THE RELATIONSHIP BETWEEN DIFFERENTIAL HEMISPHERIC ALPHA ABUNDANCE AND THE AFFECTIVE POLARIZATION OF THOUGHTS ABOUT AN ATTITUDE ISSUE

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Abstract

Three studies were designed examining individual differences in responding to persuasive communications. Results indicated that people who evinced relative left hemispheric EEG activity when thinking about an attitudinal recommendation also generated less stereotypic or affectively polarized thoughts about the issue. Strategical implications are discussed.

The general field out of which our research has developed can be called social psychophysiology and warrants comment to set the context for the three studies that we are reporting here. Social psychophysiology is characterized by the use of noninvasive procedures to study the relationships between actual and perceived physiological events and the reportable and conative effects of human association, whether real or imagined. This field of research, which has evolved from the disciplines of social psychology and psychophysiology, has advanced our understanding of a number of issues bearing upon consumer behavior. For instance, social psychophysiological research has yielded information about the effects of mass media (e.g., Zillmann, 1979, 1980), persuasive communications (e.g., Cacioppo & Petty, 1981a), induced compliance situations (e.g., Fazio & Cooper, in press), and individual differences in focus of attention (Scheier, Carver, & Matthews, in press).

There are a variety of reasons for this recent increase in interest in and use of psychophysiological procedures by social scientists. As with any research endeavor, the value of a methodological approach is a function of the expected value of the research information that is gained (e.g., the value of the theoretical insight garnered or of the convergent validity obtained) and the cost of conducting the research. The standardization of psychophysiological recording procedures (e.g., see Basmajian, Clifford, McLeod, & Nunnally, 1975 for discussions of EMG; Jennings, Berg, Hutcheson, Obrist, Porges, & Turpin, 1981 and Tursky & Jamner, in press for discussions of HR) and the quantification of the complex analog bioelectrical signals now possible using the analog-to-digital (A/D) capabilities of low-cost laboratory computers (see Cacioppo, Marshall-Goodell, Gormezano, & Scandrett, in press; Martin & Venables, 1980) have certainly lowered the cost of conducting this type of research. Perhaps more importantly, though, is the recognition of the gains in research information that investigators can now reap using a social psychophysiological approach to complement a research program on an issue. For example, we have identified six distinct benefits that have been realized in the area of social psychology (Cacioppo & Petty, in press). At the simplest level, social psychophysiological research can help to advance our understanding of the determinants of people's physiological mechanisms by expanding the set of independent and dependent variables to include powerful social factors. Second, psychophysiological procedures can provide a means of assessing the construct validity of theoretical concepts, such as attention, cognitive responses, or attitudes. Indeed, it is possible that ultimately more valid measures of attitudes can be developed since an individual may not always be willing or able to report verbally his or her global and enduring positive or negative regard for a stimulus. Third, this approach reminds us that people in the course of their daily lives respond to bodily sensations and perceptions; hence, this viewpoint can lead to the discovery and ultimately to the explanation of instances of complex human motivation and behavior that are shaped by a combination of social, dispositional, and physiological factors. Fourth, a cognizance of social psychophysiological influences can lead to refinements in existing theories of social and consumer behavior when the extant abstract formulations and "conceptual nervous systems" within these areas are found to be incompatible with the present state of knowledge about the structure and function of the human organism. Fifth, the practical demands and ecological validity of social (and consumer) research can lead to the discovery of new effects (or psychophysiological relationships) that will force refinements in or developments of psychophysiological theories. Finally, this field of research potentiates important discoveries in applied areas such as consumer behavior and behavioral medicine since the regulation (or deregulation) of the human organism is viewed within a broader social context.

In the present paper, we would like to illustrate one of these benefits: How the formulations that exist within psychophysiology can serve as a guide to alternative ways of conceiving a person's characteristics, wants, and preferences. We have drawn from the brain lateralization research to direct us to a new and reliable individual difference in relative hemispheric alpha abundance that relates to the affective polarization of a person's cognitive responses to persuasive communications (Cacioppo, Petty, & Quintanar, in press). The results of this work are discussed in terms of what we may have learned about consumer behavior and what other kinds of new effects might be derived by employing a similar approach.

