PROCESSING OF INFORMATION ACQUIRED AT A PRECONSCIOUS LEVEL OF AWARENESS: INSTRUCTION AND SEX EFFECTS ON HEMISPHERIC LATERALITY AND ACCURACY

Kinga M.Perlaki
Patricia R. Barchas

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Introduction

It is a well documented fact that the two cerebral hemispheres apprehend the world with different strategies, and learn differently (e.g., Bradshaw & Nettleton, 1981; Dennenberg, 1981). The left hemisphere is specialized for language and the right hemisphere is specialized for organization and recognition of spatial data, spatial and topographical orientation and recognition of faces. While the linguistic, analytic and logical left brain proceeds in sequential and step-wise fashion, the linguistically mute right hemisphere perceives wholes and sythesizes otherwise fragmentary information, and is advantaged for visuo-spatial tasks. The left hemisphere learns by rule and through programmed instruction. On the other hand, the right hemisphere does not learn by exposure to specific rules and examples, does not benefit from specific error correction, but does learn from experience. The right hemisphere needs exposure to associative patterns which it tends to grasp as wholes. It makes holistic or intuitive judgments and is more responsible for emotional content than the left brain.

Our chief concern in this study was to determine whether we could influence the hemisphere which is most active when using information acquired at a preconscious level of awareness, and thus approximate social situations in which the appropriate behavior depends upon information which may never be consciously processed. Functional resources associated with conscious awareness are found in the left half of the human cerebral cortex. However, one way information could be processed out of conscious awareness and yet influence behavior would be if the silent right half of the brain were engaged. To explore this idea, we searched for an established paradigm in which information that has not entered into conscious awareness must be processed. We wanted the paradigm to lend itself to measuring brain activity as an index of cognitive functioning, and also to have some kind of measurable performance attached to it.

The possibility that behavior can be influenced by stimuli that do not reach the minimal threshold necessary for conscious detection, i.e., the phenomenon of subliminal perception, has been explored by several investigators (see McConnell, Cutler & McNeil, 1958). A related concept, known as the "mere exposure effect" also has been proposed and tested experimentally (Kunst-Wilson & Zajonc, 1980; Moreland & Zajonc, 1977; Zajonc, 1968). The results of these latter studies showed that repeated exposure to stimuli below the threshold of concious awareness increased their attractiveness: subsequently they were preferred over others that were similar but unfamiliar, even though conscious differentiation between the two types was not possible. Kunst-Wilson and Zajonc (from now on referred to as, K-W & Z) concluded that affective discrimination may be performed in the absence of conscious recognition.

The K-W & Z paradigm appears to lend itself to probing empirically the kinds of processing that occur at the preconscious level and that may underlie the use of social information. In a series of pretests the K-W & Z paradigm has been adapted for this purpose, although with only behavioral measures taken. In each of these studies the stimulus slides graciously provided by K-W were utilized (Edwards, Hecker, Perlaki & Barchas, 1982).

Exploratory Study

In an exploratory study, when the exposure time was held at 3 ms, recognition and preference accuracy for females closely approximated the results reported by K-W & Z. However, possibly because of the smaller sample size, the differences were not statistically significant (Perlaki, Hecker & Barchas, 1982). Nevertheless, there were indications that subjects who perceived some details during the exposure phase were more likely to score below than above chance on the recognition task.

The stimulus slides used in this experiment were composed of irregular octagon shapes, and thus fall into the visuo-spatial category. Accordingly, the appropriate (i.e., most efficient) processing strategy for this particular task should require the relative activation of the right hemisphere. Apparently, according to the post-session interview, those subjects who had a vague recollection of the shapes seen earlier, made an attempt to recall these visual fragments and match them systematically, by relying on a conscious process which corresponds to left brain processing. The accuracy scores of these subjects were below chance. This can be explained if the preconsciously perceived visual images were stored in the right hemisphere and therefore were not directly and immediately available for the left hemispheric processing, increasing the probability of incorrect responses.

It seems that the inferior performance by those who reported seeing parts of the shapes during their initial presentation was due to the left brain processing strategy employed by these subjects. Thus, subjects who consciously possessed some kind of mental image of the target stimuli believed that they could deal with the task rationally (using the left brain), and they used a tactic which was task inappropriate, given the spatial nature of the stimuli. In contrast, those who consciously saw nothing at all during the exposure phase had no alternative but to follow their intuition when had to make a discrimination between the target and the novel stimulus objects. Therefore, appropriately to the visuo-spatial task, they activated the right hemisphere.

Neurophysiological Index of Relative Hemispheric Activity

The preliminary studies relied entirely on behavioral measures. In order to test the above explanation of differences in accuracy, the present study included relatively objective neuro-physiological measures to index the underlying brain events. To observe the activation of the two hemispheres when dealing with the information, we recorded the hemispheric brain wave activities concurrently with the behavioral data collection. The relative activity of the two hemispheres, i.e., lateralization, was measured by recording the electrical brain events directly from the scalp, via an electroencephalograph (EEG) system.

EEG recording of the ongoing brain waves indicate that a relaxed, restful state is usually associated with the appearance of a regular waveform, known as "alpha rhythm" that falls within the 8 to 13.5 Hz frequency range. When a task is presented, one side of the brain is often more responsive to the task in question and thus becomes relatively more activated that the other. Higher activation reliably results in alpha supression. Consequently, a decrease in alpha production is observed on the side which is more involved with the task. This phenomenon is referred to as "alpha block" (Bunnell, 1981). A conventional measure of such hemispheric asymmetry is the laterality index, which is expressed as a right/left (or left/right) ratio of alpha power, a ratio of right hemispheric alpha to total alpha, or a difference in power between the right and left hemispheres relative to the total power.

The use of a ratio as the laterality index for measuring relative hemispheric activity is widely accepted, as it allows using individuals as their own control yet produces scores which are comparable between subjects. However such ratio measures cannot be evaluated in the same manner as, for example, raw data. One such problem is that a modification in a ratio could be caused by changes in either the numerator, the denominator, or both. A statement about the relative increase or decrease in the ratio does not provide this specific information. Thus while a ratio index permits one to make conclusions about the relative changes among the two hemispheres it excludes the possibility of addressing questions directly about whether the observed ratio changes are due to increased activity on one side, decreased activity on the other side, or both.

Another problem is that the relative right/left hemispheric changes elicited by the treatment could be misleading unless adjusted for the hemispheric asymmetry that prevailed prior to the treatment. A solution to this problem is to adjust the experimentally induced right and left hemispheric alpha values for the pre-existing alpha level, by subtracting the baseline values from both hemispheric treatment data prior to computing the ratios. An operational weakness of using difference scores in the ratio formula is that such ratios are afflicted with some very specific problems. Since difference scores can be either positive or negative, the magnitude of the means will be greatly affected by the signs, as negatives and positives can cancel out each other, while the measures of variability, i.e., standard deviations and variances that are always positive values, will not suffer similar consequences. Thus a situation may arise, for example, in which the mean values will be smaller than the standard deviations, having the consequence that the analysis of the variances performed on difference scores will not be effective except when the effects are quite substantial. Further compounding this problem is the fact that, to begin with, there is large variability in the amount of alpha produced by various individuals. Therefore, to elicit significant treatment effects considerably larger between groups variances are necessary to compensate for the sizable within group variances.

Despite the problems involved with ratio measures, they are used as the index best suited for our questions.

Current Study

An experiment was designed to incorporate some modifications of the paradigm in order to test the "consistency" hypothesis, that (a) task appropriate hemispheric activation for processing visuo-spatial information acquired outside of the range of conscious awareness could be conditioned by instruction, and that (b) activation of the appropriate hemisphere (in this case, the right brain) would result in higher accuarcy scores. Thus consistency between the spatial nature of the task and instructions to process holistically should elicit greater right brain processing (i.e., right sided alpha supression) and greater accuracy.

In this study the type of instruction given to the subjects served as the treatment variable. The stimuli were the same for all trials, regardless of the instruction type, but the instruction was worded to impose a "holistic" mental set on half of the subjects, who were later asked to make an intuitive, affective judgment, based on feeling. For the other half, an "analytic" frame of mind was experimentally induced, with the subsequent task of making recognition judgments, based on an analytic mode of thinking.

A between-subjects design was used to avoid the response bias inherent in the within-subjects model when, due to a peculiarity of the response requirement, the order of the conditions could not randomized. In addition, the same exposure time was used for all subjects.

Experimental Hypotheses

Hypothesis 1: Instruction effect on laterality. It was hypothesized that subjects in the holistic instruction condition would be relatively more likely to use right brain processing than subjects in the analytic instruction condition. We therefore expected, because of alpha supression in the left hemisphere relative to the right during an analytic mode of thinking, and in the right relative to the left during holistic processing, to observe a greater right/left laterality ratio in the analytic instruction condition than in the holistic condition.

