The Effects of Positive and Negative Emotional States on Conjugate Lateral Eye Movements and Bilateral Finger Pulse Volume

© By Charles Meister

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Department of Psychology
Lakehead University
Thunder Bay

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Abstract

Lateral eye movement (LEM) and finger pulse volume (FPV) measures were taken while subjects responded to questions incorporating both a cognitive component, visuo-spatial or verbal processing, and an emotional component, excitement or fear. Initial LEMs immediately following stimulus offset and predominant LEM direction during a 10 second period were recorded by EOG. Both LEM measures and FPV did not yield significant bilateral differences as a function of either emotional or cognitive content. Subjects displayed a propensity for left looking across conditions.

There was an intriguing, but nonsignificant similarity between left LEMs and increased blood flow to subjects' left sides in response to negative questions. However, no clear evidence was found for hemispheric effects on LEMs or FPV.

Results are discussed in terms of the use of automation, the possible effects of subject stress and stimulus development and construction. Recommendations for future research include the gathering of evidence for the connection of hemispheric activity and LEMs at the neurophysiological level and the continued use of corroborative physiological measures such as FPV.

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When engaged in reflective thought, an aversion of gaze frequently occurs. These lateral eye movements (LEMs) are presumed to be the result of differential hemispheric activation. Evidence suggests that a question requiring verbal cognitive processing would primarily engage the left hemisphere (LH) of most right handed persons and, therefore, elicit right LEMs. Similarly, a question requiring non-verbal or spatial cognitive processing presumably would engage the right hemisphere (RH) of most right handed persons and, therefore, elicit left LEMs. Findings also indicate that negative and positive emotions in addition to verbal and spatial cognitive processing would primarily engage the right hemisphere (RH) of most right handed persons and, therefore, elicit left LEMs. However, recent evidence suggests that negative and positive emotions, in addition to verbal and spatial cognitive processing, may also cause differential hemispheric activation. The present study investigated the nature of LEMs that result from responding to questions that both require either verbal or spatial cognitive processing and incorporate a positive or negative emotional content. Of interest was whether any discernable LEM patterns would be related to only one of the two stimulus contents or to particular combinations of cognitive processing and emotional tone. Furthermore, an as yet infrequently used technique in LEM research, electro-oculography (EOG), was used to record LEMs.

LEMs

Interest in conjugate lateral eye movements began with a report by Day (1964). He had noticed in his clinical practice that patients seemed to move their eyes in a stereotypical way either to the left or right depending on their personality characteristics. Bakan (1969) postulated that perhaps LEMs are a reflection of hemispheric activation. He reasoned that right and left eye movements in humans are controlled contralaterally by Brodman's area 8, the frontal eye fields. The direction of eye movements Bakan contended would enable the inference of greater contralateral hemispheric activation. This activation denotes both cognitive activity and an increase in physiological activity. Therefore, through this internal activation eye movements would be reflective of functional hemispheric asymmetry. Furthermore, Bakan labelled subjects who have a preferred direction of gaze aversion as left movers and right movers and suggested that certain characteristics differ for the two groups. The differences he reported included hypnotic susceptibility, alpha wave activity and the choice of classical/arts majors or science and math majors among college students. Recent studies indicate that right movers tend to more closely approximate an obsessive personality style and left movers tend to more closely approximate an hysterical personality style (Smokler and Shevrin, 1979). Cognitively, right movers tend to be narrow categorizers and left movers tend to be broad categorizers (Huang and Byrne, 1978).

A parallel and distinct line of research to individual differences initiated by Kinsbourne (1972), and Kocel, Galin, Ornstein and Merrin (1972) suggests that if LEMs reflect hemispheric activation resulting from cognitive activity then the types of questions asked should also affect the direction of LEMs. If a question requires linguistic cognitive processing then the LH in most right handed persons will be differentially engaged and result in right LEMs. Conversely, if a question requires non-verbal visuo-spatial cognitive processing then the RH in most right handed persons will be differentially engaged and result in left LEMs.

In addition to the well established lateralized functions of verbal and spatial ability recent evidence suggests that LEMs are an indicator of emotional state (Schwartz, Davidson and Maer, 1975). However, two controversial areas that require careful examination before proceeding any further are the nature of the lateralization of emotion and the methodological difficulties that exist in replicating LEM research.

Lateralization of Emotion

Hemispheric Lateralization

The complementary roles of the two cerebral hemispheres in the mediation of cognitive functions is an area which has yielded many paradigms. Of note is the work of Gazzaniga (1970) and Sperry (1974) with split brain patients and other investigators working with unilaterally brain damaged patients (Milner, 1974; Reitan and Fitzhugh, 1971). Another fruitful approach has been the use of normal subjects with intact brains. For instance, dichotic listening tasks are used on the premise that a stimulus presented to one ear has stronger neural connections to its contralateral hemisphere (Studdert-Kennedy, 1975). Similarly, the projection of stimuli to the right and left visual fields is another way of discovering the differential functioning of the two hemispheres (Rizzolati, Umilta and Berlucchi, 1971). These same techniques, as well as LEMs, have been used to study the lateralization of emotion.

The Right Hemisphere and Emotion

Until recently any emotional expression was viewed as a predominantly RH function. Ross and Mesulam (1979) found that RH damage interfered with their patients' abilities to express emotion in normal tone of voice inflections used in regular conversation. Further evidence from a study by Safer and Leventhal (1977) using normal subjects found that a task requiring the evaluation based on content and the speaker's tone of voice of sentences presented monaurally revealed a left ear-RH superiority. Carmon and Nachson (1973) report a left ear-RH superiority for the perception of dichotically presented emotional nonverbal stimuli. These stimuli were sounds such as crying, shrieking and laughing of children, and adult males and females and were presented to normal university students. Gardner, Ling, Flamm and Silverman (1975) reported an inappropriateness in the emotional reactions of right hemisphere damaged patients. They reported that these patients laughed at cartoons regardless of whether they actually understood them. This is reminiscent of the inappropriateness of the indifference reaction seen in Gainotti's (1972) right hemisphere damaged patients. Gardner (1933) reporting a case involving the removal of a woman's right cerebral hemisphere for infiltrating glioma observed that, "The patient was optimistic; her attitude bordered on euphoria." (P.825). Wechsler (1975) observed that right hemisphere damaged patients displayed a distortion of emotion in the recall of emotionally charged stories.

Negative vs Positive Emotion

Evidence obtained using clinical and normal populations indicates that positive and negative emotions are subserved by the left and right hemispheres respectively. Gainotti (1972) in a landmark study using left and right hemisphere lesioned patients reported that the emotional behaviour of the patients depended upon the side on which their lesion was located. Those patients with left hemisphere damage manifested a catastrophic reaction. The symptoms included anxiety reactions, outbursts of weeping and the excessive use of profanity. Considering the likelihood of aphasia accompanying left hemisphere damage a catastrophic reaction with the realization of a language impairment seems justified. Aphasia is a language disorder which, depending on the locus of a lesion, leads to impaired language comprehension or expression or both. Those patients with right hemisphere damage displayed an indifference reaction which seemingly parallelled their left side neglect. These patients would even joke about their situation. Left side neglect is a disorder involving the total absence of an awareness of the left side of one's body or environment. Gainotti (1972) interpreted his results as evidence for the existence of an emotional dichotomy between the two cerebral hemispheres.

Further evidence originates from studies conducted at the Institute of Evolutionary Physiology and Biochemistry in Leningrad (Deglin, 1973) on the effects on depressed patients of electroconvulsive seizures in either the right or left cerebral hemispheres by administering unilateral shocks. The administration of shock to the RH produced a joyful smile on the patient's face. In contrast, electrically induced LH paralysis produced distressed and fearful facial expressions in patients. These results parallel those of Gainotti.

