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FACIAL PROCESSING ABILITY AS A FUNCTION OF SEX, CONJUGATE LATERAL EYE MOVEMENTS, EMOTIONAL VALENCE, AND FAMILIARITY

by

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ABSTRACT

Sixty-four males and sixty-four females, further categorized as left movers, bimovers, and right movers, on a measure of conjugate lateral eye movements, participated in a study of face recognition. Subjects completed a free view face recognition test, and a test requiring them to select among chimeric faces as a measure of perceptual bias in processing physiognomic stimuli. Subjects memorized two faces and were required to recognize them from two unfamiliar faces when the four were projected laterally in a tachistoscopic paradigm. Half of the subjects viewed emotional faces and half viewed only neutral faces. This was followed by a central exposure variation of the task, which was to serve as a measure of facial processing ability.

It was predicted that left movers would perform the central exposure face recognition task significantly faster than right movers. This was confirmed. There was also a tendency for left movers and bimovers to demonstrate a greater left visual field advantage on the perceptual bias measure. The perceptual bias and tachistoscopic indices of laterality were examined with correlation coefficients. It was concluded that the two indices cannot be considered equivalent in view of the instability of the tachistoscopic index as a function of procedural variations. Correlations were examined between the laterality indices and tests of facial ability. It was concluded that there may be some guarded support for the notion that a left visual field/right

hemisphere bias in processing physiognomic stimuli may be related, in some populations, to greater competence in face recognition. Predictions regarding a sex by emotional valence by visual field interaction were not confirmed. However, there were interactions involving visual field by emotional valence by familiarity (whether or not the face had been previously memorized). This latter finding was attributed to different coding straegies available under the two conditions of familiarization.

The discussion concerned the limitations of the tachistoscopic paradigm as an investigatory tool in studying laterality patterns in face recognition. This was followed by suggestions for further research.

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dissertation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. Introduction

The purpose of the present research is to investigate several issues related to face perception and cerebral hemispheric asymmetry. An attempt will also be made to relate facial processing ability to conjugate lateral eye movements (CLEM) in view of their shared common theoretical basis in cerebral laterality. The relationship between face perception and hemispheric asymmetry will be reviewed first. Three of the four hypotheses examined in the present investigation will then be introduced. This will be followed by a similar review of the CLEM literature, which will be followed by introduction of the fourth hypothesis which integrates the CLEM and face perception literature. Finally, the four specific hypotheses and related predictions will be briefly summarized.

Facial Processing Ability and Cerebral Asymmetry

The recognition of faces is a most complex and sophisticated visual achievement. We can each probably recognize hundreds of faces, all which differ in fine detail and undergo successive transformations, but we do this in a manner which is impossible to convey verbally. It depends upon learning visual pattern discriminations of great complexity. It is becoming apparent that many aspects of facial recognition, perception, and even expression, are related to the lateralization of function in the cerebral hemispheres. This information derives from an extensive body of research involving both brain-injured and normal samples.

This review will be restricted to issues in face perception in adults. Developmental issues will not be discussed since they are not directly relevant to the present investigation.

Research on Facial Processing in Brain Injured Patients:Prosopagnosia

The inability to recognize familiar faces has been reported in early descriptions of brain damaged patients,and was termed "prosopagnosia" by Bodamer (1947). Hecaen and Angelergues (1962) reported the first systematic and large scale investigation relating prosopagnosia to brain function. On the basis of 47 cases of prosopagnosia, they found that a definite majority showed evidence of lesions in the posterior right hemisphere, particularly the parieto-temporal-occipital junction. Furthermore, they reported that prosopagnosia is most often accompanied by spatial dyslexia, spatial dyscalculia, and apraxia for dressing, disturbances which have also been implicated in right hemisphere damage (Critchley, 1956).

Meadows (1974) published an extensive analysis of clinical case studies, a re-evaluation of pathological findings in reported cases. He reported that patients with prosopagnosia nearly always have a left upper quadrantal visual field defect, correlated clinically and pathologically with a right occipitotemporal lesion. The few necropsies all show bilateral lesions, but the right hemisphere lesions have all involved the region of the occipitotemporal junction. Although the consistent involvement of the right occipitotemporal lesion is clear throughout his analysis, he is reluctant to accord it with exclusive involvement in prosopagnosia. He states:

> It is natural to question whether the left hemisphere lesion is necessary at all. The evidence, however, is overwhelming that bilateral lesions are important in the overall etiology of prosopagnosia. The high incidence of bilateral disease clinically and the invariable presence of bilateral lesions in the few (eight) necropsies so far performed can scarcely have occurred by chance. (p. 197)

He finally concludes that although the posterior right hemisphere is clearly involved, severe clinical prosopagnosia may require "bilateral, though not necessarily symmetrical, damage" (p. 497).

More recently, Geschwind (1979) reached a similar inference, claiming that prosopagnosia results from bilateral lesions in the occipital areas leading into the temporal regions. This proposed area of localization is consistent with speculations that prosopagnosia may be a specialized form of the amnestic syndrome (Meadows, 1974), since the latter involves the bilateral limbic areas, buried deep in the temporal lobes.

Deficits in Facial Processing in Non-Prosopagnosic Brain Injured Patients

The rarity of clinical prosopagnosia in view of the frequent occurrence of right hemisphere damage is consistent with Meadow's conclusion that although the right posterior hemisphere is clearly involved, severe clinical prosopagnosia may require bilateral, though not necessarily symmetrical, damage. This "necessary though not sufficient" role of the right hemisphere in the disorder is consistent with research in which more sensitive face recognition and perception tests have been designed and administered to larger heterogeneous groups of brain injured patients. This has resulted in the consistent finding that patients with right posterior cerebral injuries, who are often not suffering from clinical prosopagnosia, have difficulty in recognizing faces, doing more poorly than patients with left hemisphere injuries or normal control subjects (DeRenzi and Spinnler, 1966; Benton and Van Allen, 1968; Milner, 1968).

However, the more sensitive recognition tests have mainly used unfamiliar faces, exposed only during the test situation. Since prospagnosia most prominently involves a failure to recognize well-known faces, the degree to which the right posterior deficit is related to prosopagnosia is difficult to determine. Warrington and James (1967) compared recognition of famous faces (for example, Churchill) with recognition for unfamiliar ones. Although patients with right posterior lesions (none of whom had prosopagnosia) did worse on both, no correlation between the two tests was found. However, DeRenzi, Faglioni, and Spinnler (1968) argue that this could be due to procedural differences between the two tests and their failure to control for variables such as education which might affect the recognition of famous faces.

The various methods employed in the research with brain injured populations reflects a concern with a perceptual and memory component in facial discrimination. These tests are: (1) those testing for visual memory, such as photographs of well-known public figures or of previously unknown faces after an appropriate delay (Milner, 1968); (2) those testing immediate recall of previously unfamiliar faces (De Renzi and Spinnler, 1966) and (3) various matching tests in which a photograph of a face is matched with other photographs of the same face but in different orientations or lighting conditions (Benton and Van Allen, 1968). Performance on all these tests have been shown to be impaired statistically on unselected groups of patients with right hemisphere lesions.

The body of literature involving brain injured populations does clarify the nature of the role of the right hemisphere in facial recognition. DeRenzi et al. (1968) report that their subjects with right hemisphere damage were not impaired on recognition of "eyes" and "mouths", but did score significantly lower than the left hemisphere patients when required to recognize half-faces. This suggests that it is not the visual perception per se that is impaired, but rather the integrative and synthetic processing, considered to be more characteristic of the right hemisphere, required in the perception and memory template of a face. This is consistent with the general information processing differences attributed to the two hemispheres, based upon the integration of several research findings (for example, Nebes, 1972). The left cerebral hemisphere has been considered to be superior in tasks requiring verbal or discrete, analytical processing, such as language expression and comprehension, while the right cerebral hemisphere is considered to be the one better equipped for integrative, holistic and synthetic processing (Bogen, 1969). Dricker, Butters, Berman, Samuels, and Carey (1978) examined the specific processes underlying the deficits in facial memory and encoding in alcoholic Korsakoff patients, right hemisphere injured patients, long term alcoholics, and normal control subjects. The Korsakoff and right hemisphere patients were impaired in their memory and simultaneous matching of unfamiliar faces. Their performance indicated that they matched faces on the basis of superficial features such as paraphernalia (for example, hats and moustaches) and expression rather than deeper configurational characteristics of faces. It is suggested that such superficial encoding may be partially responsible for these patients' visuoperceptual and memory problems. The unexpected similarity in performance between Korsakoff and right hemisphere patients seems intuitively consistent with the speculation that prosopagnosia may be a specialized form of the amnestic syndrome.

To summarize, the posterior regions of the right hemisphere are strongly indicated in the perceptual and memory components of facial discrimination. That prosopagnosia may require some bilateral involvement as well has been a factor in the speculation that the prosopagnosic syndrome may have some basis in an amnestic disorder. However, the need for bilateral involvement for the appearance of prosopagnosia is not surprising from another point of view. There are many indications that the left hemisphere is capable of physiognomic processing, although the processing mechanism is probably somewhat different. Diamond and Carey (1977) write:

> faces have a potential of being represented in two different ways, one of which is also used in representing non-facial stimuli and which remains available after injury to the right posterior sector of the brain (Diamond and Carey, 1977, p.2).

More specifically, the authors attribute to the right hemisphere a "configurational", more holistic, synthesizing processing of faces, and a more "piecemeal" or discrete type of processing to the left hemisphere. That both the left and right hemishpere are involved in the processing of faces is indicated by Benton and Van Allen (1968), who found that both left and right hemisphere groups were significantly inferior to a control group on a face matching task. However, the mean performance level of the patients with right hemisphere injuries was significantly inferior to that of the patients with left hemisphere lesions.

Berent (1977) examined patients before and after a single unilateral electroconvulsive treatment (ECT). Functional demands imposed by the task were the chief factors influencing the relative importance of the right or left cerebral hemisphere to task performance. When the patient's task was to choose a face based upon some familiar facial expression (the actual face was not included in the recognition set amd the patient was asked to select the "one most similar" to that originally presented), left ECT led to a significant increase in both errors and time, while right ECT did not. When the individual was asked to choose the actual face seen (which was included in the recognition set), right ECT led to a significant increase in errors, whereas left ECT showed no such effect. Berent attributed the difference to a "verbal" versus "nonverbal" component of the task.

More recently, Benton (1980) addressed this question in discussing a deficit in face recognition found in patients with left hemisphere damage. He suggested that it arises from impairment of the linguistic function. He emphasized the finding that whereas left hemisphere aphasic patients were impaired at facial recognition tasks, left hemishpere non-aphasics are able to perform as well as control subjects.

Finally, one study conducted with patients in whom the corpus collosum (the fibre tract joining the two cerebral hemispheres) has been severed for medical reasons illusrates the different processing strategies of the two hemispheres with facial stimuli. Levy, Trevarthen, and Sperry (1972) showed these patients chimeric faces which were right-half and left-half composites of very disparate faces. When these chimeric faces are flashed centrally to this kind of subject, each hemisphere tends to "fill in" the missing half of the image. Since the hemispheres are not connected there can be no awareness that the images are conflicting. When the subject is asked to recognize the face by pointing at one of a selection of natural faces, including the complete faces from which the chimeric was derived, he or she unfailingly chooses the face which corresponds to the left half of the chimera, indicating that the right hemisphere is the more signifiant one in facial recognition. However, when recognition is not required, but verbal description is, the subject names the half of the face projecting to his or her left hemisphere.

These studies support a "dual processing" model of hemispheric function which proposes that both hemispheres are capable of processing the same information, but in different ways, which may cause some types of stimuli to be more efficiently processed in one hemisphere (Patterson and Bradshaw, 1975). It may be that when the right hemisphere alone is damaged, there may be enough compensating mechanisms available to be utilized in the left hemisphere to prevent the emergence of clincal prosopagnosia, and to only be detected in more sensitive tests.

A critical issue that remains is how specific to faces the perceptual impairment arising from right hemisphere damage is. The claim has been that the right hemisphere plays a special role in processing non-verbal stimuli (Kimura, 1963). Thus, a longstanding issue has been whether the impairment in facial discrimination tasks simply represents a general impairment in the ability to process visual spatial stimuli. An alternative hypothesis is the existence of a unique analyzer for faces, possibly due to the evolutionary significance of such a skill, located primarily in the posterior right hemisphere. DeRenzi and Spinnler (1966) have directly compared face and object recognition. They found that right posterior injuries, but not other ones, impaired performance on three different recognition tests, which used faces, abstract figures, and chairs. Since performance on the faces was similar to that of the abstract figures, the authors concluded that the difficulty in recognizing faces reflected a general difficulty in making subtle discriminations. Klisch (1979) also found right hemisphere injured groups to perform significantly worse than left hemisphere injured and non-organic subjects on tests of facial recognition and three other visual recognition tests. Of course, these findings do not rule out the possibility of a special analyzer for faces in the right hemisphere in addition to a right hemisphere superiority in processing non-verbal complex visual stimuli. This issue will be discussed in greater detail in a later section.

Tachistoscopic Studies

A rich source of information about hemisphere differences in facial discrimination is the body of studies utilizing a tachistoscope to expose faces to each hemsiphere separately. Due to the pattern of anatomical connections, stimuli presented to the right visual field (RVF) of fixation project to the left hemisphere (LH), while stimuli flashed in the left visual field (LVF) project to the right hemisphere (RH). This, of course, presumes no eye movement during exposure. The tachistoscope permits the very fast exposure times considered to be too fast for eye movements to occur. Exposure times of 200-250 milliseconds or less are generally considered to be under the latency of saccadic eye movement (Wertheimer, 1954).

Despite variations in stimuli and procedures, the inital tachistoscopic studies were consistent in demonstrating a LVF (presumably RH) superiority in facial recognition. This was demonstrated with different kinds of facial stimuli, for example, photographs (Hilliard, 1973; Rizzolatti, Umilita, and Berlucchi, 1971), faces put together from Identikit sets as used by the police (Van Mastrigt, 1977; Geffen, Bradshaw, and Wallace, 1971), schematic faces (Patterson and Bradshaw, 1975), and cartoon faces (Ley and Bryden, 1979).

In these studies the subject is required to match a "target" face presented in one of the visual fields to a "comparison" face. The comparison face is either presented tachistoscopically at fixation or has been previously memorized. The subject must make a same-different judgment between the two faces, usually indicated by a manual response, though sometimes vocally. Many studies use reaction time as the dependent variable (Rizzolatti et al., 1971; Geffen et al., 1971; Rizzolatti and Buchtel, 1977; Moscovitch, Scullion, and Christie, 1976; Patterson and Bradshaw, 1975; Gilbert, 1977; Suberi and McKeever, 1977). In general, these studies reported faster reaction times to faces in the LVF/RH.

Other studies have used accuracy rather than reaction time as the dependent variable (Hilliard, 1973; Ellis and Shepherd, 1975; Marcel and Ragan, 1975; Ley and Bryden, 1977; Leehey, Carey, Diamond and Cahn, 1978; Leehey and Cahn, 1979). These have reported a superior accuracy to facial stimuli from the LVF/RH.

That the right hemisphere is dominant even in the long term storage of faces initially viewed by both hemispheres is supported by Jones (1979). Accuracy of recognition memory for faces initially seen in the central visual field was found to be greater 48 hours later when previously seen and new faces were tachistoscopically presented to the LVF/RH, than when the presentation was to the RVF/LH.

As in the brain injury studies, the distinction betweeen the role of the hemispheres in perception versus memory of faces has been investigated in the body of tachistoscopic literature.

Moscovitch et al. (1976) designed an exhaustive and brilliantly conceived series of studies using reaction time as the dependent variable. They concluded that it is the requirement for a higher level of processing, beyond the simple matching of stimulus characteristics, that is the crucial factor in favoring the right hemisphere in procesing a face. This requirement for higher level pocessing could be because the comparison face involved a memory template, as in the Jones (1979) study, which represented a higher level of abstraction needed to maintain a relatively permanent memory representation. This would be opposed to matching two faces which are presented simultaneously, where a <u>same-difference</u> judgment could be made on the basis of lower level properties such as brightness, contrast, and contour. Similarly, identifying a face by a caricature would also require matching on the basis of a higher level of representation of the comparison face. It should be noted, however, that not all of Moscovitch et al.'s conclusions have gone unchallenged (Sergent and Bindra, 1981; St. John, 1981).

Other studies appeared which demonstrated that the degree to which a LVF/RH superiority could be elicited in a tachistoscopic paradigm could be manipulated to some extent. For example, Patterson and Bradshaw (1975) and Van Mastrigt (1977) investigated the relationship between tachistoscopic visual field asymmetries and physiognomic processing as a function of "serial" and "global" processing. The former concept referred to discrete, analytic, piecemeal type processing associated with the left hemsiphere and the latter referred to the more holistic mode of perception associated with the right hemisphere. Both studies utilized the unilateral tachistoscopic presentation of target faces, to which subjects were required to compare a subsequently presented face. Patterson and Bradshaw (1975) used schematic faces made up of combinations of three features. They hypothesized that where faces are easily discriminable (the face pairs differ on all three features) a global strategy would be most efficient, and hence yield a LVF/RH superiority. However, more difficult discriminations (the target and nontarget face differ on only one feature) would necessitate a discrete serial process, whereby each feature is compared sequentially, yielding a RVF/LH superiority. Their predictions were confirmed using a reaction time measure. Van Mastrigt (1977), utilizing a similar design where he could vary six features on faces using an Identikit, reported similar findings. Recently, Sergent (1982a) was able to elicit a RVF/LH advantage by using drawings of faces that differed on only one or two features.

Although these studies were interesting from a theoretical information processing perspective, they did not challenge the basic premise that the processing of faces was primarily the domain of the right cerebral hemisphere. These studies, after all, artificially varied schematic faces so that they were significantly more difficult to discriminate than normal faces. Real human faces, of course, differ on many features, hence are probably perceived globally, and thus better processed by the right hemisphere.

However, more recently, studies have appeared in the literature which have not only failed to report a LVF/RH superiority, but in some case,have found a RVF/LH advantage. Since all these studies have used photographs of normal faces, they cannot be as easily dismissed as the studies just described of Patterson an Bradshaw (1975) and Van Mastrigt (1977). For example, both Zoccolotti and Oltman (1978) and Rapaczynski and Ehrlichman (1979) found that visual field differences varied as a function of field dependence-independence. Zoccolatti and Oltman (1978) found that field independent males demonstrated the expected LVF/RH superiority in reaction time in a tachistoscopic face discrimination task, whereas field dependent males did not demonstrate any laterality effect. Rapaczynski and Ehrlichman (1979), using female subjects, reported a significant LVF/RH superiority for faces in field independent subjects, and a significant RVF/LH superiority for faces in field dependent subjects, a reversal of the more typical pattern.

Jones (1979,1980) reported that when subjects were required to categorize faces presented in the right and left visual fields as male or female, a RVF/LH advantage results for males, though females demonstrate no consistent pattern. Jones writes:

> ...categorization of faces according to sex requires the subject to make a dichotomous classification on a familiar conceptual basis. Recognition of particular faces may be based on some gestalt representation...However, the speech hemisphere should be specialiazed for broad categorizations of information

since in human beings categorization is a set of abilities characteristically reflected in language (1980, p.495).

Marzi, Brizzolara, Rizzolatti, Umilta and Berlucchi (1974) demonstrated a RVF/LH superiority for pictures of famous people. In order to investigate the possibiltiy that their results may have been due to the verbal labelling of the faces, they repeated the experiment (Umilta, Brizzolara, Tabossi, and Fairweather, 1978). They used four photographs of initially unfamiliar faces, but systematically varied the factors of naming and familiarization (the latter by giving the subjects in the familiarization group the pictures four days before the experimental trials with instructions to familiarize themselves with the faces; the former by assigning a name to each face). They found that naming did not affect laterality differences, but for the males, familiarization of the faces was associated with a RVF/LH superiority. They attributed this change to RVF/LH processing to the possibility that "briefly presented familiar stimuli might be recognized on the basis of only one or two characteristics, thereby endowing a left hemisphere advantage (1978, p.371)."

Proudfoot (1982), in fact, deliberately set out to manipulate a RVF/LH advantage on her tachistoscopic task. Her procedure involved overlearning of a set of five stimulus faces, which she expected should encourage reliance on a single feature detection strategy, and the identification of each target face by name on the subsequent recognition trials. Using an accuracy measure, her data yielded a trend ($p<.10$) in the direction of a

RVF/LH advantage.

It would seem that the results of these last two studies obtaining a RVF/LH advantage by manipulating familiarity are at variance with the research of Leehey and Cahn (1979), who reported a LVF/RH superiority for both familiar and unfamiliar faces. A crucial difference, however, is that familiarity was defined in their study by using photographs of the subjects' colleagues as facial stimuli. Hence, familiarity was not experimentally induced but occurred under natural conditions. Leehey and Cahn attribute the difference between their results and those of Umilta et al. (1978) to the different methods of familiarization used. They suggest that when familiarization occurs mainly via photographs as in the Umilta et al. (1978) study, it is easy to code faces on the basis of discrete features, for example, a square jaw. However, when familiarizarion occurs through day-to-day encounters, the face is seen across a variety of transformations such as mood, lighting, and paraphernalia, and hence are coded as Gestalten, and are processed in the right hemisphere.

Hannay and Rogers (1979) offered a study which suggested that laterality patterns may be influenced by individual strengths or preferences in coding strategies. They found that for males, but not females, the size and direction of visual field scores on tachistoscopic face recognition was positively related to performance on a test of brightness discrimination ability. Subjects with good brightness discrimination ability tended to show a LVF/RH superiority, and those with poor brightness discrimination, a RVF/LH superiority. Also, brightness discrimination ability and Wechsler Adult Intelligence Scale Vocabulary scaled scores were significantly negatively related. The authors speculated that males with a high brightness discrimination ability are more able to code the face visually, a task presumably accomplished best by the right hemisphere. Males with low brightness discrimination possibly cannot make a visual comparison very successfully and so code the stimuli verbally, a task for which the left hemisphere is particularly adapted.

Particularly puzzling are the findings of Galper and Costa (1980), recently replicated by Proudfoot (1982). Galper and Costa's findings are aptly described in the title of their article, "Hemispheric superiority for recognizing faces depends upon how they are learned." They presented photographs of faces for initial viewing centrally under two conditions: verbal presentation of (a) molar personality or (b) physical feature information about each target face. Recognition accuracy scores displayed a highly significant pattern of within-subject contrasting hemispheric superiorities under the two informational conditions, but the direction of contrast was not consistent for all subjects. A second experiment replicated the procedures of the above experiment, except that all verbal encoding information was omitted. Under these control conditions, the "crossover" patterns of hemispheric superiority did not emerge, and subjects instead displayed consistent RVF/LH or LVF/RH superiorities. Note that an overall LVF/RH advantage did not emerge. A second session with the same experimental subjects demonstrated the reliability and generality of the crossover phenomenon. When the original encoding manipulation was applied to a new set of faces, the pattern of contrasting hemisphere superiorities again emerged. No aspect of subjects' performance in the control condition was found to predict the direction of crossover in the subsequent experimental session. The authors concluded that the intra-subject contrasts in hemispheric superiority reflect the use of alternative encoding or processing strategies under the two informational conditions, but the relation of such strategies to specific hemisphere advantage is unclear.

Proudfoot (1982) replicated Galper and Costa's procedures with some changes. Galper and Costa's design involved a large number of poorly learned, infrequently presented targets and an equal number of distractors, placing heavy demands on memory for imperfectly learned stimuli. In contrast, Proudfoot allowed a set of six faces to be overlearned, in order to demonstrate that the crossover effect is not dependent on hemispheric differences in strength or accuracy of the stored target representations. Also, Galper and Costa's design involved massed presentation of the encoding manipulation and subsequent recognition trials under one (social or physical) condition, and the massed encoding and recognition under the other condition. In contrast, Proudfoot's design involved random intermingling, during the recognition trials, of target faces learned under the two conditions and thus minimized the potential contribution of selective activation factors to any pattern of contrasting hemispheric asymmetries. Also, subjects were required to identify the photographs by name, unlike the Galper and Costa design where subjects had only to indicate recognition of the face. Finally, the subjects in Galper and Costa's study were male, while the sample in the Proudfoot study was female.

Despite all these differences, Proudfoot obtained identical results to Galper and Costa. As in the previous study, the direction of within-subject crossover was about evenly distributed between those subjects displaying LVF/RH superiority in the social encoding condition and a RVF/LH superiority in the physical encoding condition, and those subjects displaying the reverse pattern. And, as in the previous study, the direction of crossover was not related to hemispheric asymmetries in a control condition. The compatible findings of the two studies provide strong evidence that hemispheric asymmetries (or their absence) are determined by the cognitive processing and encoding strategies to which stimulus materials are subjected and not just by the nature of the stimuli themselves.

Sergent and Bindra (1981) offered some theoretical integration of the inconsistencies that were appearing in the literature. They reviewed the literature on the tachistoscopic presentation of faces. By paying particular attention to the different procedural details used in the studies, for example, reaction time versus accuracy measures, they concluded that certain conditions favor the likelihood of a LVF/RH advantage in a tachistoscopic paradigm, and hence the presumed LVF/RH advantage for processing physiognomic stimuli may to a large extent be an artifact of the tachistoscopic procedures. These conditions include (a) degraded stimulus information (for example, short tachistoscopic exposures, peripheral vision); (b) high discriminability of the faces to be compared (the faces are highly dissimilar); (c)acquaintance with the set of faces to be used and their distinguishing features; and (d) low task complexity (that is, only low level operations such as same-different discrimination or recognition are required, rather than operations requiring more complete information, such as in an identification task). Sergent and Bindra point out that most of the procedural factors that favor the emergence of a LVF/RH advantage are to some extent dictated by the nature of the typical laterality experiments on face recognition. For example, to obtain lateralized viewing, eye movements must be prevented; this requires a short exposure time and hence degraded information. This in turn leads to the use of highly discriminable (easy) comparison faces to minimize errors in reaction time tasks. Faces can be made more highly discriminable by making the distinguishing dissimilarity highly salient (for example, a large feature such as a jaw or hairline contours). Studies using an accuracy measure require the stimulus information to be even more degraded to prevent ceiling performances. Hence the exposure times are even faster than those of reaction time studies (eight milliseconds, Finlay and French, 1978; 15 milliseconds, Ellis and Shepherd, 1975; up to 120 milliseconds, Leehey and Cahn, 1979). This analysis of the conditions favoring a LVF/RH advantage appears somewhat similar to the serial/global distinction discussed earlier. However the crucial difference Sergent and Bindra argue is that, rather than being something artificial that can be manipulated into an experiment, the contribution of the left hemisphere in facial processing is a genuine one. Rather, it is the apparent right hemisphere advantage that is the methodological artifact of the tachistoscopic procedure.

The authors reinterpret the serial/global distinction in terms of each hemisphere being better equipped to handle information at different levels of sensory resolution or stimulus clarity. They argue that the left cerebral hemisphere is best equipped to process information at high levels of sensory resolution, that is, when the percept is complete and discrete, whereas the right cerebral hemisphere is at an advantage with more diffuse information. For example, DeRenzi and Spinnler (1966) found the performance of right hemisphere injured patients to be impaired relative to left injured patients on the Street Gestalt Completion Test. This test requires the identification of fragmented perceptual information. Warrington and James (1967) found impairment in the recognition of incomplete pictures of objects to be more severe in subjects with right hemisphere lesions than in subjects with left hemisphere damage. Thus, a LVF/RH advantage emerges in conditions that do not allow or require the achievement of a complete percept, and it is this which lies at the basis of the right hemisphere's advantage in holistic processing. Sergent (1982c, 1982d) does elsewhere provide some experimental support for this distinction between the hemispheres, and argues that it results from differences in the sensorimotor resolution capacities of each hemisphere. This does not mean that right hemisphere processing is speeded up by the incompleteness of the visual percept but rather that, under conditions of stimulus uncertainty, the right hemisphere may be a faster processer than the left hemisphere, whose own capacities are not allowed to emerge under these conditions. They state that:

> the idea may be examined by determining whether a LVF/RH advantage would disappear when a clear and complete percept is achievable, under the given procedural conditions (1981, p. 552).

Hence, when more complete information is provided as in the identification task of Marzi et al. (1974), where famous people had to be identified, a RVF/LH superiority emerged. The authors point out that in this particular study, longer than usual exposure durations (400 milliseconds) and therefore less degraded information was allowed to ensure an acceptable level of accuracy.

Finally, Sergent, in another article (1982a), makes the excellent point that many experiments have in fact recorded only same and not different reaction times. In what is known as a "go/no-go" paradigm, a response is made only if the tachistoscpic face is recognized. When the face is different from the target face, no response is made. For example, Rizzolatti and Buchtel (1977), Moscovitch, Scullion, and Christie (1976) (experiments three and four) chose a go/no go paradigm, providing latencies for only same responses. This may increase the probability of a LVF/RH superiority since same responses are in most cases more likely to be holistic and therefore performed faster by the right hemsphere (Patterson and Bradshaw, 1975). This suggests that research on hemispheric differences may be biased towards a right hemisphere involvement.

The analysis of Sergent and Bindra (1981) represents a significant contribution towards clarifying the specific processes tapped in tachistoscopic procedures when they are used for investigating the cerebral laterality of physiognomic processing, and thus alerts one to the limitations of the methodology and the conclusions thus derived. However, it cannot account for all the inconsistencies in the tachistoscopic literature. In particular, the findings of Galper and Costa (1980) and Proudfoot (1982) of opposing within-subject asymmetries as a function of encoding mechanism, all other procedural details and stimuli being held constant, cannot be integrated into their analysis. Furthermore, although not actually stated by the authors, the implication of their argument is that under more natural viewing conditions when clear percepts of faces are available, the right hemsphere may not be any more involved in the information processing than is the left hemisphere. Some contribution of the left hemisphere is of course supported by the brain injury literature just reviewed. However, the hypothesis of a unique and prominent role for the right cerebral hemsphere in physiognomic processing remains difficult to dismiss in view of the findings discussed in the following section.

Perceptual Bias Techniques using Chimeric Faces

Wolff (1933) noted that when faces were artificially divided into left and right halves by bisecting photographs longitudinally, subjects reported the right half to be more like the original face than the left half. The apparent asymmetry of faces was further demonstrated by making right-right and left-left composite pictures and asking the subject which composite bore closer resemblance to the original face. His results have been replicated by McCurdy (1949) and Lindzey, Prince, and Wright (1952). It might be concluded, following Wolff, that these studies indicate that the bias for the right side of the face was due to some particular content in the face itself.

Gilbert and Bakan (1973) questioned that the resemblance was a function of the characteristics of the face itself. They proposed that it might be due to a perceptual bias in the observer. By photographically reversing the face with which the left and right bilateral constructions were compared, they determined that the observed effect derives from asymmetrical left field perceptual bias rather than the qualities in the faces themselves. In other words, subjects usually chose the face made up from that half which had been in their LVF as looking more like the original face. They hypothesized that the perceptual bias might be due to a right hemisphere specialization for facial recognition, coupled with more direct image transfer from the LVF to the right hemsphere. This hypothesis was based upon the growing research strongly implicating the right hemisphere in facial recognition, and the anatomical fact that material in the LVF projects directly to the right hemisphere of the brain. The possibility that the effect might be due to a left to right scanning bias due to reading habits was rendered unlikely when the result was replicated by native Israeli subjects. Furthermore, their reasoning based upon the cerebral asymmetry of function was consistent with their observation that when left handed subjects, whom the research suggests may be less functionally lateralized (Hecaen and Sauguet, 1971) were investigated, no clear preference was given. This difference between right and left handers on this test was replicated by Lawson (1978).

This same differentiation between left and right handers emerges when the more traditional method of unilateral tachistoscopic exposure is used. McKay (1979) found that the largest percentage of individuals demonstrating a LVF/RH advantage for faces was in her group of right handed individuals with no familial sinistrality. Both left handedness and familial sinistrality were associated with decreased percentages of subjects exhibiting the pattern. Piazza (1980) reports that only right handed subjects with no familial sinistrality demonstrated significant LVF/RH advantages for the processing of faces. Left handedness and the presence of familial sinastrality resulted in weaker left or weak right visual field advantages in this task. These two studies are at variance with Gilbert (1977) who found no visual field effects due to handedness or familial sinistrality. However, he did not control for the interaction of the handedness and familial sinistrality variables as well as did the two studies cited above. Hence, the similar pattern of results obtained about the differences in laterality patterns between right and left handers with the tachistoscopic indices and the percpetual bias test, strengthens the cerebral asymmetry explanation of the perceptual bias effect.

Ellis (1975) suggests that a more plausible explanation of the perceptual bias effect can be postulated upon a model of asymmetry in cerebral attention proposed by Kinsbourne (1973). Kinsbourne argues that when either hemisphere is temporarily dominant (the left hemisphere during verbal activity, and the right during the analysis of visual spatial material), there is a tendency for contralaterally directed eye movements to occur.

Thus, when looking at faces, the right hemisphere is more active than the left hemisphere, and there is a fixation bias towards the left half of the visual field that could well mediate the preferences reported by Gilbert and Bakan (1973).

However, Campbell (1978), using the perceptual bias paradigm, found LVF biases whether the faces were allowed free view exposure or were presented centrally at fixation in a tachistoscope. Since the latter procedure would eliminate the possibility of contralaterally directed eye movements, this mitigates Ellis's objection. Campbell (1978) used the chimeric face paradigm to investigate whether the judgment of a facial expression is susceptible to lateralization in the observer. It was predicted that, for right handed subjects, a face in which a smile was confined to one half of the face, the other half being expressionless, would be perceived as happier while the smile was on the half of the face seen in the viewer's LVF. Ten men and women were photographed once when smiling and once when relaxed. Each of the photographs was cut down the midline of the face and a smile-half combined with a non-smile-half for each face. This produced a pair of chimeric faces with a half smile on the left or right. The chimeric faces were rephotographed and, using reversed negatives, mirror images of the two chimeric faces were also obtained. The faces were exposed either free view or at fixation in the tachistoscope. A pair of pictures of the same person was shown one at a time, and subjects were required to judge which member of each pair looked happier. The results demonstrated that faces were more likely to be judged happier when the smile was in the LVF. Heller and Levy (1981) replicated the procedure using the tachistoscopic exposure only, and found the effect for right handers, but not left handers.

The finding of a perceptual bias in the observer towards one of the visual fields does not rule out the possibilty of a true asymmetry in the human face as well. Campbell (1978) found that the LVF bias was more marked for mirror than for normal orientations. This indicates that under the conditions of the experiment, sitters smiled more with the left half of their face. Such a finding is actually quite consistent with a hemisphere model. Neuroanatomically, both hemispheres have ipsilateral and contralateral projections innervating facial muscles, with a greater preponderance of contralateral projections, particularly in the lower half of the face. Similar findings have been reported, as in the Campbell study, with posed expressions (Sackheim and Gur, 1978), but also spontaneous expressions (Heller and Levy, 1981). Analysis of video recordings have also reported the left side of the face to be more expressive, although some differences on the basis of handedness and sex have been found in some studies (Moscovitch and Olds, 1981; Borod and Caron, 1980). Since the present investigation deals with the perception of faces rather than facial expressiveness, this area will not be pursued further. However, the intriguing possibility exists that the side of the face which dominates the viewer's impression when he or she is looking at another person is not the side which the expresser is using most strongly.

At any rate, the reports of a LVF bias described in the above body of literature when viewing chimeric faces does suggest that the right hemisphere may, even under free viewing conditions, play the more prominent role in the perception of faces.

Is There a Unique Analyzer for Faces in the Brain?

If the right cerebral hemisphere does play a special role in the perception of faces, does that role represent anything more than an advantage in the perception of complex visual-spatial stimuli or the global, holistic mode of processing that has been attributed to that hemisphere? Does recognizing faces involve an evolutionary predisposition for interpreting the distinctive features of a face, which does not necessarily relate to the ability to recognize other common objects?

A series of experiments by Yin (1969, 1970) argue for a face specific recognition system. In the first of these (Yin, 1969), he demonstrated with normals that, compared with other classes of stimuli (houses, airplanes, men in motion), to which we are exposed in an upright position, the recognition of faces is best in an upright orientation and worst when inverted. Yin interprets this disproportionate detrimental effect of inversion on facial recognition as indicating a unique factor related only to faces. Yin's results have been replicated by Carey and Diamond (1977).

In a second study, Yin (1970) repeated the experiment with pictures of houses and faces, but compared patients with right posterior cerebral injuries, patients with other unilateral injuries (mainly left hemispere), and normal subjects. The upright and inverted presentations of houses did not show the same dissociating performance by the two patient groups. The right posterior group did worse on both tests, though the differences were not significant. The crucial relationship was that the posterior right patients did not differ from normals in recognizing inverted faces, still a complex visual stimulus, but were different in the recognition of upright faces, whereas patients with left posterior lesions performed like the normals in the recognition of both upright and inverted houses. Yin concluded that it was a capacity specific to the encoding of upright faces which patients with these lesions lost. Two objections levelled against Yin's work are the failure to control for the variables of complexity and familiarity across faces and houses. Ellis (1975) states that until stimuli of comparable complexity and familiarity to faces can be found, Yin's conclusions are not strong.

Ingate (1979) attempted to control for these two objections. To control for complexity, she constructed a set of houses to have equivalent dimensional structures as the faces she used, and repeated Yin's procedure. Despite the attempt to control the complexity of the two sets of stimuli, the effect of orientation was significantly greater on the recognition of faces than on the recognition of houses. She tested the hypothesis that the greater inversion effect for faces might reflect the greater familiarity of the subjects with the distinctive features of upright faces than those of houses. To test this, white subjects were shown photographs of white faces and a presumably less familiar category of black faces. If the inversion effect was due to differences in the differentiation of the sets of stimuli, it was predicted that the inversion effect would be greater for white faces. This prediction was not confirmed. Ingates's failure to find a difference in the inversion effect for black and white faces in white subjects would argue against the objection that it is greater familiarity of faces compared to houses that accounts for the greater inversion effects of the former.

Leehey et al. (1978) adapted Yin's methodology to a tachistoscopic paradigm. They compared visual field advantages for the recognition of upright and inverted faces under lateralized tachistoscopic presentation. They reasoned that if the right hemishpere of normal adults is involved in the perception at a face-specific level as well as a general visual spatial level, there should be an interaction between lateral field of view and orientation of face stimuli. Whatever the degree of LVF/RH advantage of upside down faces (visual stimulus equally complex to upright faces), this advantage should be even greater for upright faces (as comparable patterns, and additionally as upright faces). Their results were consistent with this prediction. While upright faces were recognized significantly better in the LVF/RH, the LVF advantage for inverted faces failed to reach significance.

This pattern of results was replicated by McKay (1979). Ellis and Shepherd (1975), on the other hand, failed to find such an interaction. However, their results are less credible than those of the other investigators. Their sample was small (eight subjects), and their exposure time (15 milliseconds) was so short as to raise the question of whether their stimuli were actually processed as faces (Chi, 1977). This latter possibility is supported by the fact that they failed to find a poorer recognition score for inverted faces, compared to upright ones.

Recently, St. John (1981) criticized the practice of comparing upright and inverted faces as method for addressing the issue of the existence of a unique analyzer for faces. He concludes that the results are difficult to interpret if one considers that inverted faces are probably less familiar, more difficult, and must be presented for longer exposure durations in order to obtain error scores similar to those associated with upright presentations. Recall Sergent and Bindra's analysis of how these variables can influence the laterality patterns in a tachistoscopic paradigm. St. John chose pictures of two kinds of common familiar shoes, sneakers and loafers, in different orientations and presented them in pairs unilaterally in a tachistoscope, and subjects were required to indicate on each trial whether the shoes were the same or different. Subjects performed an equivalent task with faces in different orientations. In order to rule out the possibility of priming of the right hemisphere due to the facial discrimination task, he ran the two different tasks in separate experimental sessions. Under these conditions, there was a significant LVF/RH advantage for faces only and not shoes. Also important was the fact that both error and reaction time measures indicated that the tasks were of equal difficulty. Thus the visual field x object interaction could not be attributed to differing levels of difficulty on discriminating the two kinds of objects. One of the interpretations of these results offered by the author is the presence of a unique analyzer for faces in the right hemisphere, apart from any other special visual spatial abilities that the hemisphere may possess.

It would seem that any resolution of this issue rests ultimately on a consensus as to what other object possesses the same degree of complexity, familiarity, and meaningfulness as a human face, and can therefore be utilized as an appropriate control in research.

The Role of Emotion in Facial Processing

If faces are a uniquely processed visual stimuli, what might account for this unique quality? Yin suggests that:

> ...the difference in looking at upside down faces results mainly from the inability to discriminate the "expression" of the face or some other attribute relating to the face as a social object; patients with right posterior injuries were unable to appreciate fully such attributes in the first place, perhaps treating faces as other types of non-human objects and were consequently less affected by inversion (Yin, 1970, p.401).

Thus the crucial variable may be the emotional salience of faces. This is consistent with the accumulating clinical (Ross and Mesulam, 1979) and experimental (Carmon and Nachson, 1973) evidence that the right hemisphere is more responsive to the emotional salience of stimuli than is the left. This notion is close to that of Hochberg (1968) who suggested that faces are seen as wholes, and well remembered, only because they express - that the unified gestalt of a particular face is formed and maintained by features in expressive harmony.

This viewpoint would predict that the right hemisphere advantage for processing faces would be greatest when looking at extremely emotional faces and less when the faces are neutral. Early studies did not control for this variable. Recently, studies have appeared, all using tachistoscopic paradigms, which have systematically explored the relationship between laterality and emotionality of the facial stimuli.

Ley and Bryden (1979) used as stimuli cartoon drawings of five adult male characters, each with five emotional expressions ranging from extremely positive, mildly positive, neutral, mildly negative, to extremely negative. Single stimuli were presented unilaterally for 85 milliseconds. Subjects were asked to compare this target face to a subsequent centrally presented face, and to decide whether the emotional expression of the two faces, and the character represented by them, were the same or different. Significant LVF/RH superiorities for both character and emotional expression discrimination were found using an accuracy measure.

To examine the independence of the character and emotion effect, two analyses of covariance were carried out. When the influence of the character error variance was removed, all of the significant main effects and interactions of the emotion error analysis were maintained. In fact, the significance levels increased. Thus, the character error variables contributed minimally to variations in the emotion error means, indicating that the face recognition did not affect emotion recognition. A second analysis of covariance was performed, this time with emotion errors as the covariate and character errors as the dependent variable. This resulted in the loss of the significant main effect for visual fields. The authors conclude:

> There are two possible explanations for this result. First, the primary analyses suggest that the character effect is smaller than the emotion effect. Second, the character effect may be partly due to the emotional expression effect (Ley and Bryden, 1979, p.136).

