Individual Differences in Relative Hemispheric Alpha Abundance and Cognitive Responses to Persuasive Communications

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Three experiments are reported investigating individual differences in interhemispheric electroencephalogram (EEG) activity and cognitive responses to persuasion. Experiment 1 indicated that subjects who were characterized by relative left hemispheric EEG activity over the parietal areas also produced a less affectively polarized profile of thought listings about the persuasive communication. Moreover, this individual difference emerged only when subjects were confronted by the forewarning and message; the basal patterns of interhemispheric EEG activity, which were obtained prior to the announcement of the attitudinal recommendation, did not portend distinguishable profiles of cognitive responding. Experiment 2 replicated the major findings of Experiment 1 using different topics and a within-subjects rather than a between-subjects design. Further analyses suggested that thinking about an attitude issue rather than responding to a persuasive communication was sufficient to obtain the above relationship between interhemispheric EEG alpha abundance and cognitive response. Experiment 3 used Tesser’s time-to-think procedure to assess interhemispheric EEG patterning as a function of the affective polarization of topic-relevant thinking. The results supported the expectation that as subjects thought longer about attitude issues they exhibited a shifting of relative hemispheric EEG activity from the left toward the right parietal areas of the cerebral hemispheres. The significance and limitations of these findings for research on attitude change and the utility of including psychophysiological approaches to elusive research problems in personality and social psychology are discussed.

Research in social psychology has generally focused on the situational determinants of behavior (see any current introductory text). The resulting literature might lead one to surmise that there are few important physiological reactions arising during social behavior, few salient sources of external information about changes in bodily states, and little heed paid to these bodily responses (but see Cacioppo & Petty, in press; Waid, in press). It is becoming increasingly informative, however, to expand the realm of social psychological methodologies and constructs to include the study of physiological reactions in order to account more fully for individual differences and social behavior (e.g., Rodin & Spitzer, in press), to select from among what appear to be equally parsimonious theories (e.g., Fazio, Zanna, & Cooper, 1977), and to obtain converging evidence for postulated intervening processes (e.g., Cacioppo & Petty, 1979, 1981a). In the present article, we illustrate that formulations from the area of psychophysiology can serve as maps to new and interesting effects within the areas of personality and social psychology. Specifically, we draw on the research and theory of functional cere-
bral asymmetry to direct us to a new and apparently reliable empirical effect concerning individual differences in relative hemispheric alpha abundance and cognitive responses to persuasive communications. Three investigations of this effect are described.

Functional Cerebral Asymmetry

Experiments using a number of different methodologies have investigated asymmetries in cerebral functioning. Although these studies have not yielded a completely consistent pattern of results, the rudimentary findings are as follows: Studies recording performance and reaction time generally show that faster and more accurate solutions are obtained when semantic stimuli (e.g., words) are presented to the left rather than the right hemisphere (e.g., through the right ear or right visual hemifield); the opposite result is likely when nonsemantic stimuli (e.g., pictures) are used (e.g., Kimura & Durnford, 1974). Studies recording bilateral electroencephalographic (EEG) activity generally find greater hemispheric activation in the left than the right hemisphere when semantic stimuli are used, whereas the opposite interhemispheric EEG patterning is found when nonsemantic stimuli are used (e.g., McKeever & Huling, 1971; Young, 1980; see Harnad, Doty, Goldstein, Jaynes, & Krauthamer, 1977). However, differential hemispheric EEG activation is also observed when only semantic stimuli are used, suggesting that cerebral asymmetry is not simply a function of the extent of the semantic processing (Cacioppo & Petty, 1980a; Ornstein, Herron, Johnstone, & Swencionis, 1979; see Searleman, 1977).

In addition to the observed lateralization on semantic and pictorial tasks, additional evidence suggests that the left hemisphere is superior to the right at tasks involving (a) the classification of objects according to their function, in contrast to their shape; (b) activities involving sequences of movements and the coordination of movements (such as those that might occur in speaking) in contrast to singular movements; and (c) perceptual problems requiring fine rather than gross temporal judgments (Corballis, 1980).

Such evidence may be taken as support for the idea that the left hemisphere is the more specialized for abstract or symbolic representation, in which the symbols need to bear no physical resemblance to the objects they represent, while the right hemisphere maintains representations that are isomorphic with reality itself—although this distinction, on close analysis, is an elusive one. (Corballis, 1980, p. 288)

Although it seems overly simplistic to ascribe diatematical processing styles or functions to the two hemispheres (cf. Bogen, 1969), a speculative distinction of this type has been advanced most recently by Tucker (1981) in his critical review of the literature on cerebral asymmetry and human emotion. Tucker (1981) argued that there are differing forms of cognitive organization in the two hemispheres that possibly are attributable to neuroanatomical factors. He suggested that the right hemisphere's "global ideation" contrasts sharply with the left's analytic manner of processing information. Moreover, he argued, the simpler, more diffuse style of the right hemisphere may lead to a more expansive emotional experience than would the left's more meticulous manner of processing the same stimulus.

Finally, the development and lateralization of language may be a predecessor of these asymmetries. Hence, although most people (particularly most right-handed men with familial histories of right-handedness) have the major neural structures for the coordination of speech functions in the left cerebral hemisphere and exhibit the pattern of results described previously, it may really be more accurate to consider which hemisphere houses the major centers for speech in combination with which hemisphere is most activated during a task. In the present article, reference to the left hemisphere rather than to the hemisphere that houses the major speech centers is made as a matter of convenience, since we used as subjects only right-handed men who reported familial histories of right-handedness.