Subsequent evidence also suggests that a complementary relationship exists between the left and right cerebral hemispheres for the mediation of different emotions. Both the direction and intensity of emotional expression and perception have become current issues. The main point is that asymmetries appear to exist. Left side composite photographs of faces are judged as more emotionally intense than right side composites (Sackheim, 1978). This was the case for all emotional expressions except happiness which showed a right side composite advantage. All of the other emotions depicted, with the possible exception of surprise, were negatively toned. Presumably, happiness showed a right side composite advantage since unlike the other negative emotions it would be differentially mediated by the left hemisphere. This result implicates the left hemisphere as being more expressive of positive emotions. Harman and Ray (1977) having subjects recall events in their lives where they had felt happy, sad, angry or fearful found that the magnitude of EEG measures sharply increased for the LH during the positive affect condition. These authors described the RH as more calm and balanced. They concluded that the two hemispheres process emotional stimuli differently depending on the type of stimulus and the amplitude of hemispheric involvement.

Theoretical Considerations

Differential Emotions Theory

Arnold (1960) postulated the existence of several distinct emotions, each with a distinct neurophysiological substrate and experiential properties. Each emotion affects a person differently. Various emotions involve different perceptions, expressions, cognitions, experiences and motor responses. Using this theory as a premise, and in view of the research available, one may argue that the previously cited neurophysiological substrates for different emotions are divided according to a positive and negative dichotomy with positive emotions lateralized to the LH and negative emotions lateralized to the RH.

Cognition and Emotion

The rationale for the relation between cognition, emotion and hemispheric asymmetry has been eloquently presented by Marcel Kinsbourne (1978). According to Kinsbourne language is an elaboration, extension and abstraction of sensorimotor functioning. A fundamental human sensorimotor behaviour is approach behaviour which is presumably mediated by the LH and therefore involves rightward orientation, locomotion, grasp and finally consummation. For example, one usually approaches another person if one feels "positive" about doing so. Kinsbourne (1972) reported a greater frequency of rightward eye and head turning in response to verbal questions. He speculated that since only a few synapses separate any two cortical neurons in the cerebrum subjects receiving, for example, a verbal stimulus will have the resultant verbal activation overflow into the right sided orientation centre located in the LH. As a result, attentional balance is driven to the right and manifests itself in eye and head turning to the right. Conversely, one may postulate that the RH mediates types of avoidance behaviour such as lateral orientation to the left perceptual field and locomotion away from an object. One may avoid another person if one feels "negative" about being near that other person.

To carry the model a conceptual step further positive emotions such as happiness and excitement may be characterized as emotional elements of approach behaviour more strongly lateralized to the LH. Negative emotions such as fear and anger may be characterized as emotional elements of avoidance behaviour more strongly lateralized to the RH.

Methodology

There is an approximate 50/50 split between successful and unsuccessful LEM studies. LEM research has been fraught with methodological problems. Controversy surrounds what constitutes an actual LEM, which LEM should be measured during a trial, stimulus questions used and the method of stimulus presentation and inducement of emotions

Opinions vary concerning what size eye movement constitutes a LEM. Some investigators have used the criterion of a LEM subtending an arc of 5 degrees or more (Kinsbourne, 1972; Ahern and Schwartz, 1979). Yet it seems impossible to maintain a uniformity of accurate measurement across studies when there are obvious variations in experimenter subject distance, illumination and whether the experimenter is scoring the LEMs in a face to face position or subsequently using videotapes. In both face to face and videotape procedures observer biases may occur.

Once the problem of what constitutes a legitimate LEM is resolved there remains the ambiguity of which LEM is the one to be measured. Is it the first LEM immediately following the conclusion of the stimulus question or the one immediately before the subject responds or perhaps one or a series of them during the subject's response? Furthermore, it seems reasonable to suggest that a series of LEMs may provide a more accurate picture of differences in hemispheric activity than a single LEM. The dominant hemisphere for a particular type of question presumably remains activated at least during the period of question processing and response formulation. This lateralization should be reflected in the frequency of LEM direction during this period.

The use of a central fixation point is crucial when the initial LEM only, is scored. For instance, Gur, Gur and Harris (1975) confronted with a subject who was looking to the right side and had made a LEM back to centre at the end of a question scored this as a left LEM. Some investigations used trials only where subjects were looking straight ahead at the end of the question (Erlichman, Weiner and Baker, 1974; Weiten and Etaugh, 1973). Other studies ensured that subjects were looking straight ahead at the beginning of a trial but failed to mention eye position at the end of a question (Gur et al., 1975; Hiscock, 1977). Other reports have totally neglected to mention initial eye position (Kinsbourne, 1972; Schwartz, Davidson and Maer, 1975; Tucker et al., 1977).

Electro-oculography

The use of electro-oculography (EOG) may eliminate many of the methodological pitfalls encountered in LEM research. The procedure for using EOG is very simple and only requires the attachment of an electrode to both temples of the subject's head and one to his forehead to serve as a ground. The cornea of the eye has a positive electrical charge relative to the retina which has a negative charge. As the eye moves the potential at the electrode becomes either positive or negative depending upon the direction of the movement. These electrical charges can then be accurately and continuously recorded on a polygraph (see Figure 2 for sample EOG records).

The use of EOG offers many advantages. The configuration of the graph clearly indicates whether the eye movement has been to the left or right. The minimum LEMs, whatever they may be, may be accurately scored by calibrating the relevant degrees to resultant polygraph deflections. The direction of eye movements may be objectively recorded for an entire trial however long that may be. By using a continuous measure of frequency of LEM direction the consideration of initial eye position becomes less critical. In addition, the centre point on the printout may be calibrated with the subject prior to commencing the experiment. Surprisingly, very few studies in the LEM literature have used EOG (Hiscock, 1977; Morgan, McDonald and MacDonald, 1971; Saring and von Cramon, 1980; Takeda and Yoshimura, 1979). However, it seems reasonable to advocate the use of EOG to obtain a constant objective record of a subject's eye movements.

Stimulus Questions

The content of stimulus questions used in LEM research usually has required the subject to process either verbal or spatial information in order to produce an answer. The assumption is that a request for spatial information will differentially engage the holistic, visuo-spatial, non-verbal right hemisphere and produce left LEMs. Conversely, a request for verbal information will differentially engage the analytical, linguistic, and logical left hemisphere and produce right LEMs. Kinsbourne (1972) has pointed out that unless subjects are pressed to the limits of their mental capacity they may be able to inhibit gaze shifts. Erlichman and Weinberger (1978) speculate that perhaps questions requiring overlearned, readily retrievable and syntactically simple responses fail to elicit LEMs. However, a high level of cognitive complexity in retrieval or response formulation may be more likely to elicit LEMs.

A problem question requiring sufficiently complex operations presumably will selectively activate one or the other hemisphere. Questions intended to selectively activate the left hemisphere are usually linguistic or analytical. Among these are definitions (Erlichman, Weiner and Baker, 1974), arithmetic problems (Kocel, Galin, Ornstein and Merrin, 1972), and spelling (Weiten and Etaugh, 1974). The most popular verbal stimulus has been proverbs (Gur, Gur and Harris, 1975; Kinsbourne, 1972). Questions intended to selectively activate the right hemisphere include visualization (Schwartz, Davidson and Maer, 1975), spatial relations (Erlichman, Weiner and Baker, 1974), and musical questions (Weiten and Etaugh, 1974).

Erlichman and Weinberger (1978) in a review article on LEM research contend that the possible argument that many LEM studies yielding nonsignificant findings are a result of poor stimulus question construction is unlikely. They present as evidence the use of identical sets of questions in both successful (Kocel, et al., 1972; Schwartz, Davidson and Maer, 1975) and unsuccessful (Erlichman, Weiner and Baker, 1974) experiments. For example, Erlichman et al., (1974) used the same questions Kocel et al., (1972) used. They further suggest that possibly the real effects of questions are a result of slight differences in the "degree of arousal or interest elicited by a question." (p.1085). They speculate that perhaps obvious differences such as whether a question is verbal or spatial are less relevant than the semantic and syntactic properties of a question and the feelings and reactions they arouse.

Method of Stimulus Presentation and Inducement of Emotion

Evidence suggests that under nonemotional circumstances LEMs are dependent upon the cognitive content and demands of a task (Kinsbourne, 1972; Kocel et al., 1972). But under stressful conditions subjects resort to a stereotypical uni-directional pattern of left LEMs regardless of question type (Tucker et al., 1977). This effect usually elicited by manipulating experimenter to subject distance has not always been successfully replicated (Berg and Harris, 1980; Hiscock, 1976; O'Gorman and Siddle, 1981). Other studies emphasize that by reducing the distance to .8 meters or less stress will play a dominant role (Gur et al., 1975).

