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CEREBRAL BALANCE, RECOGNITION ACCURACY AND CONFIDENCE

WHEN TASK PERFORMANCE REQUIRES

THE USE OF PRECONSCIOUSLY ACQUIRED INFORMATION

Kinga M. Perlaki and Patricia R. Barchas

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INTRODUCTION

A positive relationship between mere repeated exposure of a stimulus and its appeal has been documented (Moreland & Zajonc, 1977; Zajonc, 1968). The effect is independent of stimulus recognition (Wilson, 1979) and has been demonstrated with exposure so brief that it falls below the threshold of conscious awareness (Kunst-Wilson & Zajonc, 1980). On subsequent presentation these preconsciously perceived stimuli are preferred over others that are similar but unfamiliar, although conscious differentiation between the two types is not possible. This paper reports an extension of the mere exposure effect paradigm to capture the relative engagement of the brain's cortical hemispheres when instructions are given on how to approach the task.

Amongst other properties, the two cerebral hemispheres apprehend the world with different strategies and learn differently (Bradshaw & Nettleton, 1981; Dennenberg, 1981; Zaidel, 1978). The left hemisphere is more specialized for language and the right hemisphere is biased for organization and recognition of spatial data. The right hemisphere tends to make holistic or intuitive judgments and is more responsible to emotional content than the more analytic and logical left brain. In addition, the right hemisphere has been associated with mediation of emotions (Zaidel, 1977). Preferential involvement of the right hemisphere would be one way to account for the empirical finding that affective discrimination may be performed in the absence of conscious awareness.

The exposure effect paradigm is such that measurements may be taken of hemispheric brain activity as an index of brain functioning from which alterations in hemispheric balance of activity may be detected. In our use of the exposure effect paradigm selection accuracy and confidence ratings provided the behavioral measures, while at the same time the relative activity of the two hemispheres, i.e., lateralization, was assessed at the same time from recordings of the electrical brain events directly from the scalp via an electroencephalograph (EEG) system. The alpha frequency range was taken as the primary operational measure for the hemispheric involvement as activation of the brain reliably results in alpha suppression (Bunnell, 1981; Galin & Ornstein, 1972; Osborn & Gale, 1976), and the decrease in alpha production is more pronounced on the side which is more involved with the task (Morgan, Macdonald & Hilgard, 1974). Instructions on how to approach the task were given to the subjects in order to enhance the outcome on lateralization and to increase the salience of the accuracy and confidence measures. For each of the two experimental conditions an instruction was given to use a general cognitive strategy that would engage one hemisphere more than the other. This was reinforced by a behavioral request that was consistent with the general cognitive strategy. Thus, the general direction to try to do the perceptual task holistically was reinforced by the behavioral request to report which of the two stimuli were preferred, and the direction to do the task analytically was reinforced by the behavioral request to report which was recognized. Given the spatial nature of the task stimuli, the instructions given to the subjects were task appropriate (holistic and right brain) or task inappropriate (analytic and left brain). Therefore, in one condition the nature of the spatial task, the general strategy imposed, and the behavior required increased the likelihood of greater right hemispheric activity. In the other condition, both components of the instruction would have predisposed toward left hemispheric activity. In each condition, the visual spatial task alone would have been expected to potentiate relatively right hemispheric activity.

It was expected that subjects for whom the instructions were task appropriate, emphasizing a holistic strategy coupled with preference judgments, would be likely to involve their right hemisphere more compared to the left. In contrast, subjects who were asked to use a task inappropriate analytic strategy coupled with recognition judgments would show a tendency to engage their left hemisphere compared to their right. Operationally, it was predicted that, as defined by the index constructed, the right/left laterality scores would be greater in the analytic condition as compared to the holistic condition. It was also expected that a right brain holistic strategy for processing the subliminally acquired information would be associated with higher selection accuracy while a left brain analytic strategy would be detrimental to accuracy. Operationally, as defined by the index constructed, relatively lower laterality scores were predicted to correspond to relatively higher accuracy scores. Thus response accuracy and laterality were expected to be inversely related. No specific predictions were made with regard to the relationship of self-reported confidence of response to accuracy or hemispheric activity.

METHOD

Subjects

The subjects were 28 female undergraduates between the ages of 17 and 22, who were, by self-report, right-handed with no familial history of left-handedness and were also free of learning disability, speech impediments, or neurological disorders. Each subject was randomly assigned to one of the two experimental conditons, i.e., analytic or holistic instructions, thus creating two subsamples, each consisting of 14 subjects. The subjects were all volunteers who were paid for their participation.