Cerebral Asymmetry and Cognitive Responses to Persuasive Communications

In recent research on persuasion, investigators have documented the importance of the manner in which people process the information contained in personally involving persuasive communications (e.g., see reviews by Cialdini, Petty, & Cacioppo, 1981; Perloff & Brock, 1980; Petty, Ostrom, & Brock,
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1981). Recipients of a persuasive message have access to a vast store of information about most attitude issues beyond that which might be contained in a persuasive communication. It has been hypothesized that a persuasive message elicits idiosyncratic cognitive responses that can either support or contradict the externally provided arguments for the recommendation (Festinger & Maccoby, 1964; Greenwald, 1968). Accordingly, recipients are viewed as active contributors to their susceptibility or resistance to persuasion. To the extent that a message elicits recipient-generated favorable thoughts, persuasion results; to the extent that a message elicits counterarguments, resistance is more likely (Petty & Cacioppo, 1981). Finally, individual differences in cognitive responding to persuasive communications are viewed as one factor underlying individual differences in persuasion (Cacioppo & Petty, 1980b; Eagly, 1981; see also Tesser & Leone, 1977).

Although individual differences in cognitive responding have been proposed as an important topic for study, little research has been directed toward this end. Most research has focused on the situational factors affecting idiosyncratic cognitive responding and attitude change (e.g., forewarning of topic and position, forewarning of persuasive intent, message repetition). One approach to the study of individual differences is to apply as a heuristic concepts from neurocybernetics, such as those previously outlined regarding cerebral asymmetry (cf. Pribram & McGuinness, 1975; Tucker, 1981). In our attempt in the present research to use this strategy, we set forth two objectives. The initial objective was simply to determine whether there was some lateral asymmetry in cognitive responses to persuasive communications. Thus, Experiments 1 and 2 were designed primarily to document an empirical association between relative hemispheric alpha abundance and cognitive responses to persuasive communications. Relative hemispheric alpha abundance has been used previously to index the relative utilization of the opposite hemisphere; e.g., Galin & Ornstein, 1972.) The second objective was to gather some data bearing upon the possible meaning of this association.

The initial focus of our studies was on the association between relative hemispheric alpha abundance and the profile of topic-relevant thoughts generated by individuals following their exposure to a persuasive communication. There were several conceptions suggesting that right-handed men characterized by the relative activation of the right hemisphere would also evince more affectively polarized profiles of cognitive response. For instance, individual differences in the nature of a person's style of cognitive responding to an attitude stimulus can be represented along a continuum ranging from very rigid stimulus-bound reactions to very flexible elaborative reactions. According to Corballis's (1980) conclusions regarding functional cerebral asymmetry, it may be that the individuals who can be characterized by a relative activation of the left hemisphere will also be found to respond in a more elaborative, less stimulus-bound manner, whereas those individuals characterized by the relative activation of the right hemisphere will be found to respond cognitively in a more stimulus-dependent (i.e., message-dependent) fashion. Hence, the relative right activation individuals should produce thought listings that generally reflect the initial favorable or unfavorable reaction elicited by the attitudinal recommendation (i.e., an affectively polarized profile of topic-relevant thoughts), whereas the relative left activation individuals should produce a profile of listed thoughts that reflects a less affectively stereotyped reaction to the attitudinal recommendation. Similarly, if as Tucker (1981) suggests, the relative activation of the left hemisphere serves analytic processing best, then individuals characterized by relative left hemispheric activation may show less affectively polarized profiles of thought listings regarding the attitudinal recommendation. Our initial study was designed to determine if the empirical association suggested by these models of cerebral asymmetry would be obtained.

Experiment 1

In Experiment 1, subjects were given the task of judging the sound quality of an audiotape message and were exposed to either a proattitudinal or counterattitudinal message containing a mixture of strong and weak arguments on the issue. The mixture
of strong and weak arguments was utilized to increase the likelihood that the profile of thoughts listed by individuals evincing relative left hemispheric activation would be more balanced whether they are employing a more analytic style of processing or, if as Corballis (1980) contends, they are less stimulus bound and thus base their reactions less on the direction (proattitudinal or counterattitudinal) of the message than on the implications of the arguments. Following the message, subjects were asked to indicate their agreement with the recommendation they heard, to list the thoughts that had occurred to them while they waited for and listened to the message, and to complete ancillary items. EEG activity over the right and left parietal lobes was monitored during a pretreatment baseline and across the forewarning, postwarning—premessage, and message epochs. A median split was calculated on the basis of differential hemispheric alpha abundance evinced during the pretreatment baseline, and another was performed on the basis of EEG data collected across the epochs during which subjects might have been thinking about the attitude issue (i.e., forewarning, postwarning—premessage, and message epochs). A blocking factor for relative hemispheric activation was then used in the analysis of the data provided in the postexperimental questionnaire.

Method

Subjects and design. Forty right-handed men participated in the study for extra credit in an introductory psychology class. The subjects were randomly assigned to one of two experimental cells (proattitudinal vs. counterattitudinal message).

Materials. The topic of alcoholic beverages was selected because pilot testing indicated that the existing university policy regarding it was important and counterattitudinal to the undergraduates. Forewarnings and messages were developed recommending that either a stricter (counterattitudinal) or a more lenient (proattitudinal) university policy be adopted.