LEMs and Emotion

Two lines of investigation suggest that LEMs are an indicator of the emotional activation of the cerebral hemispheres (Schwartz, Davidson and Maer, 1975). These studies have taken two forms in which either cognitive questions under stressful conditions (Tucker, Roth, Arneson and Buckingham, 1977) or emotionally toned questions are presented to subjects (Ahern and Schwartz, 1979). The stressfulness of a question and answer situation has been varied by manipulating examiner position relative to subject position. Findings indicate that when interpersonal distances are short enough, verbal and spatial stimulus questions no longer are able to effectively differentially engage the two cerebral hemispheres (Hiscock, 1977; Gur, Gur and Harris, 1975). Subjects often resort to stereotypical patterns of eye movements. It is the emotional tone of the situation rather than the cognitive content of the questions that determines the direction of eye movements.

Rather than discarding the usual verbal-visual dichotomy used for LEM research Schwartz, Davidson and Maer (1975) incorporated into it an affective component. They used LEMs to measure differential lateralization for emotionally toned questions. They found a significant interaction between emotional and non-emotional questions produced a greater RH, left LEM effect. They concluded that emotional questions produced a greater RH activation.

Ahern and Schwartz (1979) in a subsequent study used LEMs to measure differential lateralization for negative and positive emotions. The experimenter asked subjects questions which were either spatial or verbal but were also positively or negatively emotionally loaded. They found that items evoking feelings of excitement elicited more right looks than those evoking feelings of fear, and fewer left looks, regardless of whether the questions required verbal or spatial cognition. The authors concluded that under highly restrictive test conditions, which have been shown to reduce content dependent eye movements, verbal/spatial effects are drastically reduced, if not eliminated, while positive and negative emotion differences remain.

It would seem that in order to study emotional responses while avoiding the entire interpersonal distance and stress controversy, items should be presented in an experimenter free environment. Such a condition could be created by having a standardized tape recorded presentation of stimulus questions. This method would facilitate the emotional loading of questions while still maintaining their cognitive integrity. In the former paradigm the cognitive component of the task is undermined by the emotional tone of the situation.

The Experiment

The present experiment was intended to conceptually replicate and extend the findings of Ahern and Schwartz (1979) regarding positive and negative emotions and LEMs. Methodological refinements included the presentation of recorded questions and the use of EOG thus providing a continuous objective record of eye movements. This study also represented an operational narrowing of the Ahern and Schwartz study to the one positive emotion, excitement, and one negative emotion, fear, found to be most effective in eliciting differences in directions of LEMs presumably indicating differences in hemispheric activation.

It was hypothesized that questions containing an emotional element of excitement or fear would differentially elicit right and left lateral eye movements, respectively. A secondary and corroborative hypothesis was that finger pulse volume (FPV) measures in each hand would indicate lateral differences corresponding to LEMs. Studies using various physiological modalities, such as electro-myography (EMG) (Ahern and Schwartz, 1979) and electro-encephalography (EEG) (Harman and Ray, 1977), have reported significant hemispheric asymmetries.

Method

Subjects

Sixty-three undergraduate psychology students (23 male, 40 female) at Lakehead University in Thunder Bay served as subjects. These subjects, selected from a larger pool, were strongly right handed as determined by the Edinburgh Handedness Inventory (Oldfield, 1971).

Apparatus

Stimulus questions were presented by means of a tape recorder placed to the left of the subject and approximately three feet back. LEMs were recorded by using a Beckman polygraph and Beckman silver-silver miniature surface electrodes attached to the temple regions of the head and a single ground electrode attached to the centre of the subject's forehead. Finger pulse volume was recorded using a photoplethysmographic transducer.

Experimental Design

There were 32 questions, 8 in each cell of a 2x2 matrix (verbal; spatial by excitement; fear). Questions were randomized within 4 blocks of 8 questions with the restriction that there be no more than two questions of each type in each block. The blocks were randomized but all subjects received the same order of questions. In addition, there were 3 warm-up questions which all subjects received in the same order. It should be noted that approxiamtely 10% of these stimulus questions were borrowed from Ahern and Schwartz (1979) and the remaining 90% were generated by the experimenter.

Procedure

Subjects were seated in a reclining chair facing an homogeneously prepared foreground. Subjects were told by the experimenter, who was present in the room throughout the experiment, that the experiment was investigating facial muscle responses to be measured while they were answering cognitive and affective questions (see Figure 3 for diagram of experimental room). At the commencement of the experiment the subjects were instructed to fixate a transparent dot of light, which appeared at the centre of the visual field, while the recorded question was being presented. The fixation dot, a projected light, automatically turned on and off with the onset and offset of each question. The disappearing light eliminated the necessity to tell subjects that they may relax and look away and therefore, avoids possible biasing cues in the experimental instructions. At this point there was a pause that lasted at least 10 seconds in which subjects were permitted to reflect on the question they had just heard, formulate a response and present their response.

Two types of LEMs were of interest; initial lateral eye movements and predominant lateral eye movements. Initial LEMs were defined as the first eye movement to occur immediately after question offset. Predominant eye movements were defined as the subject's tendency to look predominantly to the left or right during a ten second period immediately following question offset. Those LEMs subtending a criterion arc of 5 degrees or more were considered as scorable and included in subsequent analyses. It should be noted that vertical eye movements were also recorded but this measure did not yield scorable records. Hiscock has also obtained uninterpretable vertical eye movement records (Note 1).

Finger pulse volume was measured bilaterally and was continuously recorded on a Beckman polygraph by a photoplethysmographic transducer attached to the first phalange of the middle finger of the right and left hands. Finger pulse volume was scored by calculating the average of five digital pulse volume pulses over the ten second period immediately after question offset.

At the conclusion of the experiment subjects completed a stress rating questionnaire. This simply consisted of one rating scale of how stressful subjects found the experiment.

Results

Eye Movements

Two different methods of scoring lateral eye movements were employed. These were initial lateral eye movements and predominant lateral eye movements. An initial lateral eye movement was defined as the first LEM subtending an arc of 5 degrees or more following question offset. Predominant lateral eye movements was determined from the subject's tendency to look more often to the left or right during a 10 second period immediately following question offset. Again LEMs of 5 degrees or more, only, were considered and the predominant direction was defined as the direction that received more (and/or longer duration) LEMs in the 10 second period. For both of these measures blinks and stares were scored as no movement responses. Those pen deflections which defied interpretation were categorized as unscorable. The percentages of no movement and unscorable trials were the same for initial LEMs and predominant LEMs. The percentages of no movement trials for the four stimulus categories were as follows: spatial-positive, 1.589 percent; spatial-negative, 1.805 percent; verbal-positive, .727 percent; and verbal-negative, 1.482 percent. The percentages of unscorable trials were as follows: spatial-positive .350 percent; spatial-negative, .323 percent; verbal-positive, .135 percent; and verbal-negative, .350 percent.

Initial Eye Movements

The mean number of initial LEMs for each of the stimulus categories is presented in Table 1. Simple inspection indicates that, regardless of the emotional valence or cognitive processing required, subjects tended to look to the left rather than the right at almost a 2:1 ratio. An analysis of variance with sex as a between subjects factor with two levels and cognition, emotion and side as within subjects factors each with two levels revealed that the three primary interactions of interest were not significant (see appendix 1). There was no interaction of Cognition by Side, $F(1,56)=1.232$. Similarly, the interaction of Emotion by Side was not significant, $F(1,56)=.645$. The interaction of Cognition by Emotion by Side also failed to reach a significant level, $F(1,56)=.034$. Other effects, of secondary interest, are a main effect for Cognition, $F(1,56)=10.495$, $p<.002$, indicating that there were more scorable initial LEMs for verbal questions than for spatial questions, and a main effect for side, $F(1,56)=22.523$, $p<.01$, due to a greater propensity for leftward eye movements (63%) across conditions. There was also an interaction of Sex and Emotion, $F(1,56)=10.359$, $p<.002$. The negatively valenced questions elicited significantly more eye movements from females than from males, $F(1,18)=10.118$, (males, $\bar{X}$ positive=3.355, $\bar{X}$ negative = 2.802; females, $\bar{X}$ positive=3.775, $\bar{X}$ negative=3.730).

