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COGNITIVE AND AFFECTIVE RESPONSE AS A FUNCTION OF RELATIVE HEMISPHERIC INVOLVEMENT

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We sought to determine the cognitive and affective reaction to a communicative stimulus as a function of relative hemispheric involvement, and to examine by inference the internal composition of these processes. Right-handed men were asked to evaluate the sound quality of a taped radio broadcast. Each subject ($n = 10$) subsequently heard either a personally relevant or irrelevant advocacy that was either proattitudinal or counterattitudinal. An additional ten right-handed men heard a neutral and obscure news story and constituted an external control group. After listening to the tape, subjects rated their agreement with the advocacy and listed their thoughts. EEG activity was recorded from the left (P3) and right (P4) parietal lobes, was integrated through an 8–13 Hz band-pass filter, and transformed to yield a ratio score of the differences between alpha activity in the right and left hemispheres over the sum of the alpha activity in the right and left hemispheres $(P4-P3)/(P4+P3)$. Subjects then were classified as having displayed either relative major or minor hemispheric involvement on the basis of a median split of the ratio-scores. Analyses revealed that persons who displayed relative major hemispheric involvement tended to agree more with the pro- and less with the counterattitudinal advocacy when the issue was highly rather than slightly relevant. Persons who displayed relative minor hemispheric involvement, however, tended to counterargue and disagree with both pro- and counterattitudinal advocacies when the issue was highly rather than slightly relevant. Finally, there were no differences between the ratings of the neutral advocacy by persons who displayed major and minor hemispheric involvement. Two interpretations of these data which assume higher mental processes to be localized functions were considered and rejected. It is concluded that Luria's (1973) concept of functional systems provides the most parsimonious interpretation, and the nature of the functional system possibly underlying the present results was considered.

Hemispheric asymmetry has been observed during a wide variety of tasks and with differing types of subjects. From this research has evolved a type of cortical mapping in which one speaks of the major hemisphere as being the locus for linguistic functions and the minor hemisphere for artistic functions, etc. Many researchers have warned against this modern version of phrenology (e.g., Galin, 1974), but little success has been achieved in correcting this conception (cf. any introductory Psychology text) or in specifying the functional systems that account for the observed hemispheric asymmetry. Here we take up the issue of cognitive and affective response and examine the influence on them of relative hemispheric involvement (i.e., activation). Our results allow us to reject the notions suggested by some regarding the hemispheric localization of

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suggestibility and affective response. While differences were observed in the aforementioned processes, these differences appear to be due to the style of information processing which characterizes each hemisphere.

HEMISPHERIC INVOLVEMENT AND INFORMATION PROCESSING

Several lines of evidence testify that the major hemisphere is associated with sequentially coded information while the minor hemisphere is associated with holistically coded information (cf. Dimond & Beaumont, 1974; Seamon, 1974). Behavioral data indicate that faster reaction times (RTs) are displayed when verbal stimuli are presented to the right rather than left visual field or ear (thereby to the major rather than minor hemisphere for most subjects); and the opposite result is obtained for nonverbal stimuli, such as pictures of a face (Geffen, Bradshaw & Wallace, 1971; cf. White, 1969). Electrophysiological data reveal greater blocking of alpha activity in the major than the minor hemisphere during the performance of linguistic tasks, presumably due to the relative activation or involvement of the major hemisphere. And, as in the behavioral studies, this pattern is reversed when nonverbal stimuli are used (e.g., Dimond *et al.*, 1971; Doyle, Ornstein & Galin, 1974; Galin & Ornstein, 1972; McKeever & Huling, 1971). Finally, neurological and behavioral data, obtained from brain-damaged or split-brain patients, have revealed subtle deficits in the performance of verbal tasks when processed by the minor hemisphere, and in the performance of nonverbal tasks when processed by the major hemisphere (e.g., Eccles, 1973; Sperry, 1961, 1968; Sperry, Gazzaniga & Bogen, 1969).

These same lines of research have revealed that the asymmetry observed is neither invariant nor due to the objective stimulus attributes per se. As Ornstein commented recently:

"The separation is necessary, I believe, because the two hemispheres, in human beings at least, operate differently. They are not the 'language hemisphere' and the 'spatial hemisphere,' as they may appear to be at first, but two *semi-autonomous systems that process information differently* and that can be used in a specialized manner" (1978, p. 78, italics added).