Equipment

Subjects were tested in a completely dark experimental chamber that was equipped with a chair, a table that supported a chin rest, and a two-button response board. The projector screen (29.2 x 19.0 cm) was presented through a window, 75 cm in front of the sitting subject. The screen comprised the front end of a 159 cm long viewing tunnel. A slide projector equipped with an electronic shutter and shutter timer occupied the other end of the viewing tunnel. Image size was regulated by a condensor chest which was attached in front of the shutter, and to reduce illumination a neutral density filter (Kodak 96, N.D. 2.0) was affixed to the rear condensor.

The EEG signals were amplified by a Grass Model 7P511 EEG Amplifier System, and a Grass Model 5 Polygraph equipped with Grass Model R5DC Tape Reverters was used to obtain a written record of the ongoing brain activity. The Grass 7P511 was operating with 1/2 amplitude cutoff points of 1 Hz (lo) and 100 Hz (hi), and was calibrated using a Sensitivity setting of 5 to produce a 1 cm pin deflection in response to a 50 μV internal calibration pulse. The amplified EEG signals were simultaneously transmitted to a Nicolet MED-80 special purpose computer that used the Frequency Analysis Package (FAP) software program to perform on-line spectral analysis. For the purpose of this study the four frequency bands were defined as follows: (a) Delta 0-3.5 Hz, (b) Theta 4-7.5 Hz, (c) Alpha 8-13.5 Hz, and (d) Beta 14-20 Hz. The number of averages collected per sample was 10, i.e., sampling continued until 10 artifact-free sweeps were obtained. The time required to acquire a single sweep was 1.28 sec.

Stimuli

Stimuli were provided by 35-mm slides, each containing a dark irregular octagon shape against a light background. The total of 20 stimulus slides were randomly divided into two sets, each containing 10 slides. The slides used for this partial replication study were graciously provided by Dr. William Raft Kunst-Wilson and were copies of the stimuli employed in the Kunst-Wilson and Zajonc (1980) exposure effect study.

Procedure

The study consisted of two conditions based on the instructions given and was composed of an exposure phase and a test phase. Preparation of the subjects for EEG data collection took place prior to the experimental session. The behavioral data, i.e., slide selection and confidence in selection, were collected in the test phase simultaneously with the bilateral EEG data. Baseline recordings were collected prior to each phase. Samples of the bilateral EEG data were obtained from the left and right parietal sites (P3 and P4, respectively) as well as from the left and right central (C3 and C4) locations referred to the linked mastoids, following the guidelines of the International 10-20 System. The ground electrrode was placed on the forehead. The gold-cup scalp electrodes

(Grass) were applied with Grass EC2 electrode paste, and the resistence of all electrodes measured between 1000 and 5000 ohms.

Exposure Phase. During the first phase of the study subjects were asked to focus on the center of the screen as designated by a focusing slide and to watch closely for the slides that would be presented for such brief duration that they may be perceived only as brief flashes of light. Subjects were to indicate via the response buttons whether the flash was visible or not. Following two practice trials (using the focusing slide), slides of one of the two sets were flashed on the screen for 1 msec. This time value was chosen because our pilot studies (Perlaki & Barchas, 1982) supported the findings of other investigators (Kunst-Wilson & Zajonc, 1980) that under this exposure speed recognition was not better than what could have been attained by chance. Each of the 10 slides was shown five times, with a total of 50 presentations made in a pre-randomized order which was the same for all subjects.

Test Phase. At the beginning of the second phase the subjects were instructed on how to approach the task. The instruction was worded to impose a "holistic" mental set on the half of the subjects (n = 14) who were asked to make a series of preference judgments. For the other half (n = 14), an "analytic" frame of mind was induced, with the subsequent task of making a series of recognition judgments. Depending on their assignment to the conditions, half of the subjects were informed that they were going to see pairs of slides presented individually and for a longer period than before, one of which was flashed to them during the exposure phase. Their task was to view the two members of each pair analytically, and to decide which shape they thought they recognized as the one that was previously shown. The other half of the subjects were told that they would see slides presented in pairs, which they should view holistically and then inform the experimenter, via the keyboard, which slide of the two they liked better, and how sure they were of their choice. Selection decision (i.e., first or second slide) and the certainty of that judgment (i.e., more than 50% sure, or less than 50% sure) were indicated by pressing the appropriate button on the response board. Subjects in both instruction groups were asked to refrain from moving as much as possible, and to keep their right hand on the response board during the trials.