Predominant Eye Movements

The mean number of predominant LEMs across categories, as Table 2 illustrates, follows a similar pattern to that of the initial LEMs. A second ANOVA using the same independent variables as above but predominant LEMs as the dependent variable yielded similar results to those obtained with initial eye movements (see appendix 2). In fact a correlational analysis comparing initial LEMs and predominant

LEMs indicated a significant positive relationship (see Table 3). For the purpose of this correlational analysis a left movement index was generated, (L/L+R). The Cognition by Side, $F(1,56)=.761$, Emotion by Side, $F(1,56)=.195$ and Cognition by Emotion by Side interactions $F(1,56)=.571$ were all nonsignificant. There was a significant Sex by Emotion interaction $F(1,56)=6.595$, $p<.013$ again indicating significantly more eye movements from females than males to negatively valenced questions, (males, $\bar{X}$ positive=3.434, $\bar{X}$ negative=2.934, females, $\bar{X}$ positive=3.961, $\bar{X}$ negative=3.874). As with initial LEMs, there was a significant main effect for Cognition, $F(1,56)=9.429$, $p<.003$ and a significant main effect for Side, $F(1,56)=28.201$, $p<.01$.

Finger Pulse Volume

Table 4 presents the mean levels of finger pulse volume for the stimulus categories. A third ANOVA with FPV as the dependent variable and an additional between subjects variable, Channel, was conducted (see appendix 3). The Channel factor was included as a means of controlling for any minor calibration differences between the two polygraph channels. The interaction of Channel by Side, $F(1,51)=42.98$, $p<.01$, indicated a significant difference between the calibrations of the two Channels. There were no significant bilateral finger pulse volume differences as a result of cognitive content, Cognition by Side, $F(1,51)=.138$, or emotional content, Emotion by Side, $F(1,51)=.098$. There was neither a main effect of Cognition, $F(1,51)=.186$, nor a main effect for Side, $F(1,51)=.993$. Figure 1 illustrates that fluctuations in finger pulse volume tended to go in the same direction for both hands. There was however a significant main effect for Emotion, $F(1,51)=27.061$, $p<.01$. Negative emotions caused less vasoconstriction across hands.

Figure 1 illustrates a consistent trend of looking left for both positive and negative questions with the exception of a pronounced tendency to look right on the first question. Other than the anomolous presence of question one, subjects looked to the left with greater frequency throughout the experimental session.

Additional Analysis

Since the primary analyses showed no relationship between the independent variables of Cognition or Emotion and the direction of LEMs or lateralized FPV responses, two further analyses were conducted. The first analysis involved selecting a subset of subjects based on their pattern of LEMs. Davidson, Schwartz and Weinberger (Note 2) found that subjects who did not move their eyes in one direction all of the time (Uni-directionals) but in both directions (Bi-directionals) showed the predicted bilateral asymmetries in electrodermal activity (EDA) in response to affective-cognitive questions. These authors reasoned that Bi-directionals are better able to transfer the focus of their hemispheric activity than Uni-directionals in response to varying stimulus contents. In order to examine whether the effects of Cognition and Emotion might appear in this subset of subjects the present investigation ran two additional ANOVAs with Bi-directionals. They were defined as those subjects who look in one direction no less than 40% and no more than 60% of the time. Only 8 subjects demonstrated these eye movement characteristics. Table 5 illustrates that their eye movement patterns did not differ appreciably from the entire group of subjects in response to emotional content. However, unlike group patterns, they show, though slight, eye movements in the usually reported directions for verbal and spatial content. An ANOVA using initial eye movements as the dependent variable did not yield significant interactions of interest: Cognition by Side, $F(1,6)=.016$, Emotion by Side, $F(1,6)=.375$ and Cognition by Emotion by Side, $F(1,6)=1.252$ (see appendix 4). Another ANOVA using FPV as the dependent variable also yielded nonsignificant interactions: Cognition by Side, $F(1,5)=.752$, Emotion by Side, $F(1,5)=.981$ and Cognition by Emotion by Side, $F(1,5)=.464$ (see appendix 5).

To assess whether lateralized differences in LEM or FPV responding might have occurred only to particular questions, the percentages of leftward LEMs and left index FPV for each question are presented in Figure 1. As can be seen from Figure 1, with the exception of question 1, LEMs were predominantly to the left for all questions. In view of the severe valley at question 1, values for warm-up stimuli were included for purposes of comparison. These reveal that the response to question 1 is in fact a valley and not just a general upward trend. It should be noted that although the three warm-up questions were not used in the above analyses, the subjects were not aware of the distinction between these three and the remaining thirty-two questions. To assess whether or not a subset of questions might show the predicted patterns, the frequencies of left eye movements for each question were subjected to a factor analysis. The results (see appendix 6) do not show any evidence for coherent groupings of questions.

Inspection of Figure 1 reveals that nine of the eleven and nine of the twelve peaks for LEMs and FPV respectively are in response to negative stimuli. As well, the valleys generally correspond to positive questions. Although various binomial calculations could have been conducted to show that these proportions are significant, such analyses are not presented here because of their highly post hoc nature. Specifically, peaks and valleys, unlike highest and lowest scores, are not widely used concepts. Rather, the convention is to treat these similarities as tentative. Therefore, there may be an indication of an effect of emotional content on both FPV and LEMs, with negative emotional content tending to produce leftward LEMs and relatively more blood flow on the left side of the body. The correlation between the laterality indices for LEMs and FPV for the 32 questions reflected this positive relationship, $r=.310$, but was not significant ($.10<p<.05$).

The stress questionnaire revealed that of the 63 subjects 18 found the experiment not at all stressful, 32 found it somewhat stressful and 13 found it moderately to extremely stressful. The extremely stressful category was chosen by only one subject and was, therefore, combined with the moderately stressful category for purposes of analysis. In order to assess whether the responses of the 18 unstressed subjects might have been more stimulus specific than those of the remaining subjects, two additional ANOVAs were conducted. An ANOVA using initial LEMs as the dependent variable failed to yield significant interactions of primary interest: Cognition by Side, $F(1,14)=.414$, Emotion by Side, $F(1,14)=1.404$ and Cognition by Emotion by Side, $F(1,14)=.122$ (see appendix 7). The second ANOVA used FPV as the dependent variable and also did not uncover any significant interaction of primary interest: Cognition by Side, $F(1,11)=.006$, Emotion by Side, $F(1,11)=1.218$ and Cognition by Emotion by Side, $F(1,11)=2.959$ (see appendix 8). In addition, one way ANOVAs comparing the three groups on the stress rating did not reveal significant differences on any of the laterality indexes indicating that self-reports of stressfulness were not related to directional bias of either LEMs or FPV.

Table 1

Mean Number of Initial Eye Movements

Stimulus	Left		Right	
Verbal	$\overline{X}$	s.d.	$\overline{X}$	s.d.
Positive	4.931	2.239	2.621	2.076
Negative	4.517	2.011	2.414	1.836
Spatial				
Positive	4.483	2.234	2.517	2.130
Negative	4.207	2.101	2.569	1.855

Note. Maximum mean score = 8.

N=58.

Table 2

Mean Number of Predominant Lateral Eye Movements

Stimulus	Left		Right	
Verbal	$\bar{X}$	s.d.	$\bar{X}$	s.d.
Positive	5.103	2.108	2.845	2.042
Negative	4.862	1.801	2.517	1.967
Spatial				
Positive	4.724	2.231	2.483	2.071
Negative	4.500	2.319	2.690	2.113

Note. Maximum mean score = 8.

N=58.

Table 3

Intercorrelations of Dominant Lateral Eye Movement,
Initial Lateral Eye Movement, and Finger Pulse Volume
Left Indexes for Stimulus Categories

	DSN	DSP	DVN	DVP	ISN	ISP	IVN	IVP	FSN	FSP	FVN	FVP
DSN		.54**	.43**	.52**	.92**	.55**	.38**	.50**	.12	-.05	.13	.12
DSP			.41**	.60**	.58**	.90**	.45**	.54**	-.00	-.05	-.06	-.02
DVN				.37**	.37**	.34*	.88**	.42**	.12	.03	.09	.10
DVP					.55**	.58**	.47**	.86**	.10	.05	.07	.12
ISN						.64**	.37**	.59**	.07	-.08	.05	.07
ISP							.41**	.55**	.02	-.11	-.04	-.00
IVN								.53**	.11	.04	.08	.11
IVP									.06	-.01	.03	.09
FSN										.88**	.98**	.98*
FSP											.86**	.87*
FVN												.97*
FVP												

Note. N=63 for initial and predominant LEMs.