Indeed, Gazzaniga (1970, 1974) found that adults who incurred damage to a hemisphere are able to recover their ability to perform many tasks by learning to process the task in a manner consistent with the processing expertise of the remaining operative hemisphere. Similarly, normal individuals have been observed to perform the same tasks differently, some (e.g., lawyers) using analytic means while others (e.g., ceramists) using holistic means; yet both means yielded the same result (cf. Ornstein, 1978). Finally, Schwartz, Davidson & Pugash (1976) operantly trained patterns of interhemispheric alpha activity over the parietal lobes. They found verbal cognitions to predominate when the major hemisphere was relatively active, spatial/visual cognitions to predominate when the minor hemisphere was relatively active, and a state of concentration, which was unpredictable from the previous patterns, when both hemispheres were active. These studies highlight the notion of the major and minor hemispheres as components of a system, whose function or output depends in part upon the pattern of activity displayed by the components within the system (cf. Luria, 1973; Sperry, 1968; Schwartz, 1975).

HEMISPHERIC INVOLVEMENT AND AFFECT

Accordingly, most higher mental processes, including evaluative sets and affective responses, could be considered as resulting from a unique neurophysiological pattern generated during covert stimulus (i.e., information) processing. While conceivable on the basis of the research cited above, this notion is contrary to the views of advocates of hemispheric localization who hold, for instance, that the minor hemisphere is more susceptible to suggestion (e.g., Bakan, 1969; Singer & Singer, 1972) or intrinsically possesses a horrific perception of the world (Dimond, Farrington & Johnson, 1976). A major aim of the present study was to provide a test of these various views.

As was the case for information processing, an association between hemispheric involvement and *affect* has been suggested by neurological, electrophysiological, and behavioral data. For instance, persons suffering damage to the major rather than minor hemisphere were more likely to experience psychological trauma (Galin, 1974; Ornstein & Galin, 1974). Similarly, Sperry (1968) reported that during testing, split-brain persons were more likely to display displeasure when a stimulus was presented to the minor than the major hemisphere. Schwartz, Davidson & Maer (1975) asked normal persons a series of questions which differed in terms of the verbal and emotional processing requirements. They found that, as measured by contralateral eye movements, the minor hemisphere was relatively active when processing affect-laden or spatial questions; on the other hand, the major hemisphere was relatively active when processing nonaffect-laden or verbal questions; and these effects appeared to be additive. More recently, Schwartz (Note 1) reported that the facial expression elicited by sad thoughts and images were evidenced most in the left side of the face (i.e., minor hemisphere), while happy thoughts and images were evidenced most in the right side of the face (i.e., major hemisphere). Together, these results suggest that the minor hemisphere is more efficient in reacting affectively than the major hemisphere and possesses a predilection for a negative view of the world.

Dimond *et al.* (1976) tested and supported this notion in a study in which specially designed contact lenses were used to manipulate hemispheric involvement. One group wore lenses which projected light from the left visual field (and, thus, information into the right hemisphere), a second group wore lenses which projected light from the right visual field, and a third group wore no contact lenses. Subjects from each group then watched either a humorous, neutral, or unpleasant film. Postviewing ratings of the films indicated that persons who viewed the film via the minor hemisphere judged it to be more unpleasant and horrific, regardless of the type of film viewed, than did persons who viewed the film via the major hemisphere or both hemispheres. (The ratings of the latter groups of subjects did not differ from one another.)

Several interpretations are possible for the apparent association between the minor hemisphere and affect. First, the association may be due to an intrinsic (i.e.,localized) difference in mental function between the major and minor hemispheres. Dimond *et al.* (1976) favored such an interpretation: "there exists a different emotional vision between one hemisphere and the other in the normal human and . . . the (minor) hemisphere has an emotional vision which is usually suppressed but is characterized as more unpleasant and horrific than is that of the (major)" (p. 692). A second possible account for the minor hemisphere's involvement in affect is indicated in the works of Bakan (1969) and Singer & Singer (1972). They have suggested that the relative minor hemispheric involvement produces relative susceptibility to suggestion. The results of Dimond *et al.* (1976) are contraindicative of this account since the ratings of unpleasantness by persons viewing a film via the minor hemisphere were generally negative regardless of the nature of the film. But Dimond *et al.* did not directly address susceptibility to persuasion and their results do not constitute a strong disconfirmation of the hypothesis. Finally, the affective difference may not be direct, but rather may result from the various patterns of activity that emerge as the major and minor hemispheres process the information, each in their unique manner. According to this interpretation, the differential affective reactions associated with the major and minor hemispheres should be evidenced only when the individual is able (i.e., a relevant cognitive schema exists allowing for comprehension and elaboration of the stimulus—cf. Tesser & Leone, 1977) and motivated (i.e., the stimulus is personally relevant, novel, or significant, thereby attracting processing capacity—cf. Kahneman, 1973; Sokolov, 1963) to process the stimulus.†