The 10 pairs of test stimuli were obtained by pairing every slide that was presented during the first phase with one from the set that had not been shown before. The "familiar" and the new slides appeared equally often in the first and in the second position. The same stimulus pairs were presented to all subjects for a total of 10 presentations. Each image remained on the screen for exactly 1 second to allow sufficient time for its viewing.

ANALYSIS AND RESULTS

Laterality

The on-line analysis of the EEG signals provided percentage values for the total power in the alpha frequency band produced at each of the hemispheric sites, prior to the experimental manipulation (baseline data) and during test performance (test data). To express the relative hemispheric changes in alpha production by taking into account the pre-treatment (baseline) alpha level, a laterality index was computed for every subject. In the analyses to follow, the baseline immediately preceding the test phase was used to compute the index. The following formula (adapted from Mills, Perlaki & Barchas, 1983) was used to compute the laterality scores:

$$\text{Laterality} = 100\left[\frac{(R - BR)}{BR} - \frac{(L - BL)}{BL}\right]$$

where R = percentage of right hemispheric alpha during treatment

BR = percentage of right hemispheric alpha during baseline

L = percentage of left hemispheric alpha during treatment

BL = percentage of left hemispheric alpha during baseline

According to this calculation a negative index represents relatively less right-hemispheric alpha (alpha suppression) as a result of more right-sided involvement, while a positive index is the sign of reduced alpha production on the left side, suggesting that the task performance has elicited more left-sided involvement, controlling for the initial (baseline) level of alpha. This index allows individuals to be used as their own control while it maintains inter-subject comparability.

The group scores for the holistic and analytic conditions are derived from the aggregation of subject specific scores, taking into account the fact that individuals vary with regard to their normal "setting" for hemispheric balance. Similarly to our previous experience with this paradigm (Perlaki & Barchas, 1982), inspection of the central laterality scores computed for the alpha band showed no obvious treatment effects. The nonparametric test of significance (Mann-Whitney U test) also detected no statistically significant laterality differences between the analytic and the holistic groups at the central hemispheric location. Consequently, the analyses presented in this section are restricted to the laterality findings that relate to the parietal area. The parietal region has been associated with laterality effects due to spatio-manipulative tasks (Kandel & Schwartz, 1981) and visuo-spatial perception (Fried, Mateer, Ojemann, Wohn & Freido, 1982).

Averages were computed for both the analytic and the holistic groups. The mean parietal laterality score of 0.29 for subjects in the holistic instruction group was lower than the mean of 10.83 obtained for the analytic group. The median value for the analytic group was 9.26 and -1.87 for the holistic. As expected, when the instructions were to treat the task holistically and the selection decisions were based on preference, for the majority of the subjects the right hemisphere was more actively involved compared to the left. The analytic emphasis with the requirement for recognition judgments seemed to elicit a relatively more left-sided processing. Empirically, scores on the laterality index were lower under the holistic condition compared to the analytic, as predicted. The hemispheric activity for ten of the fourteen subjects in the holistic group fell to the right of the point of the index indicating equal change in the activity of both hemispheres from their own baseline. This means that for these subjects their right hemisphere became relatively more involved during the task. Nine out of the fourteen subjects in the analytic instruction condition fell to the left (Figure 1), indicating relatively more involvement on the left side. This pattern was substantiated by the subsequently performed nonparametric tests of significance (Mann-Whitney U = 57, $\underline{z} = 1.88$, $\underline{p} < .04$).