Note. N=58 for FPV.

Note. D=predominant LEMs, I=initial LEMs, F=FPV, S=spatial, V=verbal, N=negative, P=positive.

Index=(L/L+R)

*$p < .01$.

**$p < .001$.

Table 4

Mean Finger Pulse Volume for each Hand (mm)

Stimulus	Left		Right	
Verbal	$\bar{X}$	s.d.	$\bar{X}$	s.d.
Positive	4.982	3.160	5.029	2.679
Negative	5.369	3.444	5.373	2.911
Spatial				
Positive	4.978	3.369	4.904	2.873
Negative	5.238	3.381	5.273	2.815

N=55.

Table 5

Mean Number of Initial Lateral Eye Movements

For Bi-directional Subjects

Stimulus	Left		Right	
Verbal	$\overline{X}$	s.d.	$\overline{X}$	s.d.
Positive	3.778	1.093	3.889	1.167
Negative	3.222	0.972	3.778	1.394
Spatial				
Positive	3.778	1.641	2.889	1.900
Negative	3.667	1.118	3.556	1.509

Note. Maximum mean score = 8.

N=9.

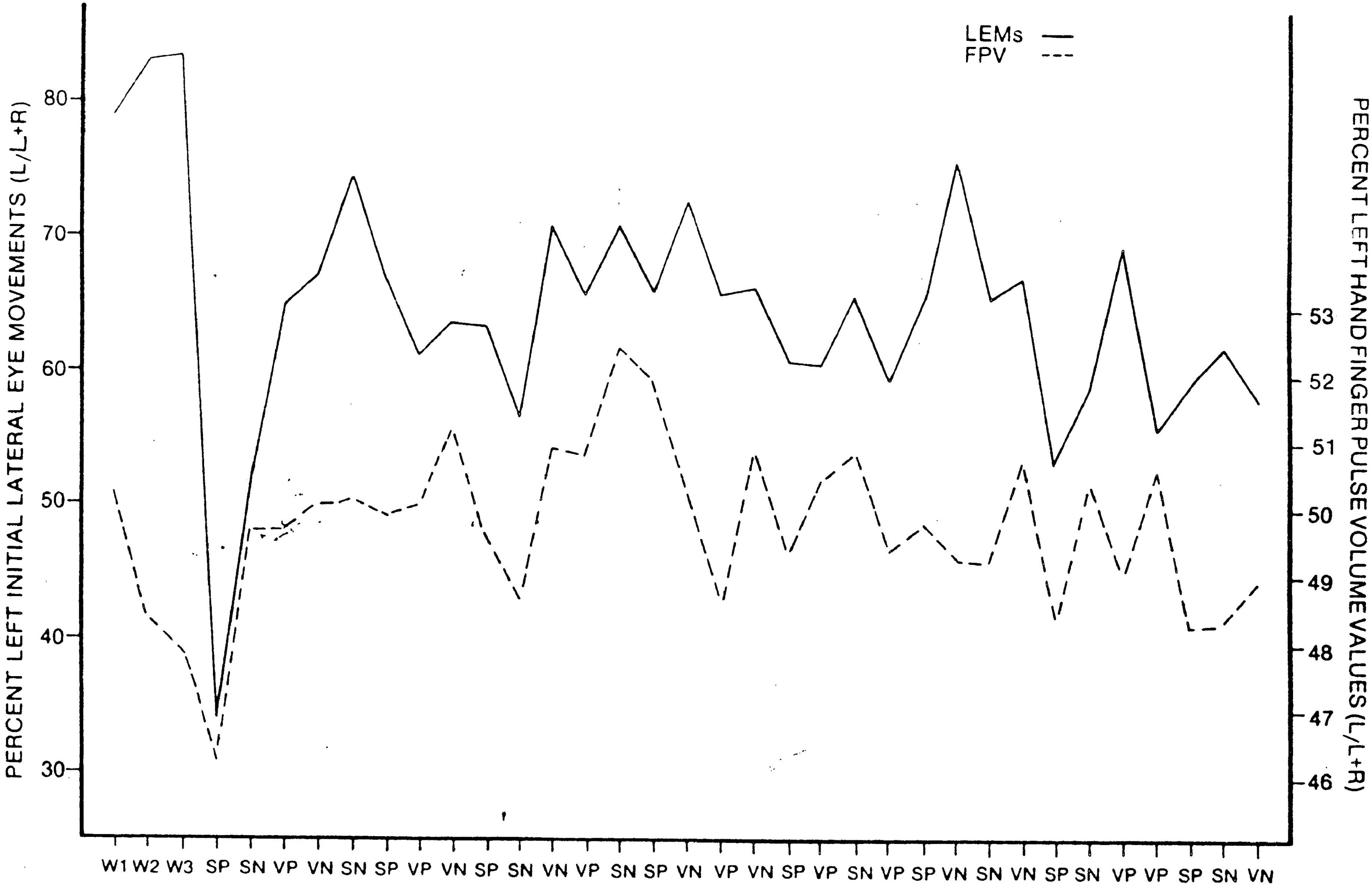
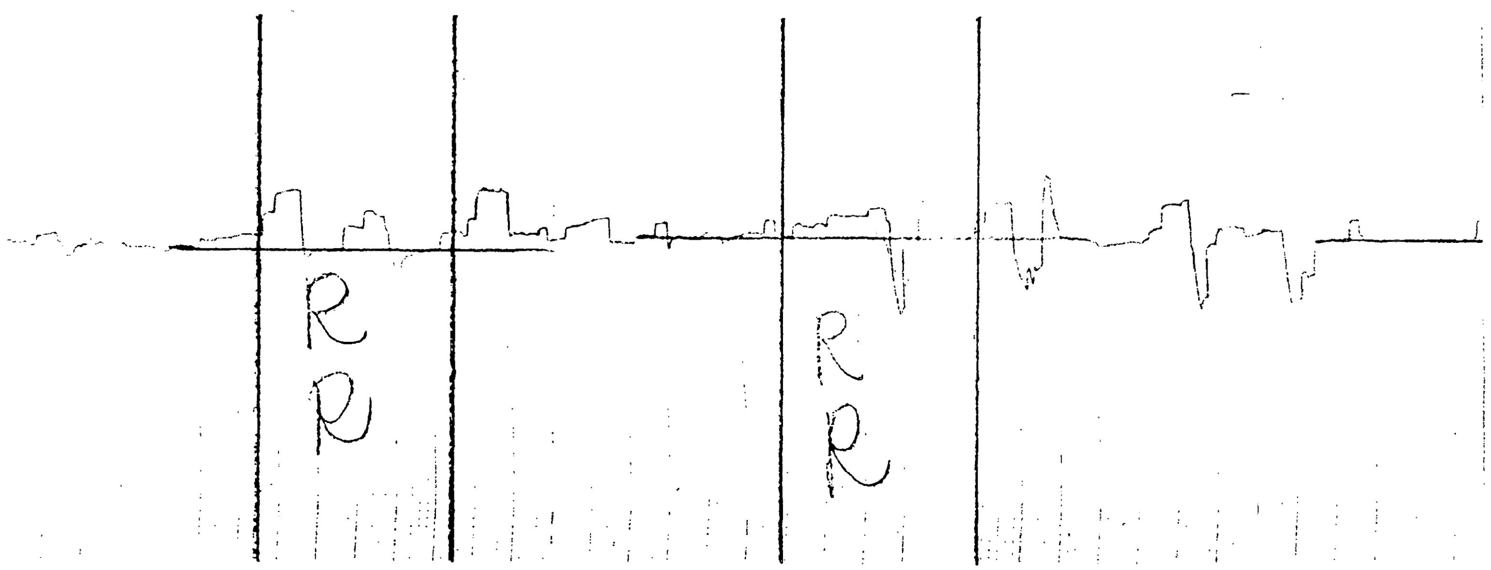