Hypothesis 2: Instruction effect on accuracy. It was predicted that in response to visuo-spatial stimuli greater accuracy scores would be observed for subjects in the holistic instruction condition compared to the analytic. We expected that manipulating the instructions, task appropriate (holistic), and task inappropriate (analytic) cognitive sets would be imposed upon the subjects, and that those relying on the holistic approach would select previously presented spatial target stimuli more frequently during subsequent testing than those who adopted the analytic strategy.

Hypothesis 3: Laterality-accuracy relationship. It was hypothesized that right brain, holistic processing would result in higher accuracy scores, while left brain, analytic strategy would be detrimental to accuracy. Therefore response accuracy was expected to show an inverse relationship to the laterality index, i.e., a relatively lower laterality ratio was predicted to correspond to relatively higher accuracy score.

No specific hypotheses were formulated regarding sex differences. Nevertheless, the design permitted empirical assessment of the question of whether under these conditions there are measurable differences between males and females in their lateralization response, and whether the effects, if any, of instruction on lateralization and performance accuracy are the same for the sexes in the population used.

Method

Subjects

The sample consisted of 48 Stanford undergraduates, 24 males and 24 females, with an average age of 19.5 and 19.0 years, respectively. All subjects expressed clear right hand preference with no familial history of left-handedness, and based on self-report were free of speech impediments, learning disability, and neurological disorders. Since this was a completely between-subjects design, each male and female subject was randomly assigned to one of the two experimental conditions (i.e., type of instruction): (a) analytic or (b) holistic. Thus 12 males and 12 females were tested under each of the two instruction types. The subjects were all volunteers who received a payment for their participation.

Materials

Stimuli. Stimuli were provided by 35-mm computer generated test slides, each containing a dark irregular octagon shape against a light background. The projected shapes measured an average of 9.2 x 8.9 cm, and when viewed from a distance of 75 cm, the mean visual angle subtending was 7.1 x 6.9 cm. The total of 20 stimulus slides were randomly divided into two 10-slide sets, Set A and Set B.

Experimental Paradigm

Following the general outline of the K-W & Z study, and using duplicates of their slides, subjects experienced an exposure phase in which they were shown a set of slides, each at a level below the threshold of conscious awareness. They were given instructions for how to do the test phase, at which time measures of both performance and brain activity were take. In the exposure phase, half of both the male and female sample were shown slides from Set A, and the other half slides from Set B. During the test phase, slides from each set were randomly assigned to a slide from the other set, thus the resulting 10 pairs each contained a previously exposed (i.e., familiar) and a novel stimulus. Set A and Set B slides appeared equally often in the first and in the second position. The same stimulus pairs were presented to all subjects. Preceding both Set A and B slide sets as well as the 10 test-pairs, was a focusing slide that consisted of a centrally positioned black "X" sign, against a light background.

Equipment

Stimulus presentation.

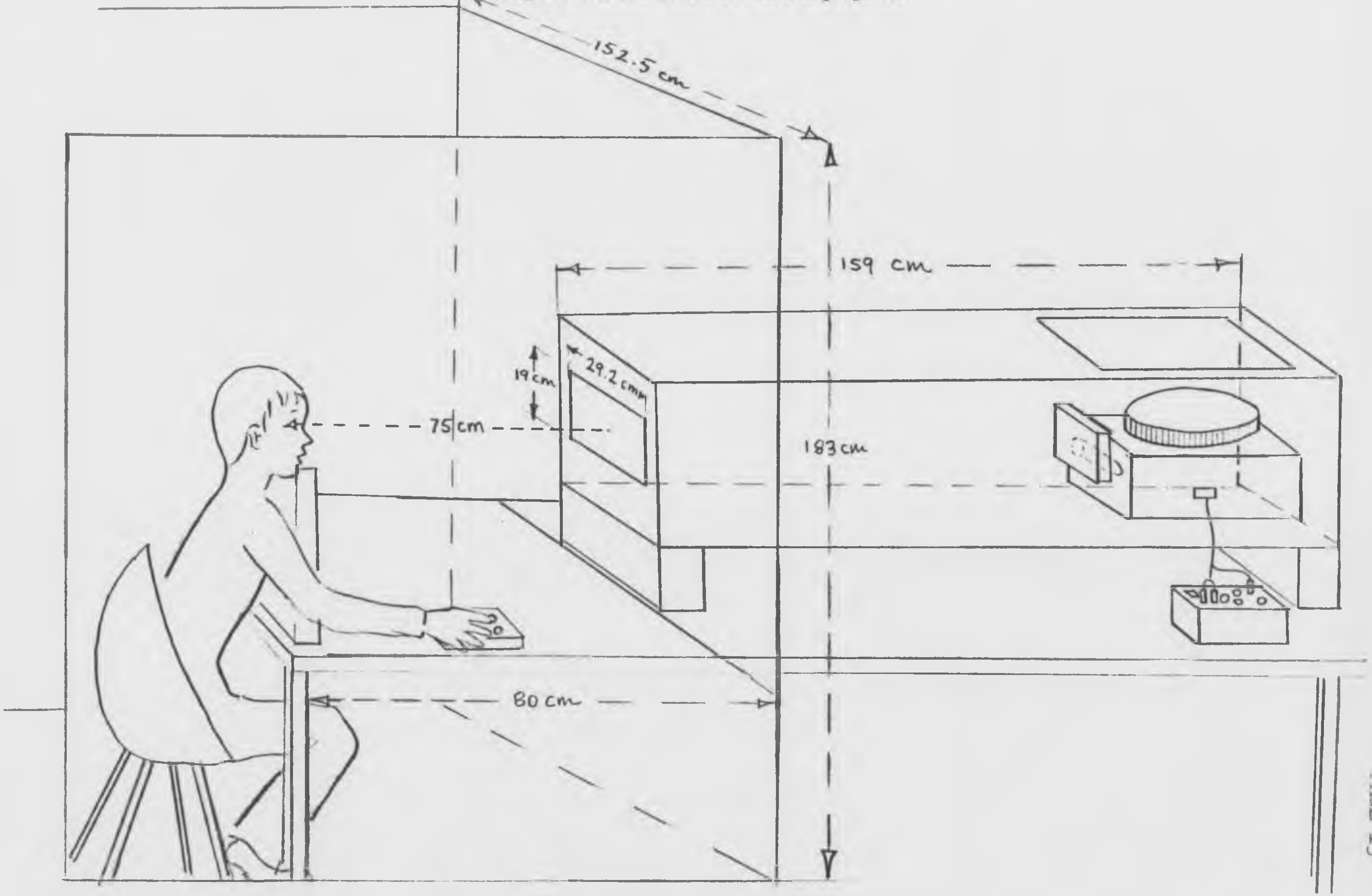
Subjects were tested in a three-sided and covered experimental cubicle with solid black walls that measured 152.5 X 152.5 cm, with a height of 183.0 cm (see Figure 1).

Insert Figure 1 about here

The cubicle, similarly to the room where it was located, was kept completely dark during the experiment. In the center of the chamber was an 80 cm long table, in front of the table stood a chair with adjustable height. A 26 cm high styrofoam chin-rest was mounted to the end of the table, facing the chair, and it was covered with black felt. On the right side of the table was a small, two-button response keyboard. The opposite end of the table was aligned to the back wall 24 cm below a window, occupied by the 29.2 X 19.0 cm Plexiglass projection screen. The screen comprised the front end of a 159 cm long viewing tunnel.

At the other end of the tunnel was a Kodak Ektagraphic Model AF-2 slide projector. A Uniblitz electronic shutter (Vincent Associates, 23XOBOX) was fastened 4.4 cm in front of the projector, and attached in front of the shutter was a rear condensor (Model 3607-606 from a 19.0 x 101.6 cm, #3622 condensor chest of an American Optical Delineascope), for the purpose of regulating image size. Exposure time and the shutter were controlled via a Uniblitz Shutter Timer (Vincent Associates, Model 310-B). Directly below the projector was a response indicator panel consisting of a red

FIGURE 1
Experimental Chamber and Equipment



and a green signal light. Stimulus illumination was reduced by a neutral density filter (Kodak 96, N.D. 2.0) that was affixed to the flat area on the rear condensor.

EEG Data collection. Electroencephalographic (EEG) data was recorded by Grass gold-cup scalp electrodes from left and right, central (C3, C4) as well as parietal (P3, P4) locations, following the guidelines of the International (10-20) Electrode Placement System. Each monopolar electrode site was referenced to the linked earlobes, and the ground was located on the forehead, at the midline above the nasion. To ensure good electrical contact, the electrodes were applied with Grass EC2 electrode paste. The resistence of all electrodes measured between 1 and 5k ohms.