Hemispheric alpha changes (relative to the baseline) came about in three different ways: (a) alpha was suppressed in both hemispheres, but to a different degree, (b) alpha increased on both sides, but to a different degree, and (c) alpha increased on one side and was suppressed on the other. For example, of the ten holistic subjects whose

Page for Figure 1

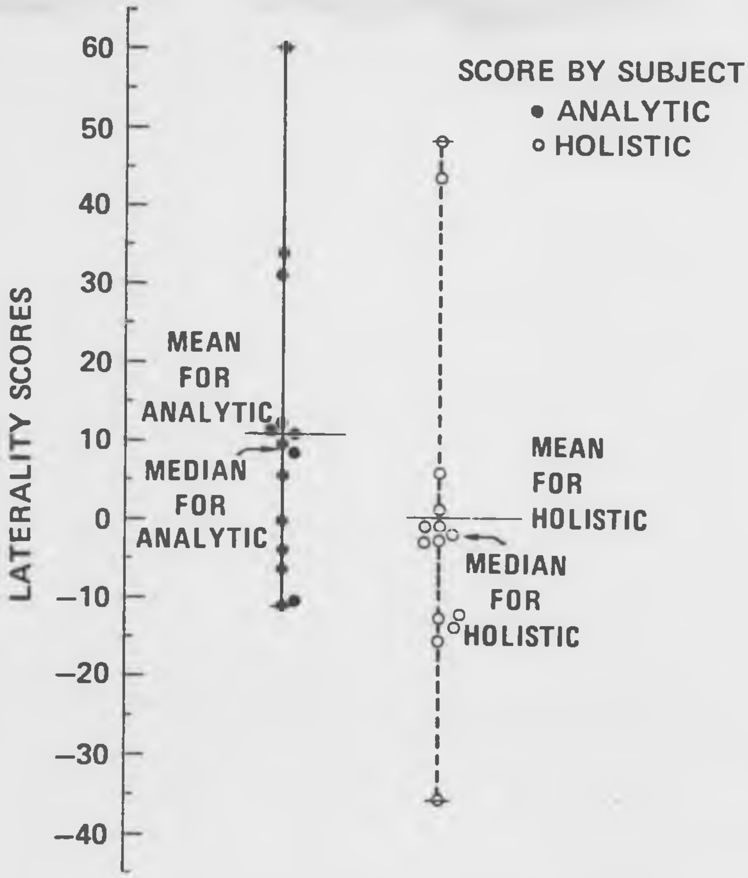

Figure 1

Laterality scores for subjects in the analytic and holistic instruction groups. According to this calculation a negative index represents relatively less right-hemispheric alpha, i.e., alpha suppression (as a result of more right-sided involvement), while a positive index is the sign of reduced alpha production on the left side, suggesting that the task performance has elicited more left-sided involvement, controlling for the initial (baseline) level of alpha.

hemispheric activity conformed to our expectation, seven showed task related alpha blocking on both sides but the suppression was relatively more prominent on the right side, two subjects increased alpha production on both sides but with a relatively smaller increase on the right side, and for one subject the predicted decrease in alpha on the right side was associated with an increase in left hemispheric alpha. (A subsequent report will explore the possibility of using the increase in beta frequency band in addition to alpha suppression to measure differential involvement of the two hemispheres, thereby providing a more direct descriptor for the relationship between wave production and hemispheric activity, to complement the indirect index provided by alpha.)

Laterality and Accuracy

The selection accuracy score for each subject was obtained by counting the number of correctly selected stimuli out of a possible 10. An accurate response was counted when during the test phase the subject chose the slide that was shown during the exposure phase over the new stimulus slide. The means of the subjects' scores on the laterality index were computed for the analytic and the holistic groups. Table 1 displays the laterality means and the corresponding selection accuracy means for the two groups.

Inspection of the means presented in Table 1 reveals that selection accuracy is somewhat higher following the holistic instruction compared to the analytic. The differences on the accuracy measures between the two groups did not reach statistical significance. However, despite the small sample size, the trend toward an inverse relationship between the behavioral and physiological measures was supported by a statistically

Table 1.

Means for Hemispheric Laterality Scores and

Selection Accuracy Scores by Instruction Type

Instruction type	Laterality*	Accuracy**
Analytic	10.83	4.71
Holistic	0.29	5.29
Column mean	5.56	5.00

*A value of 0 represents the laterality score that would occur when the left and right hemispheric activity adjusted to the baseline would be equal. By definition, a lower score indicates relatively higher right hemispheric activity and a higher score a relatively left hemispheric activity.

**A value of 5 represents the accuracy score that could be attained by guessing alone, it indicates that 5 out of the 10 possibilities were correctly selected.

significant inverse correlation ($\underline{r} = -.39$, $\underline{p} < .05$). Increased selection accuracy of the minimally exposed spatial target stimuli was more likely to occur with a relatively lower laterality index (i.e., with more right hemispheric activation), while less accurate responses had a tendency to be associated with a higher laterality index (i.e., with a relatively left-sided involvement). This suggests that selection accuracy of preconsciously perceived stimuli is enhanced when the task requirements are consistent with the functions for which the engaged hemispheric region is best suited.