The LVF/RH superiority for emotion judgments was related to the degree of affective expression. The LVF superiority was highly significant for the extremely positive expression and particularly for the extremely negative expression, but not statistically significant for the mildly positive, neutral, and mildly negative emotions. The relationship of degree of emotion to the character recognition was not as clear cut. There was a consistent LVF superiority for characters of all five emotional expressions, except for the mildly negative one. Once again, the largest visual field differences occurred with the extremely negative emotional expression.

The finding that the extremely negative emotion produced the largest LVF advantages for both the character and emotion discrimination tasks is consistent with some studies which report the right hemisphere to be more involved in producing negative emotions and the left hemisphere more involved in producing positve emotions (Rossi and Rosadini, 1967) and a similar dichotomy in the perception of positive and negative affect (Dimond and Farrington, 1977). These results are not always found, however (Harman and Ray, 1977; Milner, 1967).

Suberi and McKeever (1977) found that the presence of emotion in memorized faces resulted in an augmentation of LVF superiority. Their stimuli were 16 facial photographs from each of four models. Each model projected a "neutral", "happy", "sad", and "angry" facial expression. They wore hoods which covered their ears and hairlines. Suberi and McKeever ran three groups of female subjects. Subjects in each group memorized two target faces and were later tested using unilateral tachistoscopic presentation, and were required to judge whether the tachistoscopically presented face was the same or different than one of the faces they had memorized. One group, Group Neutral, studied neutral targets and were required to discriminate these from neutral non-target faces. A second group, Group Emotional, memorized and discriminated all emotional faces. The final group, Group Mixed, was divided into halves with half the group studying emotional faces and discriminating these from neutral non-target faces, and the other half viewing neutral target and emotional non-target faces. The authors found that the order of the groups on LVF/RH superiority magnitude , from first to least, was Group Emotional, Group Mixed, and Group Neutral. Further, the magnitude of LVF superiority did not differ significantly among the groups. Thus, it appeared that the presence of emotional affect tended to augment the LVF/RH superiority, but not significantly so.

A post hoc analysis helped to clarify the situation. The authors noted that, on debriefing, subjects generally expressed surprise that the non-target faces looked as they did, which suggested that they were not recognized distinctly in their own right, and that the discrimination of target and non-target faces was based principally on target recognition or lack of it. This prompted the authors to examine more closely the effect on performance of type of target face memorized. Half of their total group of subjects had memorized neutral target faces while the other half had memorized emotional target faces. In an analysis comparing these two groups, it was found that both groups exhibited a significant LVF/RH advantage and that, additionally, a significant groups x fields interaction existed. Subjects who had memorized emotional target faces exhibited a larger LVF/RH superiority than did subjects who memorized neutral target face.

While there was a significant overall LVF/RH advantage in Suberi and McKeever's data, differences in reaction time for the two half fields did not reach significance ($p<.10$) in the Group Neutral condition which used only neutral faces. This pattern of results, together with Ley and Bryden's finding that the visual field effect disappeared when an analysis of covariance was conducted on emotion discrimination errors, suggests that it is the emotional salience of faces that may in fact be the primary factor in accounting for their right hemisphere advantage. However, a complicating factor is that in both these studies the subjects were females (17 of the 20 subjects in the Ley and Bryden study were female). It could be argued that females are less lateralized than males in visual spatial skills (McGlone and Davidson, 1973) and that unemotional faces are closer to being simply visual spatial stimuli. Different results might have been obtained using males. Rizzolatti et al. (1971) demonstrated a highly significant visual field effect using reportedly neutral faces with a male sample.

Dixon (1977) thus set out to compare males and females in exploring the relationship between laterality in facial recognition and emotionality of the faces. He also attempted to control for a confounding factor which existed in Suberi and McKeever's (1977) study (which is also present in Ley and Bryden's design). It could be argued that emotional faces are more "complex" spatially than neutral faces; thus, judging emotional faces permits the right hemisphere to more dramatically demonstrate its hypothesized superior spatial abilties. Dixon (1977) attempted to devise a test of these alternative "spatial memory" and "emotional memory" hypotheses, that is, to design an experiment capable of unconfounding these variables in a definite manner.

Dixon's (1977) procedure was identical to Suberi and McKeever's (1977) except that he used only the neutral faces utilized by the latter. To vary the emotionality of the faces, two sets of instructons were given. One group of subjects was asked to imagine that the persons whose faces they memorized were either depressed and unhappy ("emotional" instructions) or relaxed and at ease ("neutral" instructions). These instructions were carried out during the five minute memorization period and during the short rest periods between blocks. Emotionally instructed but not neutrally insructed females exhibited a LVF/RH superiority. Surprising in terms of the research up to that point, males failed to exhibit a LVF superiority in either instructional condition. However, regardless of instructional condition or sex, subjects who perceived the faces as emotional (as measured by their ratings on a emotional-unemotional bipolar scale) demonstrated a LVF/RH superiority. One unaccounted for result was that males, but not females, who rated the faces as unemotional tended ($p<.10$) to towards a RVF/LH superiority.

Dixon concluded that the results supported the "emotional memory" model and mitigated the "spatial complexity" model for explaining the LVF advantage for emotional facial stimuli. A major contribution of his study is the need for individual validity checks on the emotionality manipulation in experimental subjects.

It is interesting to speculate on the source of the trend towards left hemispere dominance in males for faces which they perceived as unemotional. As the perceived emotionality of a face is hypothesized to "pull" a face towards the right hemisphere for processing, perhaps, as noted by Sergent and Bindra (1981), other factors in a tachistoscopic procedure can "pull" a face towards the left cerebral hemisphere. Certainly through the interaction with the faces during the five minute memorization period and the time between blocks, the subjects would be quite familiar with the stimuli. Also, it is conceiveable that, in Dixon's (1977) procedure, during the five minute memorization period in which subjects were asked to imagine the target faces as being "relaxed" and "at ease" or "saddened, frantically unhappy and deeply depressed" (p. 67), considerable verbalization and labelling occurred. In fact, the neutral instructions actually stated: "Words such as 'relaxed', 'at ease' and 'composed' might be taken to describe them at the time the pictures were taken (p. 71)." This might "pull" the face towards the left hemisphere. However, the amount of emotionality perceived by each subject would "pull" the face towards the right hemisphere. Hence, faces pereived as emotional would be better processed in the right hemisphere. But if the emotionality factor was not present, the verbal mediation involved in processing the face would result in a RVF/LH superiority. That this did not cccur for females may reflect defferences in the lateralization of verbal processing in male and female brains (McGlone, 1980).

Thus far, the research demonstrates that degree of emotionality of faces did seem to enhance right hemisphere dominance for faces, and raises some question as to whether the perception of non-emotional faces are in fact lateralized at all.

Hansch and Pizzolo (1980) investigated laterality effects for character and emotion discrimination on two separate tasks by unilaterally presenting in a tachistoscope a set of three neutral faces or a set of three emoticnal expressions. There was a significant LVF/RH advantage only for the task involving emotional expressions. However, since the LVF advantage between the two tasks did not differ significantly, the authors concluded that face perception could not be isolated from the perception of emotional expression. Although their sample included both males and females, they were not compared.

DeKosky, Heilman, Bowers, and Valenstein (1980) compared primarily male right hemisphere disease patients, left hemisphere disease patients, and control patients on a series of four free view tasks using photographs of faces. These four tasks were a character discrimination task involving neutral faces, a task whereby subjects were required to name the facial emotion presented in a photograph, a task where the subject was required to select from a number of faces the one demonstrating a named target emotion, and a same-different emotion discrimination task. The right hemisphere group performed significantly worse relative to controls on all the tasks except the one in which subjects were required to select a named target emotion, where the difference between the two brain disease groups failed to reach significance. However, it was only on two tasks, the character discrimination and the emotion discrimination, that the left hemisphere disease group did not perform significantly worse than the normal controls. This would suggest that these two tasks most clearly represent the functioning of the right cerebral hemisphere. Note that the other two tasks required some form of verbal mediation, either expressive or receptive.

Strauss and Moscovitch (1981) compared identity and emotional expression perception with a normal sample. Their task demands, however, were more difficult because identity and expression discriminations had to be made across six different characters and six expressions. For example, a _same_ judgment applied when the two tachistoscopically flashed faces expressed the same emotion regardless of whether the two actors were the same or different. Conversely, identity matches had to be made regardless of the emctional expresson so that two photographs of the same actor displaying two different emotions would still be judged as a _same_ response in the character discrimination task. Expression and identity discrimination tasks were run separately using a memory free paradigm, where the two faces to be discriminated were presented simultaneously in the same visual field. The expression discrimination task was repeated in a memory paradigm whereby subjects were required to match the unilaterally presented face to a previously memorized target expression. The authors found that in all three experiments, both males and females demonstratd significant LVF/RH advantages for _same_ responses though _different_ responses did not yield consistent visual field effects. The authors concluded that both face and expression perception call upon similar, though not identical, brain mechanisms since the perception of facial expressions in their design took longer than the perception of facial identity. Males and females did not differ in processing time for the facial expression tasks, but males were faster than females on the discrimination of facial identity. In particular, the authors note that asymmetries favoring the right hemisphere were more reliable in adult females than in males, and the females showed as large, if not larger, perceptual asymmetries as did males in face and expression perception tasks.

A similar conclusion is reached by Lavadas, Umilta, and Ricci-Bitti (1980), who compared males and females on an emotional discrimination task. In a go/no-go procedure, the authors utilized the six emotions of the Ekman and Freisen (1975) set - neutral, happy, sad, surprise, disgust, and anger. At the beginning of each series, subjects were required to depress a microswitch as quickly as possible following the unilateral presentation with the particular target emotion for that series. This design seemed to permit a separation of the processes involved in the perception of facial expressions from those underlying the perception of faces per se. The task required the subjects to compare each stimulus to a mental representation of an affective category irrespective of the face actually presented. The results showed a significant LVF/RH superiority for females but not for males. There was also a sex main effect significant only on the basis on a one-tailed test. Females yielded faster reaction times than males.

Thus far, the research seems to lean somewhat towards a suggestion that in tasks of emotion discrimination, females might be somewhat more right hemisphere lateralized than males. Although Buchtel, Campari, de Risio, and Rota (1978) had reported a LVF/RH superiority for sad and happy expressions when only male subjects were employed, Lavadis et al. (1980) point out that Buchtel et al. utilized only three facial expressions (one of them neutral), and argue that therefore their task was less sensitive in the separation of the emotional and visual spatial components of the task.

However, a study by Safer (1981) further complicates the issue. Safer made the opposite prediction. He predicted that males would demonstrate a larger right hemisphere advantage for the discrimination of emotional expression because of the better performance of the female left hemisphere relative to the male left hemisphere. His interesting hypothesis is based on reports that females are likely to be more practiced and skilled than males in describing their emotional feelings (Cozby, 1973) and that they tend to behave more consistently with reports of their emotional feelings (Cupchik and Leventhal, 1974). He proposed that females' greater integration of emotional experiences with verbal descriptions suggests that they might have special access to left hemisphere verbal codes for emotion. In addition, he cites the literature which suggests that females are somewhat more likely than males to use verbal strategies and skills in tests of spatial abiltiy, such as locating a briefly presented dot (Kimura, 1969).

In Experiment 1, subjects saw 120 pairs of facial expressions of six different emotions. Subjects saw one expression from the pair in the centre of a small screen for eight seconds. Half the subjects were told to empathize with this first expression and half were told to label it. The second expression in the pair was then briefly exposed to either the left or right visual field, and subjects indicated by verbal response whether the two expressions represented same or different emotions. Across the two conditions, Safer found greater accuracy from the LVF/RH for the males only. As predicted, females were more accurate than males from the RVF/LH. He then investigated the two strategy groups separately. In the verbal labelling group, there were no lateral asymmetries for either sex. In the empathy condition, although both males and females exhibited a LVF/RH advantage, it was significant only for the males. Also, the female labelling group was the only one to demonstrate a RVF/LH superiority which, although in itself was not significantly different from zero, was significantly different from the other three groups.

To demonstrate that the sex difference obtained above was specific to emotional processing and not general visual spatial abilty, Safer repeated the experiment but with a facial identity task. Here, a <u>same</u> judgment would refer to the comparison of identical slides, that is, same person and same expression, whereas a <u>difference</u> judgment would indicate either a different person or a different expression. Labelling and empathy instructions were not used since Safer considered them to be theoretically irrelevant for this task. He reasons:

> Whereas both verbal and imagery codes are likely to be useful in recognizing emotional expressions, imagery codes are likely to be much more effective than verbal codes in recognizing unfamiliar faces (p. 95).

In this new task, both males and females demonstrated a LVF/RH advantage. Safer thus concludes that the different pattern of results obtained from the two experiments support the differentiation between character and emotion discrimination. Their differentiation rests primarily in the use of left hemisphere verbal codes which can be utilized in the discrimination of emoticnal expressions, particularly in the case of females, whereas face dscrimination relies primarily on imagery coding, more the domain of the right hemisphere. Safer's argument would be stronger, of course, if he had in fact replicated the labelling and empathy instructions in the face discrimination task. This would more directly demonstrate that verbal labelling is not utilized in a face discrimination task even when, as in his study, emotional faces are used.

Finally, the findings of Reuter-Lorenz and Davidson (1981) complicate the issue further. Emotional and neutral facial expressions of the same individual were presented simultaneously, one to each visual field, and subjects were required to identify the side containing the affective face. Reaction times were faster to right than left visual field presentations when the expression was happy and vice versa when it was sad. The data support the hypothesis of differential hemispheric specialization for positive and negative emotion. However, Strauss and Moscovitch (1981) failed to find such a difference between happy and sad faces. Their task, though, was far more difficult, probably requiring more "higher level abstracting" (Moscovitch and Scullion, 1976).

Sex Differences in Cerebral Asymmetries for Facial Processing

The sex differences that are emerging from the recent research on the discrimination of facial expressions is interesting in view of the failure to report such differences in the body of literature preceeding the concern with the emotionality of the facial stimuli. The failure to report differences was significant in view of the suggestion by several authors that visual spatial abilties, certainly a component of facial processing, may be more lateralized in men than women (Kimura, 1969; McGlone and Davidson, 1973; McGlone and Kertesz, 1974). However, other reseachers using similar tasks have reported no sex differences in degree of lateralization (for example, Ehrlichman, 1972).

With the exception of one study (Rizzolatti and Buchtel, 1977), which will be discussed in detail later, the tachistoscopic studies do not report sex differences in the lateralization of facial recognition. Many studies have not reported the sex composition of their sample, or did not analyze for sex differences (Ellis and Shepherd, 1975; Geffen et al., 1971; Moscovitch et al., 1976), or have used ony males (Rizzolatti et al., 1971; Zoccolatti and Oltman, 1978). Studies utilizing females have demonstrated the expected LVF/RH superiority (Hilliard, 1973; Ley and Bryden, 1979; Reynolds and Jeeves, 1978). Other studies have looked at sex differences and not found them (Finlay and French, 1978; Gilbert, 1977; Leehey et al., 1978; Patterson and Bradshaw, 1975; Hannay and Rogers, 1979), including several studies using children as subjects (Marcel and Ragan, 1975; Reynolds and Jeeves, 1978; Young and Ellis, 1976). Taken together, the studies in which females have exhibited a LVF/RH superiority cover the spectrum of different procedures, stimuli, and dependent variables used in tachistoscopic studies.

Only one study reports a sex difference in a tachistoscopic face recognition task (Rizzolatti and Buchtel, 1977). During a practice session, subjects learned to recognize photographs of four faces, two of which were designated as target faces. Faces were presented unilaterally for 100 milliseconds and the subject was required to indicate manually whether each face was one of the target faces. Reaction time was the dependent variable. Males demonstrated a significant LVF/RH superiority but females did not. The authors reduced the exposure time to 20 milliseconds to make the task more sensitive to hemisphere differences. Under this condition, the hemisphere difference in males was markedly increased but there was still no evidence of lateralization in the female subjects. The authors concluded that females may have a neurologically lateralized mechanism for face recognition, but the conditions of activation are different in that females require more information in order for the specialized right hemisphere mechanism to be activated. They argue that previous studies which report LVF/RH superiority for faces have provided greater information either by double presentations (central exposure either preceeding or following the unilateral presentation) or longer exposure times.

Their hypothesis is not without some basis. Chi (1977) measured the threshold for recognition of a centrally placed photograph of a highly familiar face. The subjects in her experiment had ample experience with the restricted set of eight photographs, all of which depicted colleagues known for several years. The threshold for recognition under these favorable circumstances was 42 milliseconds. Ellis and Shepherd (1975) tachistoscopically exposed upright and upside down faces for 15 milliseconds. Contrary to consistent findings by several researchers (Yin, 1969; Leehey et al., 1978; McKay, 1979) they did not find upright faces to be better recognized than upside down faces. Leehey et al. (1978) suggest that this unexpected finding occurred because the exposure time was too fast for the faces to be processed as such. It may be that because of the 100 millisecond, and certainly the 20 millisecond, exposure times used by Rizzolatti and Buchtel (1977), their faces were not in fact being processed as faces but as general visual spatial stimuli. The LVF superiority for males but not females would be consistent with the suggestion of a greater lateralization in males for visual spatial stimuli. Recall that Sergent and Bindra (1981) argue that the more degraded the stimuli are, the more a LVF/RH advantage is favored.

Yet Ley and Bryden (1977) and Safer (1981) obtained LVF/RH advantages for females on a face discrimination task at 85 milliseconds and 30-50 milliseconds respectively. However, in both these cases, unlike the Rizzolatti and Buchtel (1977) study which utilized neutral faces, emotional faces were used. In the Ley and Bryden study, the emotional aspect of the task was particuarly salient since the task involved both emotion and character discrimination. Recall that when Ley and Bryden covaried out the emotion discrimination errors, the LVF advantage for character recognition disappeared. Recall also the Suberi and McKeever (1977) study with females where a LVF/RH was present for the emotional faces, but this difference failed to reach significance for the group that saw only neutral faces.

This suggests that the emotional valence of faces may be an important moderating variable in possible sex differences in cerebral asymmetries for processing physiognomic stimuli. Rizzolatti and Buchtel's conclusion that more information may be required for females in order to activate a neurologically lateralized mechanism for facial processing, might be modified in the following way. Both exposure time and emotionality may be moderating variables in accounting for the pattern of results observed with sex differences in the lateralization of facial perception. Emotional valence has not been controlled in most of the research in face perception. Since in many studies the faces were obtained from yearbook photos, it is quite possible that in several of the early studies, the physiognomic stimuli had a high degree of emotional valence. Emotional valence and exposure time, the latter variable noted by Rizzolatti and Buchtel

(1977), may be additive in causing a face to be perceived as a face rather than as general visual spatial material. Greater exposure may be required to extract the more subtle emotionality or "human" quality of neutral faces. The duration of exposure required may be inversely related to the degree of emotionality in the face, since the latter may be the major quality that makes a face a human and social object, distinct from other visual spatial stimuli. That the males, but not the females, demonstrated a LVF/RH advantage with neutral faces at very short exposure times, suggests then that the emotional valence of a face may be a less crucial factor in determining the LVF/RH superiority for males. In the case of neutral faces, their right hemisphere advantage may derive from that hemisphere's advantage for processing complex visual spatial stimuli, an asymmetry that females may not share (McGlone and Davidson, 1973).

This line of reasoning forms the basis of the first of the four hypotheses of the present investigation.

<u>An Examination of Sex Differences in the Role of Emotional Valence in Determining Cerebral Asymmetries in the Processing of Facial Stimuli</u>

One purpose of the present investigation will be to systematically explore emotional valence as a factor moderating the cerebral lateralization pattern of facial processing in males and females.

The specific hypothesis being investigated is as follows. The LVF/RH superiority usually demonstrated in males for facial processing can be attributed to that hemisphere's dominance in both visual spatial and emotional stimuli. In the case of females, the right hemisphere advantage for faces is more attributable to their emotional valence since a comparable cerebral lateralization might not exist for visual spatial stimuli. That the right hemisphere advantage for processing emotional material may, in fact, be even greater for females than for males is suggested by th studies described earlier by Lavadas et al. (1980) and Strauss and Moscovitch (1981), who reported females to be more reliably right hemisphere lateralized on tasks of emotional discrimination. A similar suggestion is provided in a study by Davidson and Schwartz (1976). In their study, females displayed significantly greater right hemsisphere EEG activation during emotional imagery than did males.

It should be emphasized that the present hypothesis differs from the issue explored in the Lavadas et al. (1980) and Strauss and Moscovitch (1981) studies. They compared males and females on tasks of emotional discrimination, wherein subjects were required to judge whether two expressions were the same or different. Thus, the demand characteristics of the experiment rendered the emotional aspects of the task as highly salient. That such a biasing towards one hemisphere by varying demand characteristics of the experiment can occur, has been shown by

Levy and Trevarthen (1976) with split brain patients and Seamon and Gazzaniga (1973) with normal subjects.

The present hypothesis refers only to the task of character discrimination, where it is hypothesized that the emotional valence of the faces will interact with sex in producing a LVF/RH advantage for the task. This hypothesis more clearly separates the skill of face perception from its emotional components, and examines whether the laterality patterns of facial perception can in fact be attributed to the emotionally expressive quality of the stimuli, as first suggested by Yin (1969). The present hypothesis is that this is the case for females, whereas for males it is the visual spatial nature of the stimuli which also contributes to its LVF/RH advantage.

This hypothesis can be examined only by controlling for the emotionality of the stimuli. Note that although both Strauss and Moscovitch (1981) and Safer (1981) did compare males and females on just a character discrimination task, they used emotional faces. Only two studies (Suberi and McKeever, 1977; Dixon, 1977) have controlled for the factor of emotional valence on a character discrimination task. Suberi and McKeever (1977) used two sets of faces, a priori defined neutral and emotional, and reported a LVF/RH advantage for their female subjects memorizing the emotional set, but not the neutral. The most straightforward method of investigating the present hypothesis then would be to replicate the procedure of Suberi and McKeever, using only their Group Neutral and Group Emotional conditions, and including male as well as female subjects. This in fact will be the design of the present investigation. The specific prediction is that for neutral faces, there will be a LVF/RH advantage for males, but not for females. Or, at least, the LVF/RH effect will be significantly greater for males. Females may still demonstrate a LVF/RH advantage since it is virtually impossible for even "neutral" faces to be completely devoid of emotion. For the emotional faces, however, the LVF/RH superiority will emerge for both sexes and may, in fact, be significantly greater for females.

Dixon (1977) attempted to explore an identical hypothesis. Rather than directly replicating Suberi and McKeever, however, he used only the neutral faces and manipulated their emotional valence by having subjects imagine the people whose faces they memorized to be "sad" (emotional condition) or "relaxed" (neutral condition). His most clearcut finding did not involve these manipulations. He reported that only those subjects who perceived the faces as emotional, as measured by their ratings on a semantic differential scale, exhibited a LVF/RH advantage. This was true for both males and females. A surprising finding, however, was that males, but not females who perceived the faces as unemotional, tended towards a RVF/LH superiority for the faces. It was suggested earlier that this might be attributed to implicit verbalizations occurring during the experimental manipulations. It is therefore suggested that, at this stage of research, the interaction of emotionality of faces with sex differences in laterality be investigated using the more objectively determined "a priori" operational definitions of emotionality as used by Suberi and McKeever (1977)and Ley and Bryden (1979), rather than attempting to manipulate it subjectively. This is because the possible effects of such manipulations are not known. Also, their inclusion in a study will allow less continuity with the existing body of research whereby subjects are required to make discriminations between facial stimuli without instructions to fantasize about the faces. Hence, the decison was made to conduct a straightforward replication of Suberi and McKeever's procedure, using male as well as female subjects. Furthermore, the Suberi and McKeever study is usually cited as a primary reference for the effects of emotional valence on the cerebral asymmetry of face discrimination, and should therefore be replicated with males.

Two other purposes of the present investigation are as follows.

A Comparison of Two Indices of Cerebral Lateralization for Facial Processing

Tachistoscopic studies have served as the primary method for providing an index of cerebral lateralization of facial ability in normal subjects. Zoccolatti and Oltman (1978) have specifically calculated indices based upon the direction and magnitude of differences in the two visual fields as individual measures of cerebral laterality for facial processing. An alternative method has been utilized by Lawson (1978), whose index of laterality was the degree and direction of visual field bias on the Gilbert and Bakan (1973) perceptual bias test. Lawson specified as her index of cerebral lateralization the frequency with which subjects chose the composite made up of the half of the original comparison face which lay in their LVF.

One purpose of the present research project is to correlate the tachistoscopic and perceptual bias indices of cerebral lateralization for facial processing. The tachistoscopic procedure is not only less efficient in terms of time and equipment, but also suffers from extreme artificiality due to the exposure to separate visual fields and the brief exposure times. The short exposure time necessitated in tachistoscopic studies have been considered to pose a potential validity problem in face research, since some authors (Leehey, Carey, Diamond, and Cahn, 1979) propose that a minimum amount of time is required for a face to be processed as a face with all it's emotional and social properties rather than merely as visual spatial configurations. Sergent and Bindra (1981) argue that the artificially short exposure times of tachistoscopic paradigms may enhance LVF/RH advantages because of the left hemisphere's relatively poorer ability at processing incomplete, degraded percepts. They also note how such factors as stimulus discriminabiltiy, number of stimuli used, visual degrees from fixation, and stimulus familiarity can bias the laterality patterns. Furthermore, the artificial projection of the stimuli to the separate visual fields may contribute little towards an understanding of how the cerebral hemispheres work together in real life facial perception and recognition. If a reasonably high correlation coefficient between the two indices of lateralization is found, the perceptual bias index of Gilbert and Bakan (1973) may offer a more practical and less artificial index of cerebral lateralization for faces.

The Relationship between Degree of Cerebral Lateralization and General Competence at Facial Processing

The relationship of direction and magnitude of lateralization for physiognomic processing to general overall competence in processing faces should be systematically examined. McGlone and Davidson (1973) found that males demonstrated a higher incidence of LVF/RH superiority on a dot enumeration task than did females. Males also performed better on a spatial abiltiy test. McGlone and Davidson interpreted their results to mean that females have less lateralized non-verbal visual skills than do males and that females have poorer spatial ability as a result of their lack of right hemisphere representation of these abilites.

Attempts to examine whether a similar relationship between task laterality and competence in facial ability exists have not yielded consistent results. Two studies offer results that are only marginally suggestive of a positive relationship between right hemishere bias for facial processing and general ability with faces. Gilbert (1977) found that in a tachistoscopic face discrimination task, 30% of his subjects demonstrated a RVF/LH bias for faces. A particularly significant finding was that within this subject group, there was a strong negative correlation between degree of rightward bias and performance on a free view non-tachistoscopic facial memory test. This suggested that the more the left hemisphere dominates for face processing, the more general facial recognition is impaired, consistent with McGlone and Davidson's (1973) hypothesis. However, this interpretation cannot be clearly made since when all of Gilbert's 64 subjects were combined (which included the 70% with the then more typical LVF/RH superiority), no such correlation existed. Rapaczynski and Ehrlichman (1977) found that field independent subjects exhibited faster reaction times to stimuli from the LVF/RH, while field dependent subjects were faster from the RVF/LH. It was this latter group who made significantly more error rates on the task.

On the other hand, Zoccolotti and Oltman (1978) found no support for such a relationship. They correlated visual field differences in reaction time on their tachistoscopic face discrimination task with reaction times on a central presentation variation of the same task.

The above studies are not directly comparable because of differing sex, handedness, and familial sinistrality compositions of the samples. Their measures of general competence at facial tasks differed as well.

The best-designed study is that of Lawson (1978) who controlled for handedness, sex, familial sinistrality and writing style (inverted versus non-inverted). She found that groups which demonstrated a LVF/RH bias for faces on the perceptual bias test of Gilbert and Bakan (1973) were the groups superior for memory for faces. However, her study is the only one utilizing the perceptual bias index of laterality and hence cannot be directly compared to the other studies which have used the tachistoscopic index. Furthermore, she does not describe how she measured memory for faces.

In summary, a systematic explanation of the relationship between direction and magnitude of visual field effects and overall facial processing ability, controlling for the relevnt variables of sex, handedness, familial sinistrality, measure of facial ability, and type of lateralization index , has yet to be done. Hence, in the present research project, each of the two indices of cerebral laterality will be correlated with performance on the two tasks that are intended as a measure of overall competence in processsing faces. These will be a central exposure tachistoscopic facial discrimination task and Milner's (1968) brief free view face reccgnition task, both to be described later. Since there are some weak indications that facial ability may be positively related to its degree of right hemisphere bias in an individual, the favored prediction is that degree of right hemisphere bias, as measured by the two indices, will be positively correlated with performance on the two tests of facial ability.

Conjugate Lateral Eye Movements

The previous review has examined the role played by the asymmetry of the cerebral hemsipheres in one particular cognitive ability, that of facial perception and recognition. This represents but one area of the enormous literature on the specialization of the hemispheres in various aspects of cognitive and emotional functioning. The cerebral specialization model has also provided a basis for the understanding of individual differences in cognitive abilities. It has been suggested that individuals may differ to the degree to which their left and right hemsipheres dominate in their overall functioning. Individuals might then be classified in terms of their "hemisphericity" (Bogen, 1969).

Bakan (1969) was the first to identify conjugate lateral eye movements (CLEM) as a measure of individual trait hemisphericity. CLEMS were first observed by Day (1964), who noted that presentation of a reflective question to a subject typically elicits a CLEM to the left or right. Day observed that the direction of CLEM response was a consistent individual characteristic, and that consequently subjects could be classified either as "right movers" or "left movers." More recently, it has been noted that a substantial number of subjects are not consistent in gaze direction . These have been named "bidirectional" and most recently, "bimovers" (Moretti, 1982). CLEM direction in an individual is typicaly assessed by recording the direction of the first eye movement that occurs after each question from a standard set. The reliability of CLEM direction has been subsequently established. Test-retest reliabilty between sessions have been reported ranging from .65 (Crouch, 1976) to .77 (Ehrlichman, Weiner, and Baker, 1974) and .78 (Bakan and Strayer, 1973; Etaugh and Rose, 1973). Interrater reliabilities have been high, r = .96 (Libby, 1970), and Templer, Goldstein, and Penick (1972) report that agreement of judges on 380 trials was 94.5%. Ehrlichman and Weinberger (1978), in their review of the literature, conclude that CLEM patterns are reliable characteristics of persons.

Bakan (1969) was the first to propose that CLEM direction was associated with increased activation of the contralateral hemisphere. This was based upon the finding that eye movements are controlled contralaterally by activity in Brodmann's area 8, the frontal eye fields (Robinson, 1968). Also Penfield and Roberts (1959) observed that direct stimulation of one hemisphere triggers eye movements in the contralateral direction. Other research indicates that this contralateral control of eye movements is not confined to stimulation of the frontal eye fields alone. Malamed (1977) reports that increased cerebral blood flow in one hemisphere is associated with eye movements in the contralateral direction.

Wada and Rasmussen (1960) provide additional support for the association of CLEM and contralateral hemispheric activation. They noted that sodium amytal inactivation of one hemisphere resulted in the reduction of eye movements in the direction contralateral to the anesthetized hemisphere, and consequently to neglect of the contralateral visual field. Similar clinical disorders have been observed in patients with unilateral brain injury. Generally these patients exhibit neglect of the visual field contralateral to the damaged hemisphere, although this is more frequently observed in patients with right hemisphere damage (Luria, 1973). The basis of this asymmetry in the contralateral control of eye movements has been provided by DeRenzi, Colombo, Faglioni, and Gilbertoni (1982). The authors investigated conjugate gaze paresis in 436 patients who had suffered a severe unilateral stroke. Gaze paresis was found in 120 patients, was more frequent in women, and more frequent, severe, and longlasting with patients with right-sided damage. The relationship between the specific areas of damage in each case and the presence of gaze paresis suggested that the oculomotor centres have an asymmetrical organization in the two hemispheres, diffuse on the left and localized on the right. This would explain why visual neglect occurs more frequently following right-sided brain damage.

Two areas of investigation have developed incorporating CLEM as an index of hemispheric activation. One area of research focuses on the identification of right movers and left movers as measures of trait hemisphericity, and the associated differences in personality characteristics and cognitive abilities. A second focus of investigation examines the effects of different types of questions or tasks in eliciting right or left CLEM responses. The rationale of the latter is that answers to questions requiring an analytic, sequential mode of processing, attributed more to left hemisphere functioning, should elicit CLEMS to the right (Galin and Ornstein, 1974), whereas the opposite should be the case for questions eliciting spatial or emotional processing (Schwartz and Davidson, 1976). This latter area of research is not directly relevant to the purposes of the present research and will not be discussed further.

The review will deal with research relevant to the construct validity of CLEM as a measure of individual trait hemisphericity.

Neurophysiological Correlates of CLEM as Measures of Individual Trait Hemisphericity

According to Bakan's (1969) hemisphericity model, subjects who consistently move their eyes to the right are characterized by relatively greater activity of the left hemisphere, and those who consistently look to the left are characterized by relatively greater activity of the right hemisphere. This proposed distinction between left and right movers receives support at the neurophysiological level.

Meyer (1977) examined EEG asymmetries in left and right movers while they engaged in problem solving tasks. Left movers were found to exhibit greater activity in the right hemipshere than were right movers.

In a study of event related potentials (ERP's) in response to a standard checkerboard reversal stimulus, Shevrin, Smokler, and Kooi (1980) found that right movers demonstrated greater event related potentials in the left hemisphere, while left movers showed greater amplitude right hemisphere responses. No significant sex difference or interaction of sex with eye movements was found. The authors concluded that "individuals may be characterized by a certain disposition such that lateralization of brain response is correlated with a preferred direction of looking (p. 695)."

Another measure of hemispheric activation is the measurement of the rate of cerebral blood flow by scintillation detectors placed around the scalp to detect radiation emitted by a radiosotope, Xenon 135, introduced into the cerebral bloodstream by carotid injection or inhalation of a gas. Gur and Reivich (1980) used the inhalation technique to demonstrate an association between CLEM measures and cerebral blood flow asymmetries. Eleven male left movers were compared to ten male right movers on three measures of cerebral blood flow: baseline, verbal task performance, and spatial task performance. Subjects solved the problems covertly in order to control for movement associated artifacts. When hemispheric flow was averaged across the three conditions, it was found that left movers had significantly relatively more blood flow in the right compared to the left hemisphere, while right movers showed a tendency to have more blood flow in the left than the right hemisphere. This finding strongly supports the contralateral hemispheric activation hypothesis of CLEM.

Together, these studies provide substantial support for the validity of CLEM as a measure of trait hemisphericity.

Personality Correlates of Hemisphericity

These will be reviewed only briefly since at this time the relationship between personality variables and the cerebral asymmetries are not clear. Thus the literature contributes little to the construct validation of CLEM as a trait measure of hemisphericity.

Smokler and Shevrin (1979), on the basis of Rorschach card responses, reported that left movers produced responses indicative of a hysterical personality type, while right movers responses were more indicative of an obsessive-compulsive personality. These results are consistent with previous findings which suggest that left hemisphericity is associated with defence mechanisms characterized by externalization and intellectualization, while right hemispericity is associated with denial, repression, and reaction formation (Gur and Gur, 1975). Pajurkova (1979) reported that left mover but not right mover females "repressed" in a perceptual defence paradigm.

Left movers have been found to display more facial expressivity (Newlin, 1981). Right hemisphericity has been associated with greater hypnotic susceptibility (Bakan, 1969; DeWitt and Averill, 1976; Gur and Reyher, 1973), and creativity as measured by the Remote Associates Test (Harnad, 1972). CLEMS have been related to Jungian personality variables (Prifitera, 1981) and factors enhancing susceptibility to subliminal perception (Sackheim, Packer, and Gur, 1977).

Cognitive Correlates of CLEM

Given the enormous body of research investigating cognitive abilites and their relationship to the specialization of the cerebral hemispheres, a comparison of left movers and right movers on cognitive skills offers a rich source of construct validity data. Even though the neurophysiological data are supportive of the construct of trait hemisphericity as measured by CLEM, it is important to establish to what extent this asymmetric hemispheric activation translates into measurable cognitive abilties that are theoretically consistent with the CLEM model. Bakan's (1969) model would predict that the cognitive differences between right and left movers would be consistent with the functional properties of each hemisphere. Right movers should demonstrate a relative superiority on skills requiring the verbal and analytic, sequential, discrete processing identified with the left cerebral hemisphere, and left movers should exhibit relatively greater facility on tasks tapping the more holistic, global, visual spatial abilities attributed to the right hemisphere. The hemisphere primarily activated would to some extent be determined by the task demands themselves, in which case one would predict that the hemisphericity group for whom the relevant hemisphere was the more "natural" one would excel. Where the task demands are more ambiguous or alternative strategies exist, the individually "preferred" or "dominant" hemisphere would be the one activated. The latter is presumed, of course, when CLEMS are made in response to reflective questions. The theory and therefore predictions relating to bimovers is not firm at this time. Although Bakan's model does classify them as individuals who are less lateralized in terms of cognitive hemispheric activation, it is not clear whether this cerebral organization would result in better, worse, or performance midway between right and left movers on cognitive tasks.

Ehrlichman and Weinberger (1978) critically review the research relating CLEM to various cognitive abilities. They conclude:

> These results suggest that there might be some relationship between certain aspects of laterality and CLEMS; however, they are too isolated and weak to cite as evidence for or against the hemispheric asymmetry model of CLEMS (p. 1096).

However, if one examines their review, it becomes apparent that for the identified left hemisphere tasks, the predicted differences have been obtained. For example, Bakan and Shotland (1969) and Ogle (1972) found that right movers were faster readers than left movers. Weiten and Etaugh (1973) presented left and right movers with a concept identification task; subjects were asked to find an adjective descriptive of four stimulus words. The right movers were superior at this semantic processing task. Tucker and Suib (1978) examined the relationship between CLEM and performance on the Wechsler Adult Intelligence Scale. The right movers showed a relative superiority on the verbal tests, the left movers a relative superiority on the performance tests. Not included in their review is a recent study by Moretti (1982), who compared right and left movers in performance on the Wechsler Adult Intelligence Scale - Revised. She found that for males only, the right movers as a group performed better than the left movers on the verbal factor which included the Information and Vocabulary subtests. For the females only, left movers as a group performed better than the right movers on the Block Design subtest. That the differences on the verbal factor applied to males only was attributed to the reported more consistent lateralization for verbal ability in males (McGlone, 1980).

Some indirect support for cognitive differences between right and left movers has been provided by findings which indicate that right movers are more likely to major in science/quantitative areas of study, while left movers tend to major in classical/ humanist areas (Bakan, 1969; Weiten and Etaugh, 1973; Gur, Gur, and Marshalek, 1975; Katz and Salt, 1981).

In contrast to the above literature, the predicted CLEM differences have been realized less consistently on identified "right hemsphere" tasks which, according to the hemisphericity model, should favor left movers.

Recently, Packer and Gur (reported in Gur and Reivich, 1980) found left movers demcnstrated significantly superior performance on a gestalt completion task although no significant differences were found in their verbal abilities as measured by the Miller's Analogies Test. The superior performance of left movers on perceptual closure has also been reported by Bilsker (1980).

However, there are several studies using identified "right hemisphere" tasks where the predicted differences were not obtained. Ehrlichman (1972) and Croghan (1975) were unable to find significant perfcrmance differences on verbal and spatial tests selected from the Reference Kit for Cognitive Factors. In the former study, right movers and left movers were assessed on several of these measures by calculating ipsatized data scores for each subject which reflected performance on any one given task relative to the baseline performance across all tasks. This method of data analysis has been criticized as inappropriate for between subject comparisons of ability (Bilsker, 1980). A more generalized criticism of Ehrlichman's (1972) study that would also apply to Croghan (1975) is that only two of the identified "right hemisphere" tasks had actually been validated as such (one of which has subsequently been demonstrated by Bilsker (1980) to differentiate between left and right movers in the predicted direction). Another example of this same oversight is the study by Hiscock (1977). Hiscock examined the performance of male subjects on two verbal measures (Quick Word Test, Verbal Scale of Paivio's Individual Differences Questionnaire) and two spatial measures (Spatial Relations Test and the Imagery Scale of Paivio's Individual Differences Questionnaire). Performance comparisons between right and left movers were not significant. As in the Ehrlichman (1972) and Croghan (1975) studies, a major criticism here is the lack of validational data that the designated "left" and "right" hemisphere tasks are in fact tapping these separate abilities. This is in contrast to the WAIS subtests, which have some neuropsychological validity as left and right hemisphere tasks (Golden, 1979). For example, the use of the Quick Word Test, originally developed as a measure of general intelligence, may not have been an appropriate verbal measure. This test requires subjects to identify pictures which best describe words, and picture-word matches can be made on the basis of a variety of factors. Similarly, the validity of the verbal and imaginal scales of Paivio's Questionnaire as independent measures of verbal and imaginal ability is not established. The danger of accepting tasks on the basis of face validity alone as representing left or right hemisphere abilities is illustrated by the following series of studies. Glackman (1977) proposed that left movers would be superior to right movers on several tasks involving imagery. The differences he obtained were opposite to prediction. Although the association of imagery with the right hemisphere had intuitive appeal, it had not been empirically validated as a right hemisphere task. A subsequent paper, Ornstein, Johnstone, Herron, and Swencionis (1980) has demonstrated that one of the imagery tasks on which Glackman found right movers to be superior is, in fact, associated with greater involvement of the left hemisphere, not the right hemisphere, as supposed, in normal subjects.

Finally, Fisher (1976) also failed to find performance differences between right and left movers on Bogen's (1969) appositional/propositional ratio measured by the Similarities subtest of the WAIS and the Street Gestalt Completion Test. With regard to Fisher's findings, it must be noted that the validity of the original Street test, which was used, has been questioned because of its insufficient number of stimuli and its reliance on verbal responses for stimulus identification (Bogen, DeZure, Tenhouten, and Marsh, 1972).

Finally there is one study which relates more directly to the area of facial processing. Crouch (1976) presented subjects with cartoon faces whose corresponding captions conflicted with the facial expression portrayed. Right movers were found to be more influenced by the verbal cues and left movers were more responsive to the facial cues.

The literature on the cognitive correlates of CLEM can be summarized in the following manner. The predicted differences for the designated "left hemisphere" tasks have been obtained with few exceptions. More inconsistent has been the literature relating CLEM to designated "right hemisphere" tasks. This has been largely attributed to the failure to use empirically validated "right hemisphere" tasks. This probably reflects the greater difficulty in general of obtaining pure "right hemisphere" tasks. As McGlone and Kertesz (1973) have noted, spatial processing may be influenced by both analytic, verbal or non-verbal systems and consequently it is difficult to identify measures which assess only spatial skills. On the other hand, tests tapping verbal skills tend to be more pure. This is reflected in the fact that the research on the cerebral specialization of verbal abilities is far more consistent than that of non-verbal abilities.