The EEG signals were amplified by a four-channel 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, to check the calibration, and visually monitor for artifacts, or other recording concerns (e.g., dislodged electrodes). The Grass 7P511 was operating with 1/2 amplitude cutoff points of .3 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 V internal calibration pulse. During data collection the Sensitivity was set to 7.5 (V/mm).

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. The MED-80 system used in this study has multi-channel capability with 12K memory. The buffer memory enables the independent acquisition of a sweep of time data while the processor simultaneously analyzes the data already residing in memory. The software package is designed to allow the user to define parameters, such as, up to four frequency bands, maximum frequency range, number of averages, and artificial rejection level. For the purpose of this study the four frequency bands were defined as the following: (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 artifact rejection option was used during data collection to ensure muscle and eye movement contamination-free data. Upper frequency was set to 100 Hz (consistently with the minimum 1/2 amplitude hi frequency setting on the Grass 7P511), and 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.

Procedure

Subjects were received and directed to the preparation area by a female host who also requested that they read and sign a pre-experimental consent form, while a second experimenter (male) applied the EEG electrodes. Subjects were then escorted by the experimenter to the experimental cubicle where they were instructed to sit resting their chin on the chin-rest and to maintain this position until the termination of the session. Subjects were shown how to operate the response board and were given a few trial practices. Once they were comfortably settled in their chair and seemed sufficiently relaxed, a baseline recording (Baseline 1) of 10 contamination-free samples was collected with eyes open but without focusing on any particular object.

<u>Exposure</u> <u>Phase</u>. Preceding the the slide presentation, the subjects were told to watch the screen closely for the faint flashes of light presented after a warning by the experimenter. The response board was used to indicate whether the flash was visible or not. The experimenter verbally repeated the last response to give the subjects a chance for correction in the event of incorrect key selection. Subjects were also asked to avoid blinking between the warning, "flash", and the projection of the slide.

Following two practice trials the focusing slide was presented on the screen where it remained until the subjects' eyes were properly focused on the centrally located "X" mark. Slides from either Set A or Set B (contingent on the previous random assignment) were flashed on the screen for 1 msec. Each of the 10 slides was shown five times, thus a total of 50 slides were presented in a pre-randomized order. The time required by the subject to push the response button and by the experimenter to record the response determined the duration of the interslide intervals. The average time to complete the exposure phase was 5 minutes. EEG data collection began simultaneously with the first slide presentation and continued until 10 artifact-free samples were collected. The time required to complete the exposure phase was about 5 minutes.

Test Phase. At the beginnning of the second phase, another baseline recording (Baseline 2) was obtained, as specified for the first baseline. Subjects were then given one of the two instruction types on how to approach the task. Depending on their assignment to the conditions, half of both male and female subjects were informed that they were going to see pairs of slides presented individually and for a longer period then 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. 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. The experimenter kept a record of both types of responses. 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. 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.

Following the focusing slide the 10 test-pairs were projcted on the screen, where each image remained for exactly 1 sec. Concurrently with the first slide presentation recording of the EEG signal also began and continued until 10 "clean" samples were obtained. When the 10 test trials were completed the experimenter asked those subjects who were instructed to use the "analytic" approach their reasons for selecting one slide over the other, and those who used the "holistic" approach the reasons for their preference. These responses were also recorded. A final baseline recording (Baseline 3) was obtained, as described under discussion of the previous baselines. The test phase was completed in about 5 minutes.

At the end of the session the subjects returned to the preparation area where they were asked to fill out a questionnaire (see Appendix A) and to sign a post-session consent form while the electrodes were removed and the cleanup procedure was completed. The host also answered any questions they had concerning the study. Then the subjects were paid and thanked for their participation. The time required for the entire procedure required about 20 minutes.

Analysis and Results

The two test phase indices, TC and TP--calculated from the central (C3, C4) and parietal (P3, P4) areas--and the accuracy scores provided the primary dependent measures. The independent variables were: (a) type of instruction (analytic vs. holistic), and (b) sex of subject (male vs. female). The two slide sets used as stimuli were assumed to be equivalent based on previous studies that have not found any set related behavioral differences. However, since there was no information available about their effect on cerebral activity and because of the presumed sensitivity of hemispheric activation, in order to avoid any possible confounds in the findings, the presentation of the two slide sets was randomized by the independent variables, sex and instruction type. In addition, to detect possible differences due to slide set assigment, set (Set A vs. Set B) was also treated as another independent variable and was included in the analysis as a third independent variable.

Laterality Index

The on-line analysis of the EEG signals provided the percentage values of the total spectral energy for the four sub-bands, along with the corresponding frequency of the peak energy in each sub-band. The sum of the percentages distributed across the four bands did not add up to 100%, due to .5 Hz gaps between successive bands, and to frequency loss at the high and low frequency cutoff points. Therefore, the obtained percentage values were adjusted so that the percentage value for each of the four frequency bands represented its proportion to the total frequencies collected. The corrected alpha frequency percentages were used in the subsequent analyses.

For each subject two sets of laterality indices were computed, one for the exposure phase and one for the test phase--for both central and parietal recordings--by the formula:

$$\text{Laterality} = 100 \frac{(R - B_r) - (L - B_l)}{|(R - B_r) + (L - B_l)|}$$

where R = percentage of right hemispheric alpha during treatment
B_r = percentage of right hemispheric alpha during baseline
L = percentage of left hemispheric alpha during treatment
B_l = percentage of left hemispheric alpha during baseline

Accordingly, the differences between the amount of right and left hemispheric alpha produced during the exposure phase were adjusted by the right and left Baseline 1 alpha values in order to obtain the exposure phase index. For calculating the test phase index, the alpha data collected from the homologous electrode sites were adjusted using the corresponding Baseline 2 alpha percentages.

A brief description of the development of the above laterality index formula, and the rationale supporting its use, are given in Appendix B.

The laterality index is intended to measure the asymmetry in the amount of alpha produced by the left and right hemispheres and to convey the direction of task associated asymmetry over baseline. Lower unilateral alpha production during a task presentation is associated with more brain activity on the affected side. A negative index represents relatively less right-hemispheric alpha (alpha supression) 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.

Pre-Treatment (Exposure Phase) Analysis

To ensure that prior to the experimental manipulation the groups were equivalent in their pattern of alpha production, the EEG data collected during the exposure phase were subjected to analysis.

The 2 (sex) x 2 (instruction) x 2 (set) analysis of variance (ANOVA), using the SAS statistical package (Helwig & Council, 1979), was performed on the laterality indices calculated from exposure phase data for the central and for the parietal locations. None of the effects nor their interactions were statistically significant, indicating that during the first slide presentations, prior to receiving the group-appropriate instructions (experimental manipulation), no significant differences existed between males and females assigned to either the analytic or intuitive conditions, and that the exposure phase condition was not differentiated by the independent variables.

Treatment (Test Phase) Effects

Hypothesis 1: Laterality Data. In order to evaluate the effect of instruction on hemispheric laterality, the central and parietal indices (TC and TP, respectively) were computed for the eight (sex by instruction type by set) subgroups using the data collected during the test phase. The TC means produced no systematic pattern that could be related to any of the experimental factors. The subsequently performed analysis of variance (SAS, General Linear Model, GLM procedure) also failed to detect any statistically significant differences in lateralization at the central hemispheric location. Consequently, all future discussion in this section will be restricted to the laterality findings that relate to the parietal area, which has been associated with spatio-manipulative tasks (Kandel & Schwatz, 1981) and visuo-spatial perception (Fried et al., 1982).

The means of the TP indices for males and females under the holistic and analytic instructions are presented in Table 1, while Table 2 displays the same TP means separately for Set A and Set B. As can be observed from Table 2, the laterality indices associated with the parietal site show considerable differentiation by: (a) instruction type, (b) sex, and (c) slide set.

Insert Tables 1 and 2 about here

(a) Focusing on the column means in Table 1, the smaller mean TP value for the holistic condition ($\overline{X}$ = -5.06) compared to the analytic ($\overline{X}$ = 81.73) suggests that when the instructions were to treat the task intuitively, the right hemisphere was more actively involved compared to the left. This finding was subtantiated by the subsequently performed ANOVA (GLM procedure). Table 3 contains the ANOVA results for the TP ratios, revealing the main effect for instruction type was statistically significant at the .05 level, $\underline{F}$ (1,40) = 4.17. Comparison of the four cells in Table 1 shows that the laterality ratios for both males and females were lower under the holistic compared to the analytic instruction, as demonstrated by the means of -40.84 vs. 43.91 for males, and 30.71 vs. 119.56 for females. Thus the pattern of the laterality means is consistent with the hypothesis that subjects in the holistic condition would exhibit relatively greater right brain activity.