Confidence Data

For both groups selection responses were divided by the two confidence categories: (a) more than 50% sure, and (b) less than 50% sure. Further, in each of these two categories, selection responses were classified according to whether they were accurate or inaccurate. Regardless of whether their choice was accurate or inaccurate, individual subjects showed more confidence in their selection if they had received the holistic instruction and less confidence if they had been given the analytic instruction. Figure 2 shows for the pooled choices of the holistic subjects that, out of 140 choices, 89 were made with higher confidence and 51 with lower confidence (64% vs. 36%, respectively), while for the pooled analytic group selections were made with more confidence 19 times, and with less confidence 121 times (14% vs. 86%, respectively). The Chi-square performed on the Instruction type x Confidence rating (2 x 2) contingency table was highly significant ($\chi^2 = 71.76$, $\underline{p} < .001$), indicating that a significant difference exists between the analytic and holistic groups in whether they show more or less confidence in their

Insert Figure 2 about here

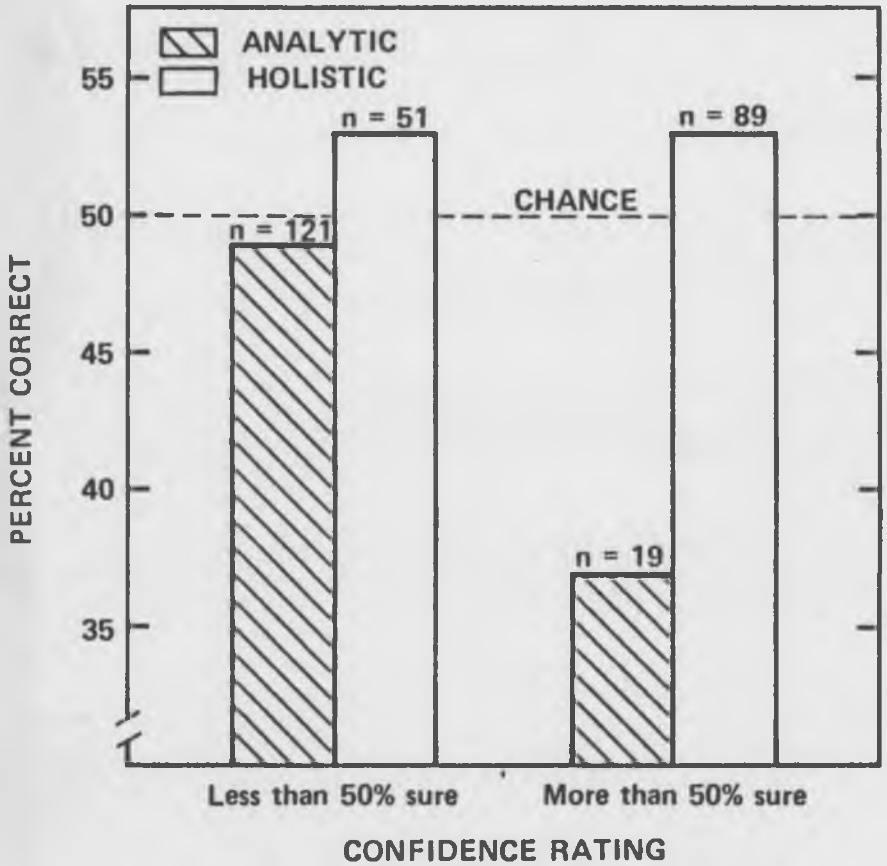

Figure 2

Means for correct selection (percent correct) of the preconsciously perceived stimuli under analytic and holistic conditions by confidence categories. The n represents the number of selection judgments out of 140 choices that fell in each confidence category for the total of 14 subjects in each of the two treatment conditions.

selection choice. In addition, inspection of Figure 2 reveals that while both confident and nonconfident subjects in the holistic group were equally accurate in their responses, those in the analytic group showed below chance recognition accuracy in both confidence categories. Confidence appears to have been associated with making an affective, subjective, task appropriate choice based on preference, and not to accuracy of that choice.

DISCUSSION

The absence of findings from the central site were accompanied by a pattern of findings when data obtained from the parietal area were analyzed. This underscores the fact that each hemisphere, while often functioning differently than the other, is in itself a complex organ with regard to function and sites of activity.