Experimental Rationale

Research on functional cerebral asymmetry has taken many forms and has yielded almost as many results and controversies. Briefly, there have been numerous refinements over the years, but the early gross observations of the effects on behavior of severing the massive tract connecting the two cerebral hemispheres (the corpus callosum) have been found in a much less noticeable form in normal individuals (e.g., see reviews by Corballis, 1980; Gazzaniga, 1970; Hansen, 1981; Tucker, 1981). People perform more accurately and more quickly when spatial tasks are presented to the right than left hemisphere, whereas the opposite effect tends to be found when linguistic tasks are presented. Similar patterns of results are found when electroencephalographic (EEG) data are examined. Schwartz, Davidson, and Pugash (1976), for instance, found that operantly training individuals to reduce the amount of alpha (8-13 Hz) brain wave activity over the left parietal (associative) area of the brain increases the likelihood that the individuals will report semantic thoughts, whereas conditioning individuals to reduce the amount of alpha activity over the right parietal area increases the chances that subjects will report imagery or spatial thoughts. (A decrease of alpha activity during a waking state is assumed to reflect increased activation of the underlying area of the brain.)

In a recent review of the literature on cerebral asymmetry and human emotion, Tucker (1981) argued that there are different forms of cognitive organization in the two hemispheres that are possibly attributable to neuroanatomical factors. Tucker suggested that the right hemisphere's "global ideation" may lead to a diffuse and expansive emotional experience, whereas the left hemisphere's "analytic" orientation may incline an individual toward a less diffuse emotional experience in response to the same stimulus. Hansen's (1981) characterization of the right and left hemispheres is similar. According to Hansen, the left hemisphere is more associated with traditional verbal, symbolic problem-solving processes than the right, whereas the right hemisphere is more associated with imaginative, spatial, and pictorial processes than the left. Corballis (1980) has characterized the psychology of the two hemispheres quite differently, arguing that the left hemisphere is more specialized for abstract representation, whereas the right hemisphere tends to maintain "representations that are isomorphic with reality itself" (p. 288).

Fortunately, similar predictions regarding individual differences in relative hemispheric alpha abundance and cognitive responses to persuasive communications can be derived from these differing notions of cerebral asymmetry. Whether the left hemisphere (of right handed men with familial histories of right handedness) inclines a more piece-meal analysis of a persuasive communication or more cognitive abstractions of the recommendation, one would expect to find the relative activation of the right hemisphere to be associated with a more affectively polarized profile of thoughts listed by subjects about the attitude issue. The primary objective of this research was to determine whether there was this association between relative hemispheric alpha abundance and cognitive responses to persuasive communications.

In the first experiment, 40 right-handed men were given the task of judging the sound quality of audio-tapes as part of what they believed was a study of people's involuntary bodily responses to communicative stimuli. Twenty subjects were exposed to a message arguing for fewer restrictions on coed visitation (a proattitudinal recommendation), and 20 heard a message advocating greater visitation restrictions (a counterattitudinal recommendation). The message, which lasted 2 minutes, was preceded by a 1-minute baseline, a 15-second forewarning of the topic and position of the message, and a 1-minute post-warning-premessage epoch. Monopolar EEG activity was amplified from the left (P3) and right (P4) parietal areas (referenced to linked ears) using wide-band AC preamplifiers, channeled through an 8-13 Hz band-pass filter, full-wave rectified, and sampled 100 times per second using a laboratory computer. This procedure transforms the complex EEG waveform into a simple measure, expressed in arbitrary units, of the abundance of alpha activity detected over each recording site. The relative alpha abundance was subsequently determined by calculating the ratio of the difference in alpha abundance at the left and right parietal sites over the total abundance of alpha evident over the recording sites (i.e., 100 x (P4-P3)/(P4+P3)). The larger the ratio, the greater the relative abundance of alpha over the right parietal region, suggesting the relative activation of the left hemisphere (see Davidson & Schwartz, 1977; Galin & Ornstein, 1972).