The final hypothesis and predictions of the present investigation can now be presented.

A Comparison of Right and Left Movers on a Controlled Facial Discrimination Task and a Comparison of their Lateralization Patterns

As reviewed, studies comparing right hemisphere injured patients with left hemisphere injured and normal controls on a facial recognition task in which subjects must identify from an array of faces those previously seen, usually report the right heemisphere injured group to perform significantly worse than the other two groups (Milner, 1968;DeRenzi and Spinnler, 1966). Given this empirical validation of the task as differentially involving right hemisphere functioning, the hemispheric asymmetry model of CLEMS would predict that left movers would perform significantly better than right movers. However, J. Bakan (1980) failed to find such a difference. In his study, subjects were required on each trial to study four faces for 10 seconds and to then identify them from an array of 12. However, tasks which reflect differences among a neuropsychological population may not be sensitive enough when used to detect differences among a normal population. Bakan himself acknowledged that his accuracy measure may not have been sensitive enough to detect differences between normal subjects, and suggested that the exposure time and unlimited time allowed for responding might have been sufficiently long for right (presumably holistic) or left (presumably analytic, discrete, possibly involving labelling) hemisphere strategies to be used. Benton (1980) and Levy, Trevarthan, and Sperry (1972) have both indicated that faces can be processed by both hemispheres, each utilizing different strategies, although the right hemisphere may be the most efficient in most cases (Patterson and Bradshaw, 1975). Bakan suggested that his procedure might be made more sensitive by (i) recording response latency times and (ii) inquiring after strategies.

The tachistoscopic procedure provides a modification of the facial recognition task that increases its sensitivity for a normal population. The replication of Suberi and McKeever's procedure which is part of the present investigation may then be sensitive enough to detect differences between left movers and right movers. The procedure is as follows. Subjects will be required to memorize two target faces. These target faces will be flashed unilaterally along with two others, and subjects will be required on each trial to indicate whether the face was or was not a target face. As in Suberi and McKeever's design, choice reaction time will serve as the dependent variable, although errors will also be analyzed. In addition to the lateral presentations utilized by Suberi and McKeever, the present study will include a central exposure condition. It is this measure which is intended to serve as the measure of general facial processing ability, sensitive enough to tap differences in a normal population, but less artificial than the unilateral presentations because the stimulus is exposed to both hemispheres, as in the case of the standard free view paradigm. After all, the hemisphericity theory of CLEM refers to the relative activity of the hemispheres when they are working together, not when they are artificially separated. The hemispheric asymmetry model of CLEMS would predict a left mover superiority in this central presentation task, given the hypothesized preferential use of the right hemisphere in left movers.

For comparison purposes to the more controlled task, a brief free view face recognition task will be included in the design. This will be the one used by Milner (1968) to discriminate among a neuropsychological population. Subjects will be shown 12 faces for a brief period of time (45 seconds), after which they must recognize these from an array of 25 faces.

The lateral presentations of the tachistoscopic task will provide data on the laterality patterns of right and left movers. In view of the hemispheric asymmetry basis proposed for the CLEM phenomenon, it is surprising that only one study has investigated the laterality pattern of right and left movers. Neilson and Sorensen (1976) related CLEM performance on a dichotic listening task with verbal stimuli. The normal right ear (presumably left hemisphere) preference found with verbal material was significantly greater for right movers. For right movers alone, there was a significant right ear superiority, but for the left movers no significant right ear superiority could be found. The authors conclude that left movers attended to a greater degree to stimuli from the left side (presumably projecting to the right hemisphere) because of habitually enhanced hemispheric activity. This same reasoning would predict a greater LVF/RH bias in left movers for facial processing, the converse to the pattern that occurred with verbal stimuli. This would be theoretically consistent with the prediction that left movers will perform significantly better on physiognomic tasks if, in fact, general facial processing ability is correlated with degree of right hemisphere bias for facial tasks. On the other hand, Neilson and Sorensen's (1976) results might simply reflect a lesser degree of cerebral lateralization in general for left movers compared to right movers.

To recapitulate, the specific prediction made for this section is that left movers will produce faster reaction times on the central exposure tachistoscopic facial discrimination task, based upon their hypothesized greater reliance on right hemisphere processing. This prediction is made in spite of J. Bakan's (1980) failure to find a significant difference between the two groups on a free view facial recognition test. It is hypothesized that the brief exposure time (60 milliseconds) of the stimuli together with the use of response latency as the dependent measure, will increase the advantage of a more holistic type of processing , relative to a more discrete, analytic type. It is hypothesized, based upon the hemisphericity model of CLEMS, that the former strategy will be more typical of left movers and, therefore, they will perform better on this particular facial recognition task. Differences in the lateralization patterns of right and left movers will be examined but no predictions made.

Summary of Four Purposes of Present Research

Purpose One: An Examination of Sex Differences in the Role of Emotional Valence in Determining Cerebral Asymmetries in the Processing of Facial Stimuli

Suberi and McKeever's (1977) procedure will be replicated with males as well as females. One group of subjects will view a priori defined emotional faces, and the other half will view a priori defined neutral faces. A sex x emotion x visual field interaction is predicted. More specifically, it is predicted that males, but not females, will exhibit a significant LVF/RH advantage with the neutral faces. However, a LVF/RH superiority will be present for both sexes with the emotional faces. This prediction will be tested by conducting an analysis of variance with sex, CLEM, and emotion as between subject factors, and visual field and response type (yes(same)/no(different)) as within-subject factors. This will be done for both reaction time and error data.

Purpose Two: A Comparison of Right Movers, Bimovers, and Left Movers on a Controlled Facial Discrimination Task and a Comparison of their Lateralization Patterns

Left movers, bimovers, and right movers will be compared on a controlled facial discrimination task. The same faces from the Suberi and McKeever (1977) study will serve as the stimuli and the task requirements will be the same as with the lateral presentations except that the faces will be flashed centrally for 60 milliseconds. It is predicted that since this mode of presentation will favor a global, holistic processing strategy over a verbal, analytical strategy, left movers will perform significantly faster than right movers. Although a free view face recognition test will serve as a comparison task and a replication of J. Bakan's (1980) study, CLEM differences are not predicted on this task since it will not necessarily favor a left or right hemisphere strategy. No predictions are made regarding the bimovers. Data from both face recognition tests will be analyzed with an analysis of variance with CLEM, sex, and emotion as the between-subject factors for the tachistoscopic test, and CLEM and sex as the between-subject factors on the free view test. The two tests of facial processing ability will be correlated to examine the extent to which they are tapping similar abilites.

<u>Purpose Three: A Correlation between Two Indices of Cerebral Laterality</u>

The two laterality indices - one based upon visual field differences in reaction time and errors on the tachistoscopic lateral presentation face discrimination task and the other derived from the perceptual bias test - will be correlated. It is predicted that the two indices will correlate positively. Scores on the perceptual bias test will also be submitted to an analysis of variance with sex and CLEM as between-subject factors.

Purpose Four: The Relationship between Cerebral Lateralization and Overall Competence with Faces

Scores on the two laterality indices will each be correlated with each of the two measures of facial processing ability. These are the central presentation tachistoscopic face recognition test and the free view face recognition test. Based upon some weak findings in previous research, the 'favored' prediction is that a LVF/RH bias on the laterality indices will be associated with better performance on the facial recognition tests.

II. Method

Subjects

A total of 138 subjects participated in the study, of whom 10 were eliminated during the course of the research for various reasons to be described below. The final sample consisted of 128 subjects, 64 males and 64 females.

All subjects were from the Simon Fraser undergraduate population. The majority were volunteers who responded to an in-class appeal for participation, although some were awarded some form of class credit. Most subjects were drawn from psychology classes, although some business and science students also participated. The age range for the males was 17 to 35. The age range for the females was 17 to 39, with the exception of two females, aged 51 and 59. Subjects were paid $3.50 for their participation.

Subjects were screened on the telephone or on a preliminary in-class questionnaire for handedness and the presence of left handedness in members of their immediate family (familial sinistrality). Only declared right handed individuals with no familial sinistrality were selected. This selection was based upon studies indicating that such individuals demonstrate the most consistent LVF (presumably right hemisphere) bias for faces

(McKay, 1979). Only subjects who reported having equivalent vision in both eyes were accepted and subjects who wore glasses were asked to bring them to the experiment. One subject was subsequently discarded during the experimental session because he forgot to bring his glasses and testing indicated that the vision of his two eyes was significantly different.

Materials

Facial Stimuli for Tachistoscopic Face Recognition Test

The facial stimuli were taken from the set used by Suberi and McKeever (1977). Their stimuli were 16 photographs of faces, involving four models, two male and two female. Each model projects a "neutral", "happy", "sad" and "angry" facial expression. The models are free of beards or moustaches, communicate the intended affects without opening their mouths, and wear hoods which cover their hairlines. Suberi and McKeever report pilot work, establishing the reliability of the intended affective expressions.

Eight of these faces were selected for the present design, the four neutral faces and the four sad faces, to serve as the stimuli for the neutral and emotional faces respectively (see faces in Appendix B). The sad faces were chosen because Suberi and McKeever reported the greatest LVH (presumably right hemisphere) superiority of the three emotional affects with them (although the small number of subjects in each affective condition precluded statistical significance of these results). The use of sad faces also appeared to be a good choice in view of the clinical data suggesting a relatively greater involvement of the right hemisphere in feelings of sadness and depression (for example, Wada and Rasmussen, 1960).

In order to establish the validity of these a priori defined neutral and emotional faces with the Simon Fraser undergraduate population, pilot studies were conducted. For these, the Suberi and McKeever faces along with some faces of apparent varying emotionality from the standardized Ekman and Freisen (Ekman and Freisen, 1975) set were used. In one study, 20 undergraduates (10 male and 10 female) were required to rate each face on a seven point scale on the neutral-emotional dimension. The four Suberi and Mckeever sad faces were rated as significantly more emotional ($\bar{x}$ = 5.04) than the four corresponding neutral faces ($\bar{x}$ = 2.50). This difference was statistically significant at the .001 level. In a second survey with 20 different undergraduates (10 male and 10 female), subjects were required to rate each face in terms of the intensity of emotional response it elicited in them. The end points of the seven point scale were defined as "I feel nothing when I look at this picture" and "This picture arouses a very intense emotional reponse in me." Subjects rated the Suberi and McKeever sad faces ($\bar{x}$ = 3.50) as eliciting significantly greater emotion in them than the four corresponding neutral faces ($\bar{x}$ = 2.81). This difference was statistically significant at the .005 level. When asked to describe the quality of their emotion to each face, the word "indifferent" was used 30 times with regard to the neutral faces, but only 11 when referring to the sad ones. Conversely, the words "sad" or "sympathetic" were used only four times in describing emotional reactions to the neutral faces, but 32 times in response to the sad faces.

The eight faces were modified slightly. They were reprinted in order to make the lighting tones constant across photographs, since the original photographs differed in this repect, possibly because of different lighting conditions when the pictures were taken. Also, identifying marks, such as moles, were removed.

Perceptual Bias Test

This task utilized a booklet in which three faces were printed per page (see Appendix C). The top face was a normal photograph. Below, side by side, were two other faces, one made up of two right halves of the top face and the other made up of two left halves of the top face. The side of the page on which the left-left and right-right composites were printed was randomized. There were a total of 19 such pages, hence 19 trials.

Free View Face Recognition Test

These stimuli were identical to those used by Milner (1968). On the card to be studied there were 12 faces, and the memory probe card contained 25 faces, 12 of which were from the study card.

Annett Handedness Questionnaire

This consists of 15 items dealing with hand preference on a variety of tasks.

Apparatus

Tachistoscopic Face Recognition Test

The subjects were seated in a sound-proof booth and maintained a constant head position by leaning their foreheads against a headrest. They faced a translucent screen at a distance of approximately 87.10 cm. from their eyes. There was a clearly marked central cross on the screen on which the subject was asked to fixate at the beginning of each trial. The faces were back projected from a Carousel slide projector on the screen either to the right or left of fixation, or centrally. The exposure time was controlled by a tachistoscopic shutter.

The image on the screen was 5.00 x 5.84 cm. in width and height repectively.

Suberi and McKeever placed their photographs so that the near and far edges correspended to .50 degrees and 2.8 degrees of visual angle respectively. In the present design, placement from fixation was determined by measuring from the centre of each face. When the stimuli were projected centrally, the centre of the face corresponded to the subject's line of fixation. When the stimuli were projected to the right or left of fixation, the centre of the face corresponded to approximately 2.35 degrees of visual angle. Since the placement of the faces within the photographic frames was not identical, there were some small differences in terms of the visual angles of the near and far edges of the photographs. In the right visual field, the near points of the photographs ranged from just over .75 degrees to 1.25 degrees of visual angle, with a median of 1.1 degrees. In the left visual field, the near points of the photographs ranged from .75 degrees to almost 1.35 degrees of visual angle, with a median of 1.0 degrees. The far edges of the photographs ranged from 3.05 to 3.55 degrees of visual angle in the right visual field, with a median of 3.4 degrees. In the left visual field, the far edges of the photographs ranged from 3.05 to 3.65 degrees of visual angle, with a median of 3.30 degrees.

These placements were more conservative than those of Suberi and McKeever, whose near and far points corresponded to .50 and 2.80 degrees of visual angle respectively. This was done in order to ensure that the stimuli projected to the separate cerebral hemispheres. It should be noted that the placements utilized in the present study are far more representative of those reported in the literature than were those of Suberi and McKeever.

Procedure

The sequence of tasks engaged in by the subject were as follows:

1. Test for CLEMS.
2. Perceptual bias test.
3. Free view face recognition test.
4. Tachistoscopic face recognition test, lateral presentations
5. Tachistoscopic face recognition test, central presentations
6. Emotion ratings of facial stimuli by subjects
7. Handedness questionnaire

This sequence of the experimental tasks was chosen on the basis of relative presumed fatigue effects and the order of importance given to the different components of the research project. The perceptual bias and free view face recognition tests were considered to be short enough to not cause undue fatigue before the tachistoscopic tasks.

Test for CLEMS

CLEMS were measured using the set of 20 questions developed by Bakan, Coupland, Glackman, and Putnam (1975) (see Appendix A). The subject was rejected if he or she failed to provide at least 15 scorable responses. Three subjects were rejected for this reason.

A slight adaptation of the instructions utilized by Pajurkova (1979) were used to minimize the number of unscorable responses. Since the experiment dealt with face perception, the rationale should have been credible. The instructions were as follows:

> I will ask you to interpret a number of different proverbs. While doing that I will be observing your face and videotaping it. I will explain the purpose of this procedure to you later. Meanwhile, I would like you to find a comfortable position and remain that way throughout this part of the experiment. Look at me until I have finished asking the question and then go ahead and answer. Try to give some interpretation for every proverb. Most proverbs have several possible interpretations, so don't worry about giving the correct answer. But I would like to hear your interpretation. Listen until I finish while looking at me, think it over, and then answer.

Eye movements were videotaped unless the subject requested otherwise. Few did so. In cases of uncertainty, the videotapes were reviewed by the experimenter and a colleague familiar with CLEM research, and consensus was attained. These cases of uncertainty were also rare.

CLEM status was calculated by using the following formula: number of right movements/total number of right and left movements. Hence, a larger ratio represented relatively more right eye movements. Using this formula, the criteria for defining left movers and right movers were ratios of 0-.30 and .70-1.00, respectively. Subjects whose CLEM ratios fell in between were categorized as bimovers.

After the subject had answered the 20 questions, he or she was asked to guess the purpose behind the questioning. Subjects who were aware that CLEMS were being measured were rejected at that point and did not particiapate further. Six subjects were discontinued for this reason.

Perceptual Bias Test

The subject was given the booklet described earlier containing the normal and chimeric photographs of faces. The experimenter was careful to place the booklet directly in front of the subject, so that the comparison (and normal) face was in the subject's direct line of vision. For each of the 19 trials, the subject was required to select which of the two composites (right side-right side or left side-left side) looked most like the original photograph of the face above (see Appendix C). A LVF (presumably right hemisphere) bias score was calculated according to the following formula: (number of trials in which subject selected the composite made up of the half-face appearing in his or her LVF in the original photograph)/19 x 100. This represented the proportion of trials on which the subject chose the chimeric face composed from the half face that had been in his or her LVF in the normal photograph of the face.

Free View Face Recognition Test

The procedure was identical to that used by Milner (1968). Subjects were shown the card of 12 faces for 45 seconds, followed by the memory probe card of 25 faces. They were required to select from the latter those faces previously seen by filling in 12 squares on a 5 x 5 grid, corresponding to the layout of the faces on the probe card. Subjects were required to make 12 choices.

Tachistoscopic Face Recognition Tests

The decision to have the central presentations in a separate block from the lateral presentations was based upon several considerations. It was considered that increasing the uncertainty of the subject as to the positioning of the stimulus might increase the intrasubject variability in reaction times. Counterbalancing the central and visual field conditions among subjects was ruled out because of the increase in intersubject variability that this would generate, given the differential practice subjects would have in the two conditions.

The decision was finally made to conduct the lateral presentations first, followed by the central condition for all subjects. The reasoning was as follows. The paradigm used in previous research has not allowed subjects familiarity with the task with centrally presented stimuli. Subjects begin the task with lateral presentations. In order for the results of the lateral condition to be comparable to previous findings, the procedure should be similar. One study (Broman, 1978) did include 40 "familiarization" trials in which faces were presented centrally while the subject learned the discrimination task. Interestingly, her adult subjects did not demonstrate the expected LVF superiority, although her child subjects did so. Although separating the two conditions of the tachistoscopic face recognition test would confound the two in terms of fatigue, practice, and familiarity effects, this was considered to be a less serious error in view of the purposes of the present investigation. The lateral and central presentation variations of this task were not necessarily considered to be measuring identical cognitive processes. In fact, the decision to include the central condition at all reflected this uncertainty as to the comparabilty of the two procedures. The central position condition was included to provide a test of facial processing ability sensitive enough to tap individual differences, yet without the added artificiality of separate lateral exposure. On the other hand, the primary purpose of the lateral condition was specifically to examine individual differences in laterality patterns. Given the continuity of this latter purpose with the existing body of literature, a replication of the standard paradigm was considered most appropriate. Hence, the decision was made to have the subjects perform the tachistoscopic task first in the lateral condition, thus replicating the standard paradigm up to that point, and then following it with the faces projected centrally.

The basic procedure was a replication of that of Suberi and McKeever (1977). Subjects memorized two "target" faces, which they were subsequently required to recognize from the other two "non-target" faces when tachistoscopically presented. Subjects were given two faces, one male and one female, with the instructions "I'd like you to get to know these two faces during the next five minutes." For subjects in the emotional condition, the memory set was taken from the four sad faces. For subjects in the neutral condition, the memory set was from the set of four neutral faces.

Within both the emotional and neutral conditions, there were four possible memory sets, given the constraint that each memory set contain one male and one female face. The four possible combinations of faces were counterbalanced across subjects so that an equal number of male and female subjects saw each combination. Thus, for the 64 subjects in the emotional condition, 16 subjects (eight male and eight female) had one of the four face combinations as a memory set. An identical counterbalancing pattern held for the 64 subjects in the neutral condition.

The general procedure for the trials was as follows:

The subject's right hand was resting on the two end buttons of a rectangular response box, with the index finger resting on the inside button, and the middle finger resting on the outside button. The response box was placed so that the right hand was resting at the subject's midline in order to minimize and spatial-response compatibility effects that occur in simple choice reactions time paradigms (Bashore, 1981). The angle of the response box was approximately at 45 degrees in order to maximize comfort and equal facility with the two fingers. Only the right hand was used, since all reported studies in which responding hand had been counterbalanced and compared failed to find a significant effect for response hand or any of its interactions (Rizzolatti et al., 1971; Moscovitch et al., 1976; Rizzolatti and Buchtel, 1977; McReynolds and Jeeves, 1978; Broman, 1978; Suberi and McKeever, 1977; Lavadas et al., 1980; Galper and Costa, 1980). (This absence of a hand effect was also found in a small pilot study of 11 subjects conducted for this research.) In addition, the absence of a responding hand x visual field interaction has been reported in other tachistoscopic paradigms involving the processing of complex visual stimuli (Gross, 1972). In fact, Rapaczynski and Ehrlichman (1979) appealed to this body of research as justification for using only the right hand in their study.[1]

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[1]After the completion of the present experiment, three studies have appeared which report an effect for right and left hand for visual field differences in a tachistoscopic face recognition paradigm. In one of three studies reported by Sergent in a

[1]Subjects in the present study indicated if the projected face was a target face by pressing one button (the "yes" button) and a non-target face by pressing the other button ("no" button). The assignment of yes and no responses to left and right buttons was counterbalanced across sex, emotional/neutral conditions, and the four target-nontarget face combinations.

Subjects had been told to expect the target and non-target faces to appear in "about equal proportions."

At the beginning of each trial a buzzer sounded for 500 msec. as a signal for the subject to fixate. One second after the termination of the buzzer, the stimulus appeared for 100 msec. The subject was instructed to respond as quickly as possible while minimizing errors. The next trial began 3.5 seconds after the subject's response. One trial occurred approximately every 6 seconds. This sequence of events was controlled by a computer program designed specifically for this

[1](cont'd) recent paper (Sergent, 1982a), reaction time was found to be significantly faster to stimuli in the visual field ipsilateral to the responding hand. This is consistent with the greater contralateral, relative to ipsilateral, control of the hands, given that stimuli in each visual field are presumed to project to the contralateral cerebral hemisphere. A similar finding was reported by Strauss and Moscovitch (1981) for one of their experiments. However, another experiment yielded a hand x visual field interaction in a direction opposite to what would be expected from neuroanatomical connections. Finally, McKeever and Dixon (1981) reported a hand x visual field interaction in a direction consistent with neuroanatomical pathways. Unfortunately, this was not reported in Dixon (1977), the dissertation upon which the published report was based. However, these three studies represent a minority in the face recognition literature. Concurrect with their publication have been many others which have reported no visual field effects as a function of right or left responding hand. These will be cited in the Discussion.

research project.

It should be noted that the exposure time used by Suberi and McKeever was 150 msec., in contrast to the 100 msec. utilized in the present experiment. This was done to ensure that exposure times were well beneath the threshold for eye movements from fixation. Pilot work did not indicate that errors increased significantly with this shorter exposure time.

Tachistoscopic face recognition test: lateral presentations

The subject was instructed to fixate at the sound of the buzzer. It was strongly emphasized that such fixation was necessary for the validity of the results, and that since the visual field in which the stimuli would appear would be randomized, there would be no advantage in not fixating. There is evidence (McKeever, Suberi, and VanDeventer, 1972) that proper instructional set and random unilateral presentation are sufficient controls for visual fixation.

This lateral condition of the task was comprised of four blocks, two practice blocks of 40 trials each, followed by two test blocks of 40 trials each. Verbal feedback for incorrect responses was provided through an intercom during the two practice blocks. The experimenter was able to observe the subject's responses on a computer terminal in the adjacent room. By following a prepared answer sheet coded for each particular subject's condition and stimuli sequence, she was able to determine when an error occurred. Although Suberi and McKeever utilized only one practice block, pilot work for the present study indicatd that two practice blocks were necessary for the majority of subjects to be able to perform the task within a 10% error rate. In order to maintain interest and motivation for the speed requirements of the task as well, the experimenter, after each block, provided the subject with an estimate of his or her reaction times during the last block.

In every block, each of the four faces was projected five times in each visual field. Hemifield of presentation and order of faces was randomized with the constraint that each face appeared once in each visual field every eight trials.

Since session time did not allow for a random re-ordering of stimuli sequence for each subject within the constraints noted above, controlling for sequence effects was attempted in the following manner. There were three trays of 40 slides, corresponding to the number of trials in a block, each with a different sequence of stimuli, such that each of the four faces would appear five times in each visual field. Hemifield of presentation and order of faces was randomized in each sequence within the constraint that each face appear once in each visual field every eight trials. The trays were labelled as Sequence A, B, and C. For each subject, a tray (and therefore sequence) was randomly selected to serve for the two practice trials, another for the first test trial, and the remaining one for the second test trial. In this way, the ordering of the three different sequences was randomized among the subjects.

Tachistoscopic face recognition test: central presentations

The central presentation condition followed the four blocks of lateral presentations. This single block was identical to the lateral blocks, except that the faces were projected centrally. The exposure time was reduced to 60 msec. in an attempt to make the level of difficulty in the central condition more comparable to that of the lateral condition.

In order to control for order effects in the central condition in a manner comparable to that of the lateral condition, three different sequences were randomized among subjects.

There was a rest period of one and one half to two minutes between blocks.

In both lateral and central conditions, the first eight trials were considered aa warm-up and discarded from the analysis.

Reaction times and response choice were recorded automatically during both practice and test trials.

Despite the fact that, within each sex, subjects were evenly distributed across the two levels of emotional valence (emotional/neutral), the four different target-nontarget face combinations, and the two finger-response patterns, this was not the case for the CLEM groups. An attempt was made, within each sex, to match as much as possible CLEM scores across these experimenter manipulated conditions. After each subject's CLEM score was calculated, he or she was assigned to a cell in either the emotional or neutral condition in such a way that he or she would be matched by a subject with a similar CLEM score in the corresponding cell in the other emotion condition.

Emotion Ratings of Faces by Subjects

After completion of the tachistoscopic tasks, more individual validation of the neutral and emotional conditions was sought by having each subject rate each of the four faces to which he or she had been exposed (see Appendix D). Subjects first rated each face on a dimension of "perceived emotion" on a scale from one to seven. Point one on the scale was defined as "face looks neutral, unemotional" and the end point of the scale was defined as "face looks extremely emotional." The subject was then required to rate each face on a dimension of "subjective emotion", that is, the intensity of the emotional response that the face elicited in the subject. Again, a seven point scale was used. Point one on the scale was defined as "I feel nothing when I look at this face" and point seven was defined as "this face arouses an intense emotional reaction in me." These individual ratings were taken since Dixon (1977) found that a LVF (presumably right hemishpere) bias on a tachistoscopic face recognition task correlated with perceived emotion ratings of the faces, but not with an a priori manipulation of emotionality of stimuli in the experimental conditions.

Handedness Questionnaire

The session was completed by having the subject fill out the Annett Handedness Questionnaire.

Design and Analysis of Results

For the analysis of the tachistoscopic face recognition tests, the 64 males and 64 females were divided into emotional and neutral groups. The former viewed the a priori defined emotional faces during the task, and the latter subjects viewed the a priori defined neutral faces. Each sex x emotion grouping included 32 subjects. Each of these groups was further divided by the finger-response pattern used for the choice reaction time dependent measure. Subjects in the index condition indicated "yes" with the index digit and "no" with the middle digit, while subjects in the middle condition indicated "yes" with the middle digit and "no" with the index digit. Thus, each sex x emotion x finger pattern cell contained 16 subjects. Although the four target-nontarget face combinations were counterbalanced across all cells, these were not analyzed. Since subjects were not categorized equally across the three CLEM groups, the final sex x emotion x finger pattern x CLEM cells for the tachistoscopic task were unequal. The cell frequencies are presented in the Results section. Although a significant main effect for finger pattern was not unexpected, it was not anticipated that it would interact with the other variables. The intention was, therefore, to collapse subjects across the two finger pattern groups.

For the remaining measures in the study (perceptual bias test, free view face recognition test) unrelated to the tachistcscopic tasks, subjects were analyzed by a two-way analysis of variance with sex x CLEM as the independent variables. Correlations between the various measures were also examined.

III. RESULTS

Sixty four males and 64 females completed the design of the experiment. They were further divided equally according to the variables under consideration on the tachistoscopic task along the dimensions of emotion(emotional/neutral) and finger pattern (Index condition, Middle condition). Hence, there were 16 subjects within each cell.

The remaining variables of the study were available for every subject. These included the Perceptual Bias test, the Free View Facial Recognition test, and the ratings of Perceived and Subjective Emotion.

CLEM groups were used as a further blocking variable. The formula described earlier for categorizing subjects as left movers, bimovers, or right movers resulted in 50 left movers, 41 bimovers, and 37 right movers. The subsequent distribution of CLEM groups within the independent groups of the tachistoscopic task are presented in Table 1.

Table 1

Distribution of CLEM Groups

Finger Pattern	CLEMS	Males Emotional	Males Neutral	Females Emotional	Females Neutral
	LM[1]	6	6	7	7
Index	BI[2]	4	6	4	4
	RM[3]	6	4	5	5
	LM	6	7	6	5
Middle	BI	6	5	5	7
	RM	4	4	5	4

[1]Left Movers
[2]Bimovers
[3]Right Movers

A 2(sex) x 2(emotion) x 2(finger pattern) analysis of variance was conducted with the CLEM ratios of the subjects as the dependent variable in order to confirm that the distribution of CLEM ratio scores across the groupings did not differ significantly. This was confirmed. As can be seen from Table 2, none of the effects even approached significance. The mean CLEM ratio was .427, reflecting the greater tendency towards left eye movements in the present sample.

Table 2

ANOVA of CLEM Scores across Experimental Conditions

Source	SS	DF	MS	F	Prob.
Sex (S)	0.00	1	0.00	0.00	.978
Finger (F)	0.01	1	0.01	0.10	.755
Emotion (E)	0.00	1	0.00	0.00	.995
SF	0.00	1	0.00	0.05	.825
SF	0.00	1	0.00	0.05	.838
FE	0.02	1	0.02	0.09	.780
SEF	0.02	1	0.02	0.09	.770
Error	12.19	120	0.10		

Error rates in tachistoscopic task

The percentage of errors for the central presentation tachistoscopic facial recognition task was 3.08%. The error rate for the lateral presentation tachistoscopic task over the last two blocks was 7.02%.

Calculation of reaction time

In organizing the reaction times for the lateral presentation portion of the tachistoscopic face recognition test, the first two blocks were considered as practice blocks.

The purpose of the practice blocks was to stabilize reaction times and to decrease the error rate to an acceptable level for a reaction time analysis of the data. Only the last two blocks were analyzed for reaction time, although all blocks were to be included in an error analysis. In each of the two blocks, the first eight trials were discarded, and of the remaining 32 trials, only correct responses were retained for analysis. For the retained trials, mean reaction times were calculated separately for _yes_-LVF, _yes_-RVF, _no_-LVF, _no_-RVF. Since this was done for two blocks, each subject had two mean reaction times each for _yes_ and _no_ responses in each visual field. The mean of these two mean reaction times for each of the four conditions was calculated for each subject. Hence, in this task, there were four scores for each subject - a mean _yes_-LVF reaction time, a mean _yes_-RVF reaction time, a mean _no_-LVF reaction time, and a mean _no_-RVF reaction time.

The one block of the central tachistoscopic face recognition test was analyzed for reaction time because of the previously attained familiarity with the task and because of the greater ease of this task relative to the lateral presentation condition, resulting in lower error rates. Again, the first eight trials were discarded, and mean reaction time for correct trials of the remaining 32 was calculated. Trials were organized by _yes_ and _no_ responses, and separate means calculated for each type of response. Data for one subject were not available for this task because of a mechanical breakdown towards the end of the session. Hence, for the central position tachistoscopic task, there were 127 subjects instead of 128. The excluded subject was a female bimover in the neutral/index condition.

In order to systematically eliminate spuriously large reaction times, Dixon's (1953) procedure for rejecting outliers was applied. In general, Dixon's formula estimates the standard deviation of a distribution of scores and, on that basis, determines the magnitude of the values which lie beyond a given probability value for that distribution. In the present study, observations lying beyond the .01 level of their distribution were eliminated. This was done for each of the separate distributions for each yes/no x visual field combination. This criterion was applied one-tailed, that is, only to excessively large observations. With few exceptions, all excessively small observations were within the normal range.

Calculation of Error Scores

An error was categorized as a yes or no error in terms of the correct response that the subject failed to make. In other words, when it is reported that a subject group made significantly more errors on the yes trials, this means that the subject group committed more errors (in this case, responded with no) on those trials in which the correct response was yes, more so than on trials in which the correct answer was no. This could be interpreted as indicating that for this particular subject group, the _yes_ trials were more difficult.

Data transformations

The decision was made to present three separate analyses of the lateral presentation tachistoscopic face recognition test. These were the following: (1) reaction time analysis over the last two blocks (2) error analysis over the last two blocks (3) error analysis based upon all four blocks. Examining the errors over all four blocks was considered to be appropriate because, due to the greater number of errors generated in the earlier blocks, an accuracy measure including them should be more sensitive than if only the last two blocks were considered. However, an error analysis over the last two blocks is also appropriate because it corresponds to the blocks used in the reaction time analysis.

In the course of analyzing the data, it became apparent that the means and standard deviations were correlated for both sets of error data and reaction time data for the lateral presentation task. The same pattern was present in the error and reaction time data for the central presentation tachistoscopic task. Group means were plotted against their respective standard deviations and correlation coefficients calculated. This was done for the following sets of data: (1) reaction time data for lateral presentation face recognition task (2) reaction time data for central presentation face recognition task (3) error data for lateral presentation task over all four blocks (4) error data for lateral presentation task over last two blocks (5) error data for central presentation tachistoscopic task. The correlation coefficients were .52,.41,.54,.67,.63, respectively. The means and standard deviations are correlated in all five cases.

Transformation of error data

A logit transformation (Mosteller and Tukey, 1977) was applied to the error data. The resulting correlation coefficients were .41,.64,.60 for the errors over four blocks, two blocks, and the central presentation, respectively. With the exception of the error data over the last four blocks, the transformation did not significantly alter the relationship between the means and standard deviations. Since the logit transformation is considered to be a powerful one, no other transformations were considered, and the decision was made to analyze the original error scores.

Transformation of reaction time data

Since reaction time data are well known to yield skewed distributions in which means and standard deviations are correlated (Hays, 1963), the decision was made to apply the logarithmic transformation at the level of the original observations. For each subject, each reaction time score was transformed into its natural logarithm. The same procedures that had been used with the original observations were applied. Observations were organized by type of response and visual fields and Dixon's procedure for rejecting outliers was applied to the transformed data. The application of Dixon's procedure resulted in the elimination of .87% of the observations in the lateral presentation condition and .50% in the central presentation condition. These transformed data were plotted in the same way as was done with the original data, and respective correlation coefficients were calculated for both the lateral and central presentation data. These were .19 and -.13, respectively, neither approaching statistical significance. This indicated that the transformation substantially reduced the correlations between the subject group means and standard deviations in both cases. Thus, the decision was made to analyze the transformed reaction time data.

For both the error and reaction time data, the relationships described above were also apparent from separate graphs drawn for each set of nontransformed and transformed data.

Organization of Results

The results will be reported in the following order:

1. Tachistoscopic face recognition test
   a. Error analysis
      1) Central presentation
      2) Lateral presentation
         a) Analysis of errors over four blocks
         b) Analysis of errors over two blocks
   b. Reaction time analysis
      1) Central presentation
      2) lateral presentation
2. Correlations between reaction time and error data
3. Perceptual Bias Test
4. Free view face recognition test
5. Correlations between perceptual bias and tachistoscopic indices of laterality
6. Correlations between laterality indices and tests of overall facial processing ability
7. Correlations between various measures of facial processing ability
8. Emotion ratings of tachistoscopic facial stimuli by subjects
9. Analyses using emotion ratings
10. Summary of Results

Due to the complexity of the interactions in the analyses to follow, many tables will include only cell means. However, in each case, there will be a corresponding complete table in the appendix.

Error analysis: Central presentation

A 2(sex) x 2(emotion) x 2(finger-response pattern) x 3(CLEM) analysis of variance was run on the error data with response(yes/no) as a within subjects factors. It should be noted that an interaction between finger pattern and response can be interpreted as a main effect for digit, that is, index or middle digit. The results of the analysis are presented in Table 3.

As can be seen from Table 3, the effects attaining statistical significance are a sex x CLEM interaction, $F(2,103) = 3.13$, $p = .05$, and a Response x Emotion interaction, $F(1,103) = 3.83$, $p = .05$ The cell means for the former are presented in Table 4 and Figure 1. The full table is in Appendix E.

From Table 4 and Figure 1 it can be seen that for the females, left movers made the fewest errors, bimovers the most, and right movers fell in between. For the males, right movers made the fewest errors, with left movers and bimovers having a similar, and higher, error rate. The poor performance of the female bimovers is particularly striking. Separate analyses were done for males and females to further examine the significance of these effects. The resulting analyses of variance are presented in Appendix F(i). For the males, $F(2,52) = .40$, $p =$

Figure 1

Errors for Sex x CLEM Interaction on Central Presentation Face Recognition Test

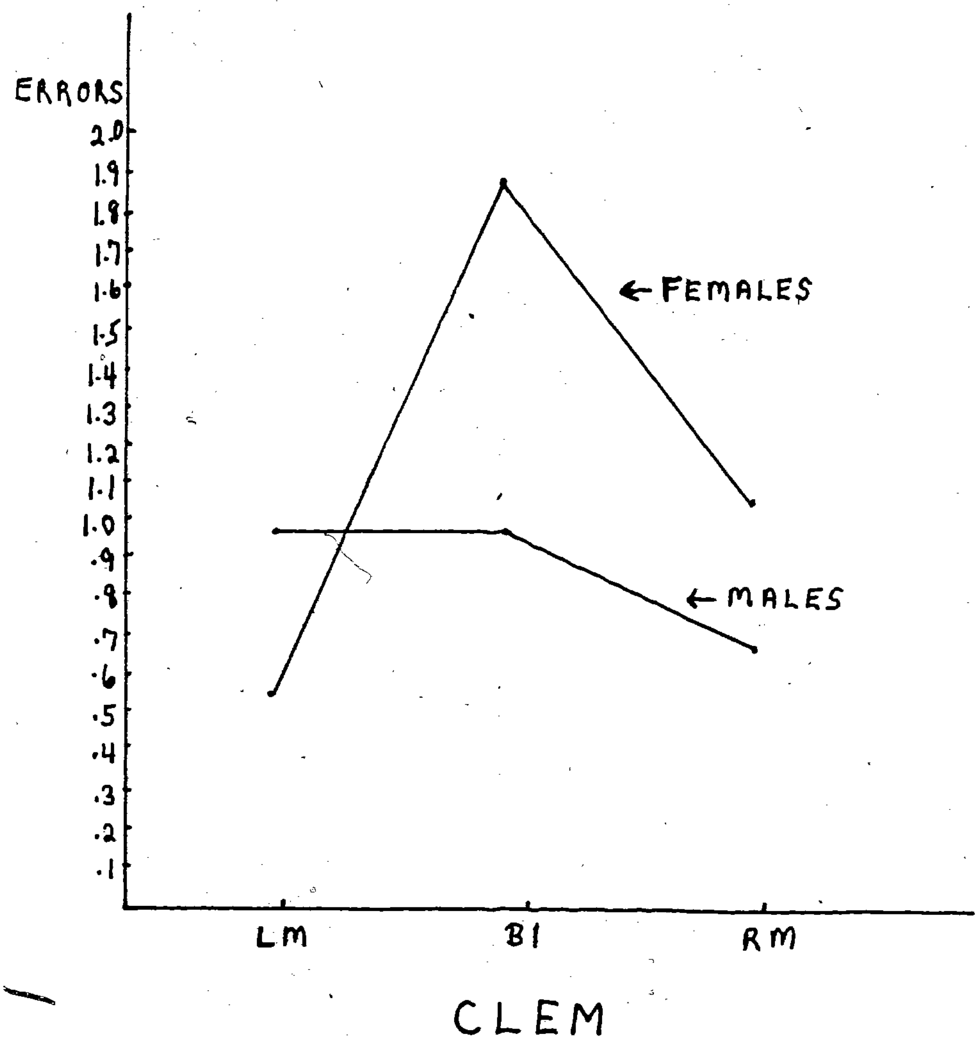

Table 3
ANOVA for Errors on Central Presentation Tachistoscopic Face Recognition Test

Source	SS	DF	MS	F	Prob.
Sex (S)	0.54	1	0.54	0.75	.389
Emotion (E)	0.91	1	0.906	1.26	.264
Finger(F)	0.02	1	0.02	0.02	.878
CLEM (C)	3.34	2	1.67	2.32	.104
SE	0.21	1	0.21	0.29	.591
SF	0.16	1	0.16	0.23	.636
EF	0.34	1	0.34	0.48	.491
SC	4.51	2	2.26	3.13	.048*[1]
EC	3.96	2	1.98	2.75	.068
FC	0.21	2	0.11	0.15	.862
SEF	1.02	1	1.02	1.42	.236
SEC	0.04	2	0.02	0.03	.972
SFC	1.16	2	0.58	0.80	.450
EFC	0.73	2	0.36	0.51	.603
SEFC	0.93	2	0.46	0.65	.526
Error	74.12	103	0.72		
Response (R)	2.16	1	2.16	2.70	.104
RS	0.00	1	0.00	0.01	.932
RE	3.06	1	3.06	3.83	.053*
RF	0.82	1	0.82	1.02	.314
RC	0.38	2	0.19	0.24	.786
RSE	0.01	1	0.01	0.01	.913
RSF	2.38	1	2.38	2.98	.087
REF	0.22	1	o.22	0.28	.597
RSC	0.13	2	0.06	0.08	.923
REC	0.73	2	0.36	0.46	.635
RFC	1.81	2	0.90	1.13	.326
RSEF	0.52	1	0.52	0.66	.420
RSEC	2.95	2	1.48	1.85	.163
RSFC	1.38	2	0.69	0.86	.426
REFC	1.78	2	0.89	1.11	.333
RSEFC	1.92	2	0.96	1.20	.306
Error	82.35	103	0.80		

[1] $p < .05$

Table 4
Mean Errors for Sex x CLEM Interaction on Central Presentation Tachistoscopic Face Recognition Test

	Left Movers	Bimovers	Right Movers
Males	1.00	1.00	.72
Females	.56	1.89	1.05

.67, and for the females, $F(2,52) = 4.74$, $p = .01$. The effect for females is statistically significant while that for males is not.

The other significant effect is the response x emotion interaction, the cell means for which are presented in Table 5.

The interaction here appears to be due to the poor performance of the neutral group on the <u>no</u> trials, relative to the other three groups.

The cell means for the trend towards an emotion x CLEM interaction, $F(2,103)$, $p = .07$, are presented in Appendix F(iii). The pattern of means indicates that this interaction is due to the large number of errors made by the bimovers in the neutral condition.

In summary, for the central presentation tachistoscopic face recognition task, two effects attained statistical significance. A sex x CLEM interaction was due to CLEM differences among the females. Female left movers made the fewest errors, bimovers the largest, with right movers in between. The source of a significant response x emotion interaction derived from a significantly greater number of errors for neutral faces on the <u>no</u> trials. Finally, a trend towards an emotion x CLEM interaction was primarily attributable to a large number of errors made by bimovers on the neutral faces.

