Conjugate lateral eye movements, cerebral dominance, and anxiety

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Introduction

When asked a question that requires reflective thought, most subjects shift their gaze either to the left or to the right. This phenomenon has been termed 'conjugate lateral eye movement' (CLEM). In neuropsychological literature, two different, though related, interpretations of CLEMs can be found. The first interpretation emphasizes that CLEMs vary as a function of question type. Several studies have, indeed, found that, on the whole, verbal problems elicit rightward CLEMs, whereas spatial problems elicit leftward CLEMs (e.g., Gur, Gur & Harris, 1975). Since verbal material is predominantly processed by the left cerebral hemisphere and spatial material is predominantly processed by the right hemisphere (Beaumont, 1983), this finding has been taken to imply that CLEMs can be used as an index of contralateral hemispheric activation (e.g., Kinsbourne, 1972).

According to the second interpretation, CLEMs can best be regarded as a trait variable that reflects individual differences in hemispheric reliance. This interpretation is based on the observation that when subjects are confronted with a series of questions (i.e., verbal and spatial problems), one can reliably differentiate between subjects who frequently shift their gaze to the right (right movers), subjects who predominantly shift to the left (left movers), and subjects who give mixed responses (bidirectional) (e.g., Hiscock, 1977). Despite some methodological shortcomings in a number of studies using CLEMs as an individual difference variable (see critical review by Ehrlichman & Weinberger, 1978), most authors agree that left movers and right movers differ in their characteristic use of one or the other cerebral hemisphere, with left movers preferring to use the right hemisphere and right movers preferring to use the left hemisphere (Tucker,
Antes, Stenslie & Barnhardt, 1978; Hantas, Katkin & Reed, 1984). Strong experimental support for the hypothesis that CLEMs reflect contralateral hemispheric reliance comes from EEG research (Shevlin, Smokler & Kooi, 1980; Newlin, Rorbaugh & Varner, 1982) and a study in which regional cerebral blood flow was recorded (Gur & Reivich, 1980).

A number of investigators have employed CLEMs to examine the relationship between hemispheric reliance on the one hand, and emotions and personality characteristics on the other hand. Left movers have been found to be more internally oriented (Day, 1967), more susceptible to hypnosis (Bakan, 1969), and to suffer more from psychosomatic symptoms (Gur & Gur, 1975) than right movers. Moreover, it has been reported that left movers are characterized more often by a hysterical personality style (Smokler & Shevlin, 1979), more frequently use internally oriented defensive mechanisms such as repression (Gur & Gur, 1975), and are better heartbeat perceivers (Hantas et al., 1984) than right movers. Based on the assumption that leftward CLEMs indicate a right hemispheric preference, these findings have been related to theories that emphasize a right hemispheric dominance for nonverbal, emotional functions (Silberman & Weingartner, 1984).

As for the relationship between hemispheric preference, as indexed by CLEMs, and anxiety, experimental results are far from clear. Day (1967) suggested that left movers tend to attribute anxiety to internal sources whereas right movers tend to localize anxiety externally. In keeping with this, Gers and Kinsbourne (1974) found that when confronted with an external, stressful situation (i.e., awaiting oral surgery), left movers appeared to be less physiologically reactive than right movers. On the other hand, Tucker, Roth, Arneson, & Buckingham (1977) found an increased frequency of leftward CLEMs during stress. To complicate the picture even more, Tucker et al. (1978) reported that high trait-anxious subjects made significantly fewer leftward CLEMs, which, according to these authors, indicates a 'decreased right hemispheric activation in trait anxiety' (p.382). This suggestion, however, was not confirmed by the research of Papsdorf, Ghannam, Kuzma, and Jamieson (1979; exp. 1 and exp. 2). These investigators observed that bidirectionalans exhibited higher trait-anxiety scores than either left or right movers. They concluded that 'the absence of hemispheric preference is a correlate of high anxiety' (p.380; see also Hiscock, 1977). A third experimental outcome was obtained by Montgomery and Jones (1984). They found that subjects with high anxiety scores made significantly more leftward CLEMs than subjects with low scores. The researchers concluded that this finding lent support to the hypothesis that emotionally responsive subjects show a preference for use of the right hemisphere.
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Several factors may have promoted the lack of consensus about the relationship between CLEMs and anxiety. First, different techniques of transforming CLEMs into a summary score have been used. For example, whereas Tucker et al. (1977) related raw frequencies of rightward and leftward CLEMs to anxiety, Montgomery and Jones (1984) related the proportion of rightward CLEMs (i.e., number of right CLEMs divided by the sum of the number of right and left CLEMs) to anxiety. Under some conditions (e.g., when subjects frequently respond with stares instead of CLEMs), these two scoring systems can yield conflicting results (Ehrlichman & Weinberger, 1978). A second factor that may have contributed to the lack of consensus is the different ways in which anxiety has been operationalized (e.g., questionnaire scores, physiological data etc.). Third, the fact that some authors (e.g., Papsdorf et al., 1979) have treated CLEMs as the independent variable, whereas others (e.g., Tucker et al., 1978) have used anxiety scores as the independent variable may also have played a role in the empirical chaos described above.

