuli and presenting the stimuli with the full complement of information available for processing as well as with only the auditory signal available.

METHOD

Subjects

Sixty neurologically normal and 29 brain-damaged right-handed English speakers served as subjects. The normal subjects included five males and five females for each 10-year age category from 16 to 75 years (Table 1). Mean age for the group was 45.5 years. None of the subjects had a history of neurological deficits or communicative disorders. Elderly normals gave no indication of dementia by history or report and were living independently in the community.

TABLE 1. AGE MEANS AND STANDARD DEVIATIONS (IN YEARS) FOR NORMAL SUBJECT GROUPS

Age Category	*Male*	*Female*	*Combined*
1. 16–25	21.2	19.4	20.3 (2.16)
2. 26–35	30.6	32.8	31.7 (3.71)
3. 36–45	40.4	41.6	41.0 (2.83)
4. 46–55	49.4	48.8	49.1 (2.85)
5. 56–65	60.2	61.2	60.7 (3.53)
6. 66–75	70.6	69.6	70.1 (2.13)
All Groups	45.6	45.4	45.5 (17.18)

The subjects with brain damage included 10 with left brain damage and aphasia (mean age = 52.9 years), 9 with right brain damage (mean age = 67.1 years), and 10 with brain trauma (mean age = 30.0 years). Hemispheric site of lesion and clinical assessment of communication functioning (e.g., aphasia test battery, neuropsychological evaluation) was completed. The left hemisphere subjects exhibited mild to moderate aphasia and included six Brocas, two anomic, and two mixed anterior types. None of the right hemisphere subjects exhibited significant neglect or neuropsychological findings suggestive of right parietal lesions. All brain trauma subjects had WAIS full scale IQs of 70 or greater, with ratings of 6 or 7 on the Rancho Los Amigos Scale. Subjects were screened to ensure that they had sufficient auditory and visual acuity (corrected, if necessary) to respond to the experimental tasks. To be included in the study, subjects also demonstrated correct performance on at least five of eight pretrial screening items representative of the experimental task.

Stimuli

Eckman and Oster (1979) reported universal recognition of six distinctive facial expressions. Four of these emotions were selected based on their portrayal ease: happiness, sadness, anger, and fear. Five three- to five-word sentences were constructed to portray each of these four emotions, for a total of 20 sentences. A 25-year-old female was videotaped as she portrayed the emotions of the sentences as if she were communicating with the viewer. For each stimulus, the linguistic and paralinguistic features of the message were consistent. Words such as *glad, sorry, scary,* and *mean* were used to convey the intended emotion by their placement in the sentence. Paralinguistic features (intonation, facial cues) were consistent with the linguistic message used to convey the emotion (Table 2).

The same 20 sentences were then produced and videotaped to develop ambiguous stimuli in which the intonation and facial cues did not corre-

TABLE 2. EXAMPLES OF CONGRUOUS AND AMBIGUOUS STIMULI

A. Congruous

Linguistic	*Stimulus*	*Paralinguistic*
Happy	I like you.	Happy
Angry	I hate you.	Angry
Sad	I have bad news.	Sad
Afraid	It's too scary.	Afraid

B. Ambiguous

Linguistic	*Stimulus*	*Paralinguistic*
Happy	It's a wonderful surprise.	Angry
Angry	I'm furious with you.	Sad
Sad	I'm sorry I missed you.	Afraid
Afraid	What's that noise?	Happy

spond with the affective wording of the message, such as "I like you" presented as if the speaker were angry. The paralinguistic affect was selected from the remaining three emotions not portrayed by the linguistic message. No ambiguous affect appeared more than two times in each group of five sentences used to express the four emotions (Table 2). The total of 40 videotaped segments (20 congruous and 20 ambiguous) were randomized for presentation, preceded by eight pretrial segments (four congruous, four noncongruous), which were included to provide subjects with practice responding to the task. The pretrial segments were coded in the four emotions in both congruous and ambiguous conditions in a manner identical to the experimental segments.

To validate the accuracy of linguistic and paralinguistic portrayals of affect presented on the tape, the stimuli were presented to five college-age normal judges in both audiovisual (AV) and audio-only (AO, with the video off) conditions. Using the closed set of four emotions employed as response choices in the study, mean agreement with the intended emotion for the five judges was 99% for both the linguistic and paralinguistic analyses.