Table 5
Errors for Response X Emotion Interaction for Central Presentation Tachistoscopic Face Recognition Test

		Emotional	Neutral	
Yes	Mean	.42	.36	.39
	(SD)	(.77)	(.66)	
No	Mean	.42	.81	
	(SD)	(.71)	(1.26)	
	N	(64)	(63)	(127)

<u>Tachistoscopic face recognition task: lateral presentation</u>

Error analysis over four blocks

For each subject, total errors across all four blocks were organized in the same manner as with the reaction time data in this task. Total errors for each of the within subject conditions were calculated: <u>yes</u>-LVF, <u>yes</u>-RVF, <u>no</u>-LVF, <u>no</u>-RVF. This data was submitted to an analysis of variance with sex(2) x emotion(2) x CLEM(3) x finger pattern(2) as between subjects factors and response type(2) and visual field(2) as within subject factors. The results of the analysis are presented in Table 6.

As can be seen from Table 6, several effects attain statistical significance. The effects that will be discussed first are those relevant to the hypotheses proposed in the Introduction. The other effects will then be briefly described.

The cell means for the visual fields x sex x CLEM interaction ($F(2,104) = 3.65$, $p = .03$) are presented in Table 7 and in Figure 2. The full table is available in Appendix G.

Table 6
ANOVA of Errors over Four Blocks for Lateral Presentation Face Recognition Test

Source	SS	DF	MS	F	Prob.
Sex (S)	1.75	1	1.75	0.08	.784
Emotion (E)	12.28	1	12.28	0.53	.469
Finger (F)	0.05	1	0.05	0.00	.963
CLEM (C)	92.09	2	46.05	1.98	.143
SE	0.00	1	0.00	0.00	.998
SF	7.45	1	7.45	0.32	.573
EF	2.76	1	2.76	0.12	.731
SC	1.94	2	0.97	0.04	.959
EC	28.34	2	14.17	0.61	.546
FC	13.53	2	6.76	0.29	.748
SEF	59.48	1	59.48	2.56	.113
SEC	60.90	2	30.45	1.31	.275
SFC	79.23	2	39.62	1.70	.187
EFC	112.71	2	56.36	2.42	.094
SEFC	22.21	2	11.11	0.48	.622
Error	2420.32	104	23.27		
Response (R)	2.59	1	2.59	0.24	.623
RS	4.32	1	4.32	0.40	.526
RE	20.32	1	20.32	1.90	.171
RF	32.00	1	32.00	3.00	.086
RC	4.41	2	2.21	0.21	.814
RSE	23.89	1	23.89	2.24	.138
RSF	2.47	1	2.47	0.23	.631
REF	18.04	1	18.04	1.69	.197
RSC	88.23	2	44.12	4.13	.019*
REC	75.56	2	37.78	3.54	.033*
RFC	0.68	2	0.34	0.03	.969
RSEF	4.56	1	4.56	0.43	.515
RSEC	46.97	2	23.48	2.20	.116
RSFC	7.12	2	3.56	0.33	.717
REFC	22.02	2	11.01	1.03	.360
RSEFC	7.07	2	3.53	0.33	.719
Error	1110.54	104	10.68		
Visual Field (V)	12.49	1	12.49	3.10	.081
VS	0.61	1	0.61	0.15	.698
VE	0.17	1	0.17	0.04	.837
VF	2.20	1	2.20	0.55	.461
VC	19.15	2	9.58	2.38	.098
VSE	1.41	1	1.41	0.35	.556
VSF	0.99	1	0.99	0.25	.621

Table 6 (cont'd)

VEF	1.64	1	1.64	0.41	.524
VSC	29.39	2	14.69	3.65	.029*
VEC	0.23	2	0.11	0.03	.972
VFC	1.20	2	0.60	0.15	.862
VSEF	7.73	1	7.73	1.92	.169
VSEC	2.10	2	1.05	0.26	.771
VSFC	16.23	2	8.11	2.01	.138
VEFC	4.99	2	2.49	0.62	.540
VSEFC	7.62	2	3.81	0.95	.392
Error	418.82	104	4.03		
RV	36.41	1	36.41	4.27	.041*
RVS	0.01	1	0.01	0.00	.974
RVE	11.05	1	11.05	1.30	.258
RVF	14.49	1	14.49	1.70	.195
RVC	3.72	2	1.86	0.22	.804
RVSE	0.04	1	0.04	0.01	.944
RVSF	0.63	1	0.63	0.07	.786
RVEF	4.52	1	4.52	0.53	.468
RVSC	17.18	2	8.59	1.01	.369
RVEC	0.30	2	0.15	0.02	.982
RVFC	11.35	2	5.68	0.67	.516
RVSEF	1.61	1	1.61	0.19	.664
RVSEC	3.12	2	1.56	0.18	.833
RVSFC	24.52	2	12.26	1 44	.242
RVEFC	2.60	2	1.30	0.15	.859
RVSEFC	12.58	2	6.29	0.74	.481
Error	886.86	104	8.53		

Inspection of Table 7 indicates that males and females differ in the pattern with which CLEM group interacts with relative accuracy of the visual fields. For the males, left movers and bimovers are more accurate in identifying faces presented in the RVF (presumably left hemisphere), whereas the opposite pattern is present for male right movers. For the females, left movers were more accurate with faces presented to their LVF (presumably right hemisphere), while both bimovers and right mover females were more accurate with faces presented in the RVF (presumably left hemisphere).

Figure 2

Errors (Four Blocks) for Visual Field x Sex x CLEM Interaction on Lateral Presntation Task

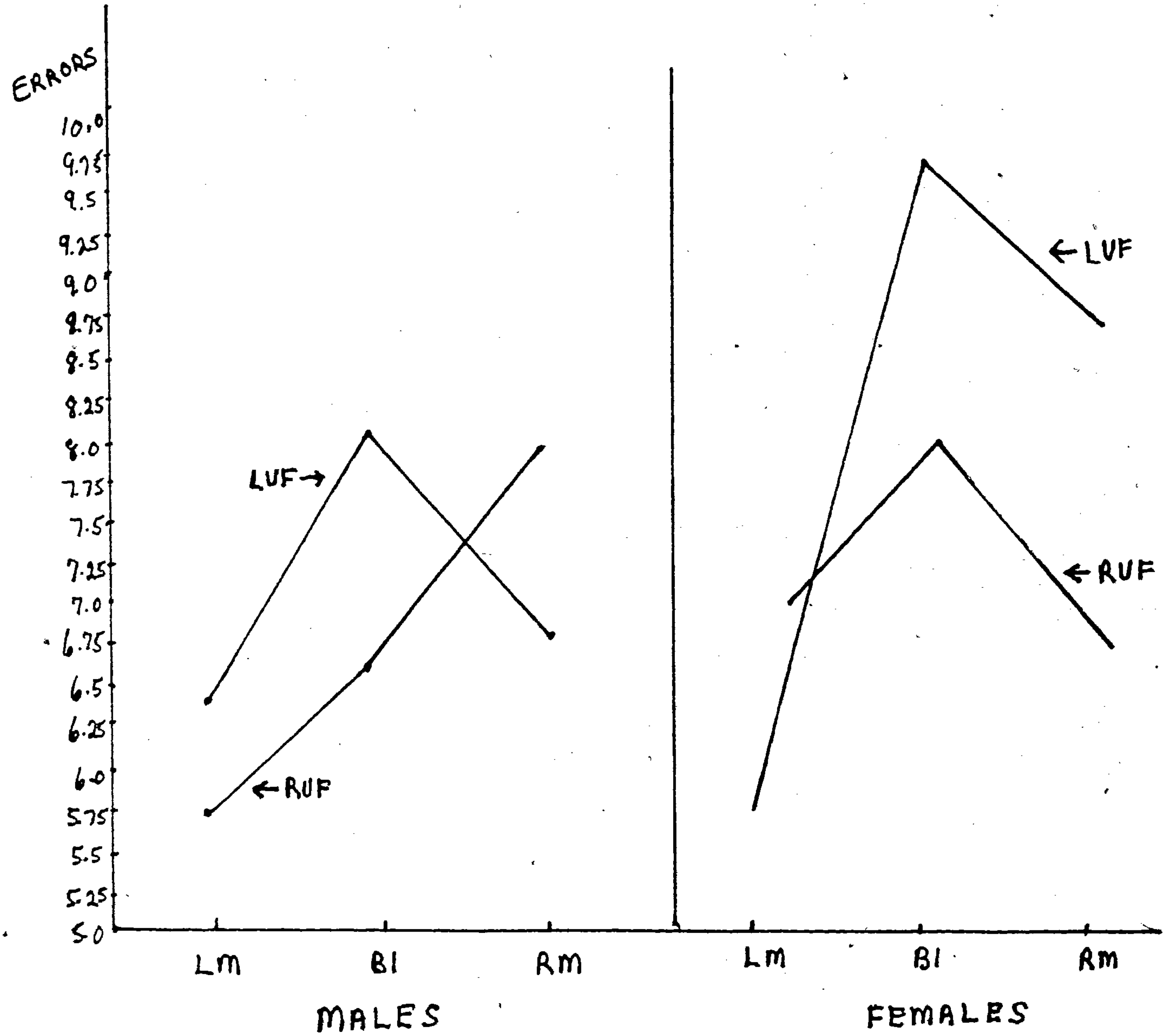

Table 7
Mean Errors (Four Blocks) For Visual Field x Sex x CLEM Interaction on Lateral Presentation Tachistoscopic Task

		Left Movers	Bimovers	Right Movers
Males	LVF	6.32	8.09	6.78
	RVF	5.68	6.57	7.89
	Combined	6.00	7.33	7.33
	RVF-LVF	-.64	-1.52	+1.11
Females	LVF	5.72	9.75	8.68
	RVF	6.92	7.95	6.58
	Combined	6.32	8.85	7.63
	RVF-LVF	+1.2	-1.8	-2.10

Separate analyses for each sex and visual field were conducted in order to more clearly identify the basis of this difference. The results of these analyses are presented in Appendices H(i), H(ii), H(iii), and H(iv).. A comparison of the male and female effects indicates that the three way visual field x sex x CLEM interaction is due to an interaction between visual field and CLEM for each sex equally, but the nature of the interactions differ. The F ratios and their corresponding p values are $F(2,52) = 3.15$, $p = .05$ for the males and $F(2,52) = 2.91$, $p = .06$ for the females. A comparison of the analysis for each visual field separately yields a significant CLEM effect for the LVF only, $F(2,104) = 3.08$, $p = .038$) and not for the RVF, $F(2,104) = 0.70$, $p = .58$). Inspection of the marginals of Table 7 shows that this is due to the greater accuracy of the left movers, followed by the right movers and bimovers. However, the absence of a sex x CLEM interaction in either visual field is puzzling, given the significant visual fields x sex x CLEM interaction in the overall analysis and the significant or marginally significant visual field x CLEM interactions for each sex. From inspection of the cell means of Table 7, however, it is clear that the CLEM effect for the left visual field is stronger for females, particularly in the greater accuracy of the left movers over the right movers, whereas, for the males, the error rates for the left and right movers are similar. For the RVF, although there is no overall CLEM effect nor sex x CLEM interaction, the directions of the CLEM trends are different for the two sexes. It is these combined differences from both visual fields that appear to contribute to the overall visual field x sex x CLEM interaction.

The cell means for the significant ($F(1,104) = 4.27$, $p = .04$) response x visual field interaction are presented in Table 8 and Figure 3.

From inspection, it is apparent that for the LVF, <u>no</u> trials were responded to more accurately than <u>yes</u> trials, whereas a smaller, but opposite pattern, is present for the RVF. Poorest performance was on the <u>yes</u> trials in the LVF.

The cell means for the significant response x sex x CLEM interaction, $F(2,104) = 4.13$, $p = .02$, are presented in Table 9 and Figure 4. The full table is in Appendix I. Separate analyses were done for each CLEM group These are presented in Appendices J(i),(ii), and (iii). These, together with the separate analyses for males and females, were examined in order to clarify the nature of this interaction. The similar size of the response x CLEM interaction for the males, $F(2,52) = 2.10$, $p = .132$, and

Figure 3

Errors (Four Blocks) for Response x Visual Field Interaction for Lateral Presentation Task

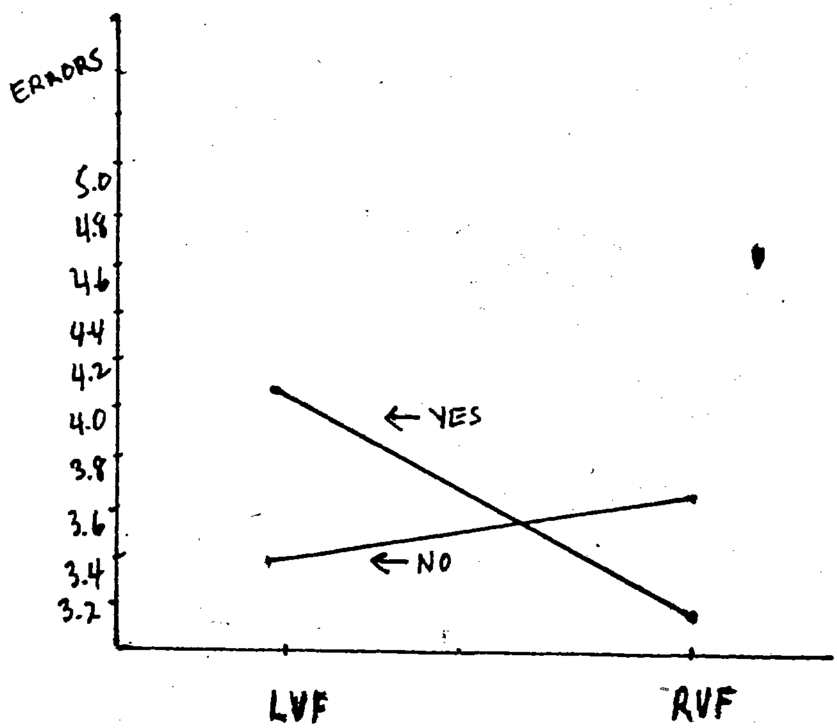

Table 8
Errors (Four Blocks) for Response x Visual Field Interaction for Lateral Presentation Tachistoscopic Task

		Yes	No
LVF	Mean	4.06	3.38
	SD	(3.55)	(3.60)
RVF	Mean	3.18	3.67
	SD	(2.94)	(3.52)
N			(128)

females, $F(2,52) = 2.25$, $p = .116$, suggests that the significant three way response x sex x CLEM interaction is due to the opposite directions in which the CLEM groups differ in their relative accuracy of yes and no responses for each sex.

The pattern of this interaction is apparent from inspection of Table 9. It is clear that the relative accuracy with the yes and no responses differs between left and right movers in opposite directions for the two sexes. For males, left movers are more accurate with the no responses, whereas right movers are more accurate on the yes trials. Conversely, for the females, left movers are more accurate with yes responses, while the opposite pattern holds for the right movers. Inspection of the separate analyses of the three CLEM groups yields the following values for the response x sex interaction. For this interaction with the left movers, $F(1,42) = 8.06$, $p = .007$. For the bimovers, the response x sex interaction produces $F(1,33) = .59$, $p = .45$). This same interaction for the right movers results in $F(1,29) = 2.43$, $p = .130$). It is clear that the response x sex interaction is most strong for the left movers, although this interaction for the right movers is not

Figure 4

Errors (Four Blocks) for Response x Sex x CLEM

Interaction for Lateral Presentation Task

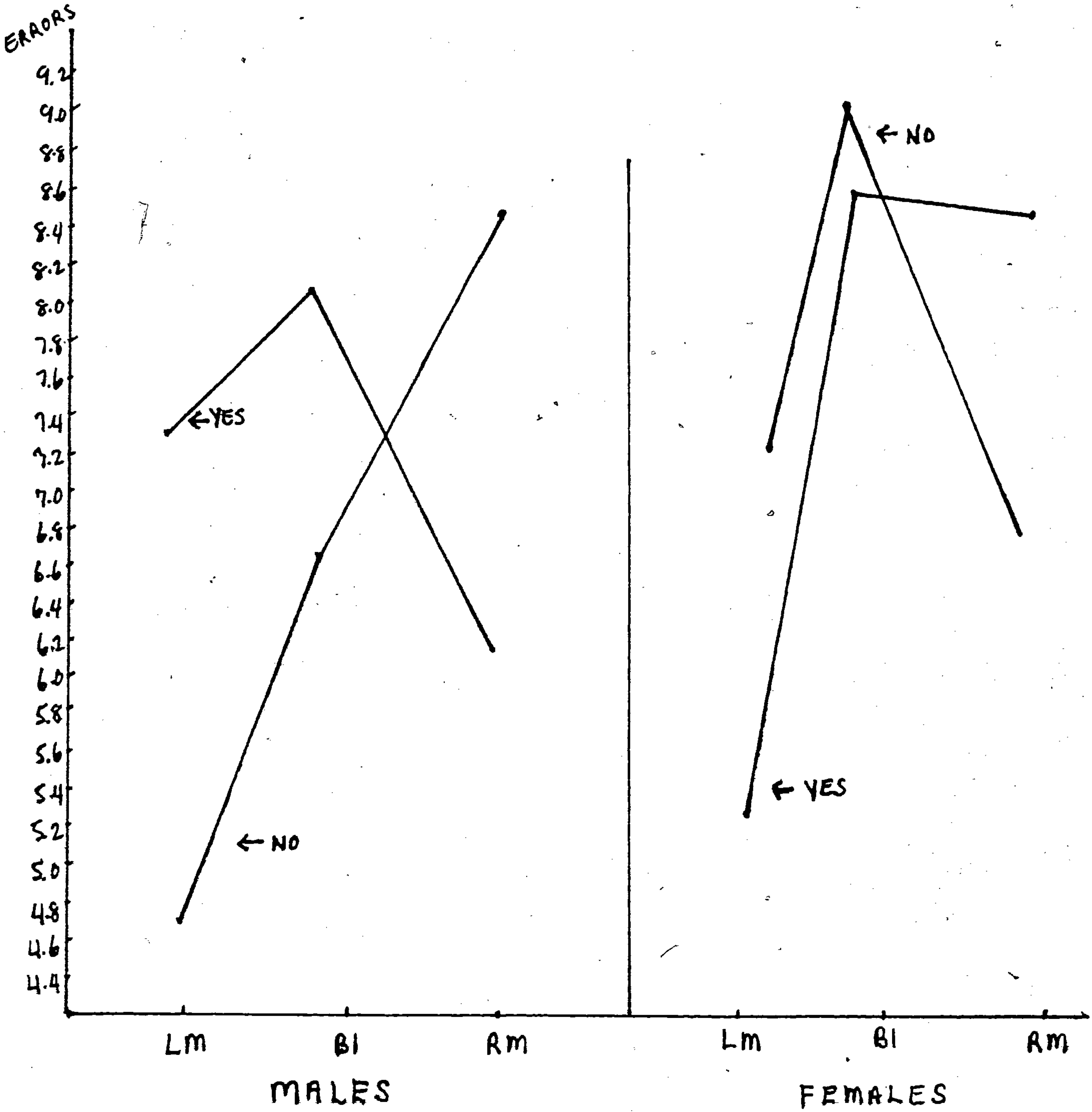

Table 9
Mean Errors (Four Blocks) for Response x Sex x CLEM Interaction for Lateral Presentation Tachistoscopic Task

		Left Mover	Bimover	Right Mover
Males	Yes	7.28	8.05	6.17
	No	4.72	6.67	8.50
Females	Yes	5.32	8.60	8.42
	No	7.28	9.05	6.74

negligible.

The cell means for the significant response x emotion x CLEM interaction ($F(2,104) = 3.54$, $p = .03$) are presented in Table 10 and Figure 5. The full table is available in Appendix K. The most striking interaction effect apparent from inspection of Table 10 and Figure 5 is the effect of the emotion/neutral dimension on the differential accuracy of the yes and no trials for the bimovers. No trials are worse in the neutral condition and yes trials are worse in the emotional condition. This is confirmed by inspection of the separate analyses for the CLEM groups in Appendix K. Only the bimovers even approach a significant response x emotion interaction, $F(1,33) = 7.18$, $p = .01$).

The results of the analysis of variance of errors over all four blocks on the lateral presentation tachistoscopic face recognition test can be summarized as follows. There is a significant visual field x sex x CLEM interaction, attributable to a CLEM difference in accuracy for females for faces presented in the LVF (presumably right hemisphere). Left movers are the most accurate followed by right movers and then bimovers. This results in left mover females demonstrating a LVF superiority,

Figure 5

Errors (Four Blocks) for Response x Emotion x CLEM

Interaction for Lateral Presentation Task

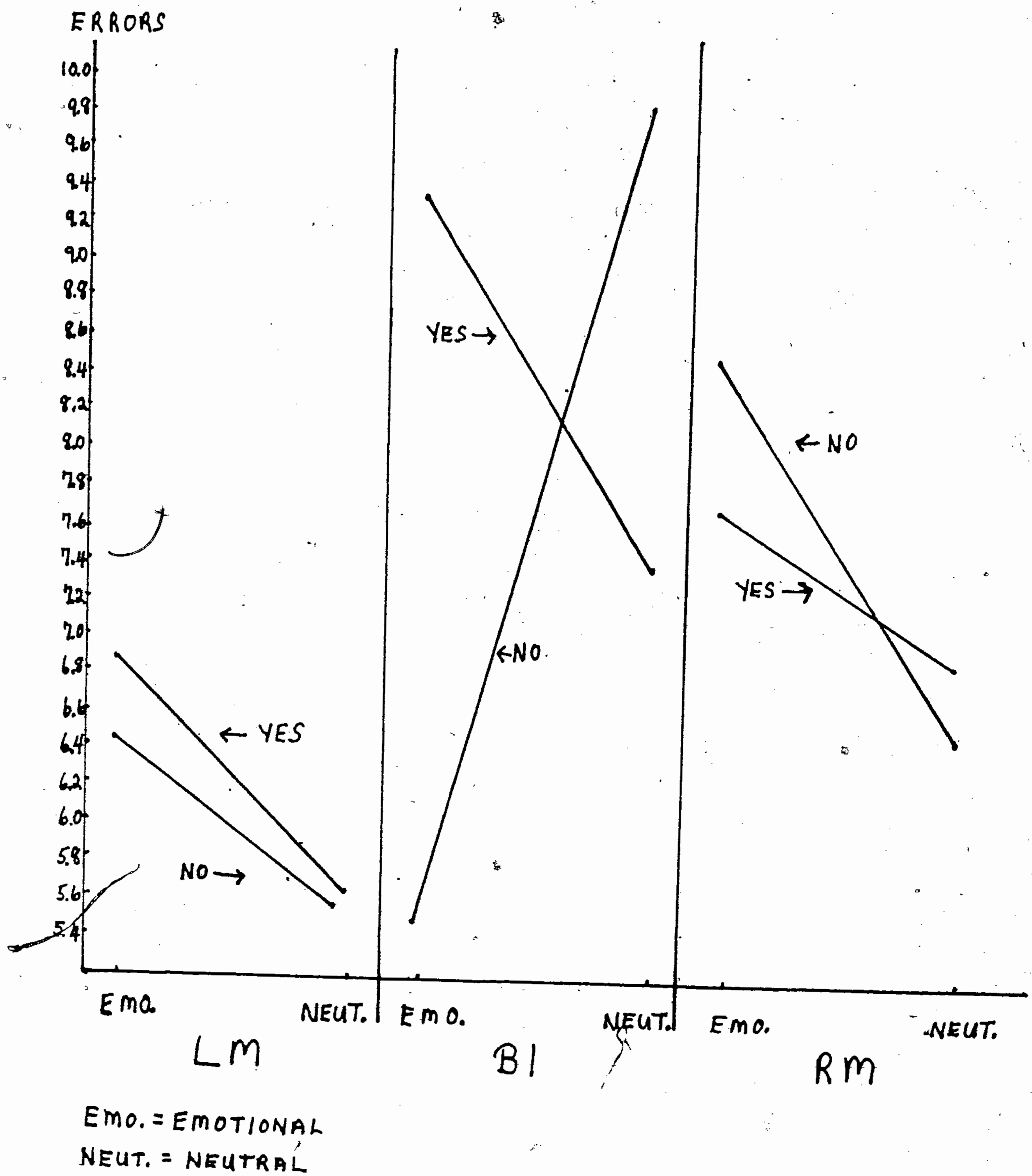

Table 10
Mean Errors (Four Blocks) for Response x Emotion x CLEM Interaction for Lateral Presentation Tachistoscopic Task

		Left Movers	Bimovers	Right Movers
Emotional	Yes	6.84	9.37	7.70
	No	6.40	5.53	8.55
Neutral	Yes	5.76	7.41	6.88
	No	5.60	9.82	6.47

while the opposite pattern holds for the right movers, and particularly the bimovers. An opposite laterality pattern is evident for the males, such that right mover males exhibit a LVF superiority, while left movers, and particularly bimovers demonstrate a greater RVF accuracy. Other findings are that the _yes_ trials are more accurately identified from the RVF, while _no_ trials are more accurately identified from the LVF. There are also response x sex x CLEM and response x CLEM interactions. The former is primarily due to opposing patterns of interaction of sex and differential accuracy of _yes_ and no trials for the left movers and right movers. The latter interaction is primarily due to the bimovers, whose _no_ trials are poorest in the neutral condition, with the opposite difference in the emotional condition.

Error analysis over last two blocks

The errors over the last two blocks were combined in the same way as with the analysis of error over the four blocks, and submitted to the same analysis of variance. The results are presented in Table 11.

Table 11
ANOVA for Errors over Last Two Blocks for Lateral Presentation Tachistoscopic Task

Source	SS	DF	MS	F	Prob.
Sex (S)	2.49	1	2.49	0.52	.472
Emotion (E)	0.02	1	0.02	0.00	.949
Finger (F)	0.08	1	0.08	0.02	.896
CLEM (C)	12.55	2	6.28	1.32	.272
SE	0.00	1	0.00	0.00	.979
SF	0.00	1	0.00	0.00	.982
EF	3.61	1	3.61	0.76	.386
SC	1.86	2	0.93	0.19	.823
EC	8.00	2	4.00	0.84	.435
FC	4.20	2	2.10	0.44	.645
SEF	7.19	1	7.10	1.49	.225
SEC	8.83	2	4.42	0.93	.399
SFC	17.31	2	8.65	1.82	.168
EFC	28.54	2	14.27	2.99	.054*
SEFC	2.08	2	1.04	0.22	.804
Error	495.56	104	4.76		
Response (R)	2.07	1	2.07	0.82	.366
RS	1.52	1	1.52	0.61	.438
RE	2.64	1	.64	1.05	.308
RF	5.25	1	5.25	2.09	.151
RC	0.02	2	0.01	0.00	.997
RSE	10.18	1	10.18	4.05	.047*
RSF	0.26	1	0.26	0.10	.750
REF	13.07	1	13.07	5.20	.025
RSC	4.60	2	2.30	0.92	.403
REC	23.86	2	11.93	4.75	.011**1
RFC	1.64	2	0.82	0.33	.722
RSEF	4.12	1	4.12	1.64	.203
RSEC	6.76	2	3.38	1.35	.265
RSFC	0.01	2	0.00	0.00	.998
REFC	0.98	2	0.49	0.19	.824
RSEFC	0.72	2	0.36	0.14	.867
Error	261.46	104	2.51		
Visual Field (V)	0.18	1	0.18	0.15	.697
VS	1.36	1	1.36	1.13	.290
VE	0.55	1	0.55	0.46	.501
VF	0.50	1	0.50	0.41	.522
VC	1.73	2	0.86	0.72	.491
VSE	0.89	1	0.89	0.73	.393
VSF	0.20	1	0.20	0.16	.687

Table 11 (cont'd)

VEF	0.41	1	0.41	0.34	.562
VSC	4.08	2	2.04	1.69	.189
VEC	0.48	2	0.24	0.20	.820
VFC	4.90	2	2.45	2.03	.136
VSEF	4.68	1	4.68	3.88	.052*
VSEC	1.06	2	0.53	0.44	.646
VSFC	3.50	2	1.75	1.45	.239
VEFC	2.30	2	1.15	0.95	.389
VSEFC	1.77	2	0.89	0.74	.482
Error	125.38	104	1.20		
RV	6.44	1	6.44	3.37	.069
RVS	0.02	1	0.02	0.01	.924
RVE	4.59	1	4.59	2.40	.124
RVF	4.31	1	4.31	2.26	.136
RVC	2.52	2	1.26	0.66	.519
RVSE	2.02	1	2.02	1.06	.306
RVSF	0.16	1	0.16	0.09	.769
RVEF	0.26	1	0.26	0.13	.715
RVSC	4.18	2	2.09	1.09	.339
RVEC	9.48	2	4.74	2.48	.089
RVFC	4.79	2	2.39	1.25	.290
RVSEF	4.68	1	4.68	2.45	.120
RVSEC	0.03	2	0.01	0.01	.993
RVSFC	8.91	2	4.45	2.33	.102
RVEFC	0.05	2	0.02	0.01	.988
RVSEFC	3.91	2	1.96	1.02	.363
Error	198.77	104	1.91		

[1]$p < .01$

Several effects attained statistical significance in this analysis. For the significant, $F(2,104) = 2.99$, $p = .05$, emotion x finger pattern x CLEM interaction, the data are reorganized in Table 12 for a clearer presentation of the pattern. (The actual mean errors and standard deviations are available in Appendix M.) The cell numbers represent differences between the index and middle finger patterns. Errors in the index condition were subtracted from errors in the middle condition for each group. Therefore, positive numbers reflect more errors in the middle condition (hence, greater accuracy in the index finger pattern), while negative numbers represent more errors in the index

Table 12
Mean Difference Scores for Errors (Two Blocks) for Emotion x Finger Pattern x CLEM Interaction for Lateral Presentation Tachistoscopic Task

	Left Movers	Bimovers	Right Movers
Emotional	-.30	-.19	+3.77
Neutral	-2.02	+2.52	-2.46

condition (and hence, less accuracy). For left movers, finger pattern did not appear to make a difference in the emotional condition, but for the neutral faces, there were more errors in the index conditon. Also, for the bimovers, an effect for finger pattern is not apparent for the emotional faces, but for the neutral faces bimovers were more accurate in the middle condition. The strongest effect appears to be for the right movers, who are more accurate in the index condition with the emotional faces, and demonstrate the opposite pattern with the neutral faces.

The significant ($F(1,104) = 5.20$, $p = .025$) response x emotion x finger pattern interaction represents an interaction of digit with emotion. The cell means, organized by index digit and middle digit rather than finger pattern, are presented in Table 13. The nature of the interaction is clear. The two digits differ in their accuracy for identifying the neutral faces, fewer errors being made with the index digit. Standard deviations are not available for these means since they were derived from combining the errors for the yes and no trials in opposing finger pattern conditions, in order to organize the data by digit.

Table 13
Mean Errors (Two Blocks) for Digit x Emotion Interaction on Lateral Presentation Tachistoscopic Task

	Emotional	Neutral
Index Digit	4.41	3.62
Middle Digit	4.12	5.44

The cell means for the significant response x emotion x CLEM interaction ($F(2,104) = 4.75$, $p = .01$) are presented in Table 14. The full table is in Appendix N. As in the equivalent analysis with the errors over all four blocks, the most striking difference here is with the bimovers, who are more accurate on the _no_ trials with the emotional faces, but more accurate on the _yes_ trials with the neutral faces.

The cell means for the significant response x sex x emotion interaction ($F(2,104) = 4.05$, $p = .05$) are presented in Table 15 and Figure 6. The full table is available in Appendix O.

As is evident from Figure 6, the interaction appears to be primarily due to the females. For this group, _yes_ and _no_ trials are equally accurate with the emotional faces. However, for the neutral faces, there is a substantial difference in the relative accuracy of the _yes_ and _no_ trials, with _no_ trials being more difficult.

The cell means for the visual field x sex x emotion x finger pattern interaction ($F(1,2) = 3.88$, $p = .052$) are available in Table 16. The full table is available in Appendix P. The interaction is due to differences in the relative accuracy in the visual fields among various sex x emotion x finger groupings. In general, both the males and females demonstrated opposite visual field differences for each finger

Table 14
Mean Errors (Two Blocks) for Response x Emotion x CLEM Interaction on Lateral Presentation Tachistoscopic Task

		Left Movers	Bimovers	Right Movers
Emotional	Yes	1.44	2.74	2.40
	No	2.20	1.42	2.75
Neutral	Yes	1.96	2.04	2.00
	No	1.72	3.73	2.18

pattern in each emotional condition. Furthermore, these patterns were in opposite directions for the two sexes. For males, LVF superiorities were present for subjects in the emotional-middle and neutral-index conditions, while RVF superiorities were present for subjects in the emotional-index and neutral-middle conditions. For females, there was a LVF superiority for subjects in the emotional-index condition, while the opposite was the case in the three other emotion/finger pattern groupings.

Although the response x visual field x emotion x CLEM interaction does not attain statistical significance ($F(2,104) = 2.48$, $p = .09$), it will be briefly described because of its theoretical significance in view of later findings. The cell means are presented in Table 17 and Figure 7. The full table is available in Appendix Q. It is apparent that the _yes_ and _no_ trials interact differently with visual field as a function of emotional valence. For the _no_ trials, there is a greater accuracy from the LVF (presumably right hemisphere) for the emotional faces, and no visual field difference in the neutral condition. However, for the _yes_ trials, in the emotional condition, both the left movers and bimovers exhibit strong RVF

Figure 6

Errors (Two Blocks) for Response x Sex x Emotion

Interaction on Lateral Presentation Task

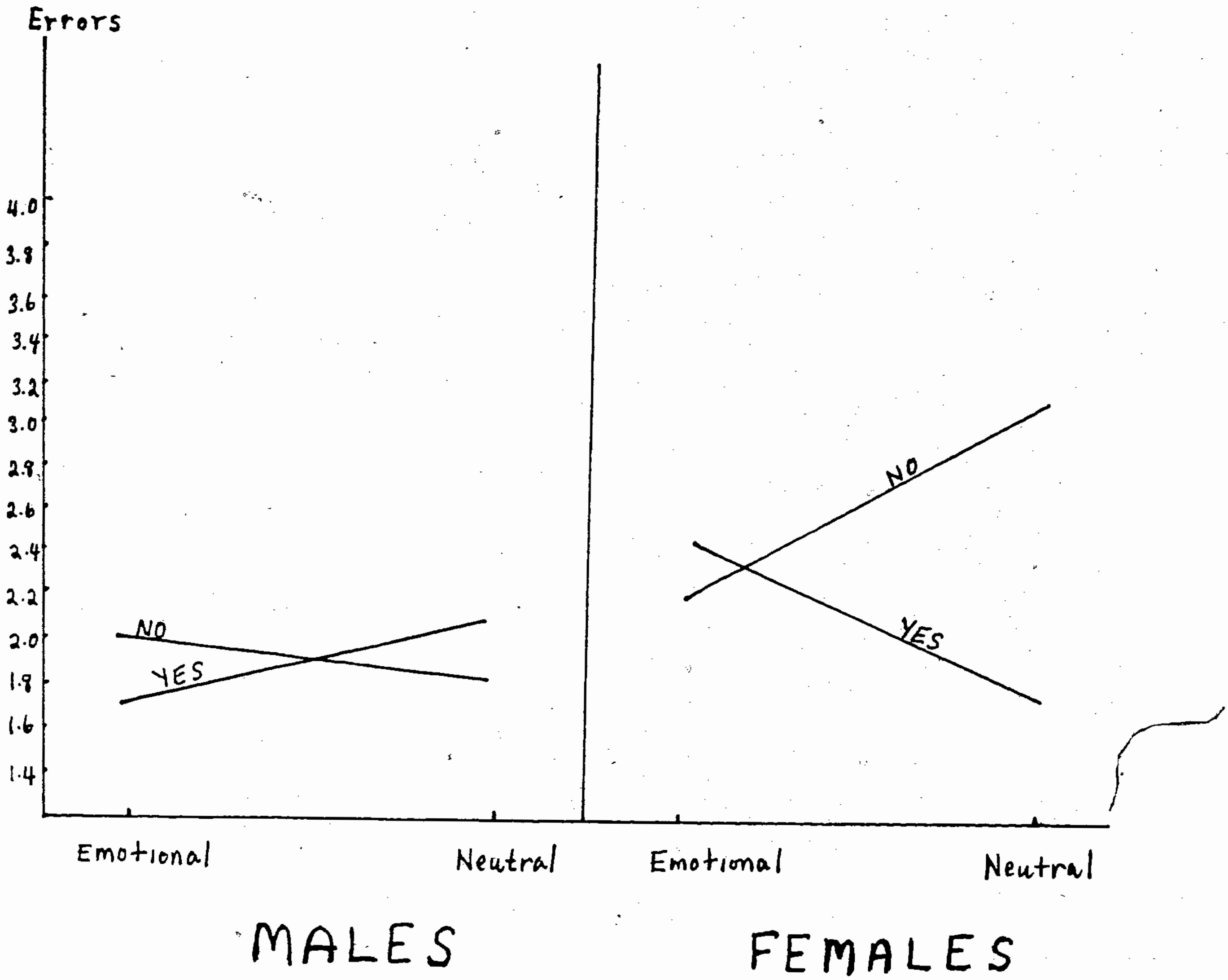

Table 15
Mean Errors (Two Blocks) for Response x Sex x Emotion Interaction on Lateral Presentation Tachistoscopic Task

	Males		Females	
	Emotional	Neutral	Emotional	Neutral
Yes	1.78	2.16	2.47	1.84
No	2.03	1.91	2.25	3.15

Table 16
Errors for Visual Field x Sex x Emotion x Finger Pattern Interaction in Lateral Presentation Tachistoscopic Task (Two Blocks)

		Males			
		Index Condition		Middle Condition	
		LVF	RVF	LVF	RVF
Emotional	Mean	2.19	1.81	1.56	2.06
Neutral	Mean	1.69	2.31	2.25	1.81
		Females			
		Index Condition		Middle Condition	
		LVF	RVF	LVF	RVF
Emotional	Mean	1.81	2.19	2.94	2.50
Neutral	Mean	2.94	2.62	2.62	1.94

superiorities, and the right movers demonstrate a weak trend in the other direction. Differences appear fairly negligible with the neutral faces.

Although the response x visual field interaction ($F(1,104) = 3.37$, $p = .07$) does not reach statistical significance, it should be noted that the differential accuracy of yes and no responses in the visual fields is the same as that reported over four blocks. In the LVF, no trials are more accurate than the yes trials, whereas there is a smaller trend in the opposite direction in the RVF.

Figure 7

Errors (Two Blocks) for Response x Visual Field x Emotion x CLEM Trend in Lateral Presentation Task

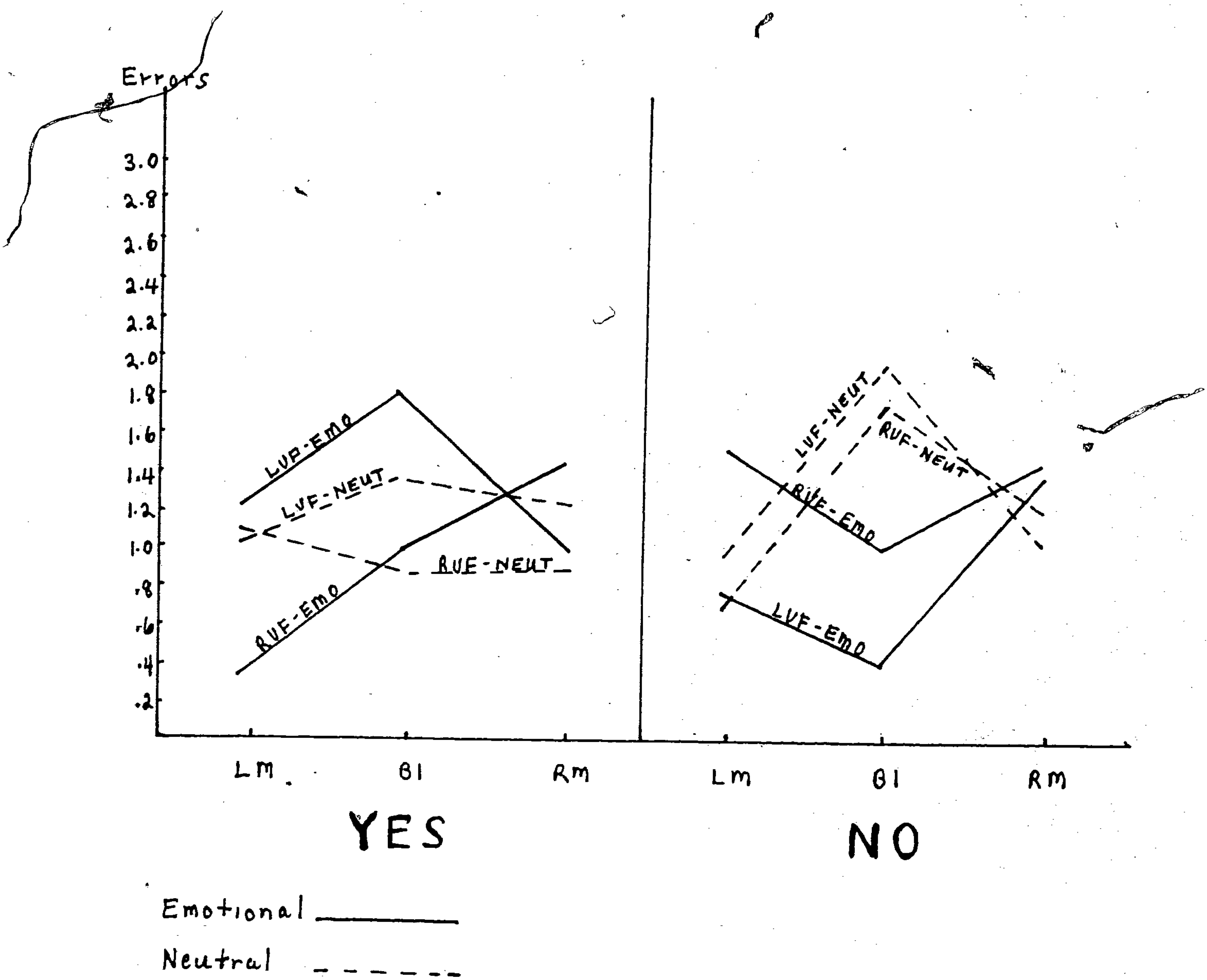

Table 17
Mean Errors (Two Blocks) for Response x Visual Field X Emotion x CLEM Trend in Lateral Presentation Tachistoscopic Task

		Yes		
		Left Movers	Bimovers	Right Movers
Emotional	LVF	1.12	1.79	1.00
	RVF	.32	.95	1.40
Neutral	LVF	.96	1.23	1.12
	RVF	1.00	.82	.88
		No		
		Left Movers	Bimovers	Right Movers
Emotional	LVF	.76	.42	1.35
	RVF	1.44	1.00	1.40
Neutral	LVF	.96	1.95	1.00
	RVF	.76	1.77	1.18

The results can be summarized as follows. As in the error analysis over four blocks, there was a significant response x emotion x CLEM interaction due to bimovers displaying differential accuracy on the yes and no responses in opposing directions for the emotional and neutral faces. There was a tendency towards a LVF superiority for emotional faces in the case of the no trials, in contrast to a trend towards a RVF superiority in the emotional condition for the yes responses. Finally, there were two effects involving finger, an emotion x finger x CLEM and visual field x sex x emotion x finger interaction.