The present study was undertaken in attempt to clarify the issue of whether CLEMs covary with anxiety in a systematic way. To avoid the drawbacks of earlier studies, the proportion of rightward CLEMs was measured in a large sample of healthy subjects. This CLEM measure has been recommended as the most appropriate summary score (Ehrlichman & Weinberger, 1978). As for anxiety measures, questionnaires were selected that are widely used by clinical researchers and professionals. Additionally, a physiological concomitant of fear, namely, spontaneous electrodermal fluctuation, was measured. Psychophysiological research has clearly documented that spontaneous fluctuations have both trait (e.g., Deitz, 1982) and state (e.g., Fowles, 1980) characteristics that are relevant to (sub)clinical anxiety. Finally, by adding a correlational approach to the 'traditional' analysis of variance, an attempt was made to circumvent the problem of defining dependent and independent variables.

Method

Subjects

Seventy-five healthy subjects (47 females and 28 males) volunteered to participate in the experiment. Their mean age was 20.8 years (range: 18–34 years). The subjects were undergraduate students recruited from psychology classes. They were paid for their participation in the study.
Assessment and apparatus

Twenty questions\(^{10}\) (5 neutral-verbal, 5 emotional-verbal, 5 neutral-spatial, and 5 emotional-spatial; Ahern & Schwartz, 1979), intended to elicit CLEMs, were posed by an interviewer facing the subject\(^{25}\). The subject's first observable eye movement was scored by the interviewer. Three response categories were used for scoring eye movements: leftward CLEMs, rightward CLEMs, and absence of CLEMs. The last category comprised stares and vertical eye movements (Ehrlichman & Weinberger, 1978). The reliability of this scoring system was established in a pilot study, in which two interviewers scored eye movements of 5 subjects using the above mentioned response categories. The mean interrater agreement proved to be satisfactory (Kappa = 0.86). In two further pilot studies, the validity of the above mentioned set of questions was examined. In the first study (N=54), it was found that CLEMs elicited by these questions were affected by question type. For example, neutral-verbal questions (which presumably involve more left than right hemispheric activation) elicited more rightward CLEMs than emotional-spatial questions (which presumably involve more right than left hemispheric activation), the means being 2.2 and 1.8 (Wilcoxon paired comparison's Z=-2.5 p=0.006). This finding suggests that, on the whole, the two types of questions induce differential hemispheric effects. The second study (N=39) examined whether individual CLEM patterns correspond to Zentrosyn's (1978) Preference Test. The Preference Test assesses an individual's preference for a right hemispheric (i.e., non-verbal/intuitive) versus left hemispheric (i.e., verbal/analytic) style of thinking. It was found that subjects with a high percentage of rightward CLEMs reported a relatively stronger preference for a left hemispheric style of thinking than subjects with a high percentage of leftward or bidirectional CLEMs (t=1.9, p<0.05, one-tailed).

Subjects were asked to complete the following questionnaires: The Edinburgh Handedness Inventory (EHI; Oldfield, 1971), the Fear Questionnaire (FQ; Marks & Mathews, 1979), and the Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky & McNally, 1986). Since it is assumed that left-handedness is associated with a reduced degree of cerebral lateralization (Beaumont, 1983; Kinsbourne, 1972) and may, consequently, affect correlations between CLEMs and anxiety, handedness (as measured by the EHI) was used as a control variable. The EHI is a reliable ten-item questionnaire which conceptualizes handedness as a continuous variable. A handedness quotient (range: -100 to +100) can be derived from the EHI, with -100 indicating pure left-handedness and +100 indicating pure right-handedness.
The FQ contains three scales: a social phobia scale, an agoraphobia scale, and a blood/injury phobia scale. In the present study, a total FQ score was computed for each subject by summing the subject's position on all three scales. It has been shown that the FQ is sensitive to phobic tendencies in normal populations (Arrindell, Emmelkamp & Van der Ende, 1985). While the FQ measures fear of external objects and situations, the ASI measures fear of interoceptive cues, such as breathing and cardiac acceleration. The ASI consists of 16 items that have also been validated for a nonclinical population (Maller & Reiss, 1987). The subject's scores on these items were summed and used in the data analysis.