Insert Table 3 about here

TABLE 1

Test Phase Laterality Index for Parietal EEG Location (TP) by Instruction Type and Sex

	Instruction Type		
Sex	Holistic	Analytic	Raw Mean
Female	30.71	119.56	75.13
Male	-40.84	43.91	1.53
Col. Mean	-5.06	81.73	

Note: Negative or smaller indices represent relatively less right-hemispheric alpha (i.e., more right-sided activity) while larger positive values indicate relatively less left-sided alpha - consistent with more left-sided activity.

TABLE 2

Test Phase Laterality Index for Parietal EEG Location (TP)

Sex	Set A Instruction Type Holistic	Set A Instruction Type Analytic	Row Mean	Set B Instruction Type Holistic	Set B Instruction Type Analytic	Row Mean	Sets A&B Combined
Female	33.60	0.30	16.95	27.82	238.82	133.32	75.13
Male	-121.68	39.99	-40.89	40.00	47.82	43.91	1.53
Col. Mean	-44.04	20.14	-11.95	33.91	143.32	88.62	

Holistic Mean (across sex and set) = -5.06
Analytic Mean (across sex and set) = 81.73

Note: Negative or smaller indices represent relatively less right-hemispheric alpha (i.e., more right-sided activity) while larger positive values indicate relatively less left-hemispheric alpha - consistent with more left-sided activity.

TABLE 3

Summary of the Analysis of Variance Results for the Parietal Laterality Index (TP)

Source	df	SS	MS	F
Instruction (I)	1	90402.88	90402.88	4.17*
Sex (Sx)	1	65000.59	65000.59	3.00
Set (St)	1	121355.15	121355.15	5.60**
I x Sx	1	50.51	50.51	0.00
St x Sx	1	2997.13	2997.13	0.14
I x St	1	6136.49	6136.49	0.28
I x Sx x St	1	118896.00	118896.00	5.49**
Error	40	866982.00	21674.56	
Total	47	1271821.31		

*p <.05
**p <.03

(b) The row means in Table 1 for the two sexes show that the males had a tendency towards more right hemispheric, i.e., intuitive processing ($\overline{X}$ = 1.53), while the females tended to be more analytic ($\overline{X}$ = 75.13). However, the ANOVA results failed to support this finding, as the sex effect did not reach statistical significance at the .05 level.

(c) Unexpectedly, the sets of slides were not neutral with respect to the laterality index. As can be seen from Table 2, pretask exposure to Set A compared to Set B, resulted in more right hemispheric alpha suppression during the test phase, based on the means of -11.95 vs. 88.62, respectively. Indeed, the set effect was also statistically significant, $\underline{F}$ (1,40) = 5.60, $\underline{p}$ < .03.

Pairwise comparison of the means computed for the eight subgroups (instruction by sex by set) further revealed that females exposed to Set B demonstrated more left hemispheric activity (i.e, produced less left sided alpha) when asked to think about the task analyically, and shifted to the right when asked to use the holistic approach. This comparison was statistically significant at the .02 level. However, males were minimally affected by the treatment under Set B pre-task exposure, and not suprisingly, this comparison failed to reach statistical significance at the .05 level. With Set A exposure, males showed a pronounced shift towards right brain processing during the holistic instruction, and a shift towards the left when instructed to approach the task analytically. However, this comparison was not statistically significant. Females in Set A demonstrated a pattern opposite to the males, i.e., shift toward the right during the analytic and toward the left during the holistic condition, but the difference was too small to reach statistical significance. The differential effect of set on males and females under the two instruction types was substantiated by a significant sex x instruction x set interaction, $\underline{F}$ (1,40) = 5.49, $\underline{p} < .03$.

In summary, our hypothesis that holistic instruction will elicit lower laterality ratios than the analytic instruction was supported by the data obtained for the total sample. However, when males and females under the two instruction type conditions were compared separately for Set A and Set B, the effect held only for females under Set B exposure. The same pattern prevaled for males under Set A pre-task exposure, but the difference between Set A, male-analytic and male-holistic groups failed to reach statistical significance.

Hypothesis 2: Accuracy Data. The accuracy score for each subject was obtained by counting the number of correctly selected stimuli out of a possible 10, that is, when the subject correctly chose during the test phase those slides that were shown during the exposure phase. The means were computed for each sex by instruction type, and are displayed in Table 4, while Table 5 contains the same means separately for Set A and Set B.

Insert Tables 4 and 5 about here

The accuracy scores were then ranked, and analyzed by nonparametric methods. Using Wilcoxon's 2-sample test (with continuity correction of .5), statistically significant differences were found between the two stimulus sets. Previously exposed slides in Set A (rank mean = 29.27) were more often recognized or selected correctly than Set B slides (rank mean = 19.73), $\underline{z} = 2.35$, $\underline{p} < .02$. No significant differences in accuracy were detected between males and females (with respective rank means of 23.67 and 25.33), nor between the two instruction types (with rank mean of 26.15 for holistic and 22.85, for analytic).

When the total sample was divided by instruction type, sex, and set, obtaining eight subgroups ($\underline{n} = 6$), the Kruskal-Wallis one-way analysis of variance detected statistically significant differences between the groups, $\chi^2 = 14.57$, $\underline{p} < .05$. Since the differences between the groups appeared to be related to the variable, set, Set A and Set B accuracy data were analyzed separately. The results showed that subjects exposed to Set B performed significantly better when instructed to view the slides holistically, and to select the one they liked more, (rank mean = 25.92) than those who were asked to look at the slides analytically, and select the one they recognized as

TABLE 4

Mean Accuracy Scores by Instruction Type and Sex

	Instruction Type		
Sex	Holistic	Analytic	Row Mean
Female	5.17	5.08	5.13
Male	5.41	4.75	5.08
Col. Mean	5.29	4.92	

Note: Maximum score = 10

TABLE 5

Mean Accuracy Scores by Sex, Instruction Type and Set

	Set A			Set B			Sets A&B Combined
Sex	Holistic	Analytic	Row Mean	Holistic	Analytic	Row Mean	
Female	4.83	5.83	5.33	5.50	4.33	4.91	5.13
Male	6.00	5.50	5.75	4.83	4.00	4.41	5.08
Col. Mean	5.41	5.66	5.54	5.17	4.17	4.67	

Holistic Mean (across sex and set) = 5.29
Analytic Mean (across sex and set) = 4.92

Note: Maximum score = 10

the previously exposed slide (rank mean = 13.54). The differences between these two groups reached statistical significance using Wilcoxon's two-sample test, $z = 2.17$, $p < .03$. None of the other comparisons (by sex or group) found significant differences.

Therefore, the prediction that subjects will respond more accurately under the holistic instruction compared to the analytic, was statistically substantiated for the Set B exposure groups only. Although males in Set A and females in Set B attained higher accuracy scores during holistic trials than during the analytic, both of these comparisons failed to yield statistically significance differences.

Hypothesis 3: Laterality vs. Accuracy Data. Displayed in Table 6 are the accuracy means for the eight subgroups, in ranking order (from highest to lowest), with the corresponding TP means. Figure 2a presents the same TP indices in graphic form.

Insert Table 6 and Figure 2 about here

In Figure 2b are the accuracy means, expressed as their differences from 5--which represents the chance level, i.e., the score that could be attained by guessing alone--thus, a positive number marks a better than, while a negative value means a worse than chance recognition. The average accuracy scores stated in this form offer the advantage of easier

TABLE 6

Ranking Order of Mean Accuracy Scores and Corresponding Laterality Ratio (TP) Means by Sex, Instruction Type and Set

Sex	Instruction	Set		Accuracy Mean	TP Mean
Male	Holistic	A		6.00	-121.68
Female	Analytic	A		5.83	0.30
Female	Holistic	B	tie	5.50	27.82
Male	Analytic	A			39.99
Female	Holistic	A	tie	4.83	33.60
Male	Holistic	B			40.00
Female	Analytic	B		4.33	238.82
Male	Analytic	B		4.00	47.82

Notes: Accuracy means are based on raw scores, i.e. the number of correctly identified stimuli out of a possible 10.