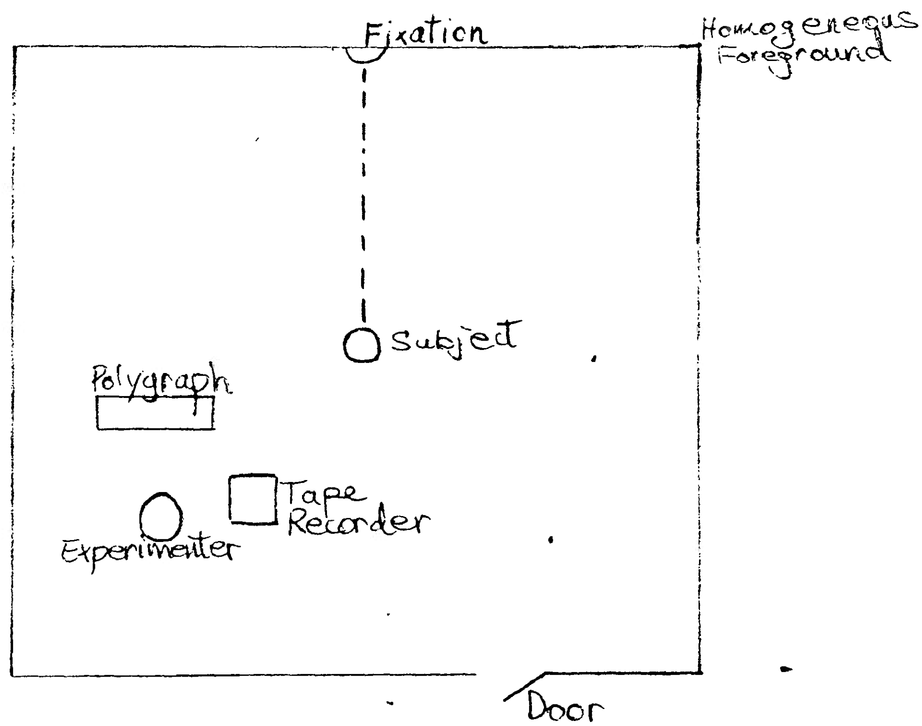
Figure 1. Percent left LEMs and percent left hand FPV in response to each stimulus question (W=warm-up; SP=spatial positive; SN=spatial negative; VP=verbal positive; VN=verbal negative).

Figure 2. Sample LEM record.



The pairs of vertical lines mark the 10 second period at the end of each question. In the two questions presented here, both the initial LEM and predominant direction were to the right (upward pen deflection). Calibration indicated that approximately 2 mm of pen deflection resulted from a LEM of 5 degrees of arc.

Figure 3. Experimental Room.



Discussion

The present results failed to reveal a significant effect of either question content or emotional tone on either the direction of lateral eye movements or the magnitude of FPV on the two hands. A post hoc selection of subjects on the basis of bi-directional eye movements also failed to provide significant evidence for hemispheric effects on LEMs or FPV, although the means for initial LEMs were in the direction consistent with reported effects of verbal and spatial question content. Examination of the LEM and FPV responses to individual questions revealed intriguing similarities between LEM and FPV responses, with the emotional tone of the question apparently affecting both. However, since the correlation between lateralized indices for LEMs and FPV only approached significance, there is not a sufficient basis to conclude that effects of either question content or emotional tone have been demonstrated.

The present failure to demonstrate effects of either cognition or emotion on FPV requires little comment since such effects have not been reported previously by others. However, the failure to demonstrate significant effects on LEMs requires consideration, in view of the sizable literature in this area.

Among the salient questions arising from the present study is whether automation in fact does represent a means of improving LEM research. EOG has not been widely used, (Hiscock, 1977; Morgan, McDonald and MacDonald, 1971; Saring and von Cramon, 1980; Takeda and Yoshimura, 1979). The usual reasons for using it, as in the present study, are to increase the accuracy of recording LEMs and to eliminate the need for a face to face experimenter-subject interaction. Hiscock (1977) reported that a subject alone condition (i.e. not face to face with the experimenter) as used in the present experiment, produces complex patterns of relatively small LEMs that nonetheless evidence a directional bias. In view of the potentially ambiguous nature of such eye movements, the use of EOG seems advisable since it provides a permanent record of subjects' responses which subsequently can be carefully scored. Although these LEM patterns were observed in the present study, the high number of scorable trials coupled with the strong correlation between initial and predominant LEMs, indicates that scoring did not pose a substantial problem.

Another possible source of noise is the predominance of left LEMs. Whatever its cause, this effect may have served to mask any question content effects which may have existed. The trend which was found when bi-directional subjects only were examined supports the plausibility of this argument. Unfortunately, very few (8) bi-directional subjects were available (using a 40 to 60 percent criterion) and effects were not significant.

Erlichman and Weinberger (1978) point out that there has been no direct evidence generated demonstrating that postulated hemisphere specific questions do in fact differentially engage the hemispheres. These authors contend that in the absence of this information a form of face validity has been relied upon. This present study as others may have suffered from this lack of tested validity. Possibly the questions used were just not complex enough or adequately constructed to elicit the desired hemispheric activation. Either the cognitive content or emotional content may not have been adequately incorporated into each question. In an attempt to assess the possibility that only some questions produced the predicted pattern of activation, a laterality index for each question was obtained for initial LEMs and plotted in Figure 1. With the exception of the first question, all questions elicited predominantly leftward eye movements. There was no strong evidence for a subset of questions producing the predicted patterns of LEMs, either from visual inspection or from factor analysis.

As Erlichman and Weinberger (1978) point out, half of the LEM studies they had reviewed, as in the present study, in fact did not report the expected LEM differences. Furthermore, Erlichman, Weiner and Baker (1974) found a significant difference in vertical gaze shifts for verbal and spatial questions with verbal questions eliciting more downward gaze shifts rather than the usual horizontal gaze shifts. Similarly, Galin and Ornstein (1974) found that verbal questions evoked more down and right movements than spatial questions. All this suggests that the effect of LEMs as a reflection of patterns of hemispheric asymmetry may either be weak or lack robustness. If the effect is simply weak, then the evidence gathered thus far may provide an accurate picture of the phenomenon. However, if the present confusion is due to a lack of robustness then greater attention must be directed toward clarifying the conditions under which the effects occur.

An unpredicted finding in the present study was the overwhelming left looking bias. One possible explanation is that the experimenters position, to the left with the equipment, (see Figure 3) may have drawn subjects' attention in this direction. Subjects, wishing to address the experimenter when responding may have shifted their gazes or turned their heads to the left. Another possible explanation is that the present study may have induced stress in subjects independent of the effects of the stimulus questions presented. Tucker, Roth, Arneson and Buckingham (1977), suggest that stress increases the frequency of leftward LEMs. The propensity of left LEMs in the present study, therefore, may have been related to a negative emotional state such as stress that subjects may have been experiening. There are many possible sources for this stress or anxiety. It may have been caused by a perceived level of difficulty in the tasks subjects were performing. Despite being told that there were no correct or incorrect answers, subjects may have been experiencing performance anxiety. The physiological measures which required five separate attachments to subjects' bodies is another possible source of anxiety. As well, the knowledge of the presence of the experimenter in the same room, though he was out of sight, may have stressed subjects. However, the plausibility of this explanation is questioned by the separate analysis of the unstressed subjects (based on their self-reports). Moreover, the stress question in the present study consisted of only one four point scale and, therefore, might be viewed with caution.

Analyses of both initial LEMs and predominant LEMs yielded several significant effects. Verbal questions produced significantly more scorable LEMs than spatial questions, indicating that verbal questions were more effective at eliciting LEMs. The explanation for this result is unclear, but others, such as Kinsbourne (1972) contend that verbal questions are more effective than spatial questions at eliciting the predicted directions of LEMs. In the present study, the verbal questions just elicited more LEMs, instead of more LEMs in the predicted direction.