To distinguish among these interpretations in the present study, subjects were led to believe they were evaluating the sound quality of a taped radio editorial produced by students of a sound-engineering course. Each subject heard one of nine professionally taped and high sound-quality communications. Eight communications concerned either a pro- or counter-attitudinal advocacy regarding a personally relevant or irrelevant issue; two different topics were employed, constituting a $2 \times 2 \times 2$ factorial design in which Message Position

† It should be noted that Dimond *et al.* (1976) acknowledged this possibility, but favored the localized account. Yet another possibility for these observations is that the situation of having the major hemisphere cut off from the visual stimuli (to which they must verbally respond) elicits a negative response. The plausibility of this account increases when one considers the fact that, in previous investigations, subjects had no choice as to which hemisphere would be activated. Hence, in the present study, the brains of our subjects selected which hemisphere would be most involved in stimulus processing. We then conducted median splits between subjects who had displayed relative major and minor hemispheric involvement. Hence, the possible negative repercussions of imposing upon the hemispheres an unnatural mode of information processing was avoided here. Future research must determine if this concern was merited.

(pro- vs. counter-attitudinal), Personal Relevance (high vs. low), and Topic (visitation hours vs. alcohol consumption) served as the between-subjects experimental variables ($n = 6$, $N = 48$). A ninth communication, which concerned an obscure news event about an archaeological dig, served as a neutral stimulus for external control conditions ($N = 12$). If differential affective responding by the major and minor hemispheres is a direct consequence of their activation, then: (a) the neutral communication should be evaluated more negatively by persons displaying relative minor rather than major hemispheric involvement; and (b) persons displaying relative minor hemispheric involvement should display greater resistance to the pro- and counter-attitudinal advocacies than persons displaying relative major hemispheric involvement since the minor hemisphere, according to this account, generally perceives stimuli more negatively than the major hemisphere. The second account offered above, that minor hemispheric involvement produces increased susceptibility to suggestion, yields a prediction exactly opposite to prediction-c above. Relative involvement of the minor hemisphere would be expected to increase the susceptibility of subjects to the pro- and counter-attitudinal advocacies. Finally, if the differential affective response of the two hemispheres results from the variate forms of information processing, then the personal relevance of the stimulus, which increases pertinent information processing activity (Petty & Cacioppo, in press), should interact with relative hemispheric involvement and perhaps also with message position. Moreover, given the absence of any personal relevance or schemas regarding the neutral stimulus, no differences between relative major and minor hemispheric involvement would be expected.

METHOD

Subjects

Sixty right-handed male undergraduates between the ages of 18 and 22 volunteered to participate in the present study. The assignment of subjects to conditions was determined randomly. The data from five subjects were lost because of problems with the apparatus ($n = 3$) or electrode placement ($n = 2$). To equate cell sizes, the data from an additional five subjects were selected randomly and deleted.†

Procedure

When subjects arrived at the laboratory, they were told that their task was to evaluate the sound quality of a taped radio-editorial, that electrodes would be attached, and that during the study we would be recording the involuntary bodily responses that accompanies a person's listening to a communication. Subjects were instructed to refrain from unnecessary movements, to breathe normally, and to keep their eyes closed throughout the study. After adaptation to the laboratory, these instructions were repeated, and subjects were told that the study would begin shortly. At this point, a computer-controlled procedure—which involved: (a) a 60 sec prewarning (baseline) interval, (b) a 15 sec forewarning, (c) a 60 sec postwarning-premessage interval, and (d) a 120 sec message—was initiated.

After listening to the tape, the subjects read the following: "Because your own opinion about the position advocated on the tape may influence the way you rate the quality of the tape, we would like to obtain a measure of how you feel about the views proposed by the speaker on each scale below." They responded to an 11-point Likert-type attitude scale to obtain a measure of the general affective reaction to the advocacy. On the next page, subjects were instructed to list everything about which they thought during the broadcast-sequence (3 minutes were provided to list thoughts). Treatment of this cognitive-response data is described below.