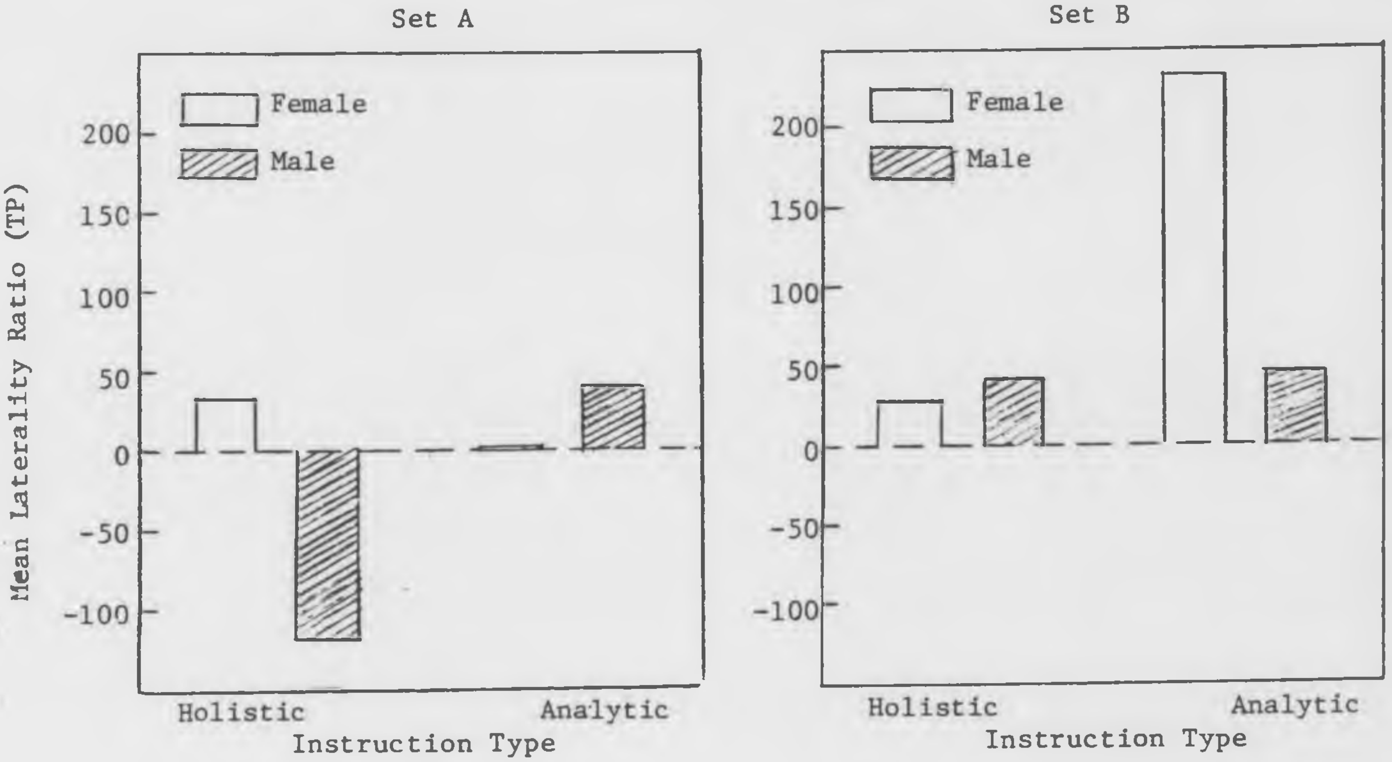
Laterality mean for the four groups with >5 Accuracy Mean = -13.39
Laterality mean for the four groups with <5 Accuracy Mean = 90.06

FIGURE 2

Average Laterality Ratio (TP) and Response Accuracy
for Sets A and B by Sex and Instruction Type

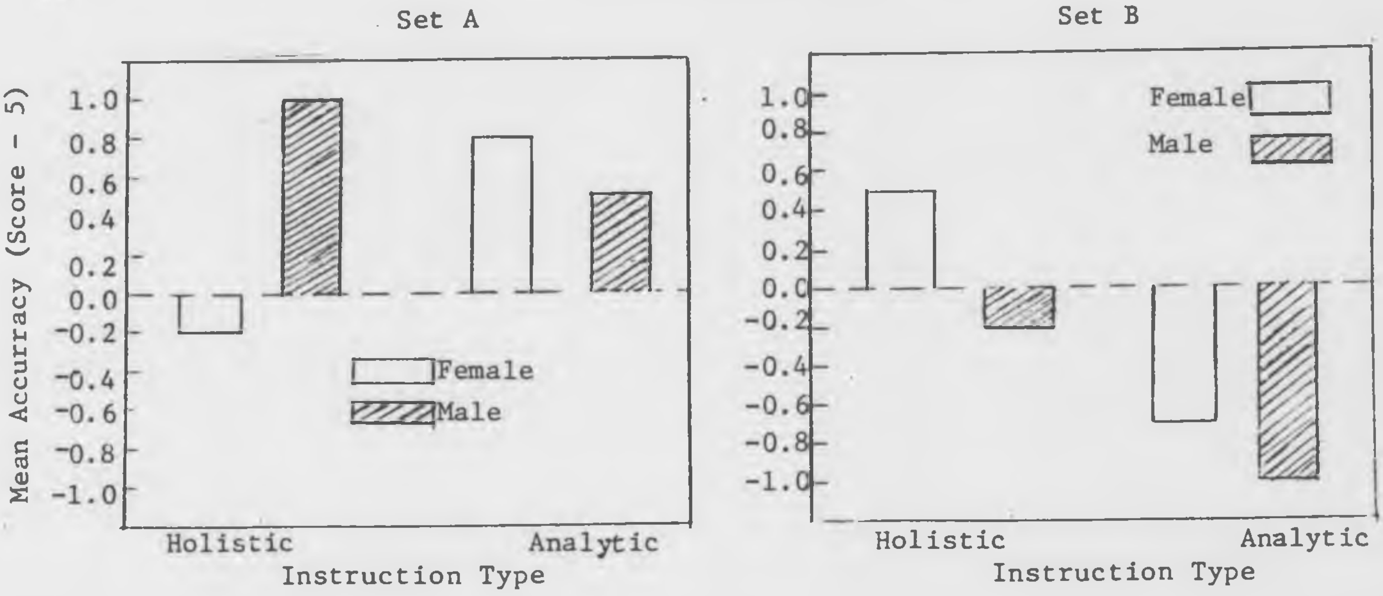
a.)

Laterality Ratio (TP)



b.)

Recognition Accuracy



visual comparability with the laterality means. They include both positive and negative values, and therefore their graphic representation requires their projection to both the positive and negative coordinate fields.

Comparison of Figures 2a and b reveal that, in general, hemispheric laterality show a pattern opposite from the accuracy measure, as expected. Males exposed to Set A exhibit low average laterality (indicative of more right than left sided involvement) under the holistic instruction with a corresponding higher accuracy mean, and a much higher index under the analytic (signalling a shift towards the left) associated with a lower accuracy mean. Females in the Set A subset show an almost identical relationship between these two measures, except in reverse. That is, a slightly higher average laterality observed during the holistic trials relative to the somewhat lower mean for the analytic correspond to lower than chance accuracy scores during the holistic and above chance scores during the analytic instructions.

When exposed to Set B females as well as males display a similar inverse relationship between the degree of laterality and response accuracy. The average laterality for females has a substantially lower mean value for the holistic compared to the analytic condition. For males the same difference is present, but to a minimal degree. In contrast, both sexes exhibited a higher accuracy mean under the holistic and a lower accuracy mean under the analytic instruction.

The finding that higher accuracy scores tend to be associated with lower laterality ratios (relatively more right brain processing) is also reflected by the laterality means obtained when the eight subgroups were divided according to whether they belong to the top four ranks (high accuracy) or the bottom four (low accuracy). Inspection of Table 6 reveals that the laterality mean computed for the combined high accuracy groups was -13.39, while the low accuracy groups attained a mean of 90.06. Thus, it appears that for the four subgroups that attained an average accuracy mean greater than 5 (more accurate), the combined laterality mean had a smaller negative value consistent with a relatively more right hemispheric processing, compared to the four subgroups who had accuracy means that fell below 5 (less accurate) and whose combined laterality mean resulted in a higher positive value, associated with relatively more left hemispheric activity. Not suprisingly, for the total sample, when averaged across instruction type, sex, and set, laterality and accuracy scores produced a small but negative correlational coefficient ($r = -0.16$, n.s.).

When the laterality-accuracy relationship was analyzed by sex, a statistically significant inverse correlation ($r = -0.64$, $p < .001$,) was found for the females but not for the males, indicating that lower laterality scores (i.e., relatively more right orientation) were more likely associated with higher accuracy scores; higher laterality indices (i.e., shift towards a more left processing mode) tended to be coupled with lower recognition accuracy. Among the correlational coefficients computed for the eight subgroups (partitioned by sex, instruction, and set) only the one for females in the analytic group who were exposed to Set B was found to be significant, ($\underline{r} = -0.82$, $\underline{p} < .05$), indicating that for females in general, and for females who received the "analytic" instruction in Set B, in particular, there was a pronounced tendency for a higher laterality ratio to be associated with a lower accuracy score.