Reaction Time Analysis of Tachistoscopic Face Recognition Tests

The reaction time data of the tachistoscopic face recognition task were analyzed in the lateral presentation condition over the last two blocks, and the single central presentation condition block was analyzed. As noted earlier, the data were altered by a logarithmic transformation and the application of Dixon's criteria for rejecting outliers.

Reaction Time Analysis of Central Presentation Tachistoscopic Face Recognition Test

As in the error analysis, each subject's trials were organized by response type. Hence, each individual's data were expressed as two mean reaction times, one for the yes trials and one for the no trials, each based upon 16 trials.

These data were subjected to an analysis of variance with sex, emotion, finger pattern, and CLEM as the between subjects factors, and response type as a within subjects factor. This analysis is presented in Table 18.

Inspection of Table 18 indicates a significant main effect for CLEM, $F(2,103) = 5.31$, $p = .006$. Notable in its absence when compared with the equivalent analysis of errors is the complete lack of a sex x CLEM interaction. The cell means for the CLEM effect are presented in Table 19. The means are transformed back into their original metric for ease of interpretation. The

Table 18
ANOVA for Reaction Time on Central Presentation Tachistoscopic Face Recognition Test

Source	SS	DF	MS	F	Prob.
Sex (S)	2.16	1	2.16	0.41	.525
Emotion (E)	3.98	1	3.98	0.75	.389
Finger(F)	1.10	1	1.10	0.21	.649
CLEM (C)	56.38	2	28.19	5.31	.006**
SE	5.58	1	5.58	1.05	.308
SF	0.46	1	0.46	0.09	.768
EF	4.25	1	4.25	0.80	.373
SC	0.43	2	0.22	0.04	.960
EC	0.10	2	0.05	0.01	.991
FC	0.57	2	0.29	0.05	.948
SEF	4.90	1	4.90	0.92	.339
SEC	5.67	2	2.84	0.53	.589
SFC	0.52	2	0.26	0.05	.953
EFC	8.88	2	4.44	0.84	.436
SEFC	1.44	2	0.72	0.14	.873
Error	546.93	103	5.31		
Response	54.04	1	54.04	69.16	.000**
RS	1.04	1	1.04	1.33	.251
RE	1.00	1	1.00	1.28	.260
RF	1.80	1	1.80	2.30	.133
RC	2.10	2	1.05	1.34	.266
RSE	0.17	1	0.17	0.22	.642
RSF	0.98	1	0.98	1.26	.264
REF	0.28	1	0.28	0.36	.550
RSC	0.05	2	0.03	0.03	.966
REC	0.93	2	0.46	0.59	.554
RFC	1.80	2	0.90	1.15	.320
RSEF	1.85	1	1.85	2.37	.126
RSEC	1.46	2	0.73	0.94	.395
RSFC	1.39	2	0.69	0.89	.415
REFC	2.34	2	1.17	1.49	.229
RSEFC	2.86	2	1.43	1.83	.166
Error	80.49	103	0.78		

standard deviations reported in the tables for the reaction time analyses need to be used differently in interpreting the size of effects. [1]

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[1] For example, a value of one standard deviation above or below the mean would be obtained by multiplying or dividing that mean by its standard deviation, respectively, rather than adding or subtracting its standard deviation.

Table 19
Reaction Times for CLEM Groups in Central Presentation Tachistoscopic Face Recognition Test

	Left Movers	Bimovers	Right Movers
Mean	488.54	522.62	549.62
SD	(1.18)	(1.16)	(1.15)
N	(50)	(40)	(37)

Table 19 shows a clear linear trend from left movers through bimovers to right movers, with left movers exhibiting the fastest reaction times and right movers the slowest.

The cell means for the significant main effect for response type are presented in Table 20. Correct _yes_ trials were responded to faster than correct _no_ trials. Unlike in the equivalent error analysis where response type interacted with emotion, no significant interaction is present here.

In summary, left movers exhibited the fastest reaction times to the faces, followed by the bimovers and then the right movers. Correct _yes_ responses were faster than correct _no_ responses.

Reaction Time Analysis for Lateral Presentation Tachistoscopic Task

The subjects' transformed reaction times over the last two blocks were organized into four groups: _yes_-LVF, _yes_-RVF, _no_-LVF, and _no_-RVF. Means for the four distributions were calculated within each block and the two means for each of the four conditions were averaged. Hence, each subject's reaction time data consisted of four means. These were submitted to an

Table 20
Reaction Times for Correct Yes and No Responses on Central Presentation Tachistoscopic Face Recognition Test

	Yes	No
Mean	492.43	541.65
SD	(1.19)	(1.18)
N		(127)

analysis of variance with sex, emotion, finger pattern, and CLEM as between subjects factors and response type and visual field as within subjects factors. The analysis is presented in Table 21.

Effects that attain statistical significance are a main effect for visual field, F(1,104) = 3.91, p = .051, a visual field x emotion interaction, F(1,104) = 5.81, p = .018, and a main effect for response type, F(1,104) = 71.90, p = .000. There are also two interaction involving finger pattern, a sex x emotion x finger pattern interaction, F(1,104) = 5.50, and a visual field x emotion x finger pattern x CLEM interaction, F(2,104) = 3.34, p = .039.

In order to clarify the source of these interactions, separate analyses of each CLEM group were examined. These are presented in Appendices R(i),(ii),and (iii).

Table 22 and Figure 8 presents the cell means for the visual fields in both the emotional and neutral conditions.

From inspection of Table 22 and Figure 8, it is clear that the significant visual field effect is due to slower reaction times from the LVF (presumably right hemisphere). It is also evident that the significant visual field effect is entirely due to the emotional faces. There is no visual field difference for

Table 21
ANOVA of Reaction Time on Lateral Presentation Tachistoscopic Face Recognition Task

Source	SS	DF	MS	F	Prob.
Sex (S)	21.15	1	21.15	1.14	.288
Emotion (E)	14.58	1	14.58	0.79	.377
Finger(F)	2.02	1	2.02	0.11	.742
CLEM (C)	57.59	2	28.79	1.55	.216
SE	7.07	1	7.07	0.38	.538
SF	15.79	1	15.79	0.85	.358
EF	0.00	1	0.00	0.00	.991
SC	5.34	2	2.67	0.14	.866
EC	14.53	2	7.26	0.39	.676
FC	8.37	2	4.18	0.23	.798
SEF	101.93	1	101.93	5.50	.021*
SEC	1.48	2	0.74	0.04	.961
SFC	13.36	2	6.68	0.36	.698
EFC	40.18	2	20.09	1.08	.342
SEFC	3.99	2	2.00	0.11	.898
Error	1926.35	104	18.52		
Response (R)	110.17	1	110.17	71.90	.000**
RS	0.04	1	0.04	0.02	.877
RE	1.19	1	1.19	0.78	.380
RF	0.64	1	0.64	0.42	.520
RC	0.61	2	0.30	0.20	.821
RSE	1.35	1	1.35	0.88	.350
RSF	0.01	1	0.01	0.01	.931
REF	0.09	1	0.09	0.06	.812
RSC	6.30	2	3.15	2.06	.133
REC	2.99	2	1.50	0.98	.380
RFC	1.01	2	0.50	0.33	.721
RSEF	1.15	1	1.15	0.75	.387
RSEC	1.62	2	0.81	0.53	.590
RSFC	6.05	2	3.02	1.97	.144
REFC	2.31	2	1.16	0.75	.473
RSEFC	2.65	2	1.32	0.87	.424
Error	159.35	104	1.53		
Visual Field (V)	2.13	1	2.13	3.91	.051*
VS	0.03	1	0.03	0.05	.827
VE	3.17	1	3.17	5.81	.018*
VF	1.07	1	1.07	1.97	.163
VC	0.69	2	0.34	0.63	.534
VSE	0.85	1	0.85	1.55	.215
VSF	1.23	1	1.23	2.25	.137

Table 21 (cont'd)

VEF	1.36	1	1.36	2.50	.117
VSC	1.80	2	0.90	1.65	.197
VEC	1.58	2	0.79	1.45	.240
VFC	0.15	2	0.08	0.14	.871
VSEF	0.09	1	0.09	0.17	.684
VSEC	2.23	2	1.11	2.04	.135
VSFC	0.66	2	0.33	0.60	.550
VEFC	3.64	2	1.82	3.34	.039*
VESEFC	1.64	2	0.82	1.50	.228
Error	56.74	104	0.54		
RV	0.83	1	0.83	1.28	.260
RVS	1.15	1	1.15	1.78	.185
RVE	0.32	1	0.32	0.49	.485
RVF	0.04	1	0.04	0.06	.810
RVC	0.52	2	0.26	0.40	.670
RVSE	0.24	1	0.24	0.38	.539
RVSF	0.00	1	0.00	0.01	.924
RVEF	0.13	1	0.13	0.21	.650
RVSC	1.73	2	0.87	1.34	.266
RVEC	1.09	2	0.54	0.84	.434
RVFC	0.11	2	0.06	0.09	.916
RVSEF	0.37	1	0.37	0.58	.449
RVSEC	0.24	2	0.12	0.19	.831
RVSFC	0.15	2	0.08	0.12	.890
RVEFC	0.60	2	0.30	0.47	.628
RVSEFC	0.03	2	0.02	0.02	.976
Error	67.27	104	.065		

the neutral faces. This interaction is opposite to what was predicted. It was predicted that emotional faces would be responded to faster from the LVF (presumably right hemsiphere), at least for the females.

The cell means for the main effect for response type are presented in Table 23. Correct <u>yes</u> trials are responded to significantly faster than correct <u>no</u> trials.

The cell means for the sex x emotion x finger interaction for reaction time data are presented in Table 24 and Figure 9. The full table is available in Appendix S.

Figure 8

Reaction Times for Visual Field x Emotion Interaction

in Lateral Presentation Task

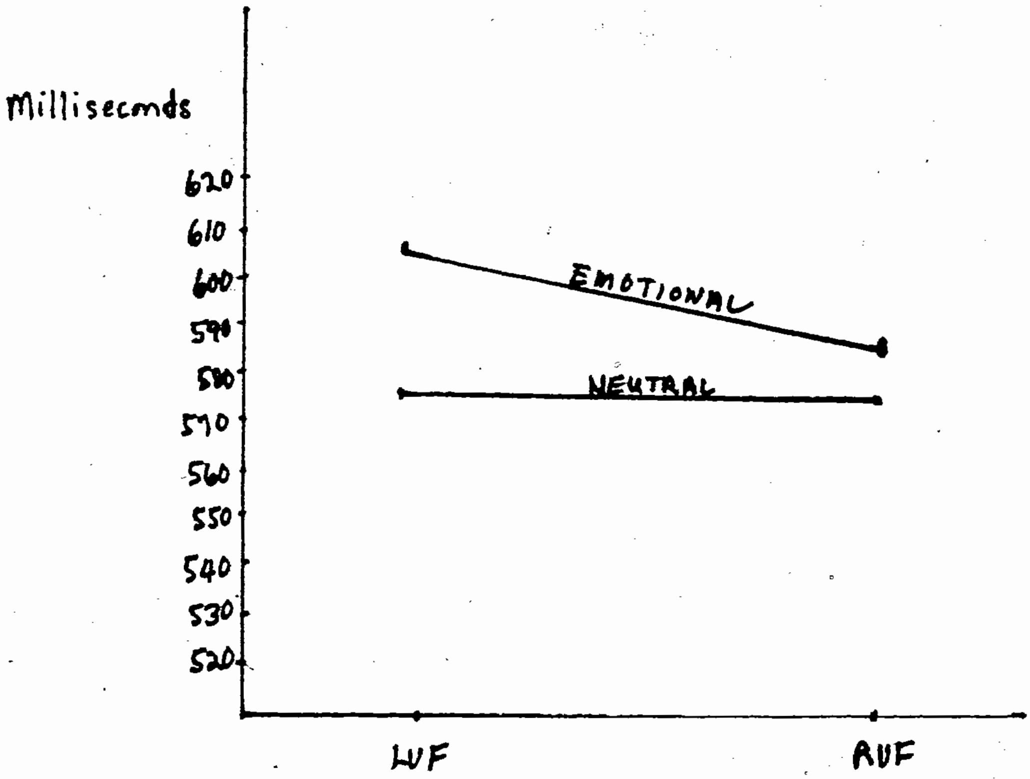

Table 22
Mean Reaction Times for Visual Fields and Emotion Conditions in Lateral Presentation Tachistoscopic Face Recognition Task

		Emotional Condition	Neutral Condition	Both Conditions
LVF	Mean	605.57	576.89	591.06
	SD	(1.27)	(1.20)	(1.24)
RVF	Mean	589.96	576.95	583.42
	SD	(1.27)	(1.19)	(1.24)
	N	(64)	(64)	(128)

Table 23
Reaction Times for Correct Yes and No Responses on Lateral Presentation Tachistoscopic Face Recognition Task

	Yes	No	
Mean	559.98	615.79	
SD	(1.26)	(1.22)	
N			(128)

It can be seen that for males, the particular _yes/no_-digit configuration made little difference with the neutral faces. However, with the emotional faces, the index finger condition (_yes_ = index digit, _no_ = middle digit) was associated with slower reaction times than the middle condition (_yes_ = middle digit, _no_ = index digit). For the females, the _yes/no_-digit configuration made a difference for both emotional and neutral faces, particularly the former. For the emotional faces, subjects in the index condition exhibited faster reaction times, while the opposite was the case for the neutral faces. In other words, the direction of reaction time differences as a function of finger pattern and emotion are in opposite directions for males and females.

Figure 9

Reaction Times for Sex x Emotion x Finger Pattern Interaction on Lateral Presentation Task

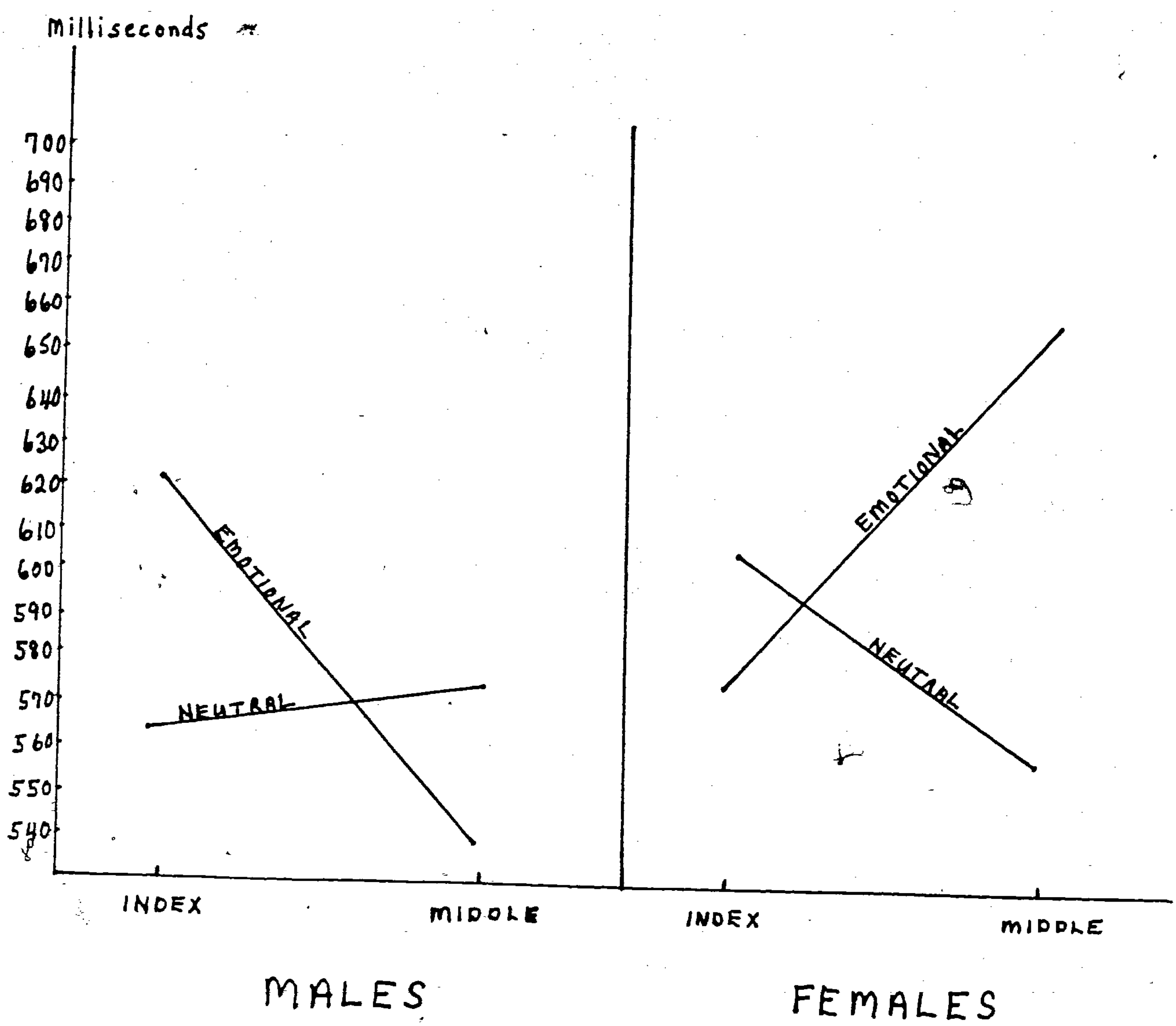

Table 24
Mean Reaction Times for Sex x Emotion x Finger Pattern Interaction in Lateral Presentation Tachistoscopic Face Recognition Task

Males

	Emotional	Neutral
Index Condition	620.32	565.22
Middle Condition	541.75	576.44

Females

	Emotional	Neutral
Index Condition	579.64	604.44
Middle Condition	655.23	562.52

The visual field x emotion x finger pattern x CLEM interaction is illustrated in Figure 10. The source of the visual field x emotion x finger x CLEM interaction was investigated by examining the separate analyses for the CLEM groups in Appendices R(i),(ii), and (iii). The F ratios and corresponding p values for the left movers and right movers are $F(1,42) = 0.00$, $p = .987$ and $F(1,29) = 0.07$, $p = .788$, respectively. This is in contrast to $F(1,33) = 7.88$, $p = .008$ for the bimovers. This indicates that the visual field x emotion x finger x CLEM interaction derives from a visual field x emotion x finger interaction for the bimovers together with the lack of such an interaction in the other two CLEM groups. This is consistent with Figure 10. Thus, for simplification purposes, the cell means for the bimovers only are presented in Table 25. The full table is available in Appendix T.

Inspection of these cell means for the bimovers indicates that the interaction is due to slower responding in the LVF than the RVF in the index condition for the emotional faces. For the

Figure 10

Reaction Times for Visual Field x Emotion x Finger Pattern Interaction on Lateral Presentation Task

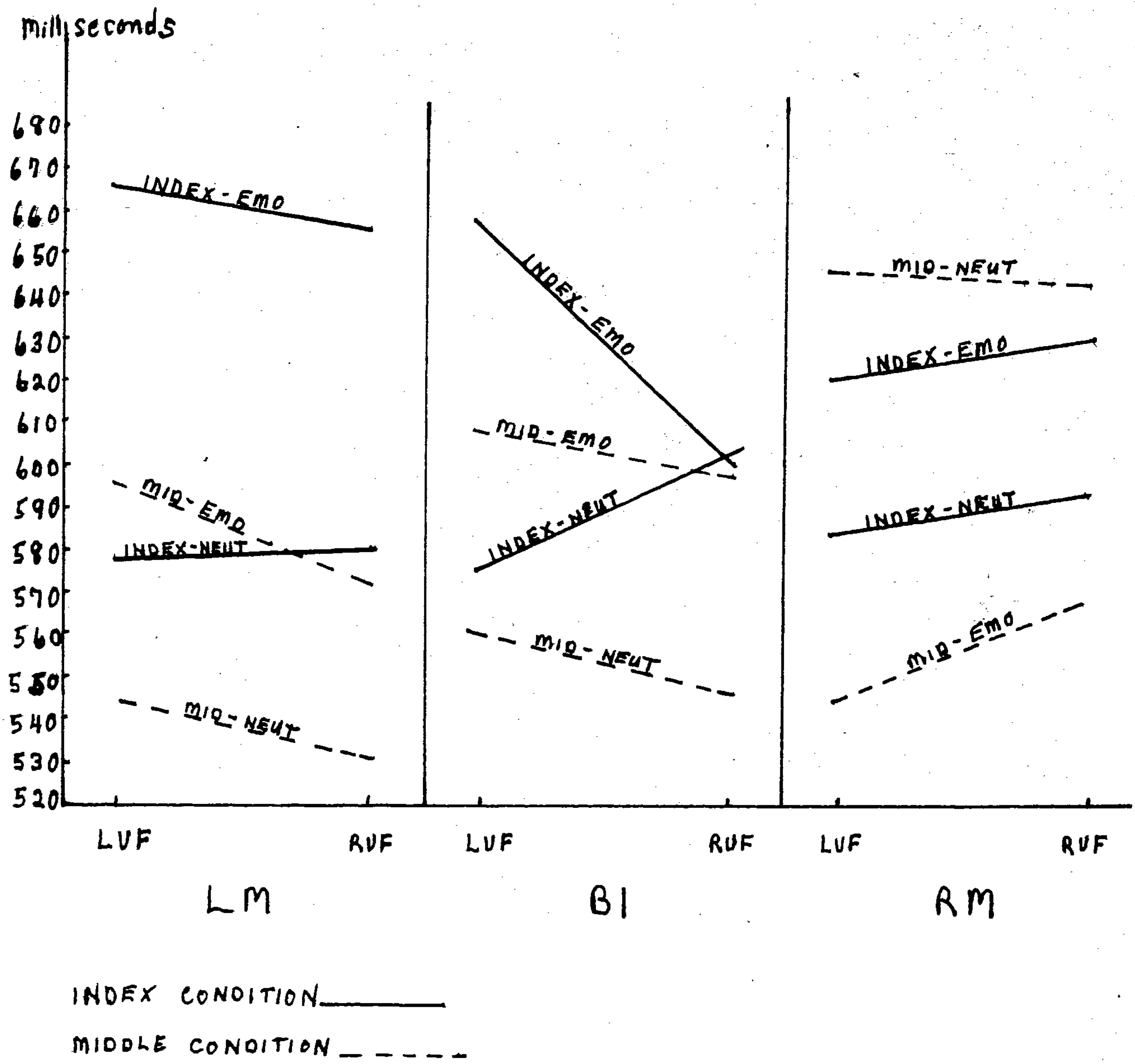

Table 25
Mean Reaction Times for Visual Field x Emotion x Finger Pattern Interaction on Lateral Presentation Tachistoscopic Task for Bimovers Only

	Emotional		Neutral	
	Index Condition	Middle Condition	Index Condition	Middle Condition
LVF	653.73	613.66	575.60	562.52
RVF	602.62	601.90	605.28	548.78

neutral faces, this pattern is the reverse. In the index condition responding is slower in the RVF than the LVF.

The results of the reaction time analysis for the lateral presentation tachistoscopic recognition test can be summarized in the following way. Although there is a significant visual field effect favoring the RVF (presumably left hemisphere), this is entirely due to the emotional faces. Yes responses are faster than no responses. There is a sex x emotion x finger pattern interaction and a visual field x emotion x finger pattern x CLEM interaction, the latter entirely due to a visual field x emotion x finger pattern interaction with the bimovers. In the latter case, the index condition enhances a RVF superiority for the emotional faces, and a LVF superiority for the neutral faces.

Correlations between Reaction Time and Error Measures

Correlations between error and reaction time data on the tachistoscopic face recognition task were examined in order to assess the degree to which similar processes were being measured by the two dependent measures. Particularly in view of the different results of the two types of analyses, it was important to assess the degree to which there may have been an speed-accuracy tradeoff. Since there was the possibility that such an effect might be present in some subjects and not others, correlations were run separately for each subject group (males, females, left mover, bimovers, right movers) as well as for the total sample.

Correlations between Reaction Time and Error Measures on Central Presentation Tachistoscopic Face Recognition Test

The correlations between the error and reaction time measures on the central presentation tachistoscopic face recognition task are presented in Table 26.

From Table 26, it can be seen that, with the exception of right movers, $r = .40$, $p = .01$, there are no significant correlations between the error and reaction time measures. However, there is a tendency towards a positive correlation in the total sample, $r = .16$, $p = .08$. Also, the correlation for the females approaches significance, $r = .16$, $p = .08$. There are no indications of an speed-accuracy tradeoff. The correlations, with the exception of one negligible one, are positive.

Table 26
Pearson Correlations between Error and Reaction Time Data on Central Presentation Tachistoscpic Face Recognition Test

	N	r
All	127	.16
Males	64	.09
Females	64	.24
Left Movers	50	-.04
Bimovers	40	.19
Right Movers	37	.40**

Correlations between Reaction Time and Errors (over last two blocks) on Lateral Presentation Tachistoscopic Face Recognition Task

The correlation between the reaction time data and errors over the last two blocks are presented in Table 27.

It can be seen from this table that the correlations between errors and reaction time for the last two blocks of the lateral presentation tachistoscopic task are significantly positively correlated for the $L^{V}F$, $R^{V}F$, and both visual fields combined. This is the case for all subject groups with the exception of the bimovers. This is consistent with the fact that bimovers made the most errors in this task, which might have rendered the reaction time data less "pure." It is important to note, however, that despite the lack of a significant positive correlation between errors and reaction time for the bimovers, the correlation is positive and hence does not indicate a significant speed-accuracy tradeoff.

Table 27
Pearson Correlations between Error (Two Blocks) and Reaction Time Data for Lateral Presentation Tachistoscopic Face Recognition Task

	N	LVF	RVF	Both Fields
All	128	.34**	.30**	.37**
Males	64	.34**	.32**	.37**
Females	64	.34**	.28**	.37**
Left Movers	50	.49**	.41**	.54**
Bimovers	41	.14	.14	.19
Right Movers	37	.37*	.33*	.38*

<u>Correlations between Reaction Time Data (over last two blocks) and Total Errors (over four blocks)</u>

Although the correlations between the reaction time and error data over the last two blocks are the most meaningful since they deal with the same two blocks, it would be interesting to examine whether the reaction time data, even though taken from the last half of the blocks, corresponds to the subjects' total error performance. Table 28 presents these correlations.

From inspection of Table 28, it is evident that the pattern of correlations are identical to those done just ~~for~~ errors over the last two blocks. In fact, the correlation coefficients are considerably larger. Even the correlation coefficients of the bimovers, though still exhibiting the weakest relationship between the two types of measures, approach statistical significance.

Table 28
Pearson Correlations between Errors (Four Blocks) and Reaction Time Data for Lateral Presentation Tachistoscopic Face Recognition Task

	N	LVF	RVF	Both Fields
All	128	.48**	.43**	.50**
Males	64	.52**	.41**	.51**
Females	64	.46**	.45**	.50**
Left Movers	50	.64**	.52**	.64**
Bimovers	41	.24	.28	.29*
Right Movers	37	.56**	.44**	.54**

<u>Correlations between Visual Field Differences by Reaction Time and Error Measures</u>

It is evident that the error and reaction time data correlated to an acceptable degree, and that there is no evidence of a significant speed-accuracy tradeoff. However, since the main dependent variable of interest in the present research is visual field differences, it is important to investigate whether laterality patterns as measured by error and reaction time data do, in fact, correspond. That is, is the ranking of subjects in terms of relativly better performance in the LVF, similar when these differences are calculated with the reaction time and error measures? For each subject, mean LVF reaction times were subtracted from mean RVF reaction times. Thus, a positve score would reflect a LVF (presumably right hemisphere) superiority, while a negative difference would indicate faster (hence, better) performance from the RVF (presumably left hemisphere). This was done as well for both sets of error data. In these cases, positive and negative differences would reflect the same laterality differences as they did in the reaction time data, since, in both cases, larger numbers reflect poorer performance. These are presented in Table 29.

These correlations are in striking contrast to the direct correlations between errors and reaction time. Not only is none statistically significant in a positive direction, many are in a negative direction, though none attains statistical significnce. Thus, there is little correspondence between the reaction time and both sets of error data for laterality differences.

Perceptual Bias Test

Ninety three of the 128 subjects chose the composite composed of the hemiface which was in their LVF in the normal photograph more often than they chose the RVF composite. This difference was submitted to a sign test (Siegel, 1956) and was highly significant ($z = 5.04$, $p = .000$).

The number of items on which each subject chose the LVF composite was divided by 19, the total number of items. Thus, each subject's score was expressed as a proportion. Proportions above .50 represent more selections of the half face falling in the viewer's LVF in the comparison photograph. Proportions below .50 would represent more frequent selection of the half face in the viewer's RVF. These scores were submitted to an analysis of variance with sex and CLEM as between subject factors. The analysis is presented in Table 30.

Table 29
Pearson Correlations between Error and Reaction Time Data for Within-Subject Visual Field Differences

	N	RTVF[1] and ERVF2[2]	RTVF and ERVF4[3]
All	128	-.06	.02
Males	64	.04	-.01
Females	64	-.14	.04
Left Movers	50	-.01	-.06
Bimovers	41	-.20	-.05
Right Movers	37	.04	.17

[1]RVF-LVF for Reaction Time Data
[2]RVF-LVF for Errors(Two Blocks)
[3]RVF-LVF for Errors(Four Blocks)

Table 30
ANOVA of Proportion of LVF Hemiface Selected in Perceptual Bias Task

Source	SS	DF	MS	F	Prob.
Sex(S)	257.32	1	257.32	1.53	.219
CLEM(C)	823.62	2	411.81	2.44	.091
SC	9.32	2	4.66	0.03	.973
Error	20580.45	122	168.69		

As can be seen from Table 30, neither the sex nor the CLEM effect attained statistical significance. However, there is a trend towards a CLEM effect, $F(2,122) = 2.44$, $p = .09$. Given its theoretical relevance to the present study, the cell means are presented in Table 31. Inspection of Table 31 indicates that the trend is due to a more pronounced LVF bias on this task for the left movers and bimovers, relative to the right movers whose selection, on the average, represents just above chance responding on the items.

Table 31
Proportions of LVF Composite Selection for CLEM Groups on Perceptual Bias Test

	Left Movers	Bimovers	Right Movers
Mean	59.14	59.58	53.87
(SD)	(12.53)	(13.09)	(13.20)
N	(50)	(41)	(37)

<u>Free View Face Recognition Test</u>

The subject's score on this test was the number of faces correctly identified. Scores were submitted to an analysis of variance with sex and CLEM as between subject factors. The analysis is presented in Table 32. There were no significant differences between CLEM groups and males and females.

<u>Correlations between Tachistoscopic and Perceptual Bias Indices of Cerebral Laterality</u>

Scores on the perceptual bias test were correlated with visual field differences for reaction time and both sets of error data. Since the perceptual bias test was scored as the proportion of trials a subject selected the face composite made up of the original hemiface that had been in his or her LVF, a larger score represents a greater tendency to choose that composite. This has been interpreted as reflecting the degree to which a subject possesses a LVF (presumably right hemisphere) bias for processing physiognomic stimuli. Since for the tachistoscopic laterality index as calculated earlier a positive

Table 32
ANOVA of Number of Faces Recalled in Free View Face Recognition Test

Source	SS	DF	MS	F	Prob.
Sex (S)	3.33	1	3.33	2.23	.138
CLEM (C)	1.57	2	.787	0.53	.591
SC	0.19	2	0.10	0.07	.937
Error	181.94	122	1.491		

number reflects better performance from the LVF, a positive relationship between the two laterality indices would be expressed by a positive correlation. It should be emphasized, however, that a positive correlation between the two would reflect a similar ranking among the subjects on both measures in terms of relative "bias" of the LVF over the RVF. It would not necessarily mean that a subject defined as "right hemisphered" by one index would necessarily be defined that way by the other.

Correlations between the perceptual bias index and the tachistoscopic laterality indices are presented in Table 33. Correlation coefficients were calculated for the perceptual bias test with reaction time and both sets of error data. The separate correlations for each subject group are presented in Table 33, followed by a list of the collapsed subject groups whose correlation coefficients attained statistical significance in Table 34. Of course, the latter correlations can only be interpreted by reference to the magnitude of the correlations of the separate cell groups in Table 33. Group correlations, when there are underlying interactions within them, must be interpreted cautiously.

Table 33

Pearson Correlations of Perceptual Bias (PB) with Tachistoscopic Visual Field Indices of Laterality

		LM			BI			RM		
		PB, RTV	PB, ERV2	PB, ERV4	PB, RTV	PB, ERV2	PB, ERV4	PB, RTV	PB, ERV2	PB, ERV4
M	E	-.15	.22	.28	.47	.64*	.44	.17	.05	.64*
	N	.25	.00	.26	-.34	.56	.68*	-.32	.23	.58
F	E	-.31	.34	-.13	-.07	-.33	-.41	-.91**	-.36	-.54
	N	.11	.48	.29	.26	-.08	-.40	.25	-.14	.05

Key: RTV = RVF-LVF for Reaction Time Data
ERV2 = RVF - LVF for Errors (Two Blocks)
ERV4 = RVF - LVF for Errors (Four Blocks)
M = Males
F = Females
E = Emotional
N = Neutral
r(+) = positive association
r(-) = negative association

Given the failure of the tachistoscopic laterality indices for the reaction time and error data to correlate, different patterns in their correlations with the perceptual bias index are not surprising. As seen from Table 33, there are significant positive correlations for male bimovers in the emotional group for errors over two blocks and in the neutral group for errors over four blocks, and for right mover emotional males over four blocks. There is a negative correlation in the female-right mover-emotional group for reaction time. Combining Tables 33 and 34, it is apparent that for the males, correlations are generally positive for both emotional and neutral faces. For females, negative correlations are with the emotional faces, particularly so in the right mover group.

Table 34
Pearson Correlations between Perceptual Bias and Tachistoscopic Indices of Laterality: Collapsed Subject Groups with Correlations Attaining Statistical Significance

Indices	Subject Group	r(+)	r(-)
PB and ERV4	Neutral	.23*	
	Males	.35**	
	Male Emotional	.33*	
	Male Neutral	.36*	
	Female Emotional		-.40*
PB and ERV2	none		
PB and RTV	Female Emotional		-.37*
	Right Movers		-.32*
	Right Mover Emotional		-.44*
	Right Mover Female		-.53*

Key: r(+) = positive association
r(-) = negative association

__Correlations between Laterality Indices and Overall Facial Processing Ability__

One of the purposes of the present investigation was to determine whether any particular cerebral organization for processing physiognomic stimuli is associated with overall ability for faces. This was examined by correlating the laterality indices with the face recognition tests. There were four laterality indices: 1) perceptual bias index; 2) visual field reaction time difference; 3) visual field difference for errors over two blocks; 4) visual field differences for errors over four blocks. The tests of facial processing abiltiy were: 1) the central presentation tachistoscopic task - reaction time; 2) the central presentation tachistoscopic task - errors; 3) errors on free view face recognition test. These were done, as before, for each subject group followed by a table indicating which collapsed subject groups attained statistical significance. These correlations are presented in Tables 35,36, 37, and 38.

From examination of Tables 35, 36, and 37, it is apparent that very few of the separate cell correlations attain statistical significance. A positive correlation, indicating that greater RVF/LH bias is associated with better ability, is present only for right mover males for emotional faces, where laterality and ability are measured by tachistoscopic reaction time and the free view test, respectively. Negative correlations, which reflect an association between LVF/RH bias and better performance are present for left mover-male-neutral and bimover-female-emotional subjects, where the measures of laterality and ability are the perceptual bias and central presentation (errors) tasks, respectively. Examination of Table 38 of the collapsed subject groups reveals certain patterns. Negative correlations, reflecting an association between LVF/RH bias and facial ability all involve subject groups with the neutral faces, with the exception of the left mover-male group. The positive correlations, reflecting an association between RVF/LH bias and better performance all involve right mover groups, one of them with emotional faces.

Table 35

Pearson Correlations between Laterality Indices and Facial Processing Ability: Perceptual Bias Test with Free View, Central Tachistoscopic (Errors) and Central Tachistoscopic (Reaction Time)

		LM			BI			RM		
		PB, FR	PB, C(ER)	PB, C(RT)	PB, FR	PB, C(ER)	PB, C(RT)	PB, FR	PB, C(ER)	PB, C(RT)
M	E	.43	.03	.27	.03	.38	.01	.23	.59	.47
	N	-.44	-.81**	-.38	.06	-.32	.14	-.22	.17	-.16
F	E	.04	.29	.07	.03	-.66*	-.06	-.34	.36	.01
	N	.18	-.19	-.20	-.45	-.29	-.11	-.22	.32	-.60

Key: FR = Free View Face Recognition Test

C(ER) = Central Tachistoscopic Face Recognition Test (Errors)

C(RT) = Central Tachistoscopic Face Recognition Test (Reaction Time)

r(+) = greater RVF/LH bias, better performance

r(-) = greater LVF/RH bias, better performance

Table 36

Pearson Correlations between Laterality Indices and Facial Processing Ability: Free View Test with Tachistoscopic Laterality Indices

		LM			BI			RM		
		FR, ERV2	FR, ERV4	FR, RTV	FR, ERV2	FR, ERV4	FR, RTV	FR, ERV2	FR, ERV4	FR, RTV
M	E	-.12	-.20	-.29	-.62	-.44	.62	.07	.50	.65*
	N	-.25	-.20	-.25	.48	-.25	-.19	-.12	-.20	.54
F	E	-.12	.04	-.28	.53	.53	.15	.15	-.05	.33
	N	-.39	-.36	.16	-.56	-.17	.35	-.47	-.27	.05

Key: FR = Free View Face Recognition Test

ERV2 = RVF-LVF for Errors(Two Blocks)

ERV4 = RVF-LVF for Errors(Four Blocks)

RTV = RVF-LVF for Reaction Time

r(+) = greater RVF bias, better performance

r(-) = greater LVF bias, better performance

Table 37

Pearson Correlations between Laterality Indices and Facial Processing Ability: Tachistoscopic Indices with Central Presentation Tachistoscopic Face Recognition Test

		LM			BI			RM		
		ERV2, C(ER	ERV4, C(ER)	RTV, C(RT)	ERV2, C(ER)	ERV4, C(ER)	RTV, C(RT)	ERV2, C(ER)	ERV4, C(ER)	RTV, C(RT)
M	E	.40	.44	-.14	.15	-.26	.18	.30	.22	-.12
	N	-.32	.06	-.54	.41	-.20	-.24	.19	.30	-.37
F	E	.27	-.05	.12	.43	.26	.36	-.23	-.31	.25
	N	.03	-.04	.08	-.33	.12	.45	.44	-.01	-.60

Key: r(+) = greater RVF/LH bias, better performance

r(-) = greater LVF/RH bias, better performance

Table 38

Pearson Correlations between Laterality Indices and Facial Processing Ability: Collapsed Subject Groups with Correlations Attaining Statistical Significance

Laterality and Ability Measure	Subject Group	r(+)	r(-)
PB and Free View	none		
PB and Central(ER)	Right Movers	.40**	
	Left Mover Neutral		-.62**
	Right Mover Emotional	.48*	
	Left Mover-Male		-.43*
PB and Central(RT)	Neutral		-.26*
	Females Neutral		-.38*
ERV2 and Free View	Neutral		-.27*
	Female Neutral		-.51**
ERV2 and Central(ER)	none		
ERV4 and Free View	Neutral		-.27*
ERV4 and Central(ER)	none		
RTV and Free View	Right Movers	.35*	
	Right Mover-Male	.57**	
RTV and Central(RT)	none		

Key: r(+) = greater RVF/LH bias, better performance
r(-) = greater LVF/RH bias, better performance

Correlations between Different Measures of Facial Processing Ability.

In order to aid in determining the extent to which different measures of facial processing abilty were tapping similar skills, correlations between them were examined. Correlations between the error and reaction time measures on the tachistoscopic task have already been reported. Although only the free view recognition and central presentation tachistoscopic tests were considered to be the primary measures, the lateral presentation variation of the tachistoscopic task was also examined in relation to the other two measures.

These correlations are reported in Tables 39, 40, and 41.

Free view and central presentatition task

Two correlations attain statistical significance from Table 39. These are for the male-left mover-emotional and the female -bimover-neutral group with the reaction time data. However, certain patterns are apparent. Bimovers, in general, have the most consistent positive association between the the free view and central presentation task. This group is followed by left movers, and then right movers, whose correlation coefficients are, with two exceptions, all negative. The coefficients for the males are generally positive for both neutral and emotional faces, except in the right mover group. For females, the

Table 39
Pearson Correlations between Tests of Facial Ability: Free View and Central Presentation Tachistoscopic Face Recognition Test (Errors and Reaction Time)

		LM		BI		RM	
		FR, C(ER)	FR, (RT)	FR, C(ER)	FR, C(RT)	FR, C(E)	FR C(RT)
M	E	-.14	.77**	.31	.42	-.14	.07
	N	.29	.25	.55	.11	.42	-.17
F	E	-.24	.37	-.08	.37	-.28	-.24
	N	-.14	.14	.54	.77**	-.40	-.05

Key: r(+) = positive association
r(-) = negative association

correlations are positive in the bimover groups, and negative in the right mover groups.

Free view and lateral presentation task

Inspection of Table 40 indicates that two correlations attain significance, the left mover-male-emotion group with the reaction time data, and the bimover-male-neutral group with errors over four blocks. The pattern that was present in the previous set of correlations is apparent here. Left movers and bimovers demonstrate a generally positive association between the free view and lateral presentation tachistoscopic task, with possibly the exception of the female-bimover-emotional group, whereas the correlations for the right movers are more consistently negative.