Materials and Apparatus

The topics of alcoholic beverages and visitation hours were selected because previous research had revealed that the existing university regulations regarding these topics were highly relevant and disagreeable to students. Forewarnings and messages were then constructed that advocated the adoption of either stricter (counter-attitudinal) or more lenient (pro-attitudinal) regulations regarding these issues either at the University of Notre Dame (at the subjects' institution—high personal relevance) or at Juanita Junior College (low personal relevance). A ninth (neutral) message was obtained from a past issue of a national news magazine and concerned a small archeological find.

† Preliminary analyses indicated the Topics factor did not alter any of the effects obtained. Hence, all analyses reported in the text were conducted after collapsing across this factor ($n = 10$, $N = 50$).

Subjects were seated in a comfortable chair, which was enclosed in a copper-mesh cage to filter electrical interference and which was located in a sound-attenuated chamber separate from the recording equipment. Monopolar EEG activity was recorded with Grass gold-plated cup electrodes from the left (P3) and right (P4) parietal area (Jasper, 1958) referenced to linked ears with Grass ear-clip electrodes. Heart rate and electromyographic activity were recorded also, the results of which are reported elsewhere since they are irrelevant to the current hypotheses.

The EEG responses were recorded by Grass wide band ac preamplifiers onto FM tape and were displayed on an eight-channel oscilloscope for visual monitoring during the experiment. Subsequently, the alpha activity from each channel was integrated through an 8–13 Hz band-pass filter, sampled 100 times per second, and quantified by a PDP-81 laboratory minicomputer.

Data Reduction

Relative hemispheric involvement was determined by calculating a ratio score for the alpha activity observed at the right and left parietal-lobe electrode sites (i.e., $(P_4-P_3)/(P_4+P_3)$). A large positive ratio score would indicate the relative presence of alpha activity in the right (minor) hemisphere and, thus, the relative activation of the left (major) hemisphere. Two such ratios were calculated: the first was calculated using the overall amount of alpha activity displayed during the broadcast sequence, and the second using the alpha activity displayed during the prestimulus interval. Hence, subjects were classified as having displayed relative major or minor involvement, once on the basis of the median split for the broadcast-sequence ratio scores, and once on the basis of the median split for the prestimulus ratio scores.

The thoughts listed in the postexperimental questionnaire (i.e., the affect-laden cognitions—cf. Cacioppo, Harkins & Petty, in press; Greenwald, 1968) were submitted to two independent judges for classification along an affectivity dimension. Hence, these measures served as an index of the specific affective reactions of subjects that resulted from stimulus (information) processing. The judges rated as a favorable thought any statement or idea which was supportive of, in agreement with, or which expressed positive affect about the advocacy or communication; scored as a counterargument was any thought or idea opposed to, challenging the reasoning or validity of, or which expressed negative affect about the advocacy or communication; and counted as neutral/irrelevant thoughts were all remaining items. The judges displayed high inter-rater agreement ($r = 0.91$). Differences in ratings were resolved through discussion.

RESULTS

Unless otherwise stated, the effects discussed are statistically significant at the $p<0.05$ level for Type-1 errors.

Hemispheric Involvement for the Broadcast-Sequence

To determine if the relative hemispheric involvement during the broadcast sequence reflected differences in mental processes, analyses of variance of the questionnaire data were conducted. Hemispheric Involvement (Major or Minor), Message Position (Pro- or Counter-attitudinal), and Personal Relevance (High or Low) served as the independent variables in these analyses. The means for each cell from these analyses are presented in Table I. Means for the external control (i.e., neutral) conditions were compared with the experimental means using the LSD test (Kirk, 1968), and the results are presented in Table I.

Inspection of Table I reveals that increasing the personal relevance of the advocacies led persons who displayed relative major hemispheric involvement to respond in a more polarized manner. This effect is evident both in the subjects' general affective reaction (i.e., agreement) and in their specific affect-laden cognitions to the advocacy. For instance, for persons who displayed major hemispheric involvement, increased personal relevance resulted in the pro-attitudinal advocacy eliciting more agreement and less counterargumentation, and the counterattitudinal advocacy eliciting less agreement and more counterargumentation. In marked contrast to this style of information processing, increasing the personal relevance of the counterattitudinal advocacy led persons who displayed relative minor hemispheric involvement to respond more negatively, both cognitively and affectively, regardless of the message position. Accordingly, the Hemispheric Involvement × Message Position × Personal Relevance interaction for agreement with the advocacy and for counterargumentation were highly significant ($F(1/32) = 6.78$, MSe = 5.61, and $F(1/32) = 4.42$, MSe=5.09