Procedures

The pretrial and experimental stimuli were presented to each of the 89 subjects two times—AV followed by AO. Responses were chosen from a score sheet that included the closed set of four emotions: happy, sad, afraid, and angry for the normal subjects. For the brain damaged subjects, pictograms as well as the words denoting the emotions were included in the response field, as depicted in Figure 1.

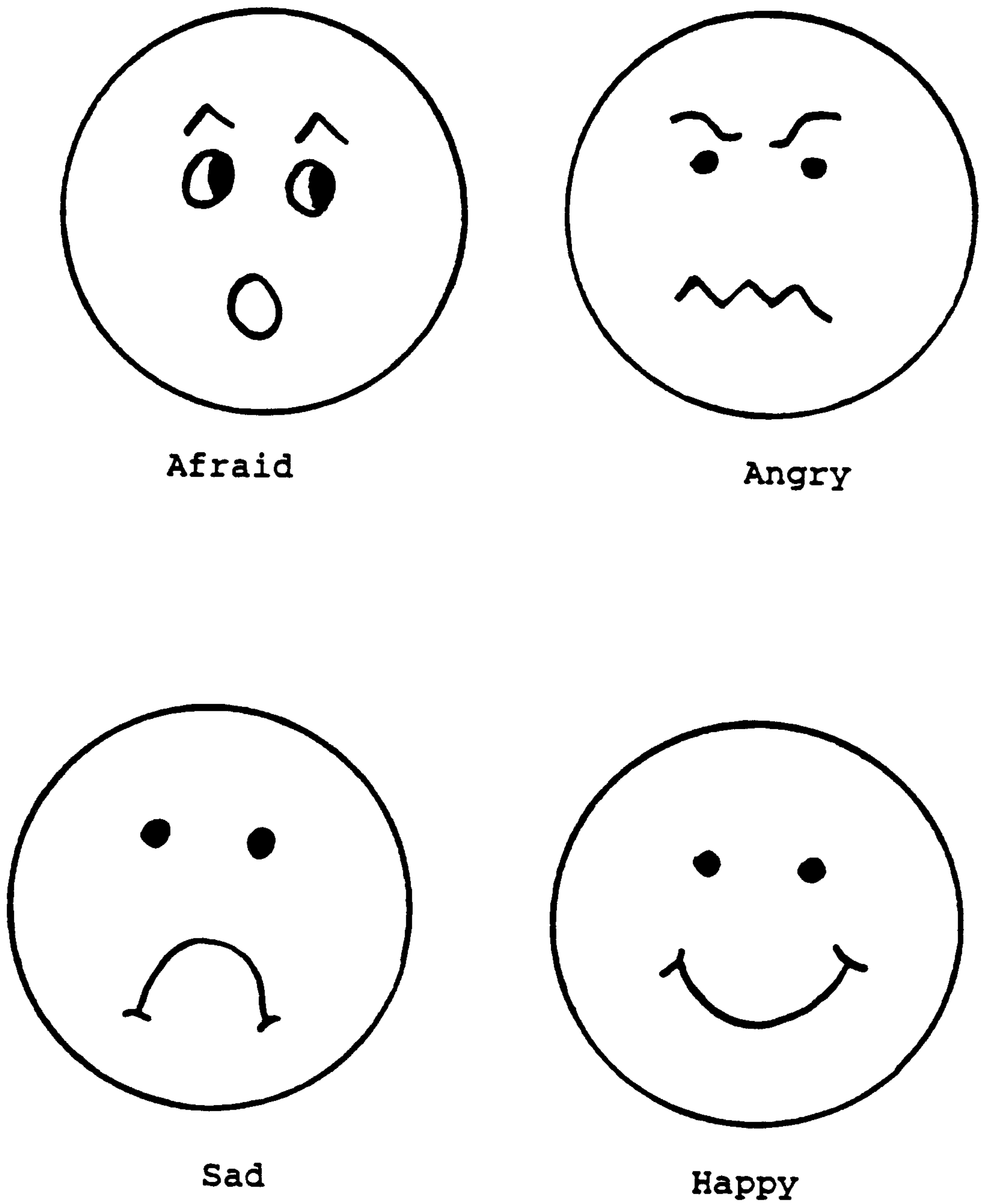

Figure 1. Verbal and pictorial response choices presented to the brain damaged subjects following each stimulus item.

RESULTS

Normal Subjects

Results from the normal subjects were used to explore potential age and gender effects and, more importantly, to serve as the normative reference for evaluating emotion recognition for the brain damaged subjects.