Summary of Statistically Significant Results

To summarize, analysis of the laterality index means calculated for the total sample resulted in the following significant findings: (1) The average laterality ratios were consistently lower under the holistic condition (indicative of a shift towards relatively right hemispheric processing) compared to the relatively higher means obtained for the analytic (consistent with relatively left sided orientation). This finding is derived from the statistically significant instruction effect. (2) The differential impact on hemispheric shift exerted by the slide sets was also substantiated by the statistically significant set effect. (3) The sex by instruction by set interaction was also statistically significant, suggesting that males responded to the two instruction types, as predicted, but only when Set A was used as the target, while females responded to the instructional manipulation, as expected, but only under Set B exposure. (4) Within sex and set comparison of the group means obtained for the two instruction types found that females in Set B employed a relatively more right-sided processing strategy relative to their baseline under the holistic condition compared to the relatively more left-hemispheric activity that followed the analytic instruction. The difference between the two female groups was statistically significant.

For the accuracy data, the differences between the two sets also reached statistical significance, due to the much higher accuracy score obtained for Set A than for Set B. Separate analysis of the two slide sets found that subjects in Set B responded significantly more accurately under the holistic condition compared to those in the analytic condition. This finding was suported by a statistically significant instruction effect for Set B. Statistically significant differences in accuracy were also detected between the eight subgroups that resulted when the total sample was divided by sex, instruction type, and set. In addition, accuracy scores showed an inverse relationship with laterality ratios. However this negative correlation was statistically significant only for the females when the data were analyzed by sex, and for females in Set B, who were instructed to treat the task analytically, when separate analyses were performed on the eight (sex by instruction type by set) subgroups.

Discussion

Out of our two physiological measures, the laterality ratios for the central cerebral area (TC) produced no statistically significant findings, suggesting that the specific task evoked less involvement from this area compared to the parietal region. Therefore, in the following discussion any reference to laterality relates to parietal activity.

Hypothesis 1: Instruction Effect on Laterality.

The first hypothesis was supported as our subjects attained a significantly greater positive laterality ratio mean when the instruction called for an analytic strategy compared to the small negative mean obtained under the holistic instruction. Thus, as predicted, the demand for "thinking" about the task resulted in more activity on the left hemisphere relative to right (with corresponding left sided alpha supression). In contrast, the request to rely on "feeling" when making a selection precipitated more right than left sided involvement.

Hypothesis 2: Instruction Effect on Response Accuracy

Somewhat higher accuracy scores were attained by both males and females when the instruction called for intuitive rather than analytic judgment, although this effect became statistically significant only when Set B served as the target. As described previously, response accuracy was strongly influenced by the same factors that were responsible for the pronounced shifts in laterality. Specifically, accuracy--similarly to laterality--was heavily influenced by the same variable, set.

Hypothesis 3: Laterality-Accuracy Relationship

As predicted, relatively right hemispheric activity (as indexed by a lower laterality ratio) was more likely to result in higher response accuracy than a relatively left hemispheric involvement (associated with higher laterality ratio) Specifically, the two measures, accuracy and laterality, were inversely related, although the negative correlation reached statistical significance only for the females and one of the subgroups. This study gives basic support to our original hypothesis that these are conditions under which preconsciously attained information can be influenced by the social situation. The chain of reasoning seems to be on the right track. However further study of the phenomenon requires that careful attention be paid to how the ideas are operationalized. It may also provide yet another piece of evidence for the speculation of K-W & Z (1980) that affective and cognitive judgments may have different bases.

It appears that our particular spatial task was executed most effectively (as evidenced by higher incidence of correct responses) when the instructions sucessfully activated the task appropriate, right hemisphere. Consequently, affective judgments were more likely associated with lower laterality ratios (reflective of right hemispheric shift) and higher accuracy scores, while cognitive judgments evoked higher laterality values (signalling a shift to the left) with a corresponding decrease in accuracy. Interestingly, when the instructions did not succeed and the "wrong" hemisphere became involved with the task, the accuracy scores reflected task appropriate laterality at the expense of consistency with the instruction. For example, the females in the analytic conditon under Set A showed a stimulus appropriate low laterality mean that was contrary to the instructions but was actually appropriate for the visuo-spatial task at hand. The corresponding high accuracy score mean, while unexpected for the instruction type, was consistent with activation of the task appropriate right hemisphere.

Sex Effect

As was stated in the introduction, no specific hypotheses were formulated regarding the expected behavior of males versus females. Nevertheless, the effect of sex was examined to detect differences in experimentally induced laterality shift that may exist between males and females.

The overall findings do not indicate the existence of strong sex related differences. As is frequently the case, the higher or lower averages obtained for males and females are overshadowed by the differences in range that could be observed within each group. In general, female subjects in this study compared to males had a tendency to rely on left more than right hemispheric processing. However, this finding may be an artifact related to the pronounced left shift observed for females with Set B exposure. Insofar as it reflects actual occurance, the female-more-left and the male-more-right finding is consistent with the literature.

The significant sex by instruction by set interaction suggests that under some conditions males and females may respond differently. As was previously observed, the reasons for this outcome are unclear, and all possible explanations at this point are highly speculative. In addition, the statistically significant inverse relationship between laterality and accuracy that was detected for the females but not for the males, indicates that for our female subjects relatively more right-hemispheric activity (operationalized by lower laterality values) is a reliable predictor of more accurate response judgments on this visuo-spatial task.

Slide Considerations

For the combined Set A and B data the instructions had similar effects on males and females, as the average laterality ratios for both sexes had smaller values in the holistic compared to the analytic condition. However, when the data were separated by stimulus sets, a very different relationship emerged between sex and instruction that appeared to be the function of the target set. It seems that males behaved according to the predictions, but only when Set A served as the target, while for females familiarity with Set B evoked a similar response.

The significant moderating effect of set on the observed response to the instructions for both males and females was an outcome that was most unexpected. Since all slides were computer generated using the same specifications, and then were randomly divided into two sets, the slide sets thus obtained were assumed to be equivalent. The strong effect of set on the behavioral as well as physiological measures of both males and females under the two instruction types suggests that for some unidentified reason the sets were sufficiently different to have a diametrically opposite impact.

Although more indepth investigation would be required to investigate all significant characteristics associated with the two slide sets, a preliminary (and rather rudimentary) examination of Set A and B detected a reverse order relationship between their vertical and horizontal dimensions. It appears that Set A slides subtend an average vertical visual angle that is somewhat greater than the horizontal visual angle, while for Set B slides the vertical visual angle is smaller than the horizontal. There is virtually no information in the literature on the effects of vertical versus horizontal visual angle differences on perception. However, sex differences have been reported in susceptibility to vertical-horizontal illusion (Murch, 1973). Apparently, when required to make an estimate about a vertical line drawn at right angle to a same size horizontal line, both sexes overestimate the size of the vertical segment, but females heve a tendency to overestimate more than males. Whether the sex by instruction interaction as the function of set is due to a somewhat similar effect, alone or in conjunction with some other yet unidentified factors cannot be stated at this point, although this possibility, however remote, should not be excluded.

Methodological Considerations

Due to a system imposed constraint, the EEG data were not time-locked to the behavioral data (accuracy judgments). The EEG samples used in the analysis were collected within as little as 12.8 sec and as long as 3 min time intervals, depending on the number of samples that had to be rejected due to artifacts in the ongoing EEG signals. On the other hand, the 10 affective or cognitive decisions were made throughout the approximately 3.5 min long trial. Since it was beyond our capability to collect EEG samples that exactly corresponded to the judgment responses, the assumption was made that an "overall" processing state (predominantly left, or predominantly right hemispheric) would prevail throughout the trial, and it would be related to the proportion of accurate responses. In the future an attempt will be made to rectify this source of methodological error.

The instruction manipulation relied solely on altering tho words in each of two phrases: _holistically_ rather than _analytically_, and _feel_ rather than _think_. Presumably, stronger instruction could more reliably induce the desired cognitive set. Questions 17 and 18 of the Post-Session Questionnaire (see Appendix A) were designed to provide information about how well the subjects understood and how closely they followed the instructions when made their judgments. At the time of this report the Questionnaire data have not been formally analyzed. However, preliminary inspection reveals that all subjects comprehended clearly the nature of the expected responses, although some subjects who received the analytic instructions restorted to a somewhat intuitive strategy due to the scant informataion that was available to them for conscious recognition.

It should also be noted that while laterality indices were calculated by taking into consideration the alpha level that prevailed prior to the test phase, no deliberate attempts were made to control "mental content" during baseline recording. Subjects were asked to relax with eyes open, without focusing on any particular object, while the baseline data were collected. It is conceivable that while some students, especially those tested in the morning, took advantage of these moments to slip back into a semi-awake state characterized by "blank" mind, others may have been actively involved with some kind of mental activity, e.g., problem solving or just plain thinking. Further analysis may well concentrate on examining the relationship between initial laterality state and subsequent experimentally induced laterality shift.