TABLE I
Mean agreement and cognitive response as a function of relative hemispheric involvement, message position, and personal relevance

	Measure			
Communication	Agreement	Counterarguments	Favorable thoughts	Neutral/irrelevant thoughts
	Median split for broadcast-sequence EEG ratio			
Relative major hemispheric involvement:				
Neutral	7.2^{bcde}	2.0^{ab}	1.4^{ab}	4.4^{c}
Counterattitudinal				
High relevance	2.8^{a}	4.0^{b}	1.0^{ab}	0.6^{a}
Low relevance	6.4^{bcd}	3.2^{ab}	1.6^{ab}	2.6^{abc}
Proattitudinal				
High relevance	9.4^{e}	1.2^{a}	3.0^{a}	1.2^{ab}
Low relevance	6.0^{bc}	4.2^{b}	3.0^{a}	0.4^{a}
Relative minor hemispheric involvement:				
Neutral	5.8^{bc}	2.8^{ab}	1.2^{ab}	3.4^{bc}
Counterattitudinal				
High relevance	4.4^{ab}	3.4^{ab}	1.2^{ab}	1.0^{a}
Low relevance	5.4^{bc}	3.4^{ab}	0.4^{b}	1.4^{ab}
Proattitudinal				
High relevance	7.4^{cde}	3.4^{ab}	2.6^{ab}	1.2^{ab}
Low relevance	9.2^{e}	1.2^{b}	2.6^{ab}	2.4^{abc}

Note. Entries for cognitive response denote the frequency of the occurrence of that category of thought in the post-experimental protocols. Higher numbers on the agreement measure indicate greater agreement with the advocacy. Unlike superscripts designate a statistically significant difference (LSD Test, $p < 0.05$). The cell size is 5 in each condition.

respectively). Importantly, the responses of persons displaying relative major and minor hemispheric involvement in the external control conditions did not differ from one another (see Table I).

Several other effects were statistically significant. As expected, the proattitudinal compared to the counterattitudinal advocacy elicited greater agreement ($F(1/32) = 18.82$, MSe $= 5.61$) and more favorable thoughts ($F(1/32) = 7.02$, MSe $= 4.36$). Second, a Message Position × Personal Relevance interaction for agreement ($F(1/32) = 4.28$, MSe $= 5.61$) revealed that increasing the personal relevance of an advocacy enhanced susceptibility to a proattitudinal advocacy, but enhanced resistance to a counterattitudinal advocacy. The fact that this pattern occurred overwhelmingly for the persons who displayed relative major hemispheric involvement but was reversed for persons who displayed minor hemispheric involvement produced the three-way interaction discussed above.

Prestimulus Hemispheric Involvement

A second set of analyses of variance was conducted to examine whether or not the basal level of hemispheric activation (i.e., the interhemispheric patterning displayed during the prestimulus interval) was associated with differing styles of responding to the stimuli. No statistically significant effects were found, though trends were similar to those obtained in the above analysis. This result is in accord with the observations by Galin and Ornstein (1974), and with the notion proposed here that affective responses result from neural circuits activated during stimulus processing and elaboration.

DISCUSSION

Several interpretations of these data are considered here. The first two can be characterized by the theory that interhemispheric differences in affective response result from localized perceptual-emotional mechanisms. According to these views, relative hemispheric involvement reflects the engagement of underlying cortical control-centers which are responsible for specific mental functions: the first view to be discussed posits that the minor hemisphere intrinsically perceives the world more negatively than the major hemisphere, while the second suggests that the minor hemisphere is more susceptible to influence. A third interpretation is considered then, namely, that hemispheric lateralization reflects the activity of the components of a functional system (Luria, 1973), and that the observed differences in cognitive and affective response are attributable to inter- and/or intrahemispheric patterning during information processing.

Localized Function or Functional System

It has been hypothesized that the major and minor hemispheres possess localized and distinct perceptual-emotional mechanisms and that the minor hemisphere perceives stimuli as being unpleasant and horrific:

"We suggest . . . that the two hemispheres of the brain of man possess an essentially different emotional vision of the world. The objective world although physically the same for each side, has a different perspective imparted to it. We suggest that the (minor) hemisphere adds its own emotional dimension which represents the thing perceived as more unpleasant and horrible . . ." (Dimond *et al.*, 1976, p. 691).