Procedure. Subjects were tested individually in a sound-attenuated room, which contained an over stuffed chair, leads for electrophysiological recording, and a speaker. Subjects were told that we would be recording their brain wave activity throughout the experiment as part of a study of “biosensorial responses to communicative stimuli,” and electrodes were attached using Grass EC2 electrode cream. Monopolar EEG activity was recorded using Grass gold-plated cup electrodes placed over the left (P3) and right (P4) parietal areas referenced to the vertex (Cz) of the skull (see Jasper, 1958). Subjects were instructed to refrain from moving unnecessarily, to breathe normally, and to keep their eyes closed throughout the study. Finally, subjects were told that they would hear a taped introductory announcement of the topic and position of the message they subsequently would hear and, somewhat later, a taped presentation of the message. Subjects were told that the task was to listen to the audio presentations and afterward to rate their sound quality.

Once a subject adapted to the laboratory, we repeated the instructions and announced that the study would begin shortly. Soon thereafter, a computer-controlled procedure began, consisting of a 60-second initial baseline and a 195-second communication epoch (i.e., a 15-second forewarning of the topic and position of the impending message, a 60-second postwarning—premessage period of silence, and a 120-second presentation of a proattitudinal or counterattitudinal message). The rationale for providing a forewarning of the topic and position was to allow the subjects time to think about the attitudinal recommendation before receiving any external information about it (Cacioppo & Petty, 1979; Petty & Cacioppo, 1977). The messages subjects heard contained a mixture of strong and weak arguments on the topic of the availability of alcoholic beverages on or near the campus.

Dependent measures. Following the persuasive communication, subjects were asked to complete a questionnaire booklet regarding their reactions to the message. Subjects first were asked to indicate on an 11-point Likert-type scale how much they agreed with the speaker’s recommendation. Subjects were told this rating was necessary because their reactions to the recommendation might alter their evaluation of the sound quality of the tape recording. On the next page of the booklet, subjects were instructed to list everything about which they had thought while they waited for and listened to the audiotape. After 2.5 minutes had elapsed, subjects were instructed to rate the items they had listed as being favorable (+), unfavorable (−), or neutral/irrelevant (0) toward the speaker’s recommendation (see Cacioppo & Petty, 1981b, for an extended discussion of the validity, sensitivity, and reliability of the thought-listing technique). Finally, subjects rated on 11-point Likert-type scales the sound quality of the taped message, the speaker’s rate of delivery and enthusiasm, their felt involvement with and the personal relevance of the message, how distracted they were from attending to the message, and the effort they expended in listening to the message.

Data reduction. The EEG activity from each recording site (P3 and P4) was amplified using Grass wideband AC preamplifiers, channeled through an 8–13 Hz band-pass filter (12 dB/octave), full-wave rectified, and sampled 100 times per second using a laboratory computer. This procedure transformed the complex EEG waveforms into a simple measure, expressed in arbitrary units

1 These analyses allowed us to explore whether individual differences in relative hemispheric EEG activity should be conceptualized as a fairly invariant trait or as a predisposition that may or may not influence cognitive responses depending on the specific situation in which the individuals find themselves (e.g., when exposed to involving, counterattitudinal persuasive communications).
units, of the abundance of alpha brain wave activity recorded over each recording site. The EEG data were also displayed on oscilloscopes for visual monitoring during the experiment so that apparent artifacts could be identified and subsequently edited. (Artifacts were infrequent and similarly distributed across conditions.)

Relative alpha abundance was determined by calculating a ratio of the difference in alpha abundance at the right and left parietal sites over the total abundance of alpha evident at the right and left parietal sites within the same sampling period (i.e., [(P4 − P3)/(P4 + P3)] × 100). The larger the ratio, the greater the relative abundance of alpha activity over the right parietal (P4) site, suggesting the relative activation of the left hemisphere. Similar ratios have previously been used in EEG studies of hemispheric asymmetry (Cacioppo & Petty, 1980a; Cacioppo, Petty, & Snyder, 1979; Davidson & Schwartz, 1977; Davidson, Schwartz, Pugash, & Bromfield, 1976; Galin & Ornstein, 1972).

Subjects' responses to the thought-listing instruction were used to calculate two measures that were developed specifically for exploring the present experimental hypotheses. A measure of the affective polarization of cognitive responses was calculated by subtracting the number of nonpredominant from predominant cognitive responses regarding the issues (Petty & Brock, 1979). For proattitudinal communications, this measure was calculated by subtracting the number of unfavorable from favorable thoughts, since favorable thoughts dominated, whereas for counterattitudinal communications, this measure was derived by subtracting the number of favorable from unfavorable thoughts, since unfavorable thoughts dominated this message. The second measure that we used was designed to assess the simple total amount of affect-laden thinking about the issue that was produced. This measure was calculated by summing the number of favorable and unfavorable thoughts that subjects listed.²

Results

Overview. Subjects anticipated and listened to a proattitudinal or counterattitudinal communication, rated their agreement with and thoughts about the message, and responded to a few ancillary items. As explained previously, relative hemispheric alpha abundance was determined for the 60-second baseline epoch and again for the 195-second epoch during which subjects were forewarned of, anticipated, and listened to the persuasive communication. No between-group differences in basal alpha ratios existed as a function of position, so a median split along the alpha ratios for each of these two epochs was performed within each group (i.e., proattitudinal and counterattitudinal) to maintain equal cell size. The results of the median splits were used as a blocking factor in the analyses of variance (ANOVA) of subjects' cognitive and attitudinal responses to the persuasive communication. To facilitate exposition of the results, relative right hemispheric alpha abundance is labeled relative left activity.