Immediately following the message, subjects were asked to list everything about which they had thought during the preceding few minutes (see Cacioppo & Petty, 1981b for a detailed description and discussion of the thought-listing procedure). Subjects rated their own thoughts as favorable (+), unfavorable (-), or neutral/irrelevant (0) toward the recommendation (cf. Petty & Cacioppo, 1977). Subjects also indicated their attitude toward the recommendation "since your feelings toward the recommendation might alter your judgments of the sound quality of the audio-tapes." Finally, subjects completed several ancillary measures pertaining to the sound quality of the audio-tape to maintain the cover story of the experiment. Subsequently, a measure of affective polarization was calculated specifically for testing the present hypothesis by subtracting the number of nonpredominant from predominant topic-relevant thoughts. For the proattitudinal communication, this measure was calculated by subtracting the number of unfavorable from favorable thoughts, whereas for counterattitudinal communications this measure was derived by subtracting the number of favorable from unfavorable thoughts.

Relative hemispheric alpha abundance was determined for two periods: The 60-second initial baseline epoch and the 195-second epoch during which time subjects could conceivably be thinking about the attitude issue. No differences in alpha-ratios were obtained as a function of Position, so a median split along the alpha-ratios for each of the two epochs described above was performed within each group (i.e., pro- and counterattitudinal groups). The results of the median splits were used as a blocking factor in the ANOVAs of subjects' cognitive and attitudinal responses to the persuasive communication.

The analyses revealed that the manipulation of Position was effective. Subjects exposed to the proattitudinal communication indicated more agreement, F (1, 36) = 15.12, $p < .001$; they also tended to generate more favorable thoughts, F (1, 36) = 3.81, $p < .06$, than subjects exposed to the counterattitudinal communication.

In tests bearing upon the experimental hypothesis, the ANOVAs indicated that individual differences in hemispheric activation prior to the initiation of the forewarning (i.e., during the initial baseline period) did not account for a significant portion of the variance in subjects' cognitive and attitudinal responses to the message that was subsequently presented ($ps > .20$). However, individuals characterized by the relative activation of the right hemisphere when anticipating and monitoring the persuasive communication did produce a more affectively polarized profile of topic-relevant cognitive responses than their counterparts, F (1, 36) = 4.02, $p < .05$, M (relative right activity) = 2.20, M (relative left activity) = 0.15. Interestingly, this individual difference emerged similarly for the proattitudinal and counterattitudinal messages and did not show concomitant variation with the simple number of favorable thoughts, unfavorable thoughts, neutral/irrelevant thoughts, or the simple number of affect-laden thoughts, or total listed thoughts. In sum, then, the relationship that was observed was consistent with the notion that a relative dearth of left hemispheric EEG activity would be inversely related to the affective polarity of the cognitive responses toward an attitudinal recommendation.

We repeated this study making a number of changes to provide a more stringent test of the replicability of these initial observations. We conducted two versions of our second study, using eight right-handed men as subjects in each version. We did this because the replicability of a number of studies of functional asymmetry has been poor and the effect that we obtained in our first study is new. To assure the generalizability of the effect we prepared persuasive messages on two new topics. Students' access to season basketball tickets and the university facilities for dining were topics in which undergraduate men were keenly interested the semester this study was conducted and were employed as the topics of persuasive communications in this study. Forewarnings and messages were developed that recommended changes that students either strongly favored or disfavored.

We also subdivided the EEG sampling epochs into four distinct periods: (a) 15-sec forewarning of the topic and

position of the message they were to hear, (b) 45-sec postwarning-premessage anticipatory epoch, (c) 60-sec persuasive message, and (d) 15-sec postmessage epoch of silence during which time subjects might reflect upon and integrate what they had heard. This breakdown of the communicative sequence allowed us to determine whether the results of the first study were attributable to subjects' reactions to a specific aspect of the broadcast sequence (e.g., to its presentation) or, more likely, to the broadcast sequence generally (e.g., when subjects are thinking about the attitude issue).

Finally, although the same basic cover story as was used in the first study was used in the second, each subject was exposed to both proattitudinal and counterattitudinal communications. This change was done so that we might reduce the number of subjects that needed to participate in the experiment.

The manipulation of Position was again effective. Pro-attitudinal compared to counterattitudinal communications elicited more agreement, F (1, 8) = 67.43, $p < .001$, fewer unfavorable thoughts, F (1, 8) = 37.70, $p < .001$, and more favorable thoughts, F (1, 8) = 33.88, $p < .001$. No other main effect for Position was statistically significant.