Both the accuracy and parietal laterality data suggest that behavioral responses as well as the ongoing brain events associated with using preconsciously attained information were differentially modified by the experimental conditions. The instructional manipulation was successful in triggering left or right hemispheric activation, as predicted. Thus, the instructions to "think" about the task coupled with a requirement for recognition resulted in more activity on the left hemisphere relative to right. In contrast, the request to rely on "feeling" when making a subjective selection based on preference occasioned more right than left sided involvement. (Empirically, the laterality score was consistently lower under the holistic instruction type than under the analytic.)

Also, as predicted, an inverse relationship was detected between the behavioral (accuracy judgments) and physiological (laterality scores) measures. Thus, increased selection accuracy of the target stimuli was more likely to occur in association with a relatively more right hemispheric activation (i.e., lower laterality index) while less accurate responses had a tendency to be associated with a relatively left-sided involvement (i.e., higher laterality index). In addition to attaining higher accuracy, subjects in the holistic group also made their selections with more confidence than the analytic group who made their selections with less confidence as well as less accuracy. The pattern of findings lends support to the notion that preferential involvement may account for the observation that affective discrimination can be performed in the absence of conscious awareness.

For this investigation William Kunst-Wilson provided copies of the spatial stimuli he and Zajonc used to study the mere exposure effect (Kunst-Wilson & Zajonc, 1980). Spatial information processing predisposes toward right hemispheric activity as does holistic perception of stimuli that cannot be subjected to feature analysis and recognition due to impoverished exposure. Further research to establish whether the same effect holds for preconsciously perceived verbal stimuli would permit assessment of the relative influence of the nature of task stimuli on relative hemispheric involvement. One could then better distinguish between explanation of differential hemispheric engagement based on the evokative nature of task stimuli (verbal or spatial) and those based on the nature of the judgments (cognitive or affective) being made. However, evidence from other research demonstrates that when the stimuli are degraded or very brief exposure time is used there is a right hemispheric advantage even for verbal material (Moscovitch, 1979, p. 393), indicating that the critical elements are stimulus degradation and exposure time, and that these are independent of stimulus content. This leads to another explanation that involves levels of conscious awareness. We know that while the left hemisphere seems to be most active in "normal consciousness" (Popper & Eccles, 1981) the linguistically impoverished right hemisphere is implicated in altered states of consciousness (Chandler & Parsons, 1977; Frumkin, Ripley & Cox, 1978; Goldstein & Stoltzfus, 1973; Goldstein, Stoltzfus & Gardochi, 1972; Harshman & Remington, 1976; Pagano & Frumkin, 1977). In the paradigm used in this study, because of the brevity of exposure, acquisition of information necessary for making accurate selection could not have entered conscious awareness and, therefore, could not have served as a standard for making a choice based on conscious, rational processes associated with the left hemisphere. Therefore, the increased selection accuracy observed when the right hemisphere was engaged could be explained because the information relevant to the task was perceived holistically and out of conscious awareness. If such should be the case, then we would argue that investigations into the neural bases for social interaction should focus on the role of the holistic, affective, silent right hemisphere in the mediation of social life.

The mere exposure paradigm should be adaptable to investigating social processes which rely on information acquired out of conscious awareness, how they are mediated by the brain, and whether they alter elements of brain functioning. If relationships such as those reported in this paper are substantiated experimentally and with reliability, an avenue should open for studying and developing sociophysiological descriptions of enduring social phenomena such as stereotyping, social comparison processes, and normative behavior.

FOOTNOTES

Subsequent to running this study, a chapter by Morris Moscovitch (1979) brought to our attention that the results of our operationalization are consistent with those that would be predicted had we used attention theory (pages 422-433). This has been a heuristically validating realization as other work out of our laboratory has explicitly explored attentional-based hypotheses. (See A Physiological Investigation of Social Status, a Stanford Department of Sociology thesis done by W. A. Harris, which used measures of hemispheric lateralization to further our earlier work on the relation of high status to attention, as measured by a scalp recorded evoked response called the Contingent Negative Variation, or CNV. This was reported in "An Attention Regulating of Social Hierarchies: High Status, Attention and the CNV Brain Wave," Barchas et al., Chapter Seven in Social Hierarchies: Essays Toward A Sociophysiological Perspective, Greenwood Press, Conn., in press.

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