Manipulation checks. The manipulation of position was effective, as the proattitudinal compared to the counterattitudinal communication elicited more agreement (proattitudinal $M = 8.00$, counterattitudinal $M = 4.75$), $F(1, 36) = 15.12, p < .001$, and tended to elicit fewer unfavorable thoughts (proattitudinal $M = 2.15$, counterattitudinal $M = 3.50$), $F(1, 36) = 3.81, p < .06$, and more favorable thoughts (proattitudinal $M = 2.30$, counterattitudinal $M = 1.35$), $F(1, 36) = 3.11, p < .09$. No other tests yielded a significant main effect for position.

Test of hypotheses. The ANOVAS revealed that individual differences in hemispheric activation prior to the initiation of the forewarning (i.e., during the pretreatment baseline) did not account for a significant portion of the variance in subjects' cognitive and attitudinal responses to the message presented subsequently ($ps > .10$).

Next, ANOVAs were performed to examine whether individuals characterized by the relative activation of the right hemisphere would, when thinking about an attitude issue

²To assess the affective polarization of the profile of listed thoughts, we considered using a difference score (see text) and a ratio score derived by dividing the difference score by the total number of favorable and unfavorable thoughts listed. Petty and Brock (1979) showed that these produce similar effects. However, it seemed plausible that the more thoughts about a topic that an individual could list, the less affectively stereotyped that particular subject may be in thinking about that issue. A difference score of affective polarization of cognitive responses does not give differential weight to differences in total verbal output, whereas the ratio score does. Because in the present research we are interested in associations between relative hemispheric EEG activation and affective polarization of cognitive response (rather than total verbal output), and because total verbal output per se might lead to relatively left hemispheric EEG activation we decided that our measure of affective polarization should not include a component attributable to total verbal output that could account for any relationships found between affective polarization of cognitive response and right hemispheric alpha abundance. Note that in the research reported here there were no differences between groups in the total number of thoughts listed. Thus, using the difference score to test between-group differences in the affective polarization of cognitive response seemed preferrable.
(i.e., when anticipating and monitoring a persuasive message) also be characterized by an affectively polarized profile of thought listings regarding the recommendation. A main effect for relative hemispheric activation on the measure of the affective polarization of the thoughts, $F(1, 36) = 4.02, p < .05$, was consistent with the hypothesis that a relative dearth of left hemispheric activity would be inversely related to the affective stereotypy of the cognitive responses (relative right activity $M = 2.20$, relative left activity $M = .15$). The notion that relative right hemispheric activation would covary with the simple total number of favorable and unfavorable thoughts listed was not supported (relative right activity $M = 5.10$, relative left activity $M = 4.20, p > .20$). Finally, as expected, the interaction of Position $\times$ Relative Hemispheric Activation was not significant for either measure.

Ancillary analyses. Additional ANOVAs revealed only one further significant effect: Subjects who evinced relative right hemispheric activation rated the speaker of the taped communication as speaking more rapidly than their counterparts rated him as speaking, $F(1, 36) = 6.69, p < .02$. No other test was statistically significant.

Experiment 2

Analyses in Experiment 1 confirmed that the selection of messages was effective in obtaining primarily favorable thoughts and agreement in the proattitudinal conditions and primarily unfavorable thoughts and reduced agreement in the counterattitudinal conditions. Moreover, the results of Experiment 1 provided information about individual differences in relative hemispheric activation and people's cognitive responses to persuasive communications. When analyses were performed to compare the responses to a persuasive communication of subjects who were characterized by a relative activation of the right hemisphere, we found that these subjects generated a more affectively polarized profile of cognitive responses than their counterparts. These subjects showed a pronounced tendency to generate primarily favorable thoughts to a proattitudinal communication and primarily unfavorable thoughts to a counterattitudinal communication when compared to subjects who were characterized by relative left hemispheric activation. There were no comparable effects, however, on the measure of total affect-laden thinking, nor was the Position $\times$ Relative Hemispheric Activity interaction significant on the measure of agreement. Moreover, the association between relative hemispheric EEG activation and affective polarization of cognitive response emerged only when blocking on the former measure was performed for data collected during the interval that subjects anticipated and listened to a persuasive communication; no significant effects were obtained when blocking was performed on the measure of relative alpha abundance that was obtained during a pretreatment baseline (during which time subjects were simply relaxing). This suggests that dispositional differences in relative hemispheric activation, at least during rest, are not predictive of the affective polarization of people's cognitive responses to persuasive communications.

Although this new effect is consistent with the model developed on the basis of work on functional cerebral asymmetry, these data are by no means definitive, given the number of null findings. Therefore, we repeated this study making a number of changes in the design and procedure to rule out alternative explanations for these observations and to lessen the likelihood of committing a Type I error.

First, we performed two internal replications of Experiment 2 to provide a stringent test of the replicability of our initial observations of this new effect. We felt this was important because the replicability of many studies of functional cerebral asymmetry has been poor.

Second, we prepared persuasive communications on two new topics to determine whether or not the results would generalize to other attitude issues.