Congruous Messages

We viewed the congruous sentences as validations of the experimental paradigm's stimuli. In other words, we expected that dynamic, brief, affective messages with highly redundant linguistic and paralinguistic information would be robust indicators of the ability to recognize emotion, and we expected little difficulty on the part of the normal subjects. Mean percent correct scores for males, females, and the subjects combined at each age level of the AV and AO conditions are shown in Table 3. Mean percent correct scores were identical for males and females in the AV condition (97.8%) and similar in the AO condition (male = 92.7%; female = 93.3%). A three way analysis of variance (ANOVA) revealed a significant effect for conditions ($p < .01$) but not age or gender ($p > .05$). Interaction effects were not significant. Thus, eliminating visual information in the audio-only condition significantly reduced the number of correct responses to the congruous messages.

Ambiguous Messages

Two analyses of responses to the ambiguous stimuli were carried out on normal subjects. First, the number of errors was determined for each subject and group. An error was defined as a response that did not reflect either the linguistic or the paralinguistic affect of the message. For example, in the message "I like you" presented as if the speaker were angry, a subject response of sad or afraid was considered an error. Mean percent error scores are shown in Table 4. Gender differences were small (<5%), and error scores were greater for AO than for the AV condition for males, females, and combined groups for all age categories. A three way ANOVA revealed significant effects for conditions ($p < .001$) but not age ($p > .05$) or gender ($p > .05$). The analysis also revealed a significant interaction ($p < .05$) between conditions and gender that reflected the differential effects of the AO condition on the performance of males and females. These

TABLE 3. MALE, FEMALE, AND COMBINED MEAN PERCENT CORRECT SCORES FOR AUDIOVISUAL (AV) AND AUDIO-ONLY (AO) CONDITIONS FOR CONGRUOUS STIMULI

Audiovisual			
Age category	*Male*	*Female*	*Combined*
1. 16–25	98	99	98.5
2. 26–35	99	98	98.5
3. 36–45	97	100	98.5
4. 46–55	99	98	98.5
5. 56–65	99	97	98.0
6. 66–75	95	95	95.0
Total	97.8	97.8	97.8
Audio-Only			
Age category	*Male*	*Female*	*Combined*
1. 16–25	92	98	95.0
2. 26–35	92	96	94.0
3. 36–45	95	97	96.0
4. 46–55	97	90	93.5
5. 56–65	93	91	92.0
6. 66–75	87	88	87.5
Total	92.7	93.3	93.0

results suggest that the effect of reducing available information for the ambiguous stimuli was to increase the frequency of errors for the normal subjects.

A second analysis used the responses to the paralinguistic and linguistic features of the ambiguous messages to establish dominance in a fashion similar to determining an ear advantage on dichotic listening tasks. For example, in the message "I hate you" presented with paralinguistic cues for fear, anger and fear were both considered correct responses, but they are based on different affective information in the stimulus—anger on the linguistic and fear on the paralinguistic. The number of responses based on linguistic features was subtracted from those based on paralinguistic cues and was divided by the total number of non-error responses. The resulting ratio is a reflection of how ambiguity is resolved in a message with conflicting affective features and can range from all paralinguistic based responses (+1.0) to all linguistic responses (–1.0).

Table 5 shows mean ratios for males and females for the AV and AO conditions. Ratios were more positive for females than for males in both conditions and showed a marked decline for both groups for the fifth and

TABLE 4. MALE, FEMALE, AND COMBINED MEAN ERROR SCORES FOR AUDIOVISUAL (AV) AND AUDIO-ONLY (AO) AMBIGUOUS STIMULI

Audiovisual			
Age category	*Male*	*Female*	*Combined*
1. 16–25	7	4	5.5 (3.50)
2. 26–35	4	2	3.0 (3.50)
3. 36–45	6	6	6.0 (5.16)
4. 46–55	10	3	6.5 (4.74)
5. 56–65	11	5	8.0 (6.33)
6. 66–75	8	4	6.0 (8.10)
Total	7.7	4	5.8 (5.61)

Audio-Only			
Age category	*Male*	*Female*	*Combined*
1. 16–25	18	12	15.0 (10.80)
2. 26–35	10	12	11.0 (8.09)
3. 36–45	17	18	17.5 (3.54)
4. 46–55	13	21	17.0 (5.38)
5. 56–65	20	14	17.0 (8.23)
6. 66–75	13	19	16.0 (7.38)
Total	15.2	16	15.6 (7.60)

sixth age groups (56–65 years and 66–75 years). ANOVA showed significant effects for age, gender, and condition ($p < .01$ for each comparison). A significant interaction ($p < .01$) was also found between conditions and age that reflected a larger effect of the AO condition for the oldest age groups.