In the present study, subjects were told they would get a mild electric shock. During the 4 min period that followed, spontaneous electrodermal fluctuations (SFs) were recorded. SFs were measured using two Beckman Ag-AgCL electrodes attached to the medial phalanges of the second and third fingers of the subject's right hand. The electrodes were filled with isotonic uni-base paste and connected to a Beckman Skin Conductance Coupler (type 9844). Electrodermal activity was measured in microsiemens. Spontaneous fluctuations were defined as deflections exceeding a criterion of 0.05 siemens within 2 sec.

Respiration rate (RR) was recorded from a Beckman Respiration Belt fastened around the subject's chest and connected to a Beckman Voltage/Pulse/Pressure Coupler. Physiological signals were fed to a Beckman R 611 polygraph. A PDP Min II microcomputer controlled response registration and analyses.

Procedure

Subjects were tested individually. Upon entering the laboratory, the subject was invited to complete the EHI, FQ, and ASI. Next, the subject was asked to sit down in a comfortable chair that had been placed in a dimly lit, sound-attenuated chamber. The apparatus was located in an adjacent room. After the recording sites had been cleaned with distilled water, the electrodes were attached with adhesive collars. The subject was then told that he/she would receive an electric shock at some stage in the experiment. A 4 min recording period followed in which no shocks, in fact, were delivered. At the end of this period, electrodes and transducer were removed. Next, the interviewer posed twenty questions, meanwhile recording CLEMs. The subject was told that the questions were derived from a test involving imagination and creativity. The distance between subject and interviewer was approximately 1.5 m.
Data reduction and analysis

Following Ehrlichman and Weinberger's recommendation (1978), CLEMs were summarized by means of a percent-right score (number of rightward CLEM/ number of rightward CLEM + number of leftward CLEM).

RR was used as a control variable; SFs due to respiratory irregularities were excluded from the data analysis. For each subject, SFs during the 4-min period were summed.

The following analyses were carried out. First, with Pearson product-moment correlations, the associations between percent-right scores, on the one hand, and EHI, FQ, ASI, and SFs, on the other hand, were examined. Second, in order to control for EHI, partial correlations between percent-right scores and FQ, ASI, and SFs were computed. Third, using percent-right score (PRS) as a between-subject factor with three levels (high PRS, moderate PRS, and low PRS), analyses of variance (ANOVA) were performed on FQ, ASI, and SF data. To control experiment-wise errors, a Bonferroni strategy was adopted. Thus, for both correlations and F-values, nominal alpha was set at 0.05/3=0.016.

Results

Table 1 shows the Pearson product-moment correlations between percentage rightward CLEM (PRS), handedness (EHI), and indices of anxiety. It should be noted that as far as the relationship between CLEM and anxiety is concerned, correlations are low and fall short of significance. Apparently, there is no connection between anxiety indices such as FQ, ASI, and SFs on the one hand, and hemispheric reliance on the other hand.

Table 1 also shows that EHI, anxiety measures, and PRS do not share much variance. By a large correlations did not become stronger when the influence of handedness (EHI) was partialled out: Partial correlations between PRS, FQ, and ASI were -0.13 and 0.06, respectively (for both correlations: d.f.=72, p>0.10, one-tailed). The PRS/FS correlation reached borderline significance when controlling for EHI (d.f.=72, r=0.20, p=0.05).

Pearson correlations assume linear relationships between variables. It could be argued that this assumption is questionable when CLEMs and anxiety measures are examined (e.g., Papsdorf et al., 1979). Consequently, ANOVAs were carried out. By dividing the PRS distribution in equal parts (33%), three groups of subjects were formed: 'Left movers' (low PRS; subjects with a PRS lower than 0.24), 'bidirectionals' (moderate PRS; subjects with a PRS between
0.25 and 0.65), and 'right movers' (high PRS; subjects with a PRS greater than 0.65). ANOVAs performed on these data yielded no significant effects [for all comparisons: F(2,72)<1.2, p>0.30].

Table 1. Pearson product-moment correlations between percentage rightward eye movements (PRS), handedness (EHI), situational fear (FQ), non-situational fear (ASI), and electrodermal spontaneous fluctuations (SF).