Third, we partitioned the EEG sampling epochs into four distinct periods: forewarning, postwarning—premessage, message, and postmessage. This allowed us to determine whether the results of Experiment 1 were attributable to subjects' reactions to a specific aspect of the experimental treatment (e.g., the message presentation) or simply to thinking about an attitude issue.
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Fourth, each subject was exposed to both proattitudinal and counterattitudinal communications. We made this change to reduce the number of subjects participating in the experiment. We felt that using within-subjects factors would be particularly helpful, since much of the time involved in testing a subject is spend touring the laboratory, assuring subjects of the safety of the equipment, explaining procedures, attaching electrodes, and waiting for attainment of a suitable (i.e., quiescent) baseline of physiological activity before initiating the experimental procedure. The minor remaining modifications of the experimental procedure are outlined in the Method section.

Method

Subjects and design. Two replications of eight right-handed men were conducted. Subjects were tested individually, with assignment to replication determined randomly. A (2 replication) × 2 (position: proattitudinal vs. counterattitudinal) × 2 (topic: season basketball tickets vs. dining hall accommodations) mixed design was used, in which replication served as the only between-subjects factor.

Materials. Students' access to season basketball tickets and the university facilities for student dining were topics in which undergraduates were keenly interested the semester in which this study was conducted. Forewarnings and messages were developed that recommended changes that students either strongly favored or disfavored. The audiotapes used in this study were prepared professionally by a local disc jockey.

Procedure. The following specific modifications were made to the experimental procedures used in Experiment 1: First, each subject listened to four communications, two on the topic of dining hall facilities and two on the topic of students' access to season basketball tickets. Communications on a particular topic were presented contiguously, with one advancing a proattitudinal position ('all students should be guaranteed access to season basketball tickets for lower-arena seats'), and one advancing a counterattitudinal position ('there should be a 50% reduction in the number of season basketball tickets allotted to students'). The order of topics and of communications on each topic was determined randomly for each replication.

Each communication was presented as a (a) 15-second forewarning of topic and position, (b) 45-second postwarning-premessage epoch of silence, (c) 60-second persuasive message, and (d) 15-second postmessage epoch of silence. Unlike in Experiment 1, each of the epochs was treated as a distinct sampling period when quantifying EEG data. The first of a pair of communications was followed immediately by the forewarning of the second (i.e., following the first and third postmessage epochs). In addition, subjects were asked to complete a dependent variable booklet following each pair of communications, and a 10-minute relaxation period separated the first and second pair of communications.

Finally, although the same cover story and instructions regarding closed eyes, movement, and so forth were used as in Experiment 1, subjects were also instructed that they would bear four communications on two topics with differing viewpoints represented between communications and that they would be asked to list their thoughts and evaluate the sound quality of the tape and recommendations that they heard. Subjects were shown the dependent measure booklet prior to the initial adaptation period.

Dependent measures and data reduction. The dependent measure booklet was nearly identical to that used in Experiment 1. However, subjects completed two sets of these booklets following each pair of communications, one for the first and another for the second communication that they just heard. Moreover, subjects were not instructed to rate their thoughts as being favorable, unfavorable, or neutral/irrelevant toward a recommended position until they completed the last of the four dependent measure booklets.

Data reduction was performed in the same manner as in Experiment 1.

Results

Overview. Blocking for the relative hemispheric alpha abundance was performed as in Experiment 1 except that, rather than calculating a single median split and series of ANOVAs on the basis of the relative alpha abundance evinced across the forewarning, postwarning-premessage, message, and postmessage epochs, separate median splits and ANOVAs were performed on the basis of the relative hemispheric alpha abundance obtained during each of these distinct epochs. (None, of course, was performed for an epoch comparable to the basal period in Experiment 1 since no comparable epoch was included in this study.)

Manipulation checks. The manipulation of position proved to be effective. Proattitudinal communications elicited more agreement than counterattitudinal communications (proattitudinal M = 6.50, counterattitudinal M = 2.41), F(1, 8) = 67.43, p < .001, fewer unfavorable thoughts (proattitudinal M = 1.53, counterattitudinal M = 3.19), F(1, 8) = 37.70, p < .001, and more favorable thoughts (proattitudinal M = 2.19, counterattitudinal M = 6.9), F(1, 8) = 33.88, p < .001. No other main effect for position was statistically significant. In addition,

3 We are grateful to Thomas Carter for his assistance in preparing the audiotapes.
there were no consistent effects due to or interactions involving the topic factor.

Tests of hypotheses. Next, one-tailed tests were conducted to assess the specific experimental hypotheses. The ANOVAS performed when blocking on the alpha ratios obtained during the separate experimental epochs (i.e., forewarning, postwarning–premessage, and postmessage) yielded very similar results. (The median splits calculated for the forewarning and message epochs yielded identical results and therefore are reported together.)

As in Experiment 1, subjects characterized by relative right hemispheric activation, when compared with their counterparts, tended also to generate more one-sided sets of topic-relevant thoughts regarding the attitudinal recommendation regardless of whether the median split was performed on alpha ratios obtained during the forewarning/message, $F(1, 8) = 4.33, p < .04$, postwarning–premessage, $F(1, 8) = 14.19, p < .01$, or postmessage epoch, $F(1, 8) = 6.95, p < .025$. The simple total of affect-laden thoughts regarding the attitude issue and the total number of listed thoughts did not differ as a function of relative hemispheric EEG activation ($ps > .10$). Cell means are presented in Table 1. No other test on the measures listed in Table 1 was significant.