According to this interpretation, the hemispheres differ not only in their method of information processing, but in the emotional perspective of each on the world. But hemispheric lateralization made no difference when an obscure neutral communication was presented to individuals. While we believe the obscurity and low relevance of this communication may have mitigated against its being processed extensively, differences in its evaluation by individuals displaying major and minor hemispheric involvement would be expected in any case by the present perceptual-emotional formulation. Hence, the absence of this effect casts doubt on this hypothesis. Also, the importance of personal relevance for affective reactions to the advocacies is at odds with the notion of localized perceptual-emotional mechanims between the hemispheres. While the objective stimulus that was presented and rated by the subjects was identical for each advocacy (i.e., the message position and message arguments), the extent of stimulus processing and elaboration, manipulated by varying the personal relevance of the advocacy, dramatically influenced the psychological responses to the stimulus (see Table I).

It also has been suggested that the minor hemisphere is more susceptible to influence than the major hemisphere (e.g., Bakan, 1969; Singer & Singer, 1972). While the minor hemisphere was observed here as being more susceptible, this effect was far from being as invariant or simple as suggested. We found that relative minor hemispheric involvement increased the individual's susceptibility to suggestion when the advocacy was proattitudinal and irrelevant to the person, or counterattitudinal and personally relevant; however, involvement of the minor hemisphere was associated with greater *resistance* to influence when the advocacy was proattitudinal and personally relevant, or counterattitudinal and irrelevant. Hence, the minor hemisphere appears to be no more intrinsically susceptible to influence than the major hemisphere.

These data can be explained parsimoniously by assuming that the hemispheres differ in their most efficient method of information processing. According to this account, differences between the hemispheres in affective response result from inter- and/or intrahemispheric patterning during information processing. Several lines of evidence from this study support this notion: As mentioned above, varying the personal relevance of an advocacy alters the nature of the information processing of the advocacy and, therefore, would be expected to alter the affective response to the stimulus. Support was obtained for this expectation. Second, the measures of affect-laden cognitions that are tied closely to this information processing should parallel the general measure of affect. Indeed, we found the effects of the experimental variables for the thought listing measures paralleled those observed for agreement, which is a more holistic measure of affective response. And third, if these differences are attributable to the manner in which the *stimulus* is *cognitively* processed, then the extent of hemispheric lateralization *prior* to the stimulus should be a poor predictor of affective response since the prestimulus interval was cognitively quiescent. Accordingly, we found that a median split of hemispheric asymmetry during the prestimulus interval failed to account for a significant portion of the variance for any measure; yet the pattern of hemispheric activation displayed *during the stimulus* was predictive of the subjective responses to the stimulus. This temporal specificity of hemispheric patterning and mental function is in accord with the present interpretation.

Two implications of this systems-analysis for the internal composition of mental functions are that: (a) the information processing systems within the major and minor hemispheres often appear to be identical because they yield similar results, but the processes are distinct; and (b) cognitive and affective responses often appear to result from totally different processes, but the processes underlying each overlap considerably (see Table I). These implications follow logically from examining the "double dissociation of function" (Teuber, 1962) which resulted from the relative hemispheric involvement in the present study.† In addition, these implications have been supported by current research in various fields of psychology. We previously noted some of the behavioural, electrophysiological, and neurological data illustrating that the major and minor hemispheres possess unique expertise (and deficiencies) in information processing. Equally substantial now is the evidence that the idiosyncratic manner in which a person cognitively responds to and elaborates upon a stimulus determines in large part the affective response toward the stimulus (cf. Janis & Mann, 1977; Petty, Ostrom & Brock, in press). These findings, which provide support for the first and second implications listed above, in turn, confer additional support to the formulation here from which these predictions were derived: that functional systems in the brain serve as the basis for higher mental processes. It remains for future research to determine the relative contributions to these mental processes made by the intra- and interhemispheric components, and to outline changes in the interrelationships among these components which accompany the maturation and change of these mental processes.

† The principle of double dissociation holds that a function cannot be attributed to the localized area of the brain if, after damage to this area, that function is lost unless an equally massive lesion or ablation of the brain in another location fails to produce the observed deficit. Similarly, if the above holds and two "different" overt responses are interrupted by damage to a particular area of the brain, then these responses could be assumed to be more closely related to one another than the overt responses might suggest. We have applied this principle here, using cortical patterning rather than damage as our preditor variable. This method may possess many benefits for brain research, but must be interpreted cautiously here since we do not yet know the validity of this procedure.

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