Table 40

Pearson Correlations between Tests of Facial Ability: Free View and Lateral Presentation Tachistoscopic Task (Errors and Reaction Time)

		LM			BI			RM		
		FR, ER2	FR, ER4	FR, RT	FR, ER2	FR, ER4	FR, RT	FR, ER2	FR, ER4	FR, RT
M	E	.43	.52	.82**	.31	.48	.41	-.26	.25	.10
	N	.24	.06	.35	.52	.65*	.33	-.22	-.28	-.30
F	E	.32	.04	.31	-.30	-.08	.15	-.26	-.02	.25
	N	.06	.31	.14	.50	.68	.63	.14	.04	.06

Key: ER2 = Lateral Presentation Task, Errors (Two Blocks)
ER4 = Lateral Presentation Task, Errors (Four Blocks)
RT = Lateral Presentation Task, Reaction Time
r(+) = positive association
r(-) = negative association

Lateral and central presentation tests of Facial ability

As noted earlier, there was some question as to the degree to which the lateral and central presentation variations of the tachistoscopic task measured the same kind of facial processing ability. Hence, the central task was correlated with the lateral presentation task for both reaction time and error data. These are presented in Table 41. A striking pattern is evident if one examines only the relationships among the error data. Bimovers exhibit high positive correlations between the two tasks, followed by right movers, whose correlations coefficients are smaller, but still positive. This is in contrast to the left movers, whose correlation coefficients are, with one exception, negative. This pattern, however, is not present with the reaction time data, where all coefficients are positive.

A summary table of the collapsed subject groups attaining statistical significance will not be presented for the correlations between the different tasks of facial ability. This is because there are simply too many of them and their listing would not provide information that is not already apparent from the patterns of the three tables just discussed. In general, the tasks were significantly positively correlated with one another. Some patterns will be described in more detail in the discussion section because of their immediate relevance to the issues under consideration.

Emotion Ratings of Tachistoscopic Facial Stimuli by Subjects

Only the ratings for perceived emotion [2] will be discussed. This is because the concept of "perceived emotion" is easier to interpret given that the ratings were made after the subject had experience with the faces. The subject's rating of "subjective emotion" [3] might be more likely to be influenced by his or her experience with the task. Furthermore, the two ratings were positively correlated, $r = .48$, $p = .000$. The emotional ratings of the faces were organized three ways. They were combined for just target faces (perceived emotion - target), for just nontarget faces (perceived emotion - nontarget), and for all

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[2]The rating was made in response to the question "How emotional does the face look to you?" See Appendix D.
[3]This rating was made in response to the instruction "Rate each face on the amount of emotion it arouses in you." See Appendix D.

Table 41
Pearson Correlations between tests of Facial Abilty: Lateral and Central Presentation Tachistoscopic Tasks (Errors and Reaction Time)

		LM			BI			RM		
		ER2, C(ER)	ER4, C(ER)	RT, C(RT)	ER2, C(ER)	ER4, C(ER)	RT, C(RT)	ER2, C(ER)	ER4, C(ER)	RT, C(RT)
M	E	-.01	-.02	.87**	.57	.61	.72*	.17	.22	.92**
	N	-.06	.02	.90**	.91**	.78**	.70*	.29	.07	.78*
F	E	-.29	-.38	.87**	.75*	.47	.62	.58	.45	.34
	N	-.11	-.15	.54	.63*	.59	.77**	.46	.50	.64

Key: r(+) = positive association
r(-) = negative association

four faces combined (perceived emotion - combined). The ratings for the faces were differentiated into target and nontarget faces, since the subject's experience with them was different. The target faces were available for the subject to study throughout the session, whereas the subject's only exposure to the nontarget faces was brief tachistoscopic exposure. This might conceivably influence the coding strategies employed.

These ratings were submitted to an analysis of variance with sex, emotion, CLEM, and finger pattern as between subject factors. The first three factors were included to investigate whether the subject groups differed in their perceived emotion ratings. Finger pattern was included only to confirm that emotion ratings did not differ significantly between the two finger pattern conditions. Unfortunately, as will become apparent, this was not the case. These three analyses of variance for the emotion ratings of the target, nontarget, and combined faces are presented in Tables 42,43 and 44, respectively.

Table 42

ANOVA of Emotion Ratings for Target Faces

Source	SS	DF	MS	F	Prob.
Sex (S)	0.13	1	0.13	0.02	.879
Emotion (E)	141.72	1	141.72	24.89	.000**
Finger(F)	4.73	1	4.73	0.83	.364
CLEM (C)	8.32	2	4.16	.073	.484
SE	1.00	1	1.00	0.18	.676
SF	7.92	1	7.92	1.39	.241
EF	6.01	1	6.01	1.06	.306
SC	0.53	2	0.26	0.05	.954
EC	4.83	2	2.42	0.42	.655
FC	3.20	2	1.60	0.28	.756
SEF	13.39	1	13.39	2.35	.128
SEC	38.72	2	19.36	3.40	.037*
SFC	5.42	2	2.71	0.48	.623
EFC	13.71	2	6.85	1.20	.304
SEFC	4.39	2	2.20	0.39	.681
Error	592.17	104	5.69		

Table 43

ANOVA of Emotion Ratings for Nontarget Faces

Source	SS	DF	MS	F	Prob.
Sex (S)	11.64	1	11.64	2.44	.121
Emotion (E)	107.42	1	107.42	22.51	.000 **
Finger(F)	21.73	1	21.73	4.55	.035*
CLEM (C)	10.38	2	5.19	1.09	.341
SE	4.00	1	4.00	0.84	.362
SF	1.50	1	1.50	0.31	.576
EF	8.45	1	8.45	1.77	.186
SC	3.02	2	1.51	0.32	.729
EC	2.01	2	1.00	0.21	.810
FC	4.45	2	2.22	0.47	.629
SEF	24.58	1	24.58	5.15	.025*
SEC	0.82	2	0.41	0.09	.918
SFC	20.40	2	10.20	2.14	.123
EFC	1.12	2	0.56	0.12	.889
SEFC	7.32	2	3.66	0.77	.467
Error	496.17	104	4.77		

Table 44

ANOVA of Emotion Ratings for Combined Faces

Source	SS	DF	MS	F	Prob.
Sex (S)	14.27	1	14.27	1.32	.253
Emotion (E)	495.90	1	495.90	45.85	.000**
Finger (F)	46.74	1	46.74	4.32	.040*
CLEM (C)	21.88	2	10.94	1.01	.367
SE	8.99	1	8.99	0.83	.364
SF	16.31	1	16.31	1.51	.222
EF	28.71	1	28.71	2.65	.106
SC	5.80	2	2.90	0.27	.766
EC	1.41	2	0.70	0.07	.937
FC	3.10	2	1.55	0.14	.866
SEF	74.27	1	74.27	6.87	.010**
SEC	50.14	2	25.07	2.32	.104
SFC	37.34	2	18.67	1.73	.183
EFC	22.41	2	11.20	1.04	.358
SEFC	20.05	2	10.03	0.93	.399
Error	1124.96	104	10.82		

As is apparent from these tables, the emotional/neutral manipulation was successful in that the a priori designated emotional faces were rated as more emotional. This was true whether the faces being rated were target or nontarget faces. The F ratios and corresponding p values for the target, nontarget, and total faces are $F(1,104) = 24.89$, $p = .000$, $F(1,104) = 22.51$, $p = .000$, $F(1,104) = 45.85$, $p = .000$, respectively. The cell means for this effect for the three sets of faces are presented in Table 45.

The perceived emotion - target ratings also yielded a significant, $F(2,104) = 3.40$, $p = .037$, sex x emotion x CLEM interaction. The means are presented in Table 46. The full table is available in Appendix U. From inspection of Table 46, it

Table 45
Emotion Ratings in Emotional and Neutral Conditions for Target, Nontarget and Combined Tachistoscopic Facial Stimuli

		Target	Nontarget	Combined
Emotional	Mean	8.84	8.89	17.73
	SD	(2.53)	(2.09)	(3.32)
Neutral	Mean	6.64	7.00	13.64
	SD	(2.21)	(2.31)	(3.53)

Table 46
Mean Emotion Ratings for Sex x Emotion x CLEM Interaction of Target Tachistoscopic Facial Stimuli

	Male		
	Left Movers	Bimovers	Right Movers
Emotional	9.25	8.70	8.20
Neutral	6.77	6.00	7.38
	Female		
	Left Movers	Bimovers	Right Movers
Emotional	8.85	7.78	10.10
Neutral	7.08	7.00	5.56

appears that for the males, left movers perceived the emotional faces as more emotional than the right movers, whereas the opposite pattern is apparent for the females in the emotional condition. For the neutral faces, there does not appear to be much difference among the CLEM groups for the males, although for the females, left movers perceived the neutral faces as more emotional than did the right movers. Probably more meaningful to examine, for the purposes of the present research, is the degree to which the manipulation was successful for the six sex x CLEM groups. Right mover females show the most striking difference between the two sets of faces, rating the emotional set of faces substantially higher in perceived emotion relative to the neutral set. The other five groups all show considerably smaller rated differences between the emotional and neutral faces. In order of magnitude of difference ratings, they are bimover-males,left mover -males, left mover-females, right mover males and bimover-females, the last two groups with mean differences of less than one.

Unfortunately, there were several interactions involving the finger pattern condition, which are difficult to account for. In the ratings for nontarget and total faces, there was a significant main effect for finger pattern. The F ratios and corresponding p values are $F(1,104) = 4.55$, $p = .035$, and $F(1,104) = 4.32$, $p = .04$, respectively. The cell means for these two sets of ratings are presented in Table 47. Subjects in the middle finger pattern condition rated the faces with less perceived emotion.

For nontarget faces, there was a significant sex x emotion x finger interaction, $F(1,104) = 5.15$, $p = .025$. The cell means are presented in Table 48 and Figure 11.The full table is available in Appendix V(i).

From inspection of Table 48 and Figure 11, it is apparent, if one assumes that finger pattern should make no difference, that the major source of the three way interaction is due to the females in the emotional condition. For this group, subjects in the index condition gave higher perceived emotion ratings than subjects in the middle condition. There is a smaller difference in the same direction for males in the neutral condition.

Table 47
Emotion Ratings of Nontarget and Combined Tachistoscopic Facial Stimuli for Each Finger Pattern

		Nontarget	Combined
Index Condition	Mean	8.34	16.28
	SD	(2.54)	(4.30)
	N	(64)	(64)
Middle Condition	Mean	7.55	15.09
	SD	(2.17)	(3.58)
	N	(64)	(64)

Table 48
Mean Emotion Ratings of Nontarget Tachtisoscopic Facial Stimuli for Sex x Emotion x Finger Pattern Interaction

Males

	Emotional	Neutral
Index Condition	8.56	7.25
Middle Condition	8.31	6.56

Females

	Emotional	Neutral
Index Condition	10.56	7.00
Middle Condition	8.12	7.19

The same sex x emotion x finger interaction is significant for the perceived emotion - combined ratings. The cell means are presented in Table 49. The full table is available in Appendix V(ii). From inspection, it is again clear that the basis of the sex x emotion x finger interaction is due to the females in the emotional condition. Here, the females in the index finger condition rated the faces as looking more emotional than the faces in the middle finger condition. Also, again, there is the same pattern with the males in the neutral condition.

It should be noted that finger pattern was similarly confounded with the ratings of subjective emotion.

Figure 11

Emotion Ratings of Nontarget Facial Stimuli for

Sex x Emotion x Finger Pattern Interaction

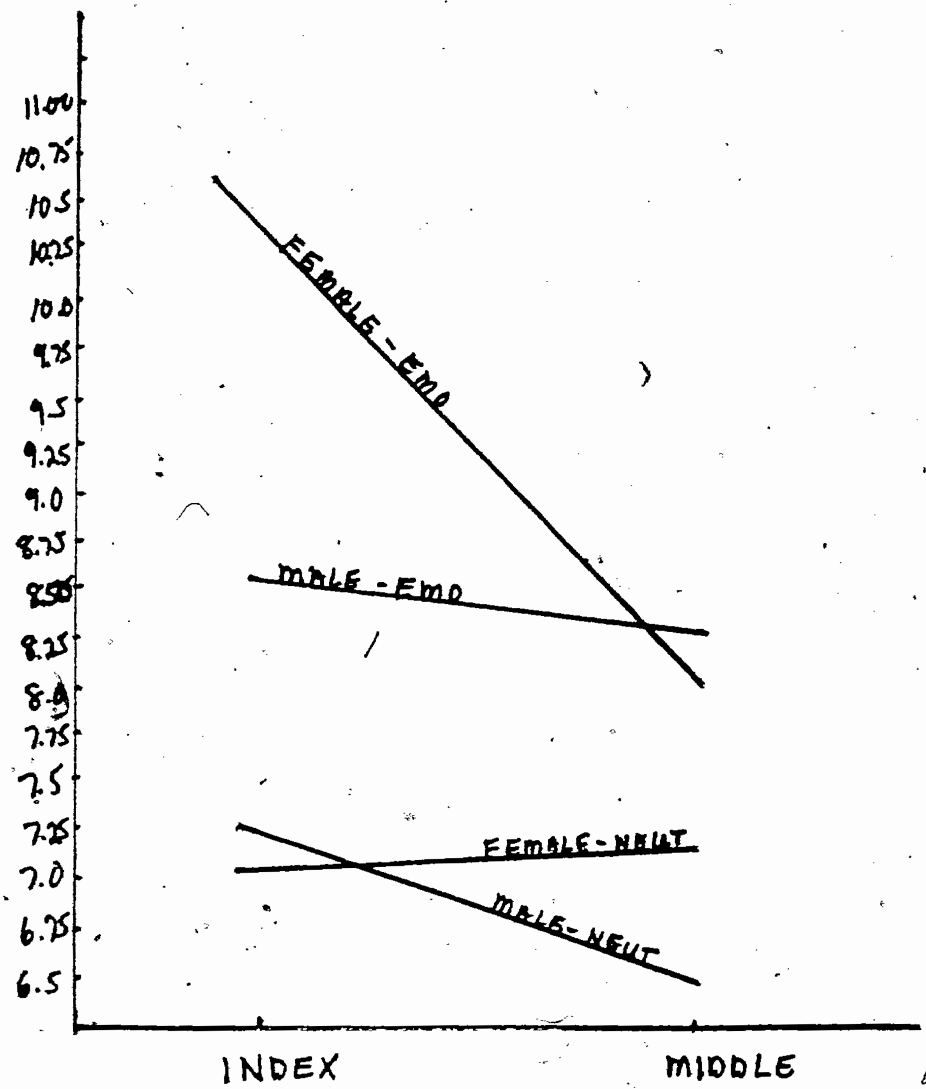

Table 49
Mean Emotion Ratings of Combined Tachistoscopic Facial Stimuli for Sex x Emotion x Finger Pattern Interaction

	Males	
	Emotional	Neutral
Index Condition	17.19	13.88
Middle Condition	17.19	13.25
	Females	
	Emotional	Neutral
Index Condition	20.56	13.50
Middle Condition	16.00	13.94

<u>Analyses Involving Subject Emotion Ratings of Facial Stimuli</u>

The significant differences found to exist between the emotion ratings and finger pattern, and their interaction with sex, were interpreted to result from sampling error. Even given that the ratings were done after the subjects' experience with the faces and hence could be affected by that exposure, there is no plausible explanation why finger pattern should be one of the influencing factors. In view of the several unexpected interactions involving finger pattern in the analyses of the lateral presentation tachistoscopic task, it was possible that these were an artifact of the confounding of finger pattern and emotional valence.

This possiblity was first investigated by conducting several analyses of covariance on all three sets of lateral presentation data, using both perceived and subjective emotion ratings, together and separately, as the covariates. These failed to remove the significant interactions inolving finger pattern.

However, an assumption of the analysis of covariance model is that the regression of the dependent variable on the covariate is homogeneous (constant) on all levels of the independent variables. Yet, the initial prediction of a visual field x sex x emotion interaction in itself involves a violation of this assumption. In addition, the previous analyses had yielded several interactions of the emotion factor with sex, CLEM, visual field, _yes_ and _no_ trials, and their interactions. Given these factors, it seemed unlikely that the basic assumptions of the analyses of covariance held in this instance, in which case the analysis of covariance was not the appropriate method of removing the confounding effects of emotion rating and finger.

This possibility was investigated by examining separate correlations of the emotion ratings with within subject visual field differences for the separate subject groups. Given the interaction of emotion with response type together with the previously noted confounding of _yes_ and _no_ trials with differential exposure to the faces involved, which could conceivably allow different coding strategies, the correlations for each subject group were conducted separately for _yes_ and _no_ trials. The emotion ratings used for the _yes_ and _no_ responses were, of course, the ones given to only those particular faces. In other words, for the _yes_ trials the ratings of the target faces were used, while for the no trials the ratings of the nontarget stimuli were used. Also, as in the previous correlations, within subject visual field differences were calculated by subtracting LVF scores from RVF scores. Perceived emotion had been rated on scale whereby larger numbers represented higher perceived emotional valence. Thus, positive correlations would indicate that greater perceived emotion is associated with a larger relative LVF (presumably right hemisphere) superiority in performance, while a negative correlation would indicate that a higher degree of perceived emotional valence is associated with a greater degree of relative RVF (presumably LH) bias.

These correlations for reaction time and the two sets of error data are presented in Tables 50 and 51 for yes and no trials respectively.

From Table 50, it is apparent that for yes trials, greater emotional valence was associated with faster reaction times from the RVF (presumably left hemisphere), relative to the LVF, for the total sample and the females, although there was a tendency for the males, $r = -.22$, $p = .08$. However, the correlation coefficient for the males does attain statistical significance with the error data over two blocks, as does the coefficient for the male left movers.

Inspection of Table 51 indicates a very different pattern for the no trials. All the significant correlations are in a positive direction. That is, greater perceived emotional valence

Table 50

Pearson Correlations of Emotion Ratings of Target Faces with Visual Field Differences (Reaction Time and Both Sets of Error Data) for Yes Trials

	N	RT	ER4	ER2
All	128	-.24**	-.07	-.02
Males	64	-.22	-.13	-.25*
Females	64	-.26*	-.03	.14
Left Movers	50	-.25	-.12	-.23
Bimovers	41	-.26	-.04	.03
Right Movers	37	-.24	-.12	.14
LM-M[1]	25	-.31	-.26	-.42*
LM-F[2]	25	-.23	-.01	-.01
Bi-M[3]	21	-.08	.00	-.26
Bi-F[4]	20	-.40	-.05	.20
RM-M[5]	18	-.34	-.11	.09
RM-F[6]	19	-.17	-.12	.17

[1]Male Left Movers
[2]Female Left Movers
[3]Male Bimovers
[4]Female Bimovers
[5]Male Right Movers
[6]Female Right Movers

Table 51

Pearson Correlations of Emotion Ratings for Nontarget Faces with Visual Field Differences on No Trials

	N	RT	ER4	ER2
All	128	.10	.10	.16
Males	64	.28*	.20	.21
Females	64	-.05	.02	.13
Left Movers	50	.24	.01	.09
Bimovers	41	.04	.12	.13
Right Movers	37	.01	.19	.27
LM-M	25	.40*	.37	.24
LM-F	25	.07	-.25	-.03
Bi-M	21	.43*	.12	.07
Bi-F	20	-.24	.09	.18
RM-M	18	.03	.07	.27
RM-F	19	-.08	.39	.39

is associated with better relative LVF (presumably right hemisphere) performance. Unlike with the _yes_ responses, these correlations are significant for the males only. Coefficients attaining statistical significance are those for the males, left movers males, and bimover males, all on the reaction time data.

Despite the lack of consistency between the error and reaction time data, not surprising in view of previous findings, it is clear that the relationship between emotional valence and within subject visual field differences is not the same across the experimental variables. It is evident that they relate in opposite directions for _yes_ and _no_ trials. Thus, the analysis of covariance is not the appropriate method for minimizing the confounding effect of emotional valence and finger pattern.

The more appropriate analysis would be to use the emotion ratings as a blocking variable. Given the significant differences in emotion ratings among the sex x CLEM groups, this also seemed indicated. This was done by approximating as closely as possible a median split with the combined emotion ratings. This involved dividing the scores into two groups of high emotion ratings and low emotion ratings at the point at which the sample would be most equally divided.The highest possible score for the four faces was 28. The point of division which resulted in the most even sample split was betweem a score of 15 and 16. Subjects whose combined ratings were greater than or equal to 16 were considered to belong to the emotional(rated) group, while subjects with emotion ratings less than or equal to

15 were considered to be in the neutral(rated) group. This resulted in a fairly even division of the sample. Sixty seven subjects were in the emotional(rated) group and 61 subjects were in the neutral(rated) group.

Ideally, the rated emotional and neutral groups should be included with all the variables, that is, sex, a priori defined emotion, finger pattern, and CLEM. However, there were not enough subjects to make the addition of another independent group feasible. Even when the highest level interaction was excluded from the analysis, the analysis could still not be run due to the presence of some empty cells. None of the original four independent variables (sex, a priori emotion, finger pattern, and CLEM) seemed appropriate to exclude since they had all been involved in significant interactions, and the failure to control for them might yield misleading results.

The decision was made to substitute the rated emotion groups for the a priori emotion groups. This was, of course, not an ideal solution since the emotional set of faces was, in fact, a different set of photographs, and could conceivably contribute variance for reasons other than their overall higher emotional valence. However, given that the a priori faces were significantly correlated with emotional valence, there would be some degree of overlap to justify the substitution. Nevertheless, this analysis cannot be considered as a substitute for the a priori analysis, but rather an alternative one using a different operational definition of emotional valence.

Other problems with this alternative analysis also indicate caution in interpretation. One is the validity of the emotion ratings themselves since subjects in the emotional and neutral conditions did not have a common anchor point, and hence the ratings in the two groups might not be comparable. For example, a rating of three in the emotional group would probably represent a higher degree of veridical emotional valence than an equivalent rating with the neutral faces. To some extent, this is corrected by the use of the overall median on which to divide the sample into emotional and neutral groups. The median point for the a priori neutral and emotional faces alone were 13/14 and 17/18, respectively. The median point for the total sample, as indicated above, was between a score of 15 and 16. Thus, the use of this division point would place the cutoffs higher and lower, relative to their own medians, for the neutral and emotional faces respectively.

Another limitation of the alternative analysis is the following. It could justifiably be argued that it would be more appropriate to conduct the analyses separately for yes and no trials since the division of the subjects into two groups on the basis of their emotion ratings would be more accurate for the separate sets of yes and no trials. In other words, a subject who might fall in to the emotional(R) group on the basis of a median split when his or her combined ratings are considered, might not necessarily be in that group when only his or her ratings of the target (yes trials) or nontarget (no) trials are considered for the median split. The correlation between the target and nontarget emotion ratings was only .27, p=.002, not a large relationship. On the other hand, only by analyzing the *yes* and *no* trials together could one be justified in discussing interactions between response type and emotional valence, an interaction that previous analyses suggested might be present. The decision was made to analyze the *yes* and *no* trials together since, as is evident by the graph in Appendix W, the misclassification of the separate *yes* and *no* trials decreases as the emotion ratings become more extreme. An assumption of the median split, of course, is that there may be considerable error at the borders, but that the more valid extreme scores will carry the analysis.

The resulting cell frequencies of this new design are presented in Table 52.

Analyses of variance using the rated rather than a priori emotion definition were conducted for the three sets of data, reaction time, error over two blocks, and errors over four blocks. For these analyses, interactions involving finger pattern and digit will be noted, the tables placed in the appendix, and not discussed further. This is because, for this researcher, they failed to clarify the interpretation of the finger pattern variable. This problem will be addressed in the Discussion. To describe them in detail at this point would make the reading unnecessarily cumbersome.

Table 52
Cell Frequencies for Analyses of Variance Using Rated Emotion

		Males		Females	
		EMO(R)[1]	NEUT(R)	EMO(R)	NEUT(R)
Index	LM	7	5	8	6
Condition	BI	5	5	4	4
	RM	7	3	6	4
Middle	LM	7	6	4	7
Condition	BI	5	6	5	7
	RM	3	5	6	3

[1]Rated

<u>Analysis of Variance using Rated Emotion with Reaction Time Data on Lateral Presentation Tachistoscopic Face Recognition Task</u>

The analysis of variance table is presented in Table 53.

The only effect from the previous analysis using the a priori definition of emotion that survived the changing error terms is that of faster reaction times to correct <u>yes</u> trials than to correct <u>no</u> trials, $F(1,104) = 69.68$, $p = .000$. The two effects involving finger pattern in the previous analysis, the sex x emotion x finger pattern interaction, and the visual field x emotion x finger pattern x CLEM interaction have disappeared. The previously significant visual field effect and the visual field x emotion interactions have also dropped out. Instead, there is a significant response x emotion x visual field interaction, $F(1,104) = 3.72$, $p = .054$, the cell means which are presented in Table 54 and Figure 12. Table 54 indicates that the three way interaction is attributed to the emotional(R) <u>yes</u> responses only demonstrating the formerly described RVF (presumably left hemisphere) bias for emotional faces. This is

Table 53
ANOVA Using Rated Emotion on Reaction Time Data for Lateral Presentation Tachistoscopic Task

Source	SS	DF	MS	F	Prob.
Sex (S)	28.87	1	28.87	1.58	.211
Emotion-R (E)	9.8	1	9.82	0.54	.46
Finger (F)	4.41	1	4.41	0.24	.62
CLEM (C)	66.47	2	33.23	1.82	.167
SE	43.77	1	43.77	2.40	.124
SF	12.59	1	12.59	0.69	.408
EF	41.95	1	41.95	2.30	.132
SC	.89	2	.45	0.02	.976
EC	60.36	2	30.18	1.65	.196
FC	9.44	2	4.72	0.26	.772
SEF	6.12	1	6.13	0.34	.564
SEC	29.99	2	15.00	0.82	.442
SFC	4.74	2	2.37	0.13	.878
EFC	2.07	2	1.04	0.06	.945
SEFC	7.08	2	3.54	0.19	.824
Error	1898.20	104	18.25		
Response (R)	98.74	1	98.74	69.68	.000**
RS	.03	1	.03	0.02	.883
RE	6.08	1	6.08	4.29	.041*
RF	1.39	1	1.39	0.98	.325
RC	.28	2	.14	0.10	.906
RSE	.74	1	.74	0.52	.471
RSF	.52	1	.52	0.37	.547
REF	.04	1	.04	0.03	.860
RSC	5.10	2	2.55	1.80	.170
REC	8.81	2	4.41	3.11	.049*
RFC	.41	2	.20	0.14	.865
RSEF	.00	1	.00	0.00	.958
RSEC	8.46	2	4.23	2.98	.055*
RSFC	2.23	2	1.11	0.79	.458
REFC	2.58	2	1.29	0.91	.405
RSEFC	1.61	2	.81	0.57	.567
Error	147.37	104	1.42		
Visual Field (V)	1.51	1	1.51	2.52	.115
VS	.02	1	.03	0.06	.813
VE	1.01	1	1.01	1.68	.198
VF	1.14	1	1.14	1.91	.170
VC	.82	3	.41	0.68	.508
VSE	.98	1	.98	1.62	.205
VSF	1.74	1	1.74	2.89	.092

Table 53 (cont'd)

VEF	.35	1	.35	0.58	.449
VSC	2.32	2	1.16	1.93	.150
VEC	.47	2	.24	0.39	.675
VFC	.14	2	.07	0.11	.891
VSEF	.04	1	.04	0.06	.803
VSEC	1.75	2	.88	1.46	.238
VSFC	.95	2	.47	0.79	.457
VEFC	1.35	2	.68	1.12	.329
VSEFC	.80	2	.40	0.67	.515
RV	.90	1	.90	1.52	.222
RVS	1.64	1	1.68	2.74	.101
RVE	2.22	1	2.22	3.72	.054*
RVF	.09	1	.09	0.16	.693
RVC	.68	2	.34	0.57	.564
RVSE	.11	1	.11	0.19	.662
RVSF	.03	1	.03	.05	.822
RVEF	.36	1	.36	.60	.442
RVSC	1.63	2	.82	1.37	.259
RVEC	2.69	2	1.34	2.26	.110
RVFC	.23	2	.11	0.19	.826
RVSEF	.24	1	.24	0.41	.523
RVSEC	.55	2	.28	0.46	.631
RVSFC	.12	2	.06	0.10	.903
RVEFC	1.43	2	.72	1.21	.303
RVSEFC	.08	2	.04	0.07	.935
Error	61.98	104	.59		

because the emotional(R) faces on the _yes_ trials are recognized significantly faster from the RVF/LH. The reaction times for the _no_ trials of the emotional(R) faces do not demonstrate this visual field difference.

Other significant effects are a response x emotion(R) interaction, $F(1,104) = 4.29$, $p = .041$, a response x emotion(R) x CLEM interaction, $F(2,104) = 3.11$, $p = .049$, and a marginally significant response x sex x emotion(R) x CLEM interaction, $F(2.104) = 2.98$, $p = .055$.

The pattern of all these interactions can be seen from Table 55 and Figure 13, which present the cell means for the four way interaction. The full table is available in Appendix X.

Figure 12

Reaction Times for Response x Emotion(R) x Visual Field Interaction for Lateral Presentation Task

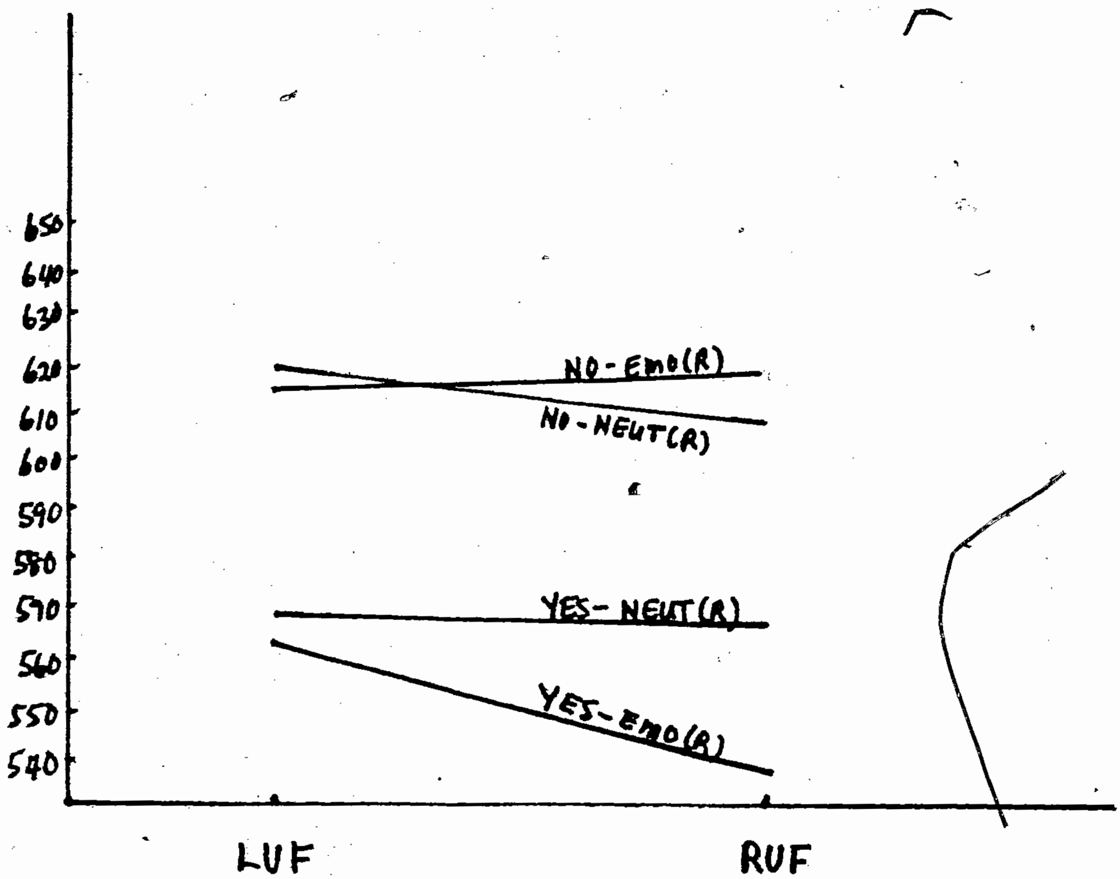

Table 54
Mean Reaction Times for Response x Emotion x Visual Field Interaction for ANOVA using Rated Emotion in Lateral Presentation Tachistoscopic Task

		Emotional(R)	Neutral(R)
Yes	LVF	561.25	570.96
	SD	(1.27)	(1.29)
	RVF	540.54	569.56
	SD	(1.25)	(1.27)
No	LVF	614.42	620.64
	SD	(1.24)	(1.22)
	RVF	616.46	611.54
	SD	(1.22)	(1.26)
	N	(67)	(61)

The meaning of the reponse x sex x emotion(R) x CLEM interaction will be described. In the case of the neutral faces, sex does not interact with the three way response x emotion(R) x CLEM interaction. For both the males and females, left movers respond fastest to the neutral faces, right movers slowest, with bimovers usually in between. It is only with the emotional(R) faces that sex enters the interaction, and then, primarily with the _yes_ responses. For the emotional(R) _yes_ responses, male left movers perform the worst (slowest) and male right movers perform the best (fastest). However, the opposite is the case for the females, where left movers perform the best and right movers the the worst. With the emotional(R) _no_ responses, in both cases, left movers are faster than right movers, as with the neutral faces.

Hence, the three way response x emotion(R) x CLEM interaction represents the the different interaction of response and CLEM on the emotional(R) _yes_ trials, compared to the pattern common to the other three types of response x emotion(R) trials.

Figure 13

Reaction Times for Response x Sex x Emotion(R) x CLEM Interaction on Lateral Presentation Task

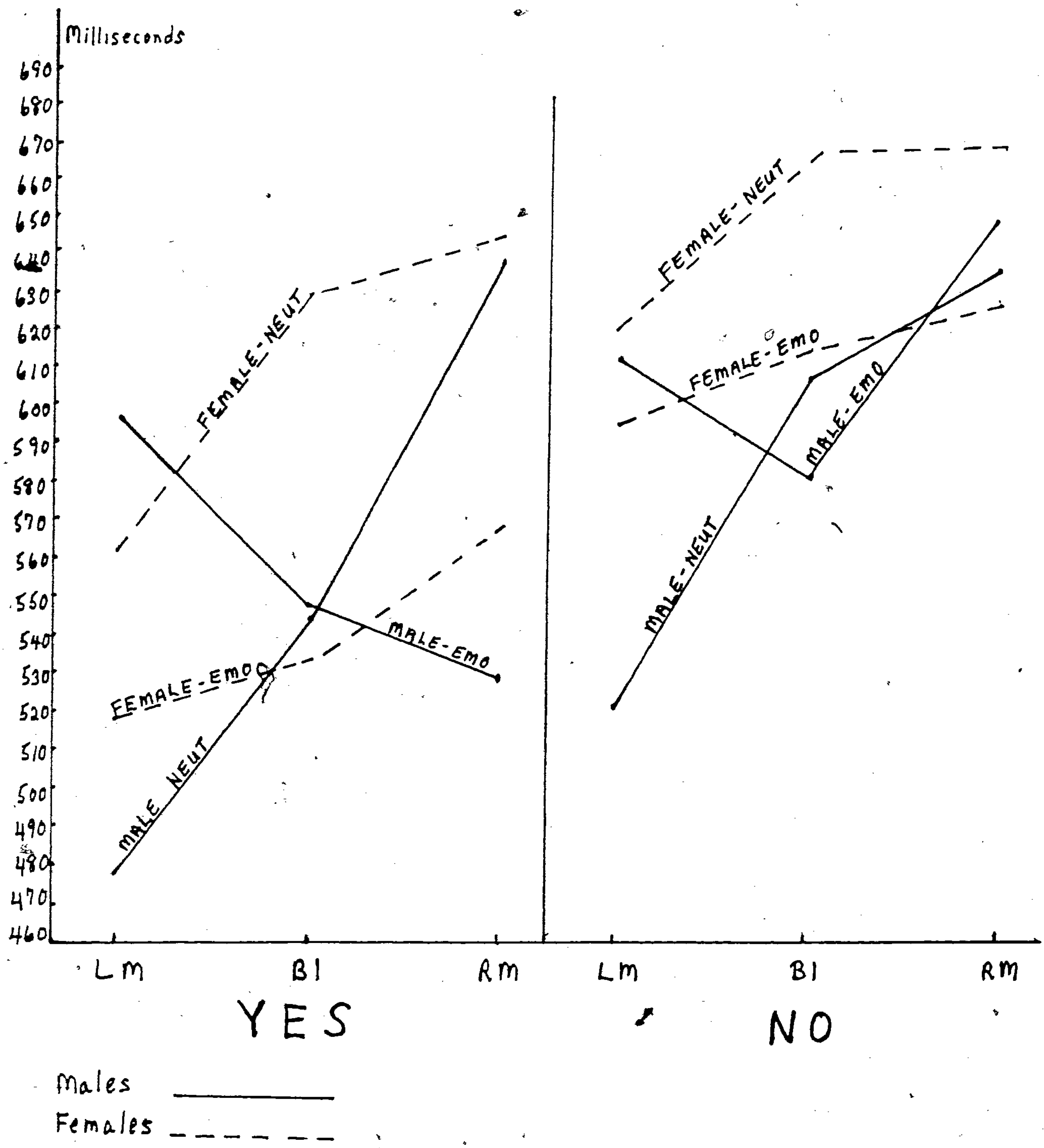

Table 55
Mean Reaction Times for Response x Sex x Emotion(R) x CLEM Interaction on Lateral Presentation Tachistoscopic Face Recognition Task

		Yes		
		LM	BI	RM
Male	EMO(R)	595.33	545.72	531.91
	NEUT(R)	478.83	541.34	638.34
Female	EMO(R)	517.87	532.80	569.06
	NEUT(R)	562.07	630.36	644.52

		No		
		LM	BI	RM
Male	EMO(R)	615.72	587.34	652.62
	NEUT(R)	521.71	611.97	638.34
Female	EMO(R)	597.52	614.58	628.47
	NEUT(R)	619.97	670.20	672.19

The two way response x emotion(R) interaction derives from the overall faster responding on the _yes_ trials in the emotional(R) condition, in the absence of any reaction time differences for the neutral faces.

The major results from the analysis of the reaction time data using rated emotion as a blocking variable can be summarized as follows. Only the _yes_ responses in the emotional(R) condition exhibited a RVF (presumably left hemisphere) bias. And it is only on these same faces that the pattern of fastest responding by left movers usually followed by bimovers and then right movers is not present, and this is for the males only. Male right movers are fastest on the emotional(R) _yes_ trials, and male left movers the slowest.

__Analysis of Variance Using Rated Emotion on Error Data (Four Blocks) on Lateral Presentation Tachistoscopic Face Recognition Task.__

The analysis of variance is presented in Table 56.

The significant effects that survived the changing error terms from the previous analysis using the a priori defined emotion factor are the response x sex x CLEM interaction, $F(2,104) = 4.53$, $p = .013$, and the visual field x sex x CLEM interaction, $F(2,104) = 3.47$, $p = .035$. No longer present are the former reponse x emotion x CLEM interaction and the significant response x visual field interaction, although the latter remains a trend in the present analysis, $F(1,104) = 3.03$, $p = .085$. New significant interactions are the following: a marginally significant _yes_ x emotion(R) x finger pattern (digit x emotion(R)) interaction, $F(1,104) = 3.73$, $p = .056$, a highly significant response x emotion(R) x finger pattern x CLEM interaction (digit x emotion(r) x CLEM), $F(2,104) = 7.77$, $p = .001$, and a visual field x emotion(R) x finger pattern x CLEM interaction, $F(2,104) = 3.61$, $p = .030$.

The cell means for the digit x emotion(R) x CLEM interation are presented in Appendix Y(i), which will also provide the means for the marginally significant digit x emotion interaction. A brief discussion of the interaction is also available in the appendix.

Table 56

ANOVA using Rated Emotion for Errors (Four Blocks) on Lateral Presentation Tachistoscopic Face Recognition Task

Source	SS	DF	MS	F	Prob.
Sex (S)	5.40	1	5.40	0.23	.634
Emotion-R (R)	14.11	1	14.11	0.60	.442
Finger (F)	0.30	1	0.30	0.01	.910
CLEM (C)	86.00	2	43.00	1.82	.168
SE	53.60	1	53.60	2.26	0.14
SF	2.54	1	2.54	0.11	.744
EF	34.63	1	34.63	1.46	.229
SC	8.65	2	4.32	0.18	.833
EC	59.48	2	29.74	1.26	.289
FC	19.06	2	9.53	0.40	.670
SEF	20.07	1	20.07	0.85	.359
SEC	9.58	2	4.79	0.20	.817
SFC	87.78	2	43.89	1.85	.162
EFC	10.84	2	5.42	0.23	.796
SEFC	59.51	2	29.76	1.26	.289
Error	2462.78	104	23.68		
Response (R)	0.09	1	0.09	0.01	.923
RS	1.70	1	1.70	0.17	.679
RE	9.45	1	9.45	0.96	.330
RF	27.71	1	27.71	2.80	.097
RC	11.02	2	5.51	0.56	.574
RSE	26.85	1	26.85	2.72	.102
REF	36.85	1	36.85	3.73	.056
RSC	89.61	2	44.81	4.53	.013**
REC	38.91	2	19.46	1.97	.145
RFC	1.48	2	0.74	0.07	.928
RSEF	0.04	1	0.04	0.00	.947
RSEC	42.89	2	21.44	2.17	.119
RSFC	22.74	2	11.37	1.15	.320
REFC	153.60	2	76.80	7.77	.0007**
RSEFC	6.91	2	3.45	0.35	.706
Error	1027.62	104	9.88		
Visual Field (V)	6.96	1	6.96	1.91	.169
VS	0.12	1	0.12	0.03	.855
VE	0.52	1	0.52	0.14	.706
VF	4.78	1	4.78	1.32	.254
VC	20.38	2	10.19	2.81	.065
VSE	0.02	1	0.02	0.01	.938
VSF	0.05	1	0.05	0.01	.905
VEF	0.93	1	0.93	0.26	.614

VSC	25.20	2	12.60	3.47	.035*
VEC	3.76	2	1.88	0.52	.597
VFC	1.96	2	0.98	0.27	.764
VSEF	6.91	1	6.91	1.90	.171
VSEC	18.75	2	9.37	2.58	.081
VSFC	19.41	2	9.71	2.67	.074
VEFC	26.23	2	13.12	3.61	.030*
VSEFC	13.51	2	6.76	1.86	.161
Error	377.39	104	3.63		
RV	25.25	1	25.25	3.03	.085
RVS	0.11	1	0.11	0.01	.910
RVE	19.11	1	19.11	2.29	.133
RVF	20.20	1	20.20	2.42	.123
RVC	5.07	2	2.53	0.30	.738
RVSE	15.83	1	15.83	1.90	.171
RVSF	0.00	1	0.00	0.00	.982
RVEF	5.10	1	5.10	0.61	.436
RVSC	17.52	2	8.76	1.05	.354
RVEC	3.52	2	1.76	0.21	.810
RVFC	10.12	2	5.06	0.61	.547
RVSEF	0.00	1	0.00	0.00	.987
RVSEC	5.10	2	2.55	0.31	.737
RVSFC	26.59	2	13.25	1.59	.210
RVSEFC	1.29	2	0.64	0.08	.926
Error	867.68	104	8.34		

The cell means for the visual field x emotion(R) x finger pattern x CLEM interaction are presented in Appendix Y(ii) with a brief description.