Ancillary analyses. Additional ANOVAS revealed several effects. Responses to the measure of involvement differed across replications, $F(1, 8) = 17.61, p < .001$; an uninterpretable Replication $\times$ Position interaction was obtained on the measure of distraction, $F(1, 8) = 9.85, p < .05$; and an interaction on the measure of felt distraction emerged between relative hemispheric activation and position for the forewarning/message, $F(1, 8) = 5.54, p < .05$, postwarning–premessage, $F(1, 8) = 6.13, p < .05$, and postmessage median splits, $F(1, 8) = 6.32, p < .05$. The form of the interaction indicated that subjects characterized by relative activation of the right hemisphere rated proattitudinal communications as being less attention-getting than the counterattitudinal communications, whereas the remaining subjects reported the opposite. Simple main effect tests were not significant.

The results of Experiment 2 were encouraging with regard to the replicability and generalizability of our initial observations. Subjects who showed a relative activation of the right hemisphere (i.e., relative left alpha abundance) also generated a more affectively polarized profile of cognitive responses to persuasive communications. This effect was obtained in two internal replications of Experiment 2, for two different attitude issues, and within each of the various epochs during which subjects were likely to be thinking about an attitude issue.

The data indicate also that subjects’ agreement with a persuasive communication was not influenced significantly by blocking on relative hemispheric activation, a result obtained in Experiment 1 as well.

Experiment 3

The aim of Experiment 3 was to test one possible causal sequence for the observations thus far—that enhancing the affective po-
larization of topic-relevant thinking leads to a shifting of the pattern of interhemispheric alpha activity to reflect greater relative alpha activity over the left hemisphere (i.e., the relative activation of the right hemisphere). To test this hypothesis we selected a paradigm that best met the need for varying the affective polarization of cognitive responses to an attitude issue. We used Tesser’s (1978) paradigm of self-generated attitude change, since it seemed especially suited to our theoretical and methodological requirements (e.g., physical movement is minimal in Tesser’s time-to-think procedure; subjects can keep their eyes closed). Briefly, Tesser and his colleagues gave subjects either a short (e.g., 10 or 20 seconds) or long (e.g., 90 seconds) epoch to think about an issue. They repeatedly found that as subjects think longer about an issue, their attitudes polarize and the profile of their thoughts about the issue changes “in the direction of greater schematic and evaluative consistency” (i.e., they give more affectively polarized cognitive responses; see Tesser, 1978, p. 290). Our expectation in this paradigm was straightforward: As individuals thought longer about an issue there would be a shifting of relative hemispheric activation toward the right hemisphere.

Method

Subjects and design. Two replications of seven righthanded men were conducted. Subjects were tested individually, with assignment to replication determined randomly. A 2 (replication) × 2 (position: proattitudinal vs. counterattitudinal) × 2 (time to think: 20 seconds vs. 90 seconds) mixed design was used in which replication served as the only between-subjects factor. The experimental conditions were ordered randomly for each replication.

Materials. An initial pool of 60 attitude statements was generated for possible use in the study. Examples of the statements that were generated are “Reducing foreign imports to curb inflation,” “Placing a tax on oil company profits,” “Edward Kennedy as president,” “Providing bus service on campus,” “Driving 55 mph to conserve energy,” and “Increasing the number and use of nuclear power plants.” Two differently randomized lists of these 60 issues were prepared, one with a 15-point rating scale (−7 = completely unfavorable, 0 = neutral, and +7 = completely favorable), and one with a 7-point rating scale (−3 = completely unfavorable, 0 = neutral, and +3 = completely favorable). Subjects expressed their attitude toward each of the 60 attitude issues on two separate occasions, initially using the first list and 1-2 weeks later using the second list. For each subject, we selected from this pool of 60 the 4 issues toward which he had consistently expressed a moderately positive attitude and the 4 issues toward which he had consistently expressed a moderately negative attitude. Thus, the issues that were selected were reliably evaluated and balanced with respect to the subject’s initial attitude. When a subject reliably expressed a moderately positive (+1 to +3 on the first scale, +1 or +2 on the second) or negative (−1 to −3 on the first, −1 or −2 on the second) attitude toward more than 4 issues, 4 were selected at random for use in the study.

Procedures. Subjects participated in two separate sessions, the first lasting approximately 30 minutes and the second lasting approximately 90 minutes. In the first session, subjects toured the laboratory, were told that the study concerned the recording of involuntary bodily responses during mental tasks, and expressed their attitudes toward the 60 attitude issues.

Each subject returned to the laboratory 1 to 2 weeks later to participate in the second of the two experimental sessions. The testing room, hook-up procedures, and general instructions were similar to those used in Experiments 1 and 2. Following the achievement of suitable EEG placements and tracings, subjects were asked to rate each of the 60 attitude issues. When subjects completed the rating task, they were given a list of 20 anagrams (e.g., mumrc, cpacacetne, eip) and were asked to take 10 minutes to unscramble as many as possible. Although subjects believed that physiological recordings were being made during this task, none were collected; instead, the experimenter used this period to select the 8 issues that were to be used during the subsequent experimental trials. A brief period of rest separated the anagram task from the onset of the experimental trials. Subjects were told that they would perform 10 more tasks (2 practice and 8 experimental trials) and that each task had four components, the onset of each of which would be signaled by a 1-second 600-Hz 50-dB (B) tone (audible but not unpleasant). It was explained that (a) they should keep their eyes closed and relax during the first 100-second interval; (b) at the sound of the tone they should open their eyes and read the attitude statement that was projected onto the screen in front of them (subjects saw a 10-second slide presentation, the onset of which was initiated by the tone); (c) at the onset of the next tone they should close their eyes and think about the attitude statement they had just read (subjects knew the length of this interval prior to its onset because different colored light-emitting diodes, LED, were illuminated during each preceding interval to indicate to the subjects that they would be given either 20 or 90 seconds to think about the issue—LED colors were counterbalanced across replications); and (d) at the sound of the tone they should open their eyes (subjects had a 120-second interval in which to relax). As in the previous experiments, timing, stimulus presentations, and the acquisition of analog data were achieved using a laboratory computer. Finally, reduction of the EEG data was performed in the same manner as in the previous studies.