Blocking for the relative hemispheric alpha abundance was performed as in the first study except that, rather than calculating a single median split for the broadcast sequence, we conducted a series of ANOVAs on the basis of the relative hemispheric alpha abundance evinced across the four epochs outlined above. One-tailed tests were conducted to assess the specific experimental hypothesis, and $p < .05$ was used as the criterion for statistical significance.

The ANOVAs revealed very similar results regardless of the epoch from which the alpha-ratios were calculated, suggesting that there are individual differences in interhemispheric responding to the forewarning and presentation of a persuasive communication (and, perhaps, to communications generally). (The median splits calculated for the forewarning and message epoch, in fact, yielded identical results.) As in the first study, subjects characterized by relative right hemispheric activation, when compared with their counterparts, tended also to generate more one-sided sets of thought-listings about the attitudinal recommendation. Cell means for the various epochs are summarized in Table 1. No other test on these measures was significant.

TABLE 1
Mean Responses to the Presentation of a Persuasive Communication as a Function of Relative Hemispheric EEG Activity[a]

	Postwarning-Premessage		Forewarning/Message		Postmessage	
Measure	Left	Right	Left	Right	Left	Right
Affective polarization of thoughts	1.00	2.16	1.19	1.97	1.13	2.03
Agreement	4.16	4.75	4.44	4.47	4.31	4.59
Unfavorable thoughts	2.22	2.50	2.25	2.47	2.16	2.56
Favorable thoughts	.78	2.09	1.31	1.57	1.16	1.72
Neutral/irrelevant thoughts	1.41	.84	1.38	.88	1.38	.88

[a]Means for the forewarning epoch are identical to those presented for the message epoch. Thus, they are presented together.

The results of this second study are encouraging regarding the replicability and generalizability of this effect. Subjects who showed a relative abundance of the alpha activity over the left hemisphere (and, presumably, relative activation of the right hemisphere) also generated a more affectively polarized profile of cognitive responses to the persuasive communications. The data, however, also indicated that subjects' agreement with a persuasive communication was not influenced by blocking on relative hemispheric activation, a result obtained in the first study, too.

The aim of our third investigation was to examine the effect on relative hemispheric EEG activation of increasing the affective polarization of a person's thoughts about an attitude issue. We used Tesser's (see Tesser, 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). Tesser and his colleagues typically give their subjects either a short (e.g., 10 or 20 sec) or long (e.g., 90 sec) epoch to think about an attitude stimulus. Using this procedure, they have repeatedly found that as subjects think longer about an issue, their attitudes polarize and the profile of their thoughts about the issue change "in the direction of greater schematic and evaluative consistency" (Tesser, 1978, p. 290).

Hence, we conducted two replications using seven right-handed men in each. A 2 (Replication) x 2 (Time-to-Think) x 2 (Position: pro- vs. counterattitudinal) mixed design was employed in which Replication served as the only between-subjects factor. The experimental stimuli and conditions were ordered randomly for each replication; in other regards, the replications were identical.

An initial pool of 60 attitude statements was generated for possible use in the study. Recommendations such as "Placing a tax on oil company profits" and "Driving 55 mph to conserve energy" were included in this initial pool. One to two weeks prior to their participation in the study, subjects expressed their attitude toward each of the 60 recommendations using a 14-point Likert-type scale. A second rating of these recommendations, which were ordered differently, was made when subjects arrived for participation in the study. The second rating, however, was made using a 7-point scale. For each subject, the four recommendations toward which the subject expressed a moderately positive attitude on both ratings and the four recommendations toward which the subject expressed a moderately negative attitude on both ratings were selected for use as experimental stimuli. This selection was achieved following the attachment of bioelectrical sensors to the subject and while he worked on a list of anagrams (e.g., mubrc). Subjects were led to believe that electrophysiological recordings were being made during the anagram task, but in fact none were obtained.

Afterwards, each subject was exposed to the eight selected attitude issues. For two of each set of four issues, the subject was given a short (20 sec) epoch to think about the attitude stimulus, whereas the subject was given a long (90 sec) epoch to think about each of the remaining issues. This, of course, means that each subject cogitated for 20 sec each on two recommendations about which he felt moderately proattitudinal, 20 sec each on two recommendations about which he felt moderately counterattitudinal, 90 sec each on two recommendations about which he felt moderately proattitudinal, and 90 sec each on two recommendations about which he felt moderately counterattitudinal.