A significant sex by emotion interaction was found for both initial and predominant LEMs. This finding indicates that females emitted significantly more LEMs than males to the negative emotional content. Although this finding cannot be related to left and right LEM differences, other studies have also reported sex differences related to the directional frequencies of LEMs regardless of question content (Weiten and Etaugh, 1974). This result also resembles reports that males and females differ in their responses to positive and negative emotional stimuli (Tucker, Roth, Arneson and Buckingham, 1977).

Oddly enough, negative emotional stimuli caused more vasodilation than positive stimuli on both sides of subjects. Since vasoconstriction is an indicator of sympathetic arousal (Bloom, Houston and Burish, 1976; Bloom and Trautt, 1977), this finding suggests that positive questions elicited more autonomic arousal than negative questions. This is opposite to what would be expected.

Since none of the analyses yielded significant effects of question content or FPV or LEMs, inspection of Figure 1 suggests that emotional content may be affecting both FPV and LEMs. Although this relationship was not significant the peaks are too similar to ignore. In particular, both FPV and LEMs show a pronounced rightward bias to more left LEMs and greater blood flow to the left side. A noticeable exception to this pattern, question 10, produces the same reversed pattern for both FPV and LEM indices suggesting that it may in fact have elicited a positive rather than negative emotional state. Assuming that negative emotions activate the right hemisphere (Ahern and Schwartz, 1979) the increase in left LEMs is in the predicted direction. However, the increase in blood flow to the left side is in the opposite direction to the conclusion suggested by Kuriychuk and Jamieson (1982) using bilateral finger temperature (FT). Although they did not find lateralized differences resulting from moderately stressful cognitive tasks, they did find that simply participating in an experiment requiring the performance of difficult cognitive tasks caused FT decreases on the left side. They suggested that the stress of participating in an experiment resulted in right hemisphere activation and contralateral vasoconstriction. The present results instead suggest that the effect may be one of contralateral vasodilation. However, while FPV and FT generally reflect the same underlying mechanism, volume of peripheral blood flow, it would be premature to infer these findings are contradictory until studies are conducted incorporating both measures. Clearly, more research is needed to establish the relationship of FPV to LEMs and FPV to hemispheric activation. The present study suggests that further investigations of hemispheric effects on FPV would be warranted.

The effects of emotional stimuli require much more empirical validation. A methodological refinement which may aid future investigations is the systematic development of stimulus questions. Measures of their reliability and validity seem essential. As well factor analytic techniques would contribute to the establishment of their content validity. The results of the present study suggest that the use of EOG would be very beneficial in establishing the existence or nonexistence of the purported causal links. It provides a very accurate and unobtrusive measure in the sense that an experimenter's face to face presence is not necessary.

The present experiment did not garner any significant evidence to support the findings of Ahern and Schwartz (1979). They found that positive emotions, especially excitement, elicited more right looks than fear and fewer left looks than fear, for both verbal and spatial questions. These authors contend that lateralization for positive and negative emotions may be more fundamental to neural organization than lateralization for verbal/spatial processing. They further postulate that an even more basic aspect of neural organization may be lateralization for approach - avoidance behaviour. It could conceivably be cautiously posited that the trends seen in Figure 1 parallel the differential strength Ahern and Schwartz found for emotional stimuli. Peaks and valleys can be divided according to their emotional content but not their cognitive content.

Although the present study and that of Ahern and Schwartz were operating from the same conceptual base, there were methodological differences which may have contributed, somehow, to the failure to replicate. Most notably the present study used EOG rather than a videotape camera and recorded questions rather than presentation by a live experimenter. Furthermore, there may have been subtle differences in the questions used by Ahern and Schwartz and those used in the present study, the majority of which were generated by the experimenter.

Replications of the Ahern and Schwartz (1979) study are needed before models incorporating emotional processing can be developed. Secondly, even after the evidence for these relationships is established, the difficult task of operationally demonstrating the links between question content, hemispheric activation and LEMs remains. In fact, some investigators contend that significant differences do not permit the inference of a hemispheric mechanism related both to question content and to LEMs. It is this connection between hemispheric activation and LEMs which constitutes the weaker link in the causal chain. Responses at the neurophysiological level are necessary. An attempt to reduce the speculative nature of LEM and hemispheric interaction has been made by Kinsbourne (1972,1973,1974). However, there is currently no evidence available to demonstrate the connection of the hemispheres to the frontal eye fields in terms of cognitive processing. In addition, corroborative physiological evidence indicative of hemispheric differences may be helpful. A measure such as FPV, for instance, should be further investigated with this goal in mind. As the present study suggests, the support for these conceptual relations is in need of a stronger body of evidence.

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Appendix 1

Analysis of Variance:

Source	df	MS	F
Sex (A)	1	46.47	35.44*
Error	56	1.31	
Side (B)	1	466.00	22.53**
A x B	1	10.23	.49
Error	56	20.68	
Cognition (C)	1	3.62	10.50*
A x C	1	.42	1.22
Error	56	.35	
B x C	1	4.76	1.23
A x B x C	1	5.35	1.38
Error	56	3.86	
Emotion (D)	1	5.17	8.14
A x D	1	6.59	10.36*
Error	56	.64	
B x D	1	2.07	.65
A x B x D	1	.60	.18
Error	56	3.20	
C x D	1	1.14	3.33

A x C x D	1	1.07	3.13
Error	56	.34	
B x C x D	1	.11	.03
A x B x C x D	1	.13	.04
Error	56	3.07	

*$p < .01$.

**$p < .001$.

Appendix 2

Analysis of Variance:

Source	df	MS	F
Sex (A)	1	63.81	38.57*
Error	56	1.65	
Side (B)	1	543.11	28.20*
A x B	1	7.92	.41
Error	56	19.26	
Cognition (C)	1	6.28	9.43*
A x C	1	.39	.58
Error	56	.66	
B x C	1	2.20	.76
A x B x C	1	1.07	.37
Error	56	2.90	
Emotion (D)	1	2.49	2.33
A x D	1	7.06	6.60*
Error	56	1.07	
B x D	1	.86	.20
A x B x D	1	.20	.05
Error	56	4.41	
C x D	1	2.21	3.43

A x C x D	1	1.30	2.02
Error	56	.64	
B x C x D	1	1.94	.57
A x B x C x D	1	.00	.00
Error	56	3.39	

*$p < .01$.

**$p < .001$.

Appendix 3

Analysis of Variance:

Source	df	MS	F
Sex (A)	1	28.80	.52
Channel (B)	1	93.60	.20
A x B	1	53.39	.96
Error	51	55.88	
Side (C)	1	.00	.00
A x C	1	6.78	.67
B x C	1	434.86	42.98**
A x B x C	1	9.91	.98
Error	51	10.12	
Cognition (D)	1	.89	1.80
A x D	1	.49	.99
B x D	1	1.97	3.98*
A x B x D	1	.01	.03
Error	51	.49	
C x D	1	.06	.14
A x C x D	1	.00	.01
B x C x D	1	1.00	2.34
A x B x C x D	1	.04	.09
Error	51	.41	

Emotion (E)	1	12.72	27.06**
A x E	1	.76	1.61
B x E	1	.04	.08
A x B x E	1	1.60	3.30
Error	51	.47	
C x E	1	.03	.09
A x C x E	1	.18	.59
B x C x E	1	.57	1.92
A x B x C x E	1	.61	2.04
Error	51	.29	
D x E	1	.07	.14
A x D x E	1	.88	1.75
B x D x E	1	.05	.11
A x B x D x E	1	.36	.71
Error	51	.50	
C x D x E	1	.16	.55
A x C x D x E	1	.73	2.50
B x C x D x E	1	.03	.11
A x B x C x D x E	1	.30	1.00
Error	51	.29	

*$p < .05$.

**$p < .01$.

Appendix 4

Analysis of Variance:

Source	df	MS	F
Sex (A)	1	.52	.75
Error	6	.69	
Side (B)	1	9.00	4.70
A x B	1	6.75	3.52
Error	6	1.91	
Cognition (C)	1	2.25	6.23*
A x C	1	.33	.92
Error	6	.36	
B x C	1	.06	.02
A x B x C	1	17.52	4.53
Error	6	3.86	
Emotion (D)	1	1.56	1.81
A x D	1	.02	.02
Error	6	.86	
B x D	1	1.00	.37
A x B x D	1	.75	.28
Error	6	2.66	
C x D	1	.00	.00

A x C x D	1	.08	3.00
Error	6	.03	
B x C x D	1	3.06	1.25
A x B x C x D	1	7.52	3.07
Error	6	2.44	

*$p < .05$.