Several other psychophysiological measures were obtained as well, the results of which will be reported elsewhere, since they were collected to address a different issue.
Results

Overview. Each subject was exposed to eight attitude issues, four of which he had judged as moderately proattitudinal and four of which he had judged as moderately counterattitudinal. In each set of four issues, the subject was given short (20-second) epochs to think about each of two issues and long (90-second) epochs to think about each of the other two issues.

Analyses of covariance (ANCOVAs) were performed on the scores of relative hemispheric alpha abundance to test the hypothesis that there would be a shift of relative alpha activity toward the left parietal lobe (i.e., a shift in relative hemispheric activation toward the right hemisphere) as subjects thought longer about an issue. The mean alpha ratio obtained during the prestimulus epoch served as the covariate in the analyses, whereas the mean alpha ratio obtained during the first and last 20 seconds of each experimental trial served as the criterion measure for the 90-second group and the full 20 seconds served as the criterion for the 20-second group (cf. Lacey & Lacey, 1958; Reuder, in McGuigan, 1979, pp. 72-76).

Adjusted cell means and one-tailed tests of the experimental hypothesis are reported in the following section.

Comparability of conditions. First, an ANCOVA was conducted to compare the relative alpha abundances observed during the 20-second conditions with those obtained during the first 20 seconds of the 90-second conditions. The analyses revealed that there were no significant differences among the conditions on this measure. This result indicates that the relative hemispheric alpha abundance that existed across experimental conditions was comparable at the outset (i.e., the first 20 seconds) of the time-to-think epochs (see left panel of Figure 1).

Test of hypotheses. Next, an ANCOVA was performed to test the specific experimental hypothesis by comparing the relative alpha abundances obtained during the 20-second conditions with those obtained during the last 20 seconds of the 90-second conditions. As is apparent from inspecting the middle panel of Figure 1, larger alpha ratios were exhibited during the 20-second than 90-second conditions, \( F(1, 12) = 4.60, p = .025 \), which is in accord with the experimental hypothesis.\(^\text{5}\) No other significant effects were found in this ANCOVA.

A second test of the experimental hypothesis was performed by comparing the alpha ratios obtained during the first and last 20 seconds of the 90-second conditions. The results were consistent with the hypothesis that there would actually be a shifting of relative

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\(^{5}\) Recall that large, positive scores indicate relative alpha abundance over the right parietal lobe and suggest relative EEG activation of the left hemisphere. This means that an increase in the relative EEG activation of the right hemisphere is indicated by a reduction in the alpha ratio depicted in Figure 1.
hemispheric alpha activity toward the left parietal lobe as subjects thought longer about an issue. As can be seen in the right panel of Figure 1, larger alpha ratios were observed during the first than last sampling epoch, \( F(1, 12) = 3.02, p = .05 \). No other test in this ANCOVA was significant.

**General Discussion**

With regard to the experimental observations, one new effect emerged consistently when thinking about an attitude issue was evoked: Individuals showing relative right hemispheric EEG activation also produced a more affectively polarized profile of cognitive responses. It is particularly interesting in regard to the reliability of these findings that conceptually similar results apparently have been obtained inadvertently in a recent study of advertising. Appel, Weinstein, and Weinstein (1979) recorded alpha activity while subjects were exposed to television advertisements three successive times. Krugman (1980) reanalyzed Appel et al.'s data for reasons unrelated to the present article. Krugman reported that alpha activity over the left hemisphere increased with repetitions of the advertisement, whereas alpha activity over the right hemisphere remained fairly constant. This pattern, of course, yields a shifting of relative interhemispheric alpha abundance from the right to the left hemisphere, as was observed in Experiment 3. As advertisements are presented repeatedly, people have more and more time to think about the attitude issue and may evince a shifting of relative hemispheric EEG activation from the left toward the right hemisphere as the affective component of their idiosyncratic representations of and thoughts about the stimulus become stereotypic.

In this series of studies, we have *not* obtained evidence of a unique relationship between relative hemispheric activation and a person's susceptibility or resistance to influence (as assessed by the agreement rating scales). In this regard it is important to note that previously observed associations between agreement and topic-relevant cognitive responses were replicated in these studies. For instance, agreement was positively correlated \( r = +.53 \) and \( +.57 \) with the number of favorable thoughts and negatively correlated \( r = -.41 \) and \( -.65 \) with the number of unfavorable thoughts listed in Experiments 1 and 2, respectively. Of course, the polarization index should not be expected to be related to agreement in a linear fashion in these studies, since the former has both positive and negative components contributing to agreement. The appropriate test for assessing the impact of relative hemispheric activation on attitudes, the interaction test of position and relative hemispheric activation, was insignificant in Experiments 1 and 2. The means were directionally consistent with the expected interaction, however, and we can only speculate that a conventional level of statistical significance might have been obtained if a more affect-oriented attitude scale (e.g., the semantic differential) had been used.