In summary, the effect of increasing age was to increase the frequency of responses based on verbal aspects of the message. Males demonstrated greater verbal-cue reliance than females did, and the effect of removing the visual information was to increase the number of responses based on linguistic cues. Results for the normal subjects showed no significant gender or age effects for the number of correct responses on congruous stimuli, or the number of errors on ambiguous stimuli. Both age and gender effects, however, were found in the resolution of ambiguous emotional messages. We note that older subjects have demonstrated greater difficulty in interpreting emotion presented via audiotaped neutral sentences (Faix & Hough, 1990), and there is evidence that females are more accurate than males in their ability to identify facial emotional expressions (Rotter & Rotter, 1988; Hall, 1978). More importantly, these findings sug-

TABLE 5. MALE, FEMALE, AND COMBINED MEAN AMBIGUITY RESOLUTION RATIOS FOR AUDIOVISUAL (AV) AND AUDIO-ONLY (AO) AMBIGUOUS CONDITIONS

Audiovisual			
Age Category	*Male*	*Female*	*Combined*
1. 16–25	.804	1.000	.902
2. 26–35	.928	.872	.900
3. 36–45	.850	.988	.919
4. 46–55	.884	.938	.911
5. 56–65	.372	.746	.559
6. 66–75	.268	.620	.444
Total	.684	.861	.772
Audio-Only			
Age category	*Male*	*Female*	*Combined*
1. 16–25	.676	.852	.764
2. 26–35	.514	.786	.650
3. 36–45	.326	.654	.490
4. 46–55	.430	.702	.566
5. 56–65	–.180	.422	.121
6. 66–75	–.270	–.066	–.168
Total	.249	.558	.404

gest that both age and gender are potentially confounding variables in the study of emotion processing.

Brain-Damaged Subjects

The purpose of including normal subjects was to develop a normative reference for comparison of the brain-damaged subjects. Percent correct (congruous stimuli) and percent error and resolution ratio values (ambiguous stimuli) were converted to z scores based on the mean and standard deviation data of normal male and female subjects of comparable age. This procedure, in effect, provided age and gender corrections for the performance of the brain-damaged subjects. For congruous stimuli, the percent correct scores on congruous messages, mean z scores for left- and right-brain-damaged subjects and the brain trauma subjects were all within one standard deviation of the normal mean ($z < \pm 1$) for the AV and AO conditions. This finding suggests that none of the brain-damaged groups were impaired in their ability to clearly interpret unambiguous emotional