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 area (i.e., a shift in relative hemispheric activation toward the right hemisphere) as subjects thought longer about an issue and regardless of the initial polarity of the position recommended. The mean alpha-ratio obtained during a prestimulus epoch served as the covariate in the analyses.

The first ANCOVA was performed comparing the relative alpha abundance observed during the 20-sec Short time-to-think conditions with that observed during the first 20 sec of the 90-sec Long time-to-think conditions. The analyses revealed that there were no significant differences among conditions on this measure. This indicates that there was comparable interhemispheric patterns of EEG activation at the outset of the time-to-think epochs.

The next ANCOVA was performed testing the specific experimental hypothesis by comparing the relative alpha abundance displayed during the 20-sec Short time-to-think conditions with those displayed during the last 20 sec of the 90-sec Long time-to-think conditions. Results of the analysis indicated that larger alpha-ratios were obtained during the Short than Long time-to-think conditions, F (1, 12) = 4.50, p = 0.025, one-tailed, a finding in accord with the experimental hypothesis. No other significant effects (e.g., the main effect for Position) was found in this analysis (ps > .15).

A second test of the experimental hypothesis was performed by comparing the alpha-ratios obtained during the first and last 20 sec of the Long time-to-think conditions. The results provided further support for the experimental hypothesis. Larger alpha-ratios were observed during the first than last sampling epoch, F (1, 12) = 3.02, p = .05, one-tailed, suggesting an actual shifting of relative hemispheric alpha activity toward the left parietal area as subjects thought longer about an attitude issue. No other test in this ANCOVA was significant.

In sum, one new effect emerged consistently in these studies, regardless of topic, replication, position, or epoch during which thinking about an attitude issue was evoked: Individuals showing relative right hemispheric EEG activation also produced a more affectively polarized profile of cognitive responses. This result is clearly in accord with Hansen's (1981) hypothesis that "Some individuals are more likely than others to rely on right-brain processes" (p. 33).

Matters of interpretation can still be debated, as these studies have been exploratory rather than definitive in nature. Nevertheless, the strategy of using what is known about psychophysiological mechanisms to derive hypotheses about social behavior proved useful in this research. Moreover, the theoretical benefits of this research strategy may work both ways. As more research in social and consumer-oriented settings is conducted, a larger database will be generated yielding new empirical effects challenging psychophysiologists and neuropsychologists to construct models accommodating a broader range of observations. As these models are developed, of course, the utility of using the present research strategy only improves.

Even at present, though, some of the existing models of hemispheric lateralization and consumer behavior are being advanced by these and other recent observations. For instance, Krugman (1971) suggested that the right brain may be primarily involved during the processing of the information in advertisements transmitted through an audio-visual mode (e.g., television), whereas the left brain may be primarily involved when processing information from advertisements presented in the print medium. In addition, Krugman suggested that this asymmetry would lead to differential recall of the advertising content, with information processed primarily with the left hemisphere being recalled verbally best. Appel, Weinstein, and Weinstein (1977) recorded alpha brain wave activity while subjects were exposed three times to television advertisements whose content was either highly memorable or not. Appel et al. did not find differential hemispheric EEG activity as a function of message recallability. These results seem inconsistent with Krugman's (1971) theorizing. In reanalyzing Appel et al.'s (1979) data, Krugman (1980) found that the brain wave activity over the left hemisphere declined with the repetition of the advertisement, whereas the activity over the right hemisphere remained more constant with repetition. This shifting of brain wave activity from the left to the right is, of course, in accord with the observations we have made: As the 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 activity from the left toward the right hemisphere as their thoughts about the issue become more stereotypic or more affectively polarized. Krugman (1980) argues that the lateral asymmetry is attributable to the fatigability of the left hemisphere and the enduring vigilance of the right. Krugman's interesting hypothesis does not account very well for the relationships we have observed between relative hemispheric alpha abundance and the affective polarization of people's thoughts about an attitude issue. Nevertheless, it remains possible that the relative fatigability of the left hemisphere contributed to the present data and is itself attributable to the less stereotypic, relatively idiographic cognitive operations performed by the left hemisphere.

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