Appendix 5

Analysis of Variance:

Source	df	MS	F
Sex (A)	1	.45	.02
Channel (B)	1	2.93	.15
A x B	0	.00	.00
Error	5	23.01	
Side (C)	1	32.06	6.55*
A x C	1	1.63	.33
B x C	1	47.04	9.61*
A x B x C	0	.00	.00
Error	5	4.90	
Cognition (D)	1	3.02	2.34
A x D	1	1.60	1.24
B x D	1	1.93	1.50
A x B x D	0	.00	.00
Error	5	1.30	
C x D	1	1.53	.75
A x C x D	1	2.40	1.18
B x C x D	1	2.04	1.00
A x B x C x D	0	.00	.00

Error	5	2.04	
Emotion (E)	1	5.50	2.96
A x E	1	.08	.04
B x E	1	1.82	.98
A x B x E	0	.00	.00
Error	5	1.84	
C x E	1	1.53	.98
A x C x E	1	.33	.33
B x C x E	1	1.04	.67
A x B x C x E	0	.00	.00
Error	5	1.60	
D x E	1	.79	.27
A x D x E	1	.69	.65
B x D x E	1	.28	.09
A x B x D x E	0	.00	.00
Error	5	2.93	
C x D x E	1	.88	.46
A x C x D x E	1	.95	.50
B x C x D x E	1	.74	.39
A x B x C x D x E	0	.00	.00
Error	5	1.90	

*$p < 05$.

Appendix 6

Factor analysis of percent left LEMs using Principle Components Analysis and Varimax Rotation yielded 11 factors explaining 73.6% of the variance. The type of question, loading .3 or greater on each factor, the actual loading values are presented below. The factors do not represent clear groupings reflecting question content.

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
VP(.32)	VP(.54)	VP(.35)	VN(.55)	SP(.58)	SP(.55)
VN(.66)	VP(.63)	SP(.58)	SN(.56)	VN(.45)	VN(.89)
SP(.35)	SN(.61)	SP(.38)	SP(.34)	VP(.44)	VP(.50)
SN(.69)	SP(.60)	SP(.43)	VN(.78)	VN(.78)	VP(.36)
VN(.55)	VP(.56)	SN(.69)	VP(.32)	VP(.33)	
		VP(.30)			

Factor 7	Factor 8	Factor 9	Factor 10	Factor 11
SP(.59)	VP(.32)	VP(.34)	SP(-.75)	VN(-.46)
SN(.54)	VP(.43)	SP(.34)	SN(.38)	VP(.40)
SP(.31)	SN(.38)	SN(.78)	VP(-.31)	VP(.42)
SP(.64)	VN(.82)	VP(.53)	VP(-.34)	
SN(.42)			VP(.33)	

P=positive, N=negative, S=spatial, V=verbal

Appendix 7

Analysis of Variance:

Source	df	MS	F
Sex (A)	1	3.41	2.50
Error	14	1.37	
Side (B)	1	159.75	10.74*
A x B	1	1.45	.09
Error	14	14.87	
Cognition (C)	1	.63	2.39
A x C	1	.53	1.99
Error	14	.27	
B x C	1	2.26	.41
A x B x C	1	1.45	.26
Error	14	5.44	
Emotion (D)	1	.07	.37
A x D	1	.15	.82
Error	14	.19	
B x D	1	3.45	1.40
A x B x D	1	.08	.04
Error	14	2.50	
C x D	1	.63	1.74
A x C x D	1	.64	1.75

Error	14	.36	
B x C x D	1	.38	.12
A x B x C x D	1	4.25	1.36
Error	14	3.12	

*$p < .01$.

Appendix 8

Analysis of Variance:

Source	df	MS	F
Sex (A)	1	16.93	.23
Channel (B)	1	70.88	.95
A x B	1	26.55	.36
Error	11	74.28	
Side (C)	1	.20	.01
A x C	1	3.58	.20
B x C	1	120.50	6.73*
A x B x C	1	8.40	.47
Error	11	17.90	
Cognition (D)	1	.00	.02
A x D	1	.27	2.02
B x D	1	.08	.62
A x B x D	1	.01	.09
Error	11	.13	
C x D	1	.00	.01
A x C x D	1	.19	1.50
B x C x D	1	.00	.01
A x B x C x D	1	.26	2.10
Error	11	.12	
Emotion (E)	1	3.36	9.59**

A x E	1	.03	.09
B x E	1	.21	.59
A x B x E	1	.19	.53
Error	11	.35	
C x E	1	.09	1.22
A x C x E	1	.04	.58
B x C x E	1	.62	8.28*
A x B x C x E	1	.18	2.45
Error	11	.07	
D x E	1	.08	.43
A x D x E	1	.60	3.23
B x D x E	1	.08	.41
A x B x D x E	1	.00	.00
Error	11	.19	
C x D x E	1	.13	2.96
A x C x D x E	1	.06	1.49
B x C x D x E	1	.00	.01
A x B x C x D x E	1	.10	2.36
Error	11	.04	

*$p < .05$.

**$p < .01$.

Appendix 9

Stimulus Questions

W1. What is a bleeding ulcer? (VN)

W2. You have just been victorious at the Wimbeldon Tennis Championships. Describe the scene as you step into the winner's circle. (SP)

W3. Picture and describe your most frightening nightmare. (SN)

1. Imagine you are running in a prestigious race and are only seconds ahead of your closest competitor as you both approach the finish line. Describe the last moments as you finish first and the ensuing scene. (SP)

2. Picture the last automobile accident you have seen. In which direction were the cars going? (SN)

3. Define the word euphoria. (VP)

4. How many syllables are there in the word executioner? (VN)

5. You are riding your bicycle heading east when a car comes out of the blue to your right. Which side of your body will be struck first? (SN)

6. Imagine you are surfing at a beach on the California coast riding a ten foot wave. You are standing sideways facing the west. Then you flip backwards, land back on your board and turn 180 degrees to your left. Which direction are you facing? (SP)

7. Name three positions of fame you would like to occupy. (VP)

8. What is a brain hemmorage? (VN)

9. Imagine you are a good gymnast and describe your floor routine. (SP)

10. Imagine standing on a train track facing east and being unable to move. A train is approaching rapidly from the north. From which side will your body be crushed? (SN)

11. How many syllables are there in the word decapitation? (VN)

12. Name three of your favourite things. (VP)

13. A brute attacks you with a knife. Which part of your body will you try to protect? (SN)

14. Picture and describe the most exciting scene that you have seen in a movie. (SP)

15. Spell the word torture. (VN)

16. Define the word excitement. (VP)

17. How many syllables are there in the word mutilation? (VN)

18. Picture the face of who you think is the best looking actor or actress. What colour is his or her hair? (SP)

19. Name three positions of power you would like to occupy. (VP)

20. If a grizzly bear took a swipe at your face and scratched you on a diagonal what parts of your face would be bleeding? (SN)

21. Name two words that rhyme with lover. (VP)

22. You have won a dream come true world cruise. Which are the first three cities you would sail to and describe the direction in which you would have to go to reach each destination. (SP)

23. Are there the same number of syllables in strangulation as in suffocation? (VN)

24. Visualize and describe that most upsetting photograph of the Vietnam War you have seen. (SN)

25. What kinds of accidents or injuries might lead to internal bleeding? (VN)

26. Imagine you are able to fly and soar above the clouds. What maneuvers would you perform? (SP)

27. Because of a faulty parachute you are plummeting to the ground. In the process of falling you rotate from an upright position backwards 180 degrees. What part of your body will be crushed first? (SN)

28. Define the word thrilling. (VP)

29. Name three words that rhyme with power. (VP)

30. Visualize and describe the most exciting musical concert you have ever attended. (SP)

31. If you were crossing a street from west to east and a car from the south smashed into you which leg would be shattered first? (SN)

32. What is meant by multiple stab wounds? (VN)

W=warm-up.

S=spatial.

V=verbal.

P=positive.

N=negative.