There are a number of other issues that require further research before answers about the theoretical mechanism underlying the present data can be definitively presented. For instance, although the study of individual differences in the relative hemispheric alpha abundance that accompanies cognitive and attitudinal responses represents a fairly microscopic analysis for personality and social psychologists, it would be considered fairly gross compared to some forms of electrocortical analysis. The EEG analysis that we used has a precedent in psychophysiology (e.g., Davidson & Schwartz, 1977; Doyle, Ornstein, & Galin, 1974; Galin & Ornstein, 1972), but far more complex and technically demanding methods have been developed recently (e.g., see Martin & Venables, 1980). The application of the more sophisticated methods to the conceptual issues introduced in this article would be informative and welcome. Until such studies are conducted, the generalizability of our results to a broader spectrum of brain wave activity or to "hemispheric utilization" should remain tentative.

Second, the subjects in this research have been characterized generally by more abundant alpha activity over the right than left parietal lobe. We have suggested thus far that a shift in relative hemispheric activation from the left toward the right hemisphere marks more affectively polarized thinking
about an attitude issue. Equally logical inferences from this data are that an attenuation of asymmetrical hemispheric activation leads to affectively polarized thinking and that cognitive exhaustion leads to a reduction in relative left hemispheric activation (e.g., see Figure 1). Any of the relationships would be interesting, and there are no data available at present with which to select among these alternatives. Indeed, more sophisticated analyses of electrocortical activity may be necessary to select among these possibilities, since the performance of linguistic tasks such as thinking about an attitude issue or listening to a persuasive communication tends to elicit the pattern of lateralized hemispheric activation that we have observed in these studies (i.e., primarily left hemispheric EEG activation).

Third, there are interesting questions of generalizability with respect to subjects. We only used right-handed men who reported familial histories of right-handedness. Sex differences might be found if one compared interhemispheric EEG patterns of men and women as they produced more and more affectively polarized profiles of thoughts about an issue. Variance for such an effect could then be partitioned into that attributable to sex differences in the lateralization of the functional centers for speech and that due to sex differences in the formulated association between relative hemispheric activation and affectively stereotypic thinking.

Fourth, the formulation itself can be partitioned into subcomponents. Recall that no association was found between relative hemispheric activation and the affective polarization of cognitive responses when a median split was performed during a pretreatment rest period (see Experiment 1), whereas covariation of these factors was found when analyzing the various epochs that subjects might be thinking about an issue (see Experiment 1 and the forewarning, postwarning-preamessage, message, and immediate postmessage epochs in Experiment 2). The observations may be attributable to different forms of cognitive response. Individual differences may exist in the manner in which people think about attitude issues and persuasive communications. Those individuals who tend to think about issues in a closed-minded fashion (Rokeach, 1960) might be expected to be especially likely to display relative right hemispheric activation. Indeed, a specific manipulation of closed-mindedness in a recent experiment produced the stereotypic pattern of thought listings seen in the present study (Petty & Brock, 1979). Also, particular stimuli (e.g., specific attitude issues, such as abortion and death) may generally elicit affectively polarized cognitive responses across individuals and elicit greater relative hemispheric activation of the right hemisphere. The generalizability that we found in Experiments 1 and 2 argues against this form of issue-specific cognitive response, but the issues that were used may not have been sufficiently extreme or heterogeneous to show a pronounced effect.

Finally, although the data from Experiment 3 suggest that more affectively polarized thinking about an attitude issue leads to a predictable effect on the pattern of interhemispheric activation, we are left with the question as to what the effects of hemispheric utilization are on the profile of cognitive responses. There obviously are methodological difficulties in experimentally testing this hypothesis. In addition, this hypothesis actually encompasses two distinct issues: (a) Is the relative abundance of alpha activity over one cerebral hemisphere indicative of the utilization of the opposite hemisphere? (b) Does the relative utilization of one or the other hemisphere alter the profile of affect-laden thoughts about an attitude issue? Tucker (1981) hypothesized that the right and left hemispheres have different ways of handling cognitively emotional arousal such as might be elicited by an attitude stimulus. The right hemisphere, with its “holistic, syncetic conceptualization of analogue data from sensory or visceral channels” (Tucker, 1981, p. 38) might well produce a more impulsive and affectively polarized form of thinking about an attitude issue than the left hemisphere.

In conclusion, we have described three investigations on an old social psychological issue—how individuals differ when forming or changing their attitudes. Gordon Allport (1935) warned that the concept of attitudes represented a complex of factors, some of which would not be apparent in a person’s
expression of an attitude. Allport described an attitude as "a mental and neural state of readiness organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related" (p. 810, italics original). Although much research since 1935 has addressed the interrelationships among the cognitive, affective, and behavioral aspects of attitudes, and some research has addressed individual differences in these aspects of attitudes, no attention has been paid to individual differences in the neural accoutrements of attitudinal processes. We would be surprised if the distinctive interhemispheric patterns of EEG activation and profiles of cognitive response we have observed do not also portend attitudes that are distinctive in some manner. The present studies may suggest how some of the lingering questions in personality and social psychology, as well as some new and interesting effects, might be advanced using theoretical and methodological developments from psychophysiology and neuropsychology. Of course, this study also shows how concepts from social psychology can benefit the testing and development of models in psychophysiology and neuropsychology, illustrating the reciprocal benefits of this and similar research strategies.

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