Analysis of Variance Using Rated Emotion on Error Data (Two Blocks) on Lateral Presentation Tachistoscopic Face Recognition Task

The analysis of variance is presented in Table 57.

The only effect which survived the changing error term from the previous analysis using the a priori definition of emotion are the response x sex x emotion(R), F(1,104) = 4.48, p = .037,

Table 57
ANOVA Using Rated Emotion of Error (Two Blocks) on Lateral Presentation Tachistoscopic Task

Source	SS	DF	MS	F	Prob.
Sex (S)	3.88	1	3.88	0.82	.368
Emotion-R (E)	4.14	1	4.14	0.87	.352
Finger	0.16	1	0.11	0.02	.881
CLEM (C)	12.07	2	6.03	1.27	.285
SE	6.55	1	6.55	1.38	.243
SF	0.44	1	0.44	0.09	.762
EF	10.80	1	10.80	2.27	.134
SC	3.89	2	1.95	0.41	.665
EC	12.91	2	6.46	1.36	.262
FC	7.38	2	3.69	0.78	.462
SEF	5.85	1	5.85	1.23	.270
SEC	2.87	2	1.43	0.30	.740
SFC	26.12	2	13.06	2.75	.069
EFC	2.75	2	1.38	0.29	.749
SEFC	17.73	2	8.86	1.87	.160
Error	494.26	104	4.75		
Response (R)	3.52	1	3.52	1.37	.245
RS	1.24	1	1.24	0.48	.490
RE	3.20	1	3.20	1.24	.268
RF	4.88	1	4.88	1.90	.172
RC	0.81	2	0.40	0.16	0.855
RSE	11.54	11.54	11.54	4.48	.037*
RSF	0.06	1	0.06	0.03	.875
REF	10.34	1	10.34	4.02	.048*
RSC	5.71	2	2.86	1.11	.333
REC	7.31	2	3.66	1.42	.246
RFC	1.00	2	0.50	0.19	.823
RSEF	0.06	1	0.06	0.02	.880
RSEC	2.15	2	1.07	0.42	.660
RSFC	0.67	2	0.34	0.13	.877
REFC	17.70	2	8.85	3.44	0.04*
RSEFC	8.55	2	4.28	1.66	.195
Error	267.83	104	2.57		
Visual Field (V)	0.16	1	0.16	0.14	.713
VS	0.78	1	0.78	0.65	0.42
VE	0.47	1	0.47	0.39	.535
VF	0.03	1	0.03	0.03	.867
VC	1.35	2	0.67	0.56	.573
VSE	0.65	1	0.65	.54	.463
VSF	0.15	1	0.15	0.12	.725
VEF	1.53	1	1.54	1.27	.262

Table 57 (cont'd)

VCS	3.26	2	1.83	1.35	.263
VEC	0.82	2	0.41	0.34	.712
VFC	6.59	2	3.29	2.74	.070
RVEF	1.17	1	1.17	0.97	.328
VSEC	4.63	2	2.31	1.92	.152
VSFC	3.33	2	1.66	1.38	.256
VEFC	1.50	2	0.75	0.62	.538
RSEFC	1.80	2	0.90	0.75	.476
Error	125.36	104	1.20		
RV	4.10	1	4.10	2.15	.146
RVS	0.02	1	0.01	0.01	.920
RVE	3.31	1	3.32	1.74	.190
RVF	5.22	1	5.22	2.74	.101
RVC	2.13	2	1.07	0.56	.573
RVSE	7.41	1	7.41	3.89	.051*
RVSF	0.02	1	0.02	0.01	.919
RVEF	0.01		0.01	0.00	.949
RVSC	4.46	2	2.23	1.17	.314
RVEC	2.41	2	1.20	0.63	.534
RVFC	5.22	2	2.61	1.37	.258
RVSEF	1.18	1	1.18	0.62	.433
RVSEC	2.84	2	1.42	0.75	.477
RVSFC	7.52	2	3.76	1.98	.144
RVEFC	1.64	2	0.82	0.43	.651
RVSEFC	7.57	2	3.78	1.99	.142
Error	198.04	104	1.90		

and the response x emotion(R) x finger pattern (digit x emotion(R)) interaction, $F(1,104) = 4.02$, $p = .048$. Inspection of the cell means indicates that the relationships are the same as in the previous analyses. Specifically, the greatest number of errors is made by the females on the no trials in the neutral(R) condition. And, again, the index digit was more accurate than the middle digit for neutral faces only. Although the significant emotion x finger pattern x CLEM and visual field x sex x emotion x finger pattern interactions from the previous analysis have disappeared, there are two trends involving interactions with finger pattern. These trends, which will not be discussed further, are a sex x finger pattern x CLEM interaction, F(2,104) = 2.75, p = .069 and a visual field x finger pattern x CLEM interaction, F(2,104) = 2.74, p = .070.

New effects are a digit x emotion(R) x CLEM interaction, F(2,104) =3.44, p = .036, and a response x visual field x sex x emotion(R) interaction, F(1,104) = 3.89, p = .051. Inspection of the cell means indicated that the pattern of the digit x emotion(R) x CLEM interaction was the same as that in the analysis just reported for errors over four blocks.

The cell means for the response x visual field x sex interaction are presented in Table 58 and Figure 14. The full table is available in Appendix Z.

From inspection of Table 58, the pattern is most clear in the case of males viewing emotional(R) faces. Emotional(R) faces are more accurately perceived from the RVF (presumably left hemisphere) in the case of yes responses, while they are more accurately perceived from the LVF (presumably right hemisphere) in the case of no responses. These trends are only marginally apparent in the case of females viewing emotional faces. In the case of the neutral(R) faces, there appears to be a sex difference with the yes responses only, with females more accurate from the RVF, with a smaller trend for males in the opposite direction.

In order to more clearly establish the site of this four way interaction, separate analyses were conducted for males and females, and emotional(R) and neutral(R) faces. These are available in Appendices AA(i),(ii),(iii), and (iv) . When the

Figure 14

Errors (Two Blocks) for Response x Visual Field x Sex x Emotion(R) Interaction on Lateral Presentation Task

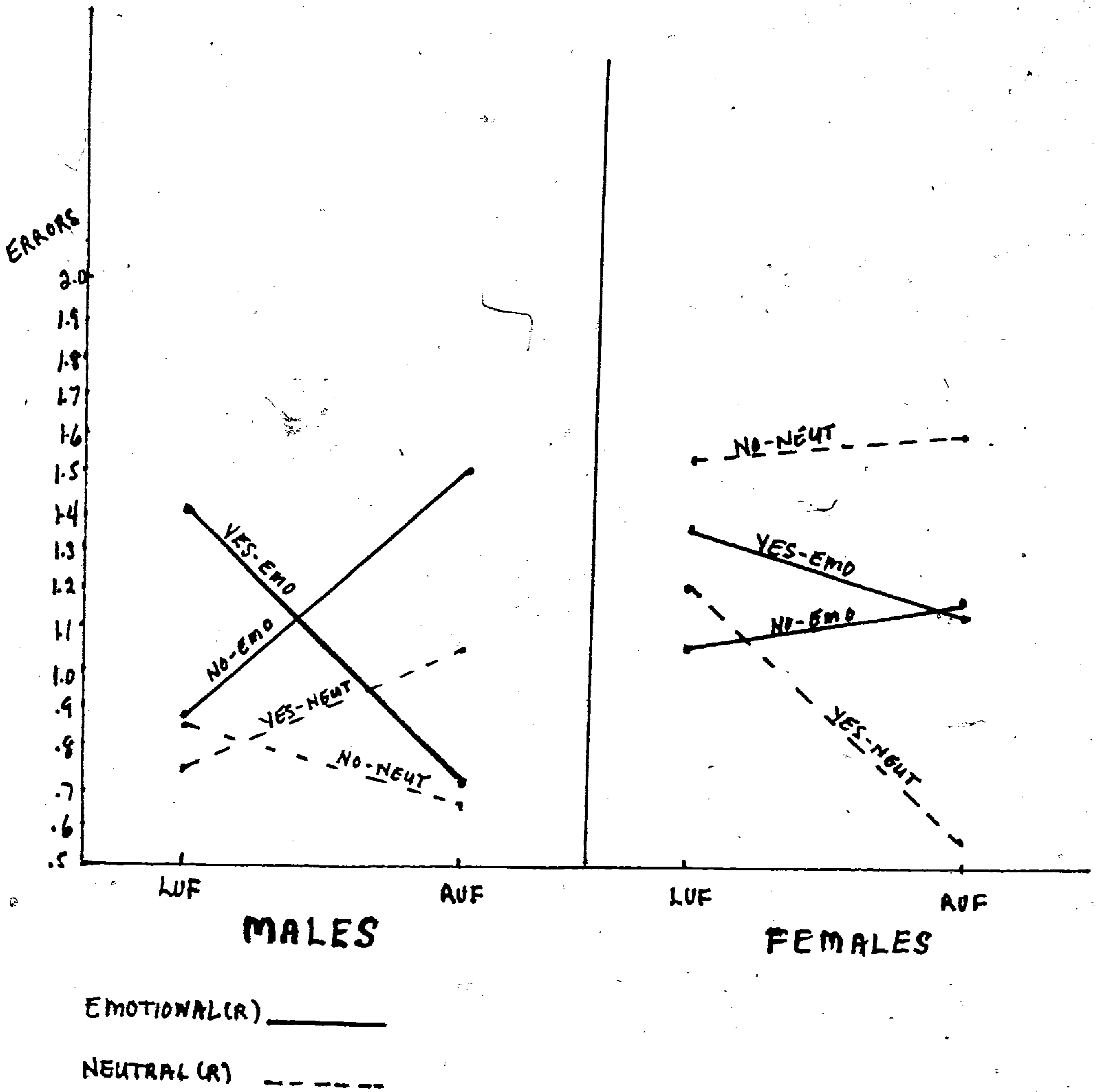

Table 58
Mean Errors (Two Blocks) for Response x Visual Field x Sex x Emotion(R) Interaction for Lateral Presentation Tachistoscopic Face Recognition Task

		Males	
		Emotional(R)	Neutral(R)
Yes	LVF	1.38	.73
	RVF	.74	1.07
No	LVF	.88	.83
	RVF	1.50	.67
		Females	
		Emotional(R)	Neutral(R)
Yes	LVF	1.36	1.22
	RVF	1.15	.55
No	LVF	1.06	1.55
	RVF	1.21	1.61

male and female subjects are analyzed separately, the response x visual field x emotion(R) interaction is present only for the males, $F(1,52) = 6.48$, $p = .014$, and not the females, $F(1,52) = 0.18$, $p = .670$. When the emotional(R) faces are examined separately, the response x visual field interaction is present, $F(1,55) = 4.07$, $p = .049$, but absent with the neutral faces, $F(1,49) = 0.01$, $p = .919$. Taken together, this pattern suggests that the major site of the response x visual field x sex x emotion(R) interaction is a response x visual field x emotion(R) interaction for the males, by which emotional(R) faces are perceived more accurately from the RVF on the <u>yes</u> trials, but more accurately from the LVF on the no trials. There is also a smaller effect for <u>yes</u> responses only, in which case the females exhibit greater accuracy from the RVF for the neutral faces, while the males exhibit a smaller trend in the other direction.

Analyses Using Rated Emotion on Central Presentation Tachistoscopic Face Recognition Test

The purpose of these analyses utilizing rated rather than the a priori definition of emotion was to attempt to minimize the confounding of finger pattern and emotional valence , and to examine laterality patterns using this operational definition of emotional valence. Although these concerns are relevant only to the lateral presentation variation of the tachistoscopic task, the effect of this altered criterion of emotional valence should be examined with the central presentation task only to ensure that this did not result in major changes. The analyses of variance on the error and reaction time data from the central face recognition test are available in Appendix BB(i) and (ii).

Analysis Using Rated Emotion on Errors for Central Presentation Tachistoscopic Face Recognition Test

The only effect which survived the change in error terms is the sex x CLEM interaction, $F(2,103) = 3.49$, $p = .034$. The formerly significant response x emotion effect has disappeared. New significant effects are a main effect for CLEM, $F(2,103) = 3.43$, $p = .036$, and a response x emotion(R) x finger pattern x CLEM (digit x emotion(R) x CLEM) interaction, $F(2,103) = 4.32$, $p = .016$.

The cell means for the main effect for CLEM are available from Table 4. Bimovers made the most errors, followed by right movers and then left movers, although the difference between the latter two groups is very small. Inspection of the cell means for the digit x emotion(R) x CLEM interaction indicates that, with the exception of the right movers in the emotional(R) condition who now make fewer errors with the index digit, the pattern is identical to that just reported in the equivalent analysis of both sets of error data in the lateral presentation variation of the task. See Appendix Y(i).

Analysis of Variance Using Rated Emotion on Reaction Time Data on Central Presentation Tachistoscopic Face Recognition Test

The two effects that were statistically significant in the previous reaction time analysis for this task both survived the changing error terms. These are the main effect for CLEM, $F(2,103) = 5.43$, $p = .006$, and response type, $F(1,103) = 58.09$, $p = .000$. There are no other significant effects.

Summary of Results

The summary of the results will follow the same organization as presented in the Organization of Results section appearing at the beginning of the Results section.

1. Tachistoscopic face recognition test

a. Error analysis

1) Central presentation

The major finding here was a sex x CLEM interaction. The CLEM effect for males was nonsignificant, while significant for the females. For the latter group, bimovers made the most errors, followed by right movers and then left movers. A response x emotion interaction was due to the poorer performance of the neutral group on the _no_ trials, relative to the other three conditions.

2) Lateral presentations

(a) Analysis of errors over four blocks

There was a significant visual field x sex x CLEM interaction. For the males, left movers and bimovers were more accurate in identifying faces presented presented in the RVF/LH, whereas the opposite pattern was present for right movers. For the females, left movers were more accurate with faces presented in the LVF/RH, while both bimovers and right mover females were more accurate with faces presented in the RVF/LH. The CLEM effect was significant only in the LVF/RH.

There was a significant response x visual field interaction. In the LVF/RH, _no_ trials were responded to more accurately than _yes_ trials, whereas a smaller, but opposite pattern was present for the RVF/LH.

A response x sex x CLEM interaction was due to the differential accuracy of the _yes_ and _no_ trials as a joint function of CLEM and sex. For males, left movers were more accurate with the _no_ trials and right movers more accurate on the _yes_ trials. For the females, left movers were more accurate with the _yes_ trials, while right movers were more accurate on the _no_ trials.

The response x emotion x CLEM interaction was due to the differential accuracy of _yes_ and _no_ trials as a function of the emotional/neutral dimension for bimovers only. _No_ trials were worse in the neutral condition, and _yes_ trials were, to a smaller extent, worse in the emotional condition

(b) Analysis of error over two blocks

There was a significant emotion x finger pattern interaction, strongest for the right movers, who were more accurate in the index condition with the emotional faces, and demonstrated the opposite pattern with the neutral faces.

A digit x emotion interaction was present in that, only for the neutral faces, fewer errors were made with the index digit.

The respone x emotion x CLEM interaction was similar to that reported over four blocks.

A response x sex x emotion interaction was primariliy due to the females. For this group, _yes_ and _no_ trials were equally accurate with the emotional faces, but, on the neutral faces, there were substantially more errors on the _no_ trials.

The visual field x sex x emotion finger pattern interaction is attributable to the males. LVF/RH superiorities were present for male subjects in the emotional- middle and neutral-index conditions, while RVF superiorities were present for subjects in the emotional-index and neutral-index condition.

Although it failed to attain statistical significance, a tendency towards a response x visual field x emotion x CLEM interaction was described. For the _no_ trials, there was a greater accuracy from the LVF/RH for the emotional faces and no visual field differences in the neutral condition. For the _yes_ trials, in the emotional condition, both left mover and bimovers exhibited strong RVF/LH superiorites, with the right movers demonstrating a weak trend in the other direction.

The response x visual field interaction, described in the analysis involving four blocks, was evident, though not significant.

b.Reaction Time Analysis

Central Presentation

Two main effects were significant. The CLEM main effect was due to fastest responding by left movers, slowest responding by right movers, and bimovers in between. A main effect for response was due to accurate _yes_ responses being faster than accuarate _no_ responses.

2.Lateral presentation

A significant main effect for visual field was entirely due to the emotional faces, as reflected in a visual field x emotion interaction. Contrary to prediction, emotional faces were reeponded to slower in the LVF/RH. Again, correct _yes_ responses were faster than correct _no_ responses.

There were also two interactions involving finger pattern, a sex x emotion x finger pattern interaction, and a visual field x emotion x finger pattern interacton, the latter due to the bimovers.

2.Correlations between reaction time and error data

The correlations between the reaction time and both sets of error data were positive for the separate visual fields, and both fields combined. However, laterality indices derived from the error and reaction time data did not even approach significance.

3.Perceptual bias test

The composite face made up of the half-face that had been in the subjects' LVF in the original photograph, was chosen significantly more often than the half face that had been in the viewer's RVF. There was a tendency (p=.09) towards a CLEM effect. Left movers and bimovers demonsrated a more pronounced LVF bias, relative to the right movers whose selection, on the average, represented just above chance responding.

4.Free view face recognition test

There were no significant main effects or interactions.

5.Correlations between tachistoscopic and perceptual bias indices of laterality

For the males, correlations were generally positive for both emotional and neutral faces. For females, there were negative correlations with the emotional faces, particularly so with the right mover females.

6. Correlations between laterality indices and tests of facial ability

Correlations reflecting an association between LVF/RH bias and facial ability all involve the neutral faces, with the exception of an overall negative correlation in the left mover-male group. Correlations reflecting an association between RVF/LH bias and better performance all involve right mover groups.

7. Correlations between different measures of facial processing ability

In general the tasks were positively correlated, although patterns exist. For correlations between the free view task and both the lateral and central presentation tasks, the relationship is most strong for the bimovers, followed by left movers, with no relationship between the tasks for right movers. For correlations between the lateral and central presentation tachistoscopic tasks, patterns are evident with the error data only. The correlations between the two tasks are highly correlated for the bimovers, and significantly, though substantially less, sc for the right movers. In contrast, the correlation coefficients for the left movers are in a negative direction, though nct significant.

8. Emotion ratings of tachistoscopic facial stimuli by subjects

For both target and nontarget faces, emotion ratings were significantly higher for the a priori emotional faces.

For target faces only, there was a significant sex x CLEM x emotion (a priori) interaction. For males, left movers rated the emotional faces as more emotional than right movers, whereas the opposite pattern was apparent for the females in the emotional condition. For the neutral faces, the main effect was for the females, where female left movers perceived the neutral faces as less emotional than with the left movers and bimovers.These differences resulted in differences among the six groups in terms of the differentiation between the emotional and neutral faces, an indication of the success of the experimental manipulation. Right mover females exhibited the most striking diffenence between the two sets of faces, folloewed by left mover-males, bimover-males, left mover-females, bimover females, and right mover males.

There was a main effect for finger pattern for the combined and nontarget faces, largely attributable to a sex x emotion x finger pattern interaction present in the nontarget and combined faces, though not negligible in the target ratings. This was dur to the females in the emotional condition, who rated the faces in the index condition significantly higher than in the middle condition.

9. Analyses involving emotion ratings

Correlations were examined between tachistoscopic laterality and individually rated emotional valence of the facial stimuli, separately for the target <u>yes</u> and <u>no</u> trials. These revealed an opposite pattern of interaction for the two response types. In the case of the _yes_ trials, the coefficients were almost all negative indicating that higher emotional valence was associated with relatively better performance from the RVF/LH. In contrast, the correlation coefficients with the _no_ trials were almost all positive indicating that higher rated emotional valence was associated with greater relative LVF/RH performance.

An alternative analysis was done, utilizing the emotion ratings as the criterion for assignment into emotional(R) and neutral(r) groups, on the basis of a near median split. The analysis with reaction time yielded a response x emotion(R) x visual field interaction. _Yes_ trials on which the faces were rated as emotional were responded to faster from the RVF/LH, resulting in a RVF/LH superiority for these trials. There was also a response x sex x emotion(R) x CLEM interaction. For all types of response x emotion(R) trials, left movers were fastest, right movers slowest, with bimovers usually in between. The exception was the emotional(R) _yes_ trials where, for the males, left movers were slowest, right movers were fastest, and bimovers in between.

The analysis of errors over four blocks did not yield effects of interest other than interactions involving digit and finger pattern, described in the appendix. With the exception of the previous response x emotion(a priori) x CLEM interaction, all previous effects were maintained.

The effect of interest in the analysis of errors over the last two blocks was a signficant response x sex x visual field x emotion(R) interaction, primarily attributable to males demonstrating a RVF/LH superiority on the the emotional(R) _yes_ trials, and a LVF/RH superiority on the emotional(R) _no_ trials.

When equivalent analyses of the central presentaion task were done, there were no major changes in the results.

IV. Discussion

Before discussion of the results can proceed, two issues which may influence their interpretation must be confronted. On is the issue of responding hand and its possible interaction with visual field given that only the right hand was used in the present study. The other is the finding of unexpected interactions of finger pattern with the other variables. These issues and their implications for the present study will be examined first. The discussion of the results will then be organized according to the four original hypotheses and predictions outlined in the introduction. This will be followed by a general discussion of the broader issues raised by the present findings and suggestions for future research.

Implications of Responding Hand

As noted in the Method section, at the time the research was designed, the literature strongly indicated that responding hand did not interact with visual field in facial recognition tasks (See footnote in Method section for a list of these studies). In fact, as noted earlier, one study (Rapaczynski and Ehrlichman, 1979) was conducted with the right hand only on this basis. After the data collection for the present study was underway, three articles were published which reported a responding hand x visual field interaction, consistent with neuroanatomical patterns - the right hand favoring a RVF/LH superiority and the left hand favoring LVF/RH superiorities. These were McKeever and Dixon (1981), Sergent (1982a, Experiment 2), and Strauss and Moscovitch (1981, Experiment 1), although in the latter study, another experiment found a responding hand x visual field interaction in the opposite direction, that is , contrary to neuroanatomical connections. The majority of studies which have appeared during this time period have reported the more typical finding of no such interaction . These are Sergent (1982a, Experiments 1 and 3), Sergent (1982b, Experiments 1,2, and 3), St. John (1981, Experiments 1,2, and 3), and Strauss and Moscovitch (1981, Experiment 2). These represent all the face recognition studies during this time using a reaction time measure and all have used right handed individuals. The other studies have used accuracy measures where response choice is indicated verbally.

The total body of research, then, favors the probability that responding hand did not bias the present results. However, given the strong purity of the sample since subjects with familial sinsitrality were also excluded, it would be cautious to keep in mind the direction of the biasing, if indeed present, and its implications for interpretation.

At this point in research, there is no evidence indicating that the biasing effect of using only the right hand would be anything other than a linear overall biasing towards the RVF/LH. Two of the hypotheses examined in this study were investigated using correlations. These would not be affected by any systematic biasing towads one visual field since the correlations would reflect _relatively_ better performance of one visual field/hemisphere over the other. These two hypotheses concerned the correlations between the perceptual bias and tachistoscopic laterality indices, and the correlations between laterality and ability at processing physiognomic stimuli. Predictions involving sex x emotion x visual field interactions, or any of their combinations, are likewise not affected since it is the _patterns_, not the absolute visual field differences that are of interest. In other words, the original prediction that emotional valence would augment a LVF/RH superiority in females, but not in males,can still be examined even if there is a systematic biasing towards one visual field. If absolute visual field differences are of interest, the problem of interpretation applies to the meaning of a no-difference or RVF/LH advantage. It could be argued that, when only the right hand is used, they might actually represent a LVF/RH advantage and no-difference, respectively. LVF/RH superiorities could,of course, be trusted. However, this issue does not appear to pose a serious interpretation problem regarding _interactions_ of the variables with visual field. The final hypothesis comparing left movers and right movers on facial processing ability is unaffected since it is the central presentation tachistoscopic task that is of concern here.

The conclusion reached is that using only the right hand probably did not bias the results of the lateral presentation task. However, even if it did, it poses no serious interpretation problems for the purposes of the present research questions.

The Problem of Finger Pattern

An unexpected effect was the interaction of finger pattern with the other variables. The obvious interpretation of its appearance in several interactions is its confounding with emotional valence as measured by the emotion ratings. When the latter were substituted in the analysis for a priori defined emotion, the interactions with finger pattern were replaced by others. That the effect of finger pattern did not disappear when the emotion ratings were controlled does not necessarily rule out the hypothesis that its effects derived from its confounding with rated emotional valence. This is because in the alternative analysis, finger pattern would no longer be counterbalanced with a priori emotion. If the variance between the a priori neutral and emotional faces was not entirely due to their differences in emotional valence, the appearance of new finger pattern interactions would not be unexpected. The proper analysis would be to control for both rated and a priori emotion. This was not possible because there were not enough subjects to carry out the analysis.

The analyses indicated that some group differences in digit accuracy were present. This could be attributed to chance factors, particularly in view of the small cell frequencies. Recurrent patterns in the various analyses also indicate the presence of interactions of response with emotion, visual field, sex, and CLEM. These interactions of response with the other variables together with some group differences in digit might yield effects involving finger pattern, since the latter in fact represents an interaction between response and digit.

Several attempts were made to identify a systematic relationship between finger pattern and the other variables by examining and comparing the interactions in which they occurred. Invariably, the hypothesis under consideration would be consistent with the finger pattern interactions in some cells but not others. There may indeed have been systematic effects occurring with finger pattern but they were being clouded by other variables also behaving in a systematic way. If finger pattern was varying systematically, that in itself is of little interest for the present investigation. The crucial question is whether this accounts for the other results not involving finger pattern, which are of interest in the present experiment. If the design was properly counterbalanced this would not be a problem since the variance of finger pattern would be a source of error variance, and would not systematically bias the data. The design was counterbalanced across sex, a priori emotion, and finger pattern. The blocking on CLEM resulted in unequal cell sizes as can be seen from Table 1, but there do not appear to be major disparities in cell sizes. Furthermore, an anlysis of variance on CLEM ratio scores, reported in Table 2, failed to yield group differences even approaching significance. The cell frequencies are somewhat, but not substantially, more uneven when rated emotion is substituted for a priori emotion, as can be seen in Table 49. Given that the cell frequencies are small, however, it would be most conservative to restrict the interpretation only to those effects or patterns that recur throughout the different analyses. These different analyses are the analyses of variance utilizing the two operational definitions of emotion (rated and a priori), each utilizing different error terms, and the correlations. Some confidence can be placed in patterns of results that emerge under different analyses. In addition, main effects or interactions should not be interpreted if they exist together with higher level interactions involving finger pattern. Since the higher level interaction cannot be interpreted, the lower level interaction could be misleading.

With these reservations and qualifications in mind, the results will now be discussed in terms of the four hypotheses outlined in the Introduction.

Hypothesis Involving a Sex x Emotion x Visual Field Interaction

The original prediction was that on the lateral presentation task, males would exhibit a greater LVF/RH advantage than would females with the neutral faces. With emotional faces, however, both would demonstrate a LVF/RH superiority, due to the augmenting of a LVF/RH bias in the case of females with emotional faces.

The prediction was clearly not confirmed since the visual field x emotion interaction in the reaction time data was opposite to prediction, and did not involve interactions with sex. When the data were re-analyzed using rated emotion, a response x sex x emotion (r) x visual field interaction was present with errors over two blocks, but it was the males, and not the females, for whom rated emotion was interacting with visual field.

Furthermore, the visual field x emotion interaction in the reaction time data cannot be meaningfully interpreted because of the underlying significant visual field x emotion x finger pattern x CLEM interaction. Referring to Figure 10, it appears that the visual field x emotion interaction is due to its interaction with finger pattern in the bimover group. The left movers appear to demonstrate no substantial visual field x emotion interaction, as reflected in their separate visual field x emotion interaction, $F(1,42) = 0.96$, $p = .333$. Right movers likewise exhibit no substantial visual field x emotion interaction, $F(1,29) = 0.30$, $p=.589$, in the other direction. Hence, it would not be appropriate to discuss the two way visual field x emotion interaction.

However, what requires explanation is why the results fail to replicate those of Suberi and McKeever, at least for the females. The lateral presentation task was esentially a replication of Suberi and McKeever (1977) and the facial stimuli were taken from their set. They used only a female sample. Recall that Suberi and McKeever (1977) reported that females who memorized emotional faces demonstrated a greater LVF/RH advantage in reaction time compared to a group who memorized neutral faces, whose LVF/RH advantage in the latter case failed to reach significance. Hence, what requires discussion is the failure of the emotional faces in the present study to be processed faster in the LVF/RH relative to the neutral faces, at least for females. This problem will be approached by exploring factors that might bias the emotional faces away from a LVF/RH advantage.

This cannot be attributed to the exclusive use of the right hand in the present design since this would not alter the direction of the effect. One would still expect faster responding from the LVF/RH for the emotional faces relative to the neutral faces.

There were some modifications made of Suberi and McKeever's procedure. As noted earlier, the photographs were retouched to remove moles and to make the lighting more uniform. Removing discrete cues such as moles should theoretically have decreased the likelihood of a RVF/LH effect. Making the lighting more uniform, which was necessary only for the emotional faces, may have attenuated a LVF/RH bias for face recognition, since the latter is correlated with ability in brightness discrimination (Hannay and Rogers, 1979). However, the difference between the original and retouched photographs was small.

Suberi and McKeever utilized an exposure time of 150 milliseconds, while that used in the present study was 100 milliseconds. Also, the placement of the facial stimuli from fixation were slightly more extreme than that of Suberi and McKeever (the near edges corresponding to 1.0 degree versus .5 degrees, respectively). These changes might make the task more difficult, and might favor the RVF/LH since such a hemispheric change-over has been demonstrated to occur as facial discrimination becomes more difficult, such as when faces differ on only one feature (Patterson and Bradshaw, 1975; Sergent, 1982a). From examination of the facial stimuli in the appendix, it is clear that these stimuli are in fact much less discriminable than faces typically employed in tachistoscopic face recognition studies, primarily because the hair is covered. Most of the studies using photographs have included the model's hair. The reasoning behind covering hair is that it eliminates the possibility of using hairstyle as a discrete cue rather than processing the face itself. It may be, however, that removing hairdos significantly alters the difficulty of the task which might encourage a discrete or analytic rather than global processing of the face and may also remove an important aspect of a face that gives it its social and emotional properties, which may be related to its lateralization. Thus, the small changes made in the present design may have been enough for the faces to be biased away from a LVF/RH advantage. It should be noted, however, that according to some researchers (Sergent, 1982b), decreased exposure time and greater retinal eccentricity would increase the likelihood of a LVF/RH advantage because of the right hemisphere's advantage in processing incomplete degraded stimuli.

These factors, however, are not specific to the emotional faces. Inspection of the two sets of faces in the appendix suggest an obvious difference between them. In the neutral set all eyes are looking ahead. In the emotional set, the eyes differ in direction of gaze and in one case the eyes are semi-closed. Conceivably the faces in the emotional set could be identified on the basis of such discrete characteristics (in fact, several subjects made comments to this effect), whereas this would be more difficult with the more uniform neutral faces, where the subject might be required to identify the face more on the basis of a global impression. Van Mastright (1977) reports findings which suggest that eyes are a major cue in face recognition when faces are projected laterally in a tachistoscope. More importantly, Sergent (1982a) found that a RVF/LH superiority emerged for faces differing in one or two features when the difference lay in the upper part of the face, suggesting a top to bottom serial analysis of the stimuli in the RVF/LH. Identification on the basis of discrete cues might bias a task towards the RVF/LH. These four emotional faces comprised only one third of the emotional faces used by Suberi and McKeever, who also used happy and angry faces (in independent groups). Inspection of their complete set of faces indicates that this problem of discriminable cues is particularly a problem with the "sad" faces. It may be that since these faces comprised only part of their emotional stimuli, it contributed less to their total effect. The only inconsistency with this explanation, however, is that Suberi and McKeever report that the "sad" faces produced the largest, though not significantly so, visual field differences favoring the LVF/RH.

This raises the important issue of comparability of the emotional and neutral stimuli in face recognition tasks, along dimensions other than emotional valence. This is a problem when emotional valence is defined by different sets of faces as in the Suberi and McKeever design and that of Ley and Bryden (1979). This is difficult to control for, but might be handled by having pairs of stimuli rated in terms of discriminability, or having them rated while viewed upside down (Koopman, 1981)[1] to detect the contribution of factors other than emotionality to their discriminability ratings.

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[1] Personal communication

Safer's (1981) finding that subjects who were instructed to verbally label the emotions of the target faces failed to demonstrate a LVF/RH bias raises another possiblity. The four emotional faces were all intended to be "sad," but if one examines the set, it is obvious that although the four faces conveyed unhappiness, more subtle distinctions could be made. Subjects referred to the faces as "sad," "miserable," "pouting," "in agony," "petulant" and "puzzled." This indicates that there was enough variation for verbal labelling.

The five minute memorization period, together with opportunities to view the faces between blocks, provided ample time for subjects to become familiar with the discrete features and to learn to identify the emotional faces on this basis when presented laterally, as well as to label them verbally. Recall the research indicating that familiarization of faces through photographs is related to switching the laterality advantage over to the RVF/LH (Umilta et al., 1977). Proudfoot (1982) also set out to bias her face recognition task towards a RVF/LH superiority by having subjects overlearn a small set of five faces.

However, this long familiarization period was common to both the present design and that of Suberi and McKeever. As noted, discrete coding and verbal labelling may have been encouraged more in the present experiment because the "sad" faces particularly lent themselves to such strategies. Another possibility that cannot be ruled out stems from the subtleties and pressures of the experimental situation. In this study, immediate feedback was given on the two practice blocks for errors, as well as an estimate of reaction time and errors at the end of each block. This was done because Dixon (1977) reported that the task was so difficult that it was necessary to exclude 21 out of 89 subjects whose error rates were above ten percent. Suberi and McKeever (1977) gave feedback after each block for reaction time only. Dixon (1977), who used Suberi and McKeever's long familiarization period as well as their "neutral" set of faces, provided subjects with immediate feedback for errors throughout the session as well as information about reaction times at the end of each block. It may be significant that neither Dixon (1977) nor the present study obtain the clear-cut LVF/RH findings of Suberi and McKeever. It may be that the immediate feedback for errors is somewhat aversive to subjects and motivates them to reduce them. In this particular experiment, the researcher's impression was that subjects were highly motivated to reduce their errors, which may have motivated them to strive for cues or strategies to aid in identification. Also, immediate feedback may provide a shaping procedure by which the subjects can learn to identify the stimuli by reliable cues.

Suberi and McKeever report that their significant interaction of visual field with emotion was a function of the faces which had been memorized (target faces). It is notable that in the present experiment there were significant differences in the emotion ratings given to these faces in the form of a sex x emotion x CLEM interaction (see Table 46). This resulted in substantial differences among the six subject groups which, if one assumes the ratings were not entirely due to response biases among the different groups, suggests that the success of the experimental manipulation differed among the six groups.

When the visual field differences in these subject groups were compared for the emotional and neutral faces, it became apparent that the degree to which the emotional group demonstrated a greater LVF/RH bias relative to the neutral group, bore an almost identical ranking to subject group differences in emotion rating between the emotional and neutral faces. The ranking of subject groups on the degree of differentiation in emotion ratings to the a priori neutral and emotional faces are as follows, from most to least: 1) female right movers 2) male bimovers 3) male left movers 4) female left movers 5) male right movers 6) female bimovers. The ranking of subject groups on degree to which there was a relatively greater LVF/RH advantage on the emotional faces compared to the neutral ones is as follows, from largest to smallest: 1) male bimovers 2) female right movers 3) male left movers 4) female left movers 5) male right movers 6) female bimovers. The rankings were submitted to a Spearman Rank Correlation and $r = .943$, $p = .01$ (one-tailed). This is admittedly a crude measure, but is consistent with the possibility that the failure to replicate the results of Suberi and McKeever may be attributed to a more successful experimental manipulation on the emotional/neutral variable in their female sample. This might be due to differences in sample composition.

This finding can be integrated into the previous discussion. Because of stimulus characteristics of the emotional faces which lend them to strategies of discrete cue utilization or verbal labelling, possibly encouraged by the feedback conditions of the experiment, they are biased towards a RVF/LH advantage. However, if in a subject group there is a significantly stronger impact of the emotional faces, this will cause them to be preferentially stored in the right hemisphere (this is Suberi and McKeever's interpretation of their effect), and hence more easily recognized from the LVF/RH relative to the neutral faces.

Although the present study failed to clarify the interaction of emotional valence and visual field as a function of sex, other interesting patterns are evident. A recurrent pattern that runs through the several analyses are an interaction of visual field and response as a function of emotional valence. The two-way visual field by response interaction illustrated in Figure 3, is present in all analyses of variance involving errors. It is due to the no trials being responded to more accurately than than the yes trials in the LVF/RH and yes trials being responded to more accurately in the RVF/LH. Although this interaction is not present in the a priori reaction time analysis, $F(1,104) = 1.28$, $p = .260$, when one examines the *yes* and *no* trials separately (see Appendices R(iv),(v)), the visual field effect is signficant for the *yes* trials only, $F(1,104) = 4.61$, $p = .034$, while negligible for the *no* trials, $F(1,104) = 0.26$, $p = .612$. There is a reponse x emotion(R) x visual field interaction in the reaction time data when rated emotion is substituted for a priori emotion. As illustrated in Figure 12, this is attributed to emotional(R)-*yes* faces being recognized faster from the RVF/LH. A similar interaction of visual field as a joint function of emotion(R) and response is evident in the error analyses. In the a priori error analysis of errors over two blocks, there is a tendency ($p = .089$) towards a response x visual field x emotion x CLEM interaction, as illustrated in Figure 7. Emotional(R)-*yes* trials are responded to more accurately from the RVF/LH, while emotional(R) *no* trials are responded to more accurately from the LVF/RH. This pattern appears only for left movers and bimovers. The same pattern emerges in the error analysis over two blocks using rated emotion in the form of a response x sex x emotion(R) x visual field interaction, as illustrated in Figure 14. For males, emotional(R) faces were identified more accurately from the RVF/LH in the case of *yes* trials, with a greater accuracy from the LVF/RH in the case of emotional(R) *no* trials. This pattern is in evidence from a comparison of Tables 50 and 51, where correlations between rated emotional valence and degree of LVF/RH advantage for the *yes* and *no* trials were negative and positive respectively. Although the specific nature of these interactions in terms of interactions with sex and CLEM are not consistent, probably due to the various sources of error in the data plus the different error terms in the two sets of analyses of variance, the pattern is clear. The factor of emotional valence interacts with visual field in opposite directions for _yes_ and _no_ trials.

That stimuli on _yes_ trials should be recognized more accurately or quickly from the RVF/LH is entirely consistent with the previous discussion of the effect of familiarization or overlearning on laterality patterns in face recognition. In this particular design (as in that of Suberi and McKeever), _yes_ trials represent the viewing of target faces, which were the ones allowed the long period of familiarization and overlearning. This would allow subjects an opportunity to develop analytical and/or verbal strategies for detecting them. There are other explanations. Sergent (1982c) interprets the differentiaton between the cerebral hemispheres not so much in terms of an analytic/holistic dichotomy, but rather on the different capacities for sensory resolution in the two hemispheres. The left cerebral hemisphere is most efficient when more defined stimuli are available or required for a certain task, whereas the right cerebral hemisphere is at an advantage when the stimulus information is more degraded. The long period of familiarization would allow the target stimuli to be well defined whereas:

> the preferential tuning of the right hemisphere to the low frequency contents of incoming information may give this hemisphere a special role not only in preliminary processing of a visual stimulus but also in the initial stages of learning and familiarization with novel information (1982c, p.268)

This is consistent with the finding that in the error analyses, no trials were more accurately identified from the LVF/RH. In this particular experiment, subjects' exposure to the nontarget faces was only brief tachistoscopic exposure and hence would allow less opportunity for developing identification strategies based upon discrete cues or verbal labelling. The subject would need to rely on grasping a total global impression of the stimulus. Most studies on face recognition do not demonstrate an interaction of response with visual field, but when they do it is usually in a direction opposite to that of the present study (Patterson and Bradshaw, 1975). This has been attributed to the holistic processing usually being involved in same responses relative to different responses, where serial processes are considered to be more often utilized. However, in most face recognition studies, yes and no are not confounded with greater and lesser familiarization as in the present design. Usually, none of the facial stimuli have been seen free view (St. John, 1981), or all the stimuli have been previously seen for the same period of time (Strauss and Moscovitch, 1981).

A surprising finding is the interaction of the response x visual field pattern with emotional valence. The finding that emotional faces were more accurately identified from the LVF/RH in the case of no trials in the error analysis is consistent with the previous research where greater emotionality of facial stimuli is associated with greater LVF/RH advantage over neutral faces. This is also consistent with the inference that in this particular design, it is the nontarget no faces that may be more comparable to the previous research (e.g. Ley and Bryden, 1979) in terms of familiarization of the stimuli. However, the greater RVF/LH advantage on the yes trials for emotional faces, relative to neutral ones in both the reaction time and error data, is new and unexpected. Recall Safer's (1981) finding that when subjects were instructed to verbally label the emotional expression on a face, the LVF/RH advantage for emotional faces failed to emerge. Although in the present experiment subjects were not instructed to verbally label the faces, there was enough variability in the faces so that this could be done. It is also reasonable to conclude that the more emotionally distinctive a face is perceived to be, the easier it is to code it verbally. And, of course, there would be more opportunity to do so in the case of familiar than unfamiliar faces, particularly if one is searching for cues or strategies with which to identify them. Thus, the consistent findings of repsonse x emotion x visual field interactions is not at variance with the theoretical premises in the literature.

Again, what is puzzling is the lack of continuity with Suberi and McKeever (1977) who report that, although yes trials were significantly faster than no trials, they did not interact with the other variables. One possibility may be the lesser tendency on the part of their subjects, for reasons discussed earlier, to rely on discrete cues for the identification of the stimuli. Also, Suberi and McKeever (1977) did not utilize subject ratings of the faces, and the response x emotion x visual field interactions in this experiment were more prominent when the emotion ratings were utilized to define the emotional/neutral groups.