Summary

In conclusion, the immediate aim of the present study was to examine the effects of instruction and sex on accurate recognition of minimally exposed spatial stimuli, and on the concurrent cerebral processes.

Both our accuracy and laterality data suggest that behavioral response as well as the ongoing brain events in response to processing information attained preconsciously may be modified by altering instructional emphasis. The results confirmed that instructional manipulation to trigger left or right hemispheric emphasis was successful, although for some of the subgroups this was true only under certain conditions. Specifically, males exposed to one of the slide sets were more likely to behave as predicted, while females responded to the other slide set in similar manner. Notwithstanding the fact that the instruction effect, as measured by the laterality ratio (TP), could be modified by the "incidental" factor, set, the group means for the total sample, as well as for both sets under the holistic instruction type were consistently lower than under the analytic, as predicted. An inverse relationship was also detected between our behavioral (accuracy judgments) and physiological (laterality ratios) measures, as predicted. In general, a relatively more right hemispheric activation (i.e., lower laterality value) was more likely to result in more accurate recognition of the spatial target stimuli, while a relatively left sided involvement (i.e., higher laterality index) showed a tendency to be associated with less accurate responses. The laterality-accuracy correlation did not reach statistical significance for the total sample. It appears, however, that the relationship exists. The relationship should be clarified in future studies using a larger sample or fewer subgroups with improved methodology.

The present study allows us to begin to approach otherwise obscure cerebral processings that accompany types of behavior that are the focus of our interest; especially the ways social information that is out of conscious awareness may be processed. We now have a paradigm which will be adaptable to asking questions about how certain social processes are mediated by the brain, and how they alter elements of brain functioning. We now believe that such social information is analogous to spatial information in that both evoke relatively right hemispheric processing. If this contention can be substantiated experimentally with reliability then a new avenue will be open for studying such significant social phenomena as stereotyping, social comparison processes, and normative behavior.

References

Bradshaw, J.L., & Nettleton, N.C. The nature of hemispheric specialization in man. The Behavioral and Brain Sciences, 4, (1), March, 1981, 51-92.

Bunnell, D. E. Components of visual attentiveness in suppression of the occipital alpha rhythm. Paper presented at the Society of Psychophysiological Research, Washington, D. C., 1981.

Dennenberg, V. H. Hemispheric laterality in animals and the effects of early experience. The Behavioral and Brain Sciences, 4, (1), March 1981, 1-50.

Doyle, J. C., Ornstein, R., & Galin, D. Lateral specialization of cognitive mode: II. EEG frequency analysis. Psychophysiology, 1974, 11 (5), 567-578.

Edwards, C.A., Hecker, R.R., Perlaki, K.M., & Barchas, P.R. Minimally exposed visual-spatial stimuli: The mere exposure effect and sex differences in recognition accuracy. (Tech. Rep. #79) Stanford: Stanford University, Program in Sociophysiology, January, 1982.

Fried, I., Mateer, C., Ojemann, G., Wohn, R., & Feido, P. Organization of visuo-spatial functions in human cortex. Brain, 1982, 105, 349-371.

Grabow, J. D., Aronson, A. E., Greene, K. L, & Offord, K. P. A comparison of EEG activity in the left and right cerebral hemispheres by power-spectrum analysis during language and non-language tasks. Electroencephalography and Clinical Neurophysiology, 1979, 47, 460-472.

Helwig, J. T., & Council, K. A. SAS user's guide. Gary, North Carolina: SAS Institute Inc., 1979.

Kandel, E. R., & Schwartz, J. H. Principles of neural sciences. New York: Elvier North Holland Inc., 1981.

Kunst-Wilson, W. R., & Zajonc, R. B. Affective discrimination of stimuli that cannot be recognized. Science, 1980, 207, 557-558.

McConnell, J. V., Cutler, R. L., & McNeil, E. B. Subliminal stimulation: An overview. American Psychologist, 1958, 13, 229-242.

Moore, W. H. A study of alpha hemispheric asymmetries for verbal and nonverbal stimuli in males and females. Brain and Language, 1980, 9, 338-349.

Moreland, R. L., & Zajonc, R. B. Is stimulus recognition a necessary condition for the occurance of exposure effects? Personality and Social Psychology, 1977, 35 (4), 191-199.

Morgan, A. H., Macdonald, H., & Hilgard, E. R. EEG alpha: Lateral asymmetry related to task, and hypnotizability. Psychophysiology, 1974, 11 (3), 275-282.

Morgan, A. H., McDonald, P. J., & Macdonald, H. Differences in bilateral alpha activity as a function of experimental task, with a note on lateral eye movements and hypnotizability. Neuropsychologia, 1971, 9, 459-469.

Murch, M. G. Visual and auditory perception. Indianapolis: The Bobbs-Merrill Co. Inc., 1973.

Perlaki, K. M., Hecker, R. R., & Barchas, P. R. Sex differences in recognition and preference accuracy under three exposure time conditions. (Tech. Rep. #80) Stanford: Stanford University, Program in Sociophysiology, January, 1982.

Zajonc, R. B. The attitudinal effects of mere exposure. Journal of Personality and Social Psychology Monograph Supplement, 1968, 9 (2,Pt.2), 1-27.

APPENDIX A

Laboratory for Social Research
Stanford University

POST-SESSION QUESTIONNAIRE

This form contains questions that are relevant for analysis of the brain wave measures that were collected during the pattern discrimination task. It is important for the data analysis that each question be answered as completely and as honestly as possible. Responses will be held in strict confidence. They are stored by subject number, not name, and are seen only by the social scientists in charge of the study.

Thank you for your cooperation.

INSTRUCTIONS

For most of the questions you are to check the answers which best fit your situation or best describe your experience. There are a few questions which ask you to write in the answer. Please answer as fully as you can.

Date______________________ Subject #___________

Age__________ Sex_______

1. Do you consider yourself:

a. Right-handed _____
b. Left-handed _____
c. Ambidextrous _____

2. Is your mother (biological):

a. Right-handed _____
b. Left-handed _____
c. Ambidextrous _____
d. Don't know _____

3. Is your father (biological):

a. Right-handed _____
b. Left-handed _____
c. Ambidextrous _____
d. Don't know _____

4. Please indicate by a number how many (if any) of your biological siblings or half siblings (not step-siblings) fall into these categories.

a. Of a total of _____, _____ are Right-handed
b. Of a total of _____, _____ are Left-handed
c. Of a total of _____, _____ are Ambidextrous
d. Of a total of _____, I don't know about_____

5. What year in school are you?

a. Freshman _____
b. Sophomore _____
c. Junior _____
d. Senior _____
e. Graduate _____

6. What is your college major? ______________________
minor? ______________________

7. What is (are) your favorite subject(s)? ___________________________________

8. What is your least favorite subject? ___________________________________

9. What is your strongest academic area? ___________________________________

10. What is your weakest academic area? ____________________________

11. Have you ever studied or played a musical instrument? Yes___ No___

12. What is your native language? ____________________________

13. If you speak another language (or languages) please list.

____

14. Do you have any visual impediments?

a. No	____
b. Yes, I wear eyeglasses	____
c. Yes, I wear contact lenses	____
d. Other	____

15. Please indicate if you are or have ever been afflicted by any of the following:

a. Learning disability (e.g., dyslexia)	____
b. Speech impediment (e.g., stuttering)	____
c. Neurological disorders (e.g., epilepsy)	____
d. Visual disorders (e.g., amblyopia, stabismus, astigmatism)	____

16. Were you aware of any shapes during the <u>first</u> set of slide presentation?

    a. If so, please describe your impressions of them.

    b. If not, please describe what you experienced.

17. Please write down, as closely as you can recall, the instruction given to you prior to the <u>second</u> set of slide presentation.

18. Please describe as best you can, how you made your decision regarding one slide over the other, within each pair. What criteria, if any, did you use?

APPENDIX B

Laterality Ratio

One requirement of the hemispheric specialization research is to establish means for measuring task induced hemispheric asymmetries. Review of the relevant literature reveals that investigators adopted various forms of a right to left, or left to right ratio as the unit for expressing the laterality shift observed in the raw or transformed EEG data. For example, Doyle, Ornstein and Galin (1974) used a simple R/L ratio of average alpha power. Other researchers used a modified version of this ratio, i.e., R/R+L (Moore, 1980; Morgan, McDonald, & Mcdonald, 1971), where right sided alpha was adjusted to the total alpha. Using this formula, a value greater than .50 indicates more left than right activity (i.e., less left sided alpha), the score of less than .50 corresponds to a relatively more right sided processing (decrease in alpha production on the right), and .50 is associated with hemispheric equality. In their later work, Morgan and her colleagues (1974) adopted a variant of this formula that produced more comprehensible figures. Using a relative percent difference ratio, 100(R-L/R+L), relatively more left processing is indicated by a positive score, and relatively more right sided activity by a negative value, while a zero value is reflective of equal left and right sided alpha production.