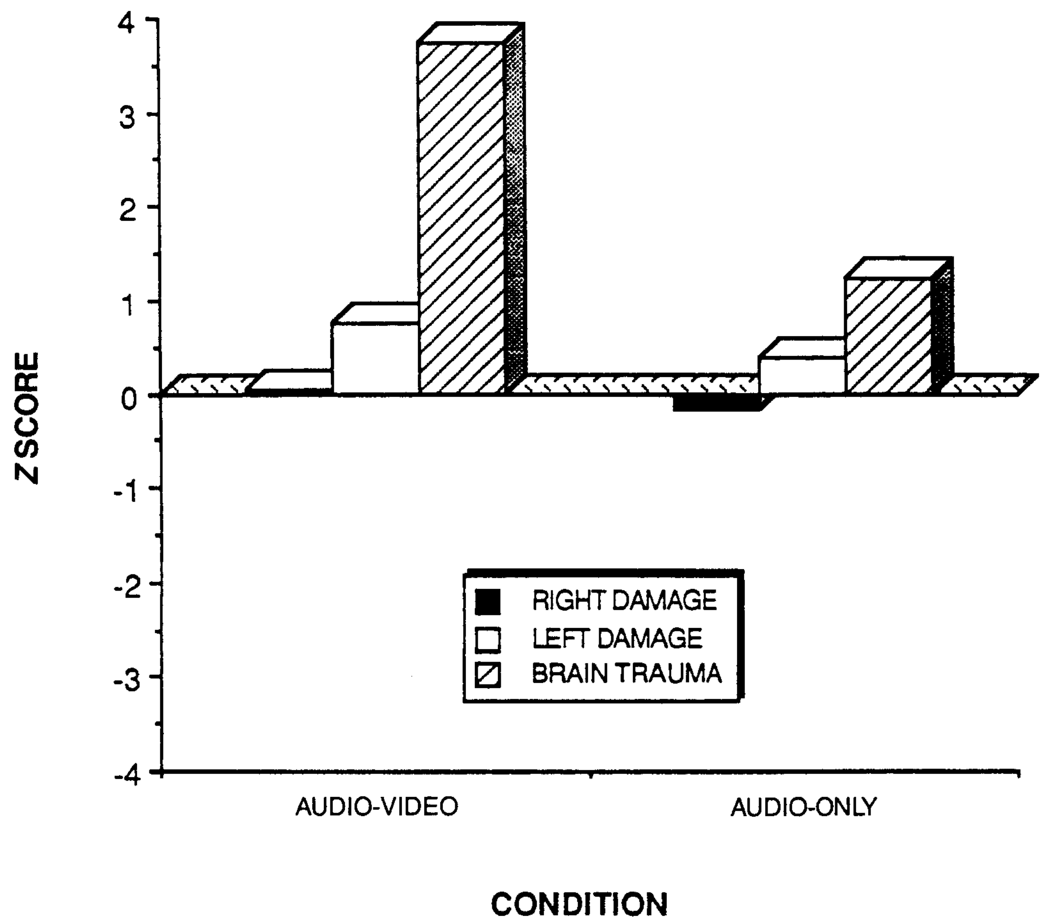

Figure 2. Mean percent incorrect z scores for ambiguous stimuli by three brain damaged subject groups in two stimulus conditions.

stimuli. For ambiguous stimuli, mean percent incorrect z scores for the three brain damaged groups are shown in Figure 2. Z scores were within 1.0 for the right- and left-brain-damaged subjects but were +3.73 and +1.26 for the brain trauma group for the AV and AO conditions, respectively. This suggest that there is an increased frequency of errors on ambiguous stimuli in bilateral brain trauma compared to unilateral brain damage. This finding suggests that both hemispheres are active participants in the resolution of emotional ambiguity.

Figure 3 shows the mean raw score values of the resolution ratios for the three groups of experimental subjects. These results may be interpreted as demonstrating a marked reliance of the right-brain-damaged subjects on verbal processing compared to the other two groups for both conditions. However, when mean z scores are examined, which reflect age and gender corrections, (Figure 4) it can be seen that all three brain damaged