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<th>PRS</th>
<th>EHI</th>
<th>FQ</th>
<th>ASI</th>
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<tr>
<td>EHI</td>
<td>0.04</td>
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<td>FQ</td>
<td>-0.12</td>
<td>-0.03</td>
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<tr>
<td>ASI</td>
<td>0.06</td>
<td>-0.30*</td>
<td>0.38*</td>
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<tr>
<td>SF</td>
<td>0.16</td>
<td>-0.11</td>
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*p < 0.05, one-tailed, N = 75

Discussion

In the present study, no significant correlations between CLEMs and anxiety measures were found. Moreover, correlations did not increase dramatically when controlling for handedness. Obviously, these findings do not help clarifying contradictory conclusions reached in earlier studies. Yet, there are several reasons to consider the current data worthy of note. First, there are no grounds for suspecting that our failure to reject the null hypothesis (i.e., no relationship between CLEMs and anxiety) is due to methodological shortcomings. Data gathered in pilot experiments suggested that the questions used in the present study elicited CLEMs indicative of hemispheric activation and reliance. Furthermore, anxiety variables had acceptable standard deviations and were measured in a relatively large sample. Second, the present study deviates from previous work in that anxiety was defined in terms of clinically relevant measures such as FQ, ASI, and SFs. Several authors have suggested that research on hemispheric reliance and anxiety is important because it may have implications for treatment (Papsdorf et al., 1979). Clearly, the findings presented above do not support this suggestion.

The most parsimonious interpretation of the data presented above is that there is no straightforward relationship between hemispheric
reliance and the various indices of anxiety. Consequently, our findings cast serious doubts on the soundness of the hypotheses prompting this line of research. This conclusion makes sense when the following points are taken into account.

(1) Research concerned with cerebral lateralization of anxiety has been guided by fact finding rather then by strong theoretical predictions. Thus, on the basis of a selective review of experimental findings one could support the view that (trait-)anxiety is a left hemispheric operation (Tucker, 1981; Tyler & Tucker, 1982), the view that negative emotions such as anxiety are primarily mediated by the right hemisphere (Silberman & Weingartner, 1986), and the view that anxious subjects are characterized by interhemispheric competition, i.e., the absence of cerebral specialization for emotions (e.g., Papsdorf et al., 1979). In passing, it should be noted that this inconsistency is not limited to studies relating CLEM to anxiety. For example, studies which sought to illuminate the relationship between handedness and anxiety have also yielded conflicting results (e.g., Hicks & Pellegrini, 1978 vs. Merckelbach, De Ruiter, & Olff, 1989).

(2) Some authors (e.g., Montgomery & Jones, 1984) have proposed that a clear relationship between hemispheric reliance and anxiety is only evident when stable trait measures of anxiety are employed. The problem with this proposal is, of course, that questionnaire measures of trait and state anxiety typically correlate positively with each other (Eysenck & Mathews, 1987). More to the point in the present context is the fact that anxiety is a theoretical concept which refers to loosely coupled physiological, subjective, and behavioural response systems rather than to a hard phenomenal lump. Solid evidence has indicated that the physiological, subjective, and behavioural aspects of anxiety do not necessarily covary together (Hodgson & Rachman, 1974). One can go even further: measures which claim to tap one particular aspect of an emotion (e.g., the behavioural response system), usually show low intercorrelations. As Öhman (1988) noted, 'essentially, it seems that we are left with a plethora of potentially relevant indices of emotion that covary only to a modest degree, if at all...' (p.13). In this light it would be highly surprising to find that the various measures of anxiety are all related to a stereotyped reliance on one or the other cerebral hemisphere.

To summarize, in the present study no correlations were found between hemispheric reliance and clinically relevant indices of anxiety. Although disappointing, this finding is noteworthy because earlier studies in this field have largely failed to use these clinically relevant measures. Obviously, the task of future studies is to gain insight into the cerebral dynamics underlying a whole range of
anxiety variables rather than the development of a 'grand' theory about hemispheric reliance and anxiety.

Notes

1. A copy of the questions is available upon request.

2. Some authors have argued that, because of their anxiety producing character, face-to-face situations induce CLEMs indicative of an individual difference variable. In contrast, non-face-to-face situations would elicit CLEMs reflecting question type (e.g. Gur, Gur & Harris, 1975; but see also O'Gorman & Siddle, 1981).

References


Gur, R.E. & Gur, R.C. & Harris, L.J. (1975). Hemispheric activation, as measured by the subjects' conjugate lateral eye movements, is influenced by experimenter location. *Neuropsychologia, 13*, 35-44.


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