Somewhat different methods were used by Grabow, Aronson, Green, and Offord (1979), who compared three techniques to index the laterality differences as the function of various tasks. EEG data from the homologue sides were collected for the resting state (baseline) and during the performance of several different tasks. The first approach called for the calculation of differences in alpha activity between the right and left sides (ΔRL_i), separately for each task, simply as:

$$\Delta RL_i = R_i - L_i, \text{ for task } i=1,\ldots.n$$

where R_i and L_i are the alpha values associated with the current task (marked by subscript "i") at the right and left sides.

The second approach used basically the same formula, but the data for both sides were adjusted for the corresponding baseline as:

$$\Delta RL_{i1} = (R_i - R_1) - (L_i - L_1)$$

in which subscript "i" denotes the experimental data collected from the right and left sides, and subscript "1" refers to the baseline values.

The third approach attempted to compensate for the laterality changes that occur with the passage of time and on which the task induced laterality shift is superimposed, by adjusting the right and left differences for the preceding state (denoted by subscript "i-1"), prior to the presentation of the current task (marked by subscript "i"), by using the formula:

$$\Delta RL_{i,i-1} = (R_i - R_{i-1}) - (L_i - L_{i-1})$$

For the purpose of the present study we found it necessary to develop our own laterality measure, since none of the above formulas satisfied all three of our objectives, i.e., to be able to: (a) measure right hemispheric activity relative to the left, (b) relate the right to left differences to the total alpha level, i.e., scale by the overall alpha activity, and (c) adjust for the pre-treatment differences that exist between right and left hemispheric activity.

All of the just reviewed methods meet our first criterion. The formula used by Morgan et. al., (1974), i.e., 100/(R-L/R+L), is acceptable by the second criterion as well, however it does not allow control for the pre-treatment laterality state. Only the laterality measure presented by Grabow et al. (1979) incorporated this particular feature; on the other hand, their laterality units are simply expressed as difference scores rather than the ratio of the R-L differences. To comply with all our requirements we decided to combine the desired features of both of these formulas (as cited in Grabow et al., 1979 and Morgan et al., 1974) which resulted in:

$$\text{Laterality} = 100 \, \frac{(R_i - R_{i-1}) - (L_i - L_{i-1})}{(R_i - R_{i-1}) + (L_i - L_{i-1})}$$

where R_i and L_i denote the right and left hemispheric alpha levels during experimental manipulation, while R_{i-1} and L_{i-1} represent right and left alpha values recorded during resting, immediately before treatment.

This feature of our laterality ratio represents a deviation from the one tested by Grabow and collegues, but we believe that neither the second approach that used only the baselines collected at the beginning of the session, nor the third that corrected only for the preceding task performance are entirely acceptable. Therefore, we collected a first baseline immediately before the first (exposure) phase and a second baseline between the completion of the first and the second (test) phase. Thus, R_{i-1} and L_{i-1} were replaced by B_r (right alpha collected during baseline) and B_l (left alpha collected during baseline), resulting in Formula 1:

$$\text{Laterality} = 100\,\frac{(R - B_r) - (L - B_l)}{(R - B_r) + (L - B_l)}$$

The first baseline was used to adjust the exposure phase data, and the second baseline for correcting the test phase data.

While at first Formula 1 appeared to be functional, closer examination revealed several potentially problematic features. As mentioned previously, using the ratio measure (Morgan et al., 1974) a positive or relatively larger value represents relatively more left than right processing (i.e., relative decrease in left sided alpha) while a negative or smaller number is consistent with relatively higher right hemispheric activation (manifested by alpha supression on the right side). However, when the R and L values become $R - B_r$ and $L - B_l$, difference scores that appear in both the numerator and the denominator, the outcome of this ratio may be inaccurate. Since task processing acts (to a larger or smaller degree) as an alpha blocker, the alpha values obtained during baseline are almost always greater than those collected during task performance. Thus the two difference scores (one for the right, and one for the left side) in the numerator will be most likely negative.

This situation is illustrated by Example (a):

$$\text{let } R = 20 \quad \text{and} \quad L = 15$$
$$B_r = 40 \quad \text{and} \quad B_l = 30$$

then,

$$\begin{aligned} \text{Numerator} &= (R - B_r) - (L - B_l) \\ &= (20 - 40) - (15 - 30) \\ &= (-20) - (-15) \\ &= -5 \end{aligned}$$

If, as in this example, the difference score for the right side exceeds the left (i.e., exhibits a greater alpha block indicative of a more right sided activity relative to the left) then the resulting numerator value will be negative, similarily to the one obtained for the ratio numerator, R - L.

The reversal of the left and right hemispheric values, i.e., relatively more left hemispheric activity marked by more pronounced alpha suppression on the left side, is illustrated by Example (b):

$$\begin{aligned} &\text{let } R = 15 \quad \text{and} \quad L = 20 \\ &\phantom{\text{let }} B_r = 30 \quad \text{and} \quad B_\ell = 40 \end{aligned}$$

then,

$$\begin{aligned} \text{Numerator} &= (R - B_r) - (L - B_\ell) \\ &= (15 - 30) - (20 - 40) \\ &= (-15) - (-20) \\ &= 5 \end{aligned}$$

Again, this is consistent with the ratio formula, as a larger difference for the left side (laterality shift to the left) results in a positive value. It is then apparent that the locus of the problem is not in the numerator but in the denominator. To verify this fact the values of Example (a) were computed by Formula 1, thus providing Example (c):

$$\begin{aligned} \text{Laterality} &= 100 \, \frac{(R - B_r) - (L - B_\ell)}{(R - B_r) + (L - B_\ell)} \\ &= 100 \, \frac{(20 - 40) - (15 - 30)}{(20 - 40) + (15 - 30)} \\ &= 100 \, \frac{(-20) - (-15)}{(-20) + (-15)} \\ &= 100 \, \frac{-5}{-35} \\ &= 100 \, (0.143) \\ &= 14.3 \end{aligned}$$

While in this example alpha supression is more pronounced on the right side compared to the left, the final outcome is a positive value signifying exactly the opposite, that is, it indicates a more left than right sided processing! The reason for this inconsistency is quite obvious. When the negative numerator is divided by the negative denominator the resultant value is always positive, destroying the meaning of the previously established directional outcome. Conversely, completing the calculations for Example (b), rather than obtaining a positive value consistent with the relatively more pronounced left sided alpha supression, the the 5/-35 ratio results, unacceptably, in a negative value. To resolve this conflict, the solution then is to ensure that the denominator be always positive. It has been established that the sign of the numerator represents the direction of the laterality shift, i.e., negative or smaller value denotes a shift to the right, and a positive or greater value corresponds to a shift to the left. If the positive status of the denominator is permanently secured (as in the R-L/R+L ratio) then the sign of the numerator will always dictate the direction of the resultant ratio, since negative divided by positive produces a negative value, while a positive divided by a positive also yields a positive outcome.

A simple and mathematically sound solution for eliminating the negative sign from the denominator is to use the absolute value of the sum of the two difference scores. A modification of Formula 1 incorporated this feature, and resulted in Formula 2:

$$\text{Laterality} = 100 \frac{(R - B_r) - (L - B_\ell)}{|(R - B_r) + (L - B_\ell)|}$$

The values used in Example (c) when substituted into Formula 2 provide Example (d) with the following result:

$$\begin{aligned} \text{Laterality} &= 100 \frac{(20 - 40 - (15 - 30)}{|(20 - 40) + (15 - 30)|} \\ &= 100 \frac{(-20) - (-15)}{|(-20) + (-15)|} \\ &= 100 \frac{-5}{|-35|} \\ &= 100 \frac{-5}{35} \\ &= 100\ (-0.143) \\ &= -14.3 \end{aligned}$$

Thus Formula 2 will result in a ratio that is compatible with our conception of a negative shift (towards the direction of a relatively more right sided processing) in laterality balance.

Similarily, calculation of the laterality shift, using the values given in Example (b) and Formula 2, is illustrated by Example (e):

$$\text{Laterality} = 100 \frac{(15 - 30 - (20 - 40)}{|(15 - 30) + (20 - 40)|}$$

$$= 100 \frac{(-15) - (-20)}{|(-15) + (-20)|}$$

$$= 100 \frac{5}{|35|}$$

$$= 100 \frac{5}{35}$$

$$= 100 (0.143)$$

$$= 14.3$$

Again, appropriately for the model, the formula will produce a ratio that is reflective of a positive laterality shift, which is associated with a relatively more left sided processing.