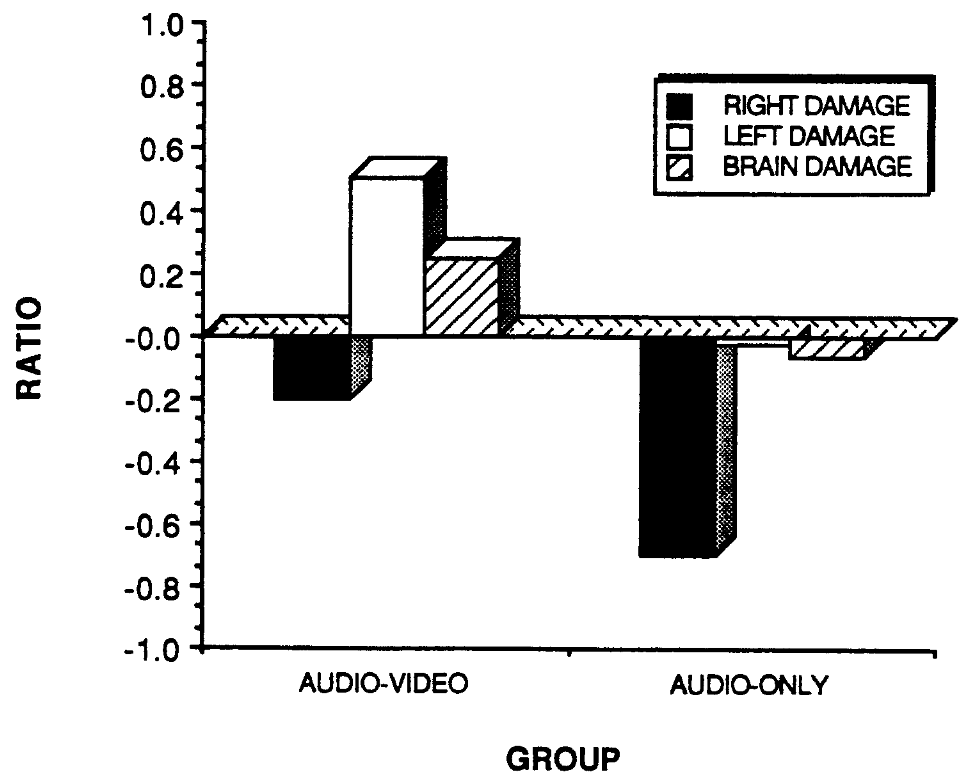

Figure 3. Mean resolution ratio raw scores for three brain damaged subject groups in two stimulus conditions.

groups demonstrate verbal processing strategies or a greater reliance on verbal cues in resolving the ambiguous stimuli. Interestingly, earlier studies have reported significant differences between left- and right-brain-damaged subjects and normals (Marquardt, Stadt & Lukas, 1991) and between brain trauma and normal subjects (Richburg, 1987).

DISCUSSION

The three brain-damaged groups demonstrated few differences from neurologically normal subjects in the ability to interpret robust congruous emotional sentences. This suggests that findings of no differences as a function of lesion site (Schlanger, Schlanger, & Gerstman, 1976) may be partially related to the interpretive task's lack of difficulty. Both paralinguistic and linguistic information were available in both the stimulus and the response field.

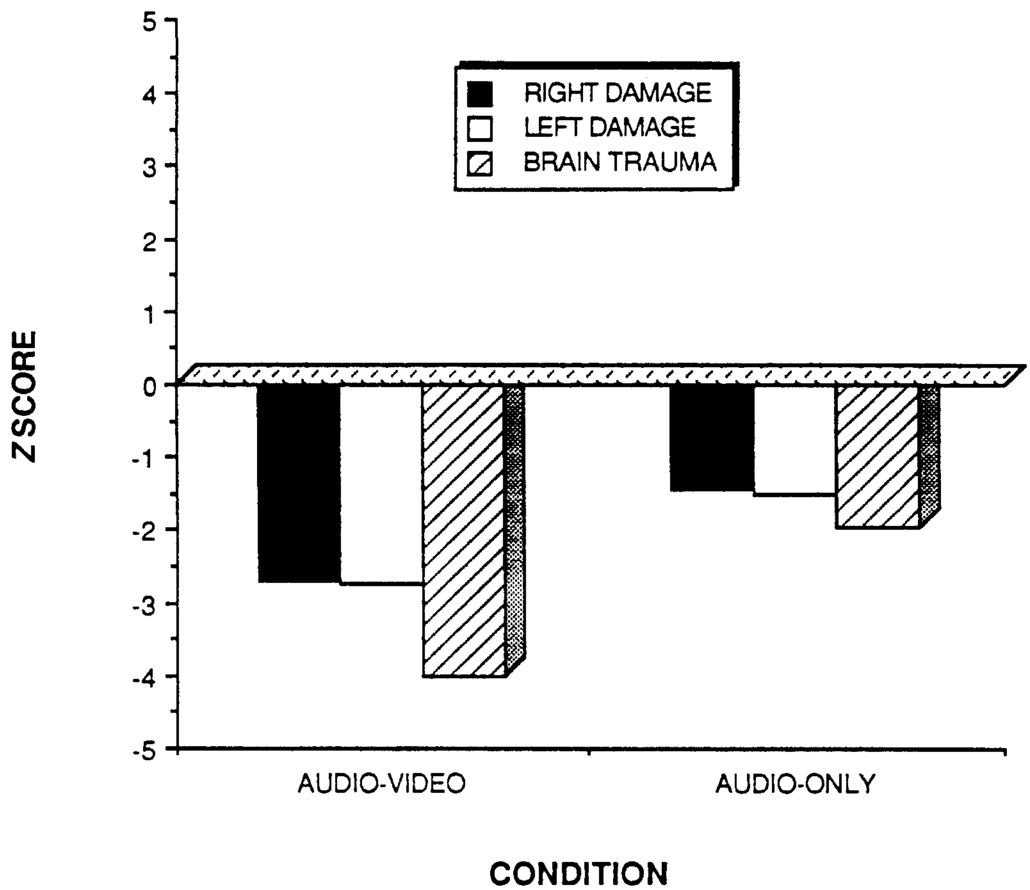

Figure 4. Mean resolution ratio z scores for three brain damaged subject groups in two stimulus conditions.

Brain trauma subjects demonstrated a marked increase in errors on the ambiguous task compared to right- and left-brain-damaged subjects. One interpretation of this result is that both hemispheres are active participants in processing ambiguous emotional stimuli. If so, then a single intact hemisphere allows an accurate exclusion of incorrect choices and focuses the problem solving on the two emotions represented in the stimuli.

The resolution ratios for all three groups were more negative than for neurologically normal subjects. This suggests that brain-damaged subjects more often used *verbal* cues to resolve emotional ambiguity. This is not surprising, as right hemisphere subjects might be expected to have impaired ability to interpret facial features and intonational contours and, therefore, rely on verbal cues to resolve ambiguity. It is a particularly ubiquitous finding for the aphasic subjects, however, because it may suggest that when faced with ambiguous information, they utilize verbal strategies for problem solving instead of the more intact paralinguistic processing functions of the right hemisphere. Moreover, it appears to contradict anecdotal clinical observations that aphasic subjects capitalize on paralinguistic cues (facial expression, intonation) to communicate when language function is severely compromised. We would argue that both hemispheres have interactive strategies for resolving complex or ambiguous emotional stimuli, but a key element of the resolution is the greater reliance on verbal processing, or at least a heightened value assigned to verbal elements of the stimulus when the brain is damaged.

Finally, comparing AV and AO conditions for congruous and ambiguous stimuli demonstrated a relatively linear effect of excluded visual information. The effect of presenting auditory information only was to decrease the number of correct responses on the congruous stimuli and to increase the frequency of errors on the ambiguous stimuli.

ACKNOWLEDGMENT

We are indebted to Vicki Stadt, Patricia Lukas, and Terry Richburg for their help in data acquisition for this study.

REFERENCES

Braun, C., Lussier, F., Baribeau, J., & Ethier, M. (1989). Does severe traumatic closed head injury impair sense of humour? *Brain Injury, 3,* 345–354.

Cancelliere, A., & Kertesz, A. (1990). Lesion localization in acquired deficits of emotional expression and comprehension. *Brain and Cognition, 13,* 133–147.

DeKosky, S., Heilman, D., Bowers, D., & Valenstein, E. (1980). Recognition and discrimination of emotional faces and pictures. *Brain and Language, 9,* 206–214.

Eckman, P., & Oster, H. (1979). Facial expressions of emotions. *Annual Review of Psychology, 30,* 527–554.

Faix, L., & Hough, M. (1990, November). *Identification of vocally expressed emotions throughout aging.* Paper presented at the convention of the American Speech-Language-Hearing Association, Seattle, WA.

Hall, J. (1978). Gender effects in decoding nonverbal cues. *Psychological Bulletin, 85,* 845–857.

Jackson, H., & Moffat, N. (1987). Impaired emotional recognition following severe head injury. *Cortex, 23,* 293–300.

Mammucari, A., Caltagirone, C., Eckman, P., Friesen, W., Gainotti, G., Pizzamiglio, L., & Zoccolotti, P. (1988). Spontaneous facial expression of emotions in brain-damaged patients. *Cortex, 24,* 521–533.

Marquardt, T., Stadt, V., & Lukas, P. (1991). [Resolution of ambiguous emotional messages in right and left hemisphere brain damage]. Scholars project. Center for Communication and Technology, University of Texas, Austin. Unpublished raw data.

Richburg, T. (1987). Interpretation of emotional stimuli by closed head injured patients. Unpublished master's thesis, University of Texas, Austin.

Ross, E. (1988). Language related functions of the right cerebral hemisphere. In F. Rose, R. Whurr, & M. Wyke (Eds.), *Aphasia.* London: Shurr Publishers.

Rotter, N., & Rotter, G. (1988). Sex differences in the encoding and decoding of negative facial emotions. *Nonverbal Communication, 12,* 139–148.

Schlanger, B., Schlanger, P., & Gerstman, L. (1976). The perception of emotionally toned sentences by right hemisphere-damaged and aphasic subjects. *Brain and Language, 3,* 396–403.

Silberman, E., & Weingartner, H. (1986). Hemispheric lateralization of functions related to emotion. *Brain and Cognition, 5,* 322–353.

Tompkins, C., & Flowers, C. (1985). Perception of emotional intonation by brain-damaged adults: The influence of task processing levels. *Journal of Speech and Hearing Research, 28,* 527–538.