The failure to find a LVF/RH advantage for the emotional(R) no trials in the reaction time data is somewhat surprising given the positive correlations of Table 51. This may be because the effect itself is smaller, or it may be due to some biasing towards a RVF/LH advantage in the reaction time data because of the failure to use the left hand.

Although the study failed to confirm the prediction of greater emotional valence being required in the case of females in order to activate a right hemisphere advantage, there was some suggestion that lesser emotional valence was associated with greater difficulty in identification of unfamiliar faces. There was a response x sex x emotion interaction for errors over two blocks for both the a priori analyses and the analyses using rated emotion (see Figure 6). In both these interactions, the greatest number of errors was for females in the neutral faces on the no trials.

Comparison of CLEM Groups on Facial Processing Abiltiy

The prediction regarding the above hypothesis was that left movers would respond significantly faster than right movers on the central presentation tachistoscope face recognition test, and that there would be no difference on the free view test. Both these predictions were confirmed. This was to be interpreted as indicating that on the free view task alternative coding strategies were available. On the other hand, brief tachistoscopic exposure would favor a more global, holistic style of processing, hypothesized to be more typical of left movers than right movers because of the greater role of the right hemisphere in the cognitive processing of the former group. The faster reaction times of the left movers is also consistent with Sergent's conceptualization of the right hemisphere as an "early" processor (see Sergent, 1982c for her research suggesting this interpretation). She means by this that the right hemisphere is better equipped to process the diffuse degraded early input of stimuli, whereas the superiority of the left hemisphere may emerge at later stages when more refined cognitive processing is possible. If left movers were able to identify the face from the less complete information available at an earlier stage of processing than were the right movers who might need to process the visual trace further before a decision could be made, this would be reflected in faster reaction times for the left movers.

A finding that was not specifically predicted but is consistent with the CLEM theory was the tendency ($p = .09$) towards a CLEM effect on the perceptual bias test. Left movers and bimovers demonstrated a greater LVF bias on this test than did right movers, whose responding was, on the average, just above chance. This provides an excellent example of the interaction between task demands and individual trait hemisphericity. Superimposed upon the overall LVF bias demonstrated by the subjects were variations among the CLEM groups.

Together, these two findings offer further construct validation for the trait hemisphericity interpretation of CLEM.

There are, however, some less clear cut findings. One is the sex x CLEM interaction with errors on the central presentation task. There was no significant CLEM effect for males. For the females, the most striking effect was the poor performance of the bimovers, together with the greater accuracy of the left movers compared to right movers. Although CLEM effects were not specifically predicted for the error measure, the finding for the females would be consistent with CLEM theory. What is inconsistent is the sex x CLEM interaction on the error measure in the absence of such an interaction on the reaction time measure. One consideration might be that on the central presentation task with a 3.08% error rate, an accuracy measure might not be particularly sensitive. Another difference is that accuracy and reaction time measure similar but not identical processes. This is evident from the present study in the error and reaction time data. There was no significant difference in the overall accuracy of the _yes_ and _no_ trials in contrast to a large main effect for speed of processing. The finding that a judgment of _same_ is faster than a judgment of _different_ is a consistent finding both in the face perception and information processing literature (Bamber, 1969). It must be remembered that accuracy measures reflect whether or not the correct decision was reached, and decisions can be reached through different strategies. Reaction time, however, measures how quickly a correct decision is reached and may therefore illuminate differences in processing styles or the stages at which information is being processed. They should, to some extent, be positively correlated in a tachistoscopic procedure since strategies requiring a longer processing time are also less likely to be accurate in the long run since the visual trace declines rapidly with time. However, in a task with a 3.08% error rate, reaction time is clearly the measure of choice, particularly when hypotheses are being tested, as in the present study, that deal with subtle differences in information processing.

The argument could be made that without the demonstration of an overall LVF/RH advantage in the lateral presentation task, there is no convincing evidence that the central presentation task is in fact a "right hemisphere" task. Or that, at the least, one might expect interactions of the CLEM groups along the dimensions of emotional/neutral or _yes/no_ consistent with the laterality differences demonstrated on the lateral presentation task.[2] However, this is only if one assumes that identical strategies were being utilized in both tasks. Despite the positive correlations between the two tasks on reaction time, there were several indications that the tasks were different. For one, there was no CLEM main effect in the lateral presentation task together with a substantial effect on the central presentation variation. The task was easier as reflected in the lower error rate, which would not necessitate or encourage the use of discrete cues for recognition. Despite the greater ease of the task because of it more central placement, exposure time was considerably shorter (60 milliseconds) which, according to Sergent, should invoke the special advantage of the right hemisphere in processing diffuse information.

The crucial difference is the central viewing, with the more natural presentation of the stimuli to both visual fields. One can justifiably argue that it is on this task, rather than one involving the artificial separation of the hemispheres and its unique task demands, on which the more typical cognitive strategies of individuals will emerge. Correlations between these two tasks might indicate to what extent the lateral presentation task was related to the more typical cognitive processing of each CLEM group. Although the correlations with

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[2]It should be noted that if the exclusive use of the right hand in this study did bias the reaction time data towards the RVF/LH, then if the left hand had been used as well this objection might not exist.

the reaction time data were uniformly positive, the patterns in the error data are meaningful. As described in the Results section, the correlations were largest with the bimovers, substantially less so though significant for the right movers, and in a negative direction for the left movers. The highest correlations for the bimovers are unlikely to be attributed to their higher error rates and hence greater variability on the central task, since right movers and left movers have only a small difference in their error rates on the central task yet their correlation coefficients with the lateral presentation task are considerably different. The pattern of correlations is consistent with CLEM theory. Since, according to the CLEM model, bimovers rely on the two hemispheres about equally, their typical cognitive functioning would be least disrupted by a task that engages each hemisphere separately. The right movers would demonstrate some relationship between the two tasks because of the task demands of the lateral presentation task which involved a considerable degree of RVF/LH and analytic, serial processing. On the other hand, for the left movers, the task demands required on the lateral presentation task would be unlike their typical cognitive processing. The CLEM model does allow that the cognitive strategies of the CLEM groups can vary from their typical style when the task demands are high.

Thus there are several indications that the lateral presentation task involved different task demands for optimal performance than did the central presentation task, and therefore the failure to demonstrate a LVF/RH advantage on the former does not invalidate the original interpretation applied to the CLEM differences on the central presentation task.

Perceptual Bias and Tachistoscopic Indices of Laterality

The a priori intention was to examine correlations only for the total sample or , at the most, separate correlations for the emotional and neutral faces. This was also the case with the hypotheses relating laterality patterns to facial ability. The separate subject group correlations were conducted only when the presence of underlying interactions became apparent. Given this, to examine only total sample correlations would be misleading. This in turn created the problem of calculating numerous correlations, which would invite chance factors to operate. This is not a trivial problem. Hence, it would be legitimate only to interpret patterns evident in the correlations, rather than individual coefficients themselves.

In view of the previous dicussion of the response x emotion x visual field interactions and the task demands of this particular lateral presentation task, it seems surprising that any positive relationships emerged at all between the perceptual bias index and the tachistoscopic laterality index. The pattern that emerges from inspection of Tables 33 and 34 is that of generally positive correlations with males for both emotional and neutral faces. All significant negative correlations are with the females with the emotional faces, particularly in the right mover group. Thus, the pattern is one of either positive or no correlation, with negative correlations among females with the emotional faces, particularly in the case of right movers.

That the laterality indices of the emotional faces should be more negatively related to the perceptual bias index is not surprising, given their interaction with response and visual field. This, in turn, was interpreted to be in part due to their greater verbal and discrete cue codability under conditions allowing for familiarization. However, why the laterality patterns on the emotional faces should be particularly negatively related to the perceptual bias indices for females, especially right movers, is not clear.

At any rate, it is obvious that the perceptual bias index cannot be considered as a simple substitute for the tachistoscopic indices of laterality. This is due to the instability of the tachistoscopic laterality measure as a function of amount and type of previous exposure with the faces as well as specific attributes of the facial stimuli themselves. It may well be that the perceptual bias task can be considered as a substitute for a particular procedural variation of the tachistoscopic paradigm with certain sets of faces. But this hardly constitutes a substitution for an experimental paradigm.

Laterality and Facial Ability

The question as originally formulated - is a type of cerebral organization for cerebral processing related to overall ability? now appears rather naive and simplistic, in view of the above discussion. The question should be rephrased in terms of what measure of laterality, and what particular measures of facial ability free view, tachistoscopic lateral presentation, tachistoscopic central presentation, familiar faces, unfamiliar faces, emotional faces, neutral faces?

Nevertheless, an attempt will be made to interpret the patterns of correlations. One pattern prominent from examination of Table 38 is that the significant negative correlations (which reflect a positive association between LVF/RH bias and better facial ability) all involve subject groups using neutral faces. The one exception is the overall negative correlation with the left mover-male group. In contrast, the positive correlations (reflecting a positive association between RVF/LH bias and better facial ability) all involve the right mover groups. The same differentiation between the emotional and neutral faces appears again. That a LVF/RH bias is more likely to be associated with better performance on the neutral faces is consistent with the fact that, unlike the emotional faces in some conditions, they were not to the same extent identified more accurately or quickly from the RVF/LH. This in turn may have been due to particular stimulus characteristics which made verbal or discrete cue coding less available for them than for the emotional faces.

Thus, there may be some guarded support for the belief that a LVF/RH bias may be related to better ability in general in processing physiognomic stimuli, at least for some populations. This would parallel McGlone and Davidson's (1976) conclusion that a LVF/RH advantages in processing visual-spatial tasks are related to an overall advantage for visual-spatial processing.

That the opposite relationship appears to be present for right movers is interesting. It may be that one's performance on face recognition tasks is best if one's strategy is consistent with one's typical cognitive style (or hemisphericity) or areas of strength. This may explain why the bimovers performed worse on the accuracy measures of both tachistoscopic tasks. CLEM theory, as now formulated in relation to bimovers, would identify this group as the one with the least consistent cognitive style.

General Discussion and Suggestions for Further Research

The findings and problems encountered in this study raise broader issues.

One concerns the validity of the tachistoscopic procedure for investigating laterality differences in face recognition. Research prior to this study suggested that laterality measures could be manipulated by varying the nature of the stimuli and task demands. These problems are evident in this study. Some effects (or their absence) could be attributed to idiosyncracies in the photographs themselves. Although the issue of familiarity with the facial stimuli had been addressed before, what is particularly significant in the present study is the interaction between familiarity and emotion in altering laterality patterns. This warrants serious concern since the role of emotional valence is considered at this time to be a major moderating variable in the laterality patterns for facial recognition. If this factor interacts with other procedural details of the tachistoscopic procedure and these are not controlled for or identified, the findings derived from tachistoscopic procedures could be misleading.

In addition, variables such as exposure time and size of visual angle subtended by the stimuli have been demonstrated to alter laterality patterns (Sergent, 1982b). Another problem with tachistoscopic procedures, specific to those using reaction time measures, is the concern that errors be kept to a minimum. This has led to the common practice of discarding subjects whose error rates exceed some arbitrary cutoff, usually 10-15%. This was planned for the present experiment. A frequency distribution of errors was plotted with the intention of eliminating subjects whose error rates fell in the extreme tail of the distribution. On this basis, seven subjects were to be eliminated. However, the decision was reversed when it was realized that the seven subjects included only bimovers and right movers, and to eliminate them would have biased the uneven distribution of CLEM groups even more. Given the presence of several interactions involving CLEM, this suggests that the practice of eliminating subjects with the poorest accuracy may bias reaction time findings in a systematic manner.

The ultimate issue is one of ecological validity in terms of what is actually meant by face recognition. The tachistoscopic procedure may remain a useful device for information processing purposes, but to what extent and in what aspects its use in face recognition research relates to facial processing in real life or even media encounters should be examined. Note that different patterns emerged even between the lateral and central presentation variations. One important issue differentiating natural from laboratory face recognition is that of intentional versus incidental learning. In real life and media encounters individuals do not set out to memorize faces, yet the capacity for face recognition appears enormous. Perhaps, then, different processes are involved in natural versus laboratory face recognition. One area of investigation might be to correlate various laboratory tests of facial recognition with some more ecologically valid criterion, for example, situations in which the incidental learning of faces could be measured. One might even start with individuals who report "I never forget a face." This, of course, would probably require controlling for broader variables such as personality or social interest, but if these are relevant to naturally occuring face perception, they should not be overlooked. To some extent this issue was touched upon in the present experiment by examining the correlations between the tachistoscopic procedures and the free view test, and the generally positive correlations are encouraging. However, it is not clear to what extent these measures relate to the incidental learning of faces. THe instructions for the free view test were vague -"I'd like you to get to know these faces during the next 45 seconds."

The practical limitations of the tachistoscopic procedure can be overwhelming in terms of time, equipment, and subject selection in designs requiring large numbers of subjects. Given both their practical and theoretical problems, one area of investigation might be to explore the possibilities of the perceptual bias test as an alternative measure of laterality. Its consistent findings thus far are encouraging when compared to the more unstable findings of tachistoscopic studies. Also, its task demands seem intuitively to resemble natural facial processing more than the tachistoscopic procedure since it does not require subjects to actively set out to memorize faces. Some of the research questions presently being explored might be adapted to a perceptual bias paradigm. For example, the role of emotional valence could be explored by varying the emotionality of the faces used and investigating whether this enhances the LVF/RH bias. This is similar to, but not identical with, present research being carried out with chimeric faces (Campbell, 1978) which examine whether the perception of a face as emotional varies with the visual field in which the emotional expression (for example, a smile) is placed. A particularly useful application of the perceptual bias test might be in developmental research which thus far has utilized only the tachistoscopic procedure. This would eliminate the problem of sustaining the interest and concentration of young children which is present when the tachistoscopic paradigm is used with this population. Certainly the perceptual bias procedure, like the tachistoscopic one, would have its problems and limitations. However, its limits and possibilities should be explored.

Another area warranting further investigation is the interaction of CLEM with sex. These interactions are evident throughout the study, and have been reported elsewhere (Moretti, 1982). It would seem that the construct validity of the trait hemisphericity model is secure enough at this point to permit finer elaborations of the theory.

The meaning of the bimover category warrants further investigation. The pattern of results in the present study indicate that bimovers are not related in a simple linear fashion to left and right movers, but are a distinct group in themselves. There is some suggestion from patterns in the results that right movers may be a distinct group, with less differences between left movers and bimovers. However, this may be due in part to the general bias in the present sample to left CLEMS so that the bimovers in this study may be more "left" than "right". Also, the alignment of the bimover group with the other two groups seemed often to vary as a function of both sex and the emotional/neutral dimension.

Finally, it should be noted that the present findings were collected on a rather pure group - right handers with no familial sinistrality. Generalizations to other populations should be made cautiously.

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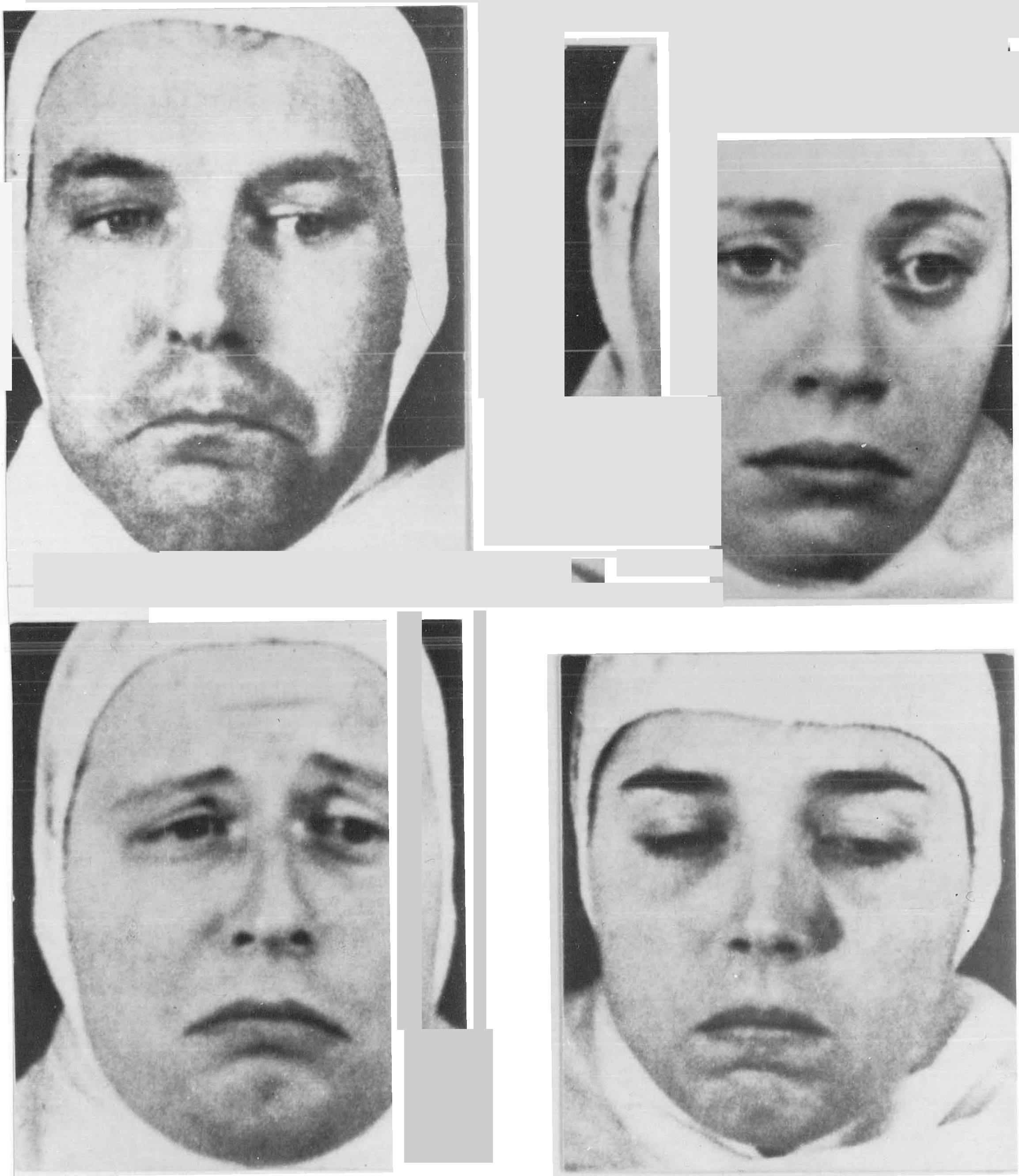
Appendix A

The CLEM Questionnaire

1. What is the meaning off the proverb: a watched pot never boils.
2. What is the meaning of the proverb it is an ill wind that blows one good fortune.
3. Make up a sentence using two forms of the same verb.
4. Tell me two verbs beginning with "N".
5. What is the meaning of the proverb: a poor worker blames his tools.
6. Spell "therapeutic".
7. What is the meaning of the proverb: call no man happy till he's dead.
8. List two adverbs.
9. What is the meaning of the proverb: lend your money and lose your friends.
10. What is the meaning of the proverb: more than enough is too much.
11. List two prepositions.
12. What is the meaning of the proverb: words should be weighed, not counted.
13. What is the meaning of the proverb: he is rich who has few wants.
14. Define inflation.
15. What is the meaning of the proverb: a rolling stone gathers no moss.
16. Make up a sentence using two adverbs.
17. Tell me two verbs beginning with "R".
18. What is the meaning of the proverb: the hardest work is to go idle.
19. What is the meaning of the proverb: what saddens a wise man gladdens a fool.
20. Define the word "economics".

Appendix B(i)

Facial Stimuli: 1) Emotional 2) Neutral



Appendix B(ii)

Facial Stimuli

Appendix C

Perceptual Bias Test

Appendix D(i)

Emotion Rating Sheets: 1) Perceived 2) Subjective

Please rate each face on the following scale in terms of how much emotion you perceive in that face. That is, how emotional does the face look to you?

1 2 3 4 5 6 7

Face looks neutral, unemotional — Face looks extremely emotional

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

Appendix D(ii)

Emotion Rating Sheets

Please rate each face on the amount of emotion it arouses in <u>you</u>. This emotion can be positive, negative, or of any type. Whatever the emotion it arouses in you, just rate the <u>amount</u> of the emotion on the following scale.

1	2	3	4	5	6	7
I feel nothing when I look at this face						Face arouses an extreme emotional reaction in me

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

Appendix E

Table 4

Errors for Sex x CLEM Interaction on Central Presentation Tachistoscopic Face Recognition Test

		Left Movers	Bimovers	Right Movers
	Mean	1.00	1.00	.72
Males	(SD)	(1.02)	(1.61)	(.67)
	N	(25)	(21)	(18)
	Mean	.56	1.89	1.05
Females	(SD)	(.77)	(1.79)	(1.02)
	N	(25)	(19)	(19)

Appendix F(i)

ANOVA for Males only on Errors on Central Presentation Task

Source	SS	DF	MS	F	Prob.
Emotion	1.01	1	1.01	1.45	.233
Finger	0.14	1	0.14	0.21	.650
CLEM	0.55	2	0.28	0.40	.674
EF	0.09	1	0.09	0.13	.717
EC	1.75	2	.875	1.26	.293
FC	0.22	2	0.11	0.16	.856
EFC	0.00	2	0.00	0.00	.996
Error	36.16	52	0.70		
Response	1.21	1	1.21	1.66	.204
RE	1.39	1	1.39	1.90	.174
RF	3.05	1	3.05	4.16	.046*
RC	0.04	2	0.02	0.03	.975
REF	0.03	1	0.03	0.04	.836
REC	0.69	2	0.34	0.47	.628
RFC	0.04	2	0.02	0.03	.974
REFC	3.81	2	1.90	2.60	0.05
Error	38.15	52	0.73		

Appendix F(ii)

ANOVA for Females only on Errors on Central Presentation Task

Source	SS	DF	MS	F	Prob.
Emotion	0.12	1	0.12	0.16	.689
Finger	0.04	1	0.04	0.05	.826
CLEM	6.92	2	3.46	4.65	.014**
EF	1.26	1	1.26	1.69	.200
EC	2.22	2	1.11	1.49	.234
FC	1.10	2	0.55	0.74	.481
EFC	1.58	2	0.79	1.06	.353
Error	37.96	51	0.74		
Response	0.95	1	0.95	1.10	.300
RE	1.68	1	1.68	1.94	.170
RF	0.20	1	0.20	0.23	.632
RC	0.47	2	0.23	0.27	.765
REF	0.70	1	0.70	0.81	.372
REC	2.86	2	1.43	1.65	.202
RFC	3.12	2	1.56	1.80	.175
REFC	0.00	2	0.00	0.00	.999
Error	44.20	51	.867		

Appendix F(iii)

Errors for Emotion x CLEM Tendency in Error Analysis on Central Presentation Task

	Emotional		
	LM	BI	RM
Mean	.76	.79	1.05
(SD)	(.92)	(1.13)	(.94)
N	25	19	20

	Neutral		
	LM	BI	RM
Mean	.84	2.00	.70
(SD)	(.94)	(2.00)	(.77)
N	25	21	17

Appendix G

Table 7

Errors (Four Blocks) For Visual Field x Sex x CLEM Interaction on Lateral Presentation Tachistoscopic Task

			LM	BI	RM
	LVF	Mean	6.32	8.09	6.78
		(SD)	(4.63)	(6.25)	(5.14)
Males	RVF	Mean	5.68	6.57	7.89
		(SD)	(3.98)	(4.48)	(5.91)
	Combined	Mean	6.00	7.33	7.33
	RVF-LVF	Mean	-.64	-1.52	+1.11
	N		(25)	(21)	(18)
	LVF	Mean	5.72	9.75	8.68
		(SD)	(4.67)	(5.60)	(6.94)
Females	RVF	Mean	6.92	7.95	6.58
		(SD)	(4.83)	(4.75)	(5.00)
	Combined	Mean	6.32	8.85	7.63
	RVF-LVF	Mean	+1.2	-1.8	-2.10
	N		(25)	(29)	(19)

Appendix H(i)

ANOVA for Males Only on Errors (Four Blocks) on Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Emotion (E)	6.10	1	6.10	0.26	.611
Finger(F)	4.37	1	4.37	0.19	0.667
CLEM(C)	38.11	2	19.05	0.82	.447
EF	18.32	1	18.32	0.79	.380
EC	3.19	2	1.59	0.07	.934
FC	32.70	2	2	16.35	
				0.70	.501
EFC	104.87	2	52.43	2.25	.116
Error	1213.011	52	23.33		
Response (R)	6.81	1	6.81	0.48	.493
RE	0.07	1	0.07	0.01	.944
RF	26.15	1	26.15	1.83	.182
RC	59.98	2	29.99	2.10	.132
REF	20.34	1	20.34	1.43	.238
REC	88.07	2	44.03	3.09	.054*
RFC	2.93	2	1.47	0.10	.902
REFC	26.08	2	13.04	0.91	.407
Error	742.12	52	14.27		
Visual Field(V)	3.80	1	3.80	1.23	.273
VE	1.28	1	1.28	0.41	.522
VF	3.08	1	3.08	0.99	.323
VC	19.47	2	9.74	3.15	.051*
VEF	8.25	1	8.26	2.67	.108
VEC	1.90	2	0.95	0.31	.737
VFC	7.04	2	3.52	1.14	.329
VEFC	11.00	2	5.50	1.78	.179
Error	160.878	52	3.09		
RV	17.63	1	17.63	2.74	.104
RVE	6.24	1	6.24	0.97	.330
RVF	4.63	1	4.53	0.70	.405
RVC	5.74	2	2.87	0.45	0.64
RVEF	5.77	1	5.77	0.90	.348
RVFC	1.39	2	0.69	0.11	.898
RVEFC	7.99	2	4.00	0.62	.542
Error	334.82	52	6.44		

Appendix H (ii)

ANOVA for Females Only on Errors (Four Blocks) for Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Emotion	6.17	1	6.17	0.27	.608
Finger	3.14	1	3.14	0.14	.715
CLEM	55.32	2	27.66	1.19	.311
EF	43.91	1	43.91	1.89	.175
EC	84.87	2	42.44	1.83	.171
FC	58.88	2	29.44	1.27	.290
EFC	32.58	2	16.29	0.70	.500
Error	1207.30	52	23.22		
Response	0.11	1	0.11	0.02	.902
RE	44.11	1	44.11	6.23	.016*
RF	8.34	1	8.34	1.18	.283
RC	31.88	2	15.94	2.25	.116
REF	2.23	1	2.23	0.31	.577
REC	33.01	2	16.50	2.33	.107
RFC	4.82	2	2.41	0.34	.713
REFC	2.66	2	1.33	0.19	.829
Error	368.43	52	7.08		
Visual Field	9.30	1	9.30	1.88	.177
VE	0.30	1	0.30	0.06	.807
VF	0.12	1	0.12	0.02	.877
VC	28.87	2	14.43	2.91	.063
VEF	1.12	1	1.12	0.23	.636
VEC	0.46	2	0.23	0.05	.955
VFC	10.18	2	5.09		
			1.03	.365	
VEFC	1.48	2	0.74	0.15	.861
Error	257.94	52	4.96		
RV	18.79	1	18.79	1.77	0.189
RVE	4.85	1	4.85	0.46	.502
RVF	10.58	1	10.58	1.00	.323
RVC	15.20	2	7.60	0.72	.494
RVEF	0.36	1	0.36	0.03	.854
RVEC	0.77	2	2	0.39	.964
RVFC	33.90	2	16.95	1.60	.212
RVEFC	7.01	2	3.50	0.33	.720
Error	552.05	52	10.62		

Appendix H(iii)

ANOVA for LVF Only for Errors (Four Blocks) on Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	2.21	1	2.21	0.14	.704
Emotion	4.77	1	4.77	0.31	.578
Finger	1.46	1	1.46	0.10	.758
CLEM	94.41	2	47.20	3.08	.050*
SE	0.72	1	0.72	0.05	.829
SF	6.94	1	6.94	0.45	.502
EF	0.07	1	0.07	0.00	.946
SC	14.20	2	7.10	0.47	.630
EC	11.77	2	5.88	0.38	.682
FC	11.18	2	5.59	0.37	.695
SEF	55.05	1	55.05	3.60	.061
SEC	42.74	2	21.37	1.40	.252
SFC	81.05	2	40.52	2.65	.076
EFC	70.63	2	35.32	2.31	.104
SEFC	19,20	2	10.00	0.65	.522
Error	1591.43	104	15.30		
Response	29.22	1	29.22	3.09	.082
RS	1.96	1	1.96	0.21	.649
RE	30.67	1	30.67	3.25	.074
RF	44.78	1	44.80	4.74	.031*
RC	7.97	2	3.98	0.42	.657
RSE	10.95	1	10.95	1.16	.284
RSF	0.30	1	0.30	0.03	.858
REF	20.31	1	20.31	2.15	.146
RSC	44.37	2	22.19	2.35	.100
REC	34.96	2	17.48	1.85	.162
RFC	6.10	2	3.05	0.32	.725
RSEF	5.80	1	5.80	0.61	.435
RSEC	32.77	2	16.39	1.73	.182
RSFC	3.69	2	1.84	0.20	.823
REFC	11.00	2	5.49	0.58	.561
RSEFC	0.622	2	0.31	0.03	.968
Error	982.26	104	9.44		

Appendix H(iv)

ANOVA for RVF Only for Errors (Four Blocks) on Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	0.15	1	0.15	0.01	.912
Emotion	7.68	1	7.68	0.64	.426
Finger	0.79	1	0.79	0.07	.798
CLEM	16.84	2	8.42	0.70	.499
SE	0.69	1	0.69	0.06	.811
SF	1.50	1	1.50	0.13	.724
EF	4.33	1	4.33	0.36	.549
SC	17.13	2	8.56	0.71	.492
EC	16.81	2	8.40	0.70	.499
FC	3.54	2	1.77	0.15	.863
SEF	12.16	1	12.16	1.01	.316
SEC	20.27	2	10.13	0.84	.433
SFC	14.41	2	7.20	0.60	.550
EFC	47.07	2	23.53	1.96	.146
SEFC	9.83	2	4.92	0.41	.665
Error	1247.71	104	12.00		
Response	9.78	1	9.78	1.00	.319
RS	2.37	1	2.37	0.24	.623
RE	0.70	1	0.70	0.07	.789
RF	1.71	1	1.71	0.18	.676
RC	0.16	2	0.08	0.01	.992
RSE	12.98	1	12.98	1.33	.252
RSF	2.80	1	2.80	0.29	.593
REF	2.24	1	2.25	0.23	.632
RSC	61.03	2	30.52	3.13	.048*
REC	40.90	2	20.45	2.10	.128
RFC	5.93	2	2.96	0.30	.739
RSEF	0.37	1	0.37	0.04	.845
RSEC	17.32	2	8.66	0.89	.415
RSFC	27.94	2	13.97	1.43	.244
REFC	13.63	2	6.81	0.70	.500
RSEFC	19.03	2	9.51	0.97	.381
Error	1015.15	104	9.76		

Appendix I

Table 9

Errors (Four Blocks) for Response x Sex x CLEM Interaction for Lateral Presentation Tachistoscopic Task

			Left Mover	Bimover	Right Mover
	Yes	Mean	7.28	8.05	6.17
		(SD)	(4.70)	(6.03)	(5.79)
Males	No	Mean	4.72	6.67	8.50
		(SD)	(5.03)	(7.12)	(8.02)
	N		(25)	(21)	(18)
	Yes	Mean	5.32	8.60	8.42
		(SD)	(3.77)	(5.42)	(7.03)
Females	No	Mean	7.28	9.05	6.74
		(SD)	(5.83)	(5.80)	(5.50)
	N		(25)	(20)	(19)

Appendix J(i)

ANOVA for Left Movers Only for Errors (Four Blocks) onLateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	0.10	1	0.10	0.01	.940
Emotion	13.63		13.63	0.75	.391
Finger	10.58	1	10.58	0.58	.450
SE	6.14	1	6.14	0.34	.564
SF	6.89	1	6.89	0.38	.541
EF	29.47	1	29.47	1.62	.210
SEF	0.99	1	0.99	0.05	.81[illegible]
Error	762.70	42	18.16		
Response	1.87	1	1.87	0.26	.614
RS	58.21	1	58.21	8.06	.007**
RE	0.53	1	0.53	0.07	.788
RF	17.91	1	17.91	2.48	.123
RSE	1.24	1	1.24	0.17	.680
RSF	0.64	1	0.64	0.09	.767
REF	0.50	1	0.50	0.07	.794
RSEF	0.71	1	0.71	0.10	.755
Error	303.16	42	7.22		
Visual Field	0.30	1	0.30	0.09	.771
VS	10.42	1	10.42	2.95	0.09
VE	0.21	1	0.21	0.06	.810
VF	3.49	1	3.49	0.99	.326
VSE	1.81	1	1.81	0.51	.478
VSF	0.02	1	0.02	0.01	.936
VEF	3.29	1	3.29	0.93	.340
VSEF	148.11	42	3.53		
YV	20.86	1	20.86	3.57	.066
YVS	2.25	1	2.25	0.39	.538
RVE	6.48	1	6.48	1.11	.298
YVF	1.75	1	1.75	0.30	.587
RVSE	2.68	1	2.68	0.46	.502
RVSF	2.31	1	2.31	0.40	.532
RVEF	0.68	1	0.68	0.12	.735
RVSEF	12.16	1	12.16	2.08	.156
Error	245.28	42	5.84		

Appendix J(ii)

ANOVA for Bimovers Only for Errors (Four Blocks) on Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	3.51	1	3.51	0.16	.688
Emotion	5.20	1	5.20	0.24	.625
Finger	0.56	1	0.56	0.03	.872
SE	39.43	1	39.43	1.85	.184
SF	75.18	1	75.18	3.52	.070
EF	58.34	1	58.34	2.73	.108
SEF	47.90	1	47.90	2.24	.144
Error	704.77	33	21.36		
Response	5.08	1	5.08	0.41	.528
RS	7.36	1	7.36	0.59	.448
RE	89.68	1	89.68	7.18	.011**
RF	10.04	1	10.04	0.80	.377
RSE	1.22	1	1.22	0.10	.756
RSF	8.08	1	8.08	0.65	.427
REF	4.13	1	4.13	0.33	.570
RSEF	2.65	1	2.65	0.21	.648
Error	412.39	33	12.50		
Visual Field	28.06	1	28.06	6.28	0.017*
VS	0.10	1	0.10	0.02	.880
VE	0.02	1	0.02	0.01	.943
VF	0.10	1	0.10	0.02	.880
VSE	0.25	1	0.25	0.06	.814
VSF	13.90	1	13.90	3.11	.087
VEF	2.82	1	2.82	0.63	.433
VSEF	13.56	1	13.56	3.30	.091
Error	147.50	33	4.47		
RV	18.89	1	18.89	1.59	.216
RVS	11.60	1	11.60	0.98	.330
RVE	2.40	1	2.40	0.20	.656
RVF	23.71	1	23.71	2.00	.167
RVSE	0.43				
1			0.43	0.04	.849
RVSF	19.81	1	19.81	1.67	.205
RVEF	6.27	1	6.27	0.53	.472
RVSEF	0.62	1	0.62	0.05	.820
Error	391.52	33	11.86		

Appendix J(iii)

ANOVA for Right Movers Only for Errors (Four Blocks) on Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	0.01	1	0.01	0.00	.989
Emotion	22.41	1	22.41	0.68	.416
Finger	2.89	1	2.89	0.09	.769
SE	15.35	1	15.35	0.47	.500
SF	2.64	1	2.64	0.08	.779
EF	29.00	1	29.00	0.88	.355
SEF	25.73	1	25.73	0.78	.384
Error	952.84	29	32.86		
Response	0.50	1	0.50	0.04	.849
RS	33.05	1	33.05	2.43	.130
RE	5.59	1	5.59	0.41	.527
RF	6.51	1	6.51	0.48	.495
RSE	61.71	1	61.71	4.53	.042*
RSF	0.27	1	0.27	0.02	.889
REF	31.07	1	31.07	2.28	.142
RSEF	6.97	1	6.97	0.51	.480
Error	395.00	29	13.62		
Visual Field	1.31	1	1.31	0.31	.582
VS	18.88	1	18.88	4.44	.044
VE	0.19	1	0.18	0.04	.835
VF	0.26	1	0.26	0.06	.807
VSE	1.59	1	1.59	0.37	.546
VSF	3.32	1	3.33	0.78	.383
VEF	1.15	1	1.15	0.27	.607
VSEF	0.06	1	0.05	0.01	.906
Error	123.21	29	4.25		
RV	3.06	1	3.06	0.35	.556
RVS	3.33	1	3.33	0.39	.539
RVE	3.06	1	3.06	0.35	.556
RVF	0.16	1	0.16	0.02	.894
RVSE	0.19	1	0.19	0.02	.884
RVSF	2.80	1	2.80	0.32	.573
RVEF	0.13	1	0.13	0.01	.904
RVSEF	2.80	1	2.80	0.32	.573
Error	250.06	29	8.62		

Appendix K

Table 10

Errors (Four Blocks) for Response x Emotion x CLEM Interaction for Lateral Presentation Tachistoscopic Task

			Left Movers	Bimovers	Right Movers
	Yes	Mean	6.84	9.37	7.70
		(SD)	(4.71)	(5.87)	(7.32)
Emotional	No	Mean	6.40	5.53	8.55
		(SD)	(6.26)	(4.86)	(8.13)
	N		(25)	(19)	(20)
	Yes	Mean	5.76	7.41	6.88
		(SD)	(3.93)	(5.47)	(5.50)
Neutral	No	Mean	5.60	9.82	6.47
		(SD)	(4.81)	(7.24)	(4.81)
	N		(25)	(22)	(17)

Appendix M

Errors (Two Blocks) for Emotion x Finger Pattern x CLEM Interaction

		Emotion		
		LM	BI	RM
Index Condition	Mean	3.69	5.25	3.45
	(SD)	(4.27)	(6.25)	(5.56)
	N	13	8	11
Middle Condition	Mean	3.58	3.36	7.22
	(SD)	(3.53)	(3.29)	(6.08)
	N	12	11	9

		Neutral		
		LM	BI	RM
Index Condition	Mean	4.69	4.40	5.33
	(SD)	(2.95)	(5.06)	(2.83)
	N	13	10	9
Middle Condition	Mean	2.67	6.92	2.88
	(SD)	(2.67)	(5.21)	(2.53)
	N	12	12	8

Appendix N

Table 14

Errors (Two Blocks) for Response x Emotion x CLEM Interaction on Lateral Presentation Tachistoscopic Task

			Left Movers	Bimovers	Right Movers
Emotional	Yes	Mean	1.44	2.74	2.40
		(SD)	(1.78)	(3.69)	(3.00)
	No	Mean	2.20	1.42	2.75
		(SD)	(3.08)	(1.95)	(3.54)
	N		(25)	(19)	(20)
Neutral	Yes	Mean	1.96	2.04	2.00
		(SD)	(2.13)	(2.44)	(2.09)
	No	Mean	1.72	3.73	2.18
		(SD)	(1.90)	(3.60)	(2.24)
	N		(25)	(22)	(17)

Appendix O

Table 15

Errors (Two Blocks) for Response x Sex x Emotion Interaction on Lateral Presentation Tachistoscopic Task

		Males		Females	
		Emotional	Neutral	Emotional	Neutral
Yes	Mean	1.78	2.16	2.47	1.84
	(SD)	(2.92)	(2.22)	(2.78)	(2.20)
No	Mean	2.03	1.91	2.25	3.15
	(SD)	(3.04)	(2.54)	(2.92)	(2.92)
	N	(32)	(32)	(32)	(32)

Appendix P

Table 16

Errors for Visual Field x Sex x Emotion x Finger Pattern Interaction in Lateral Presentation Tachistoscopic Task (Two Blocks)

Males

		Index Condition LVF	Index Condition RVF	Middle Condition LVF	Middle Condition RVF
Emotional	Mean	2.19	1.81	1.56	2.06
	(SD)	(2.84)	(2.76)	(2.06)	(2.38)
	N	(16)	(16)	(16)	(16)
Neutral	Mean	1.69	2.31	2.25	1.81
	(SD)	(1.89)	(2.27)	(2.35)	(1.52)
	N	(16)	(16)	(16)	(16)

Females

		Index Condition LVF	Index Condition RVF	Middle Condition LVF	Middle Condition RVF
Emotional	Mean	1.81	2.19	2.94	2.50
	(SD)	(2.69)	(2.93)	(2.82)	(2.39)
	N	(16)	(16)	(16)	(16)
Neutral	Mean	2.94	2.62	2.62	1.94
	(SD)	(2.08)	(2.06)	(3.59)	(2.05)
	N	(16)	(16)	(16)	(16)

Appendix Q

Table 17

Errors (Two Blocks) for Response x Visual Field X Emotion x CLEM Trend in Visual Field Tachistoscopic Task

Yes

			Left Movers	Bimovers	Right Movers
Emotional	LVF	Mean	1.12	1.79	1.00
		(SD)	(1.54)	(2.59)	(1.34)
	RVF	Mean	.32	.95	1.40
		(SD)	(.63)	(2.04)	(1.85)
Neutral	LVF	Mean	.96	1.23	1.12
		(SD)	(1.77)	(2.00)	(1.27)
	RVF	Mean	1.00	.82	.88
		(SD)	(1.04)	(1.14)	(1.36)

No

			Left Movers	Bimovers	Right Movers
Emotional	LVF	Mean	.76	.42	1.35
		(SD)	(1.44)	(.96)	(1.81)
	RVF	Mean	1.44	1.00	1.40
		(SD)	(1.78)	(1.41)	(2.11)
Neutral	LVF	Mean	.96	1.95	1.00
		(SD)	(1.24)	(2.24)	(1.27)
	RVF	Mean	.76	1.77	1.18
		(SD)	(1.16)	(1.88)	(1.59)

Appendix R(i)

ANOVA for Left Movers Only for Reaction Times in Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	3.54	1	3.54	0.15	.704
Emotion	4.06	1	4.06	0.17	.684
Finger	1.65	1	1.65	0.07	.795
SE	.67	1	.67	0.03	.869
SF	3.78	1	3.78	0.16	.695
EF	15.89	1	15.89	0.66	.423
SEF	23.57	1	23.57	0.97	.330
Error	1017.73	42	24.23		
Response	36.31	1	36.31	32.20	.000**
RS	4.76	1	4.76	4.22	.046*
RE	0.00	1	0.00	0.00	.962
RF	0.10	1	0.10	0.09	.766
RSE	2.56	1	2.56	2.27	.139
REF	0.15	1	0.15	0.13	.718
RSEF	.47	1	.47	0.42	.522
Error	47.36	42	1.12		
Visual Field	1.74	1	1.74	5.32	.026*
VS	.02	1	.02	0.05	.822
VE	.31	1	.31	0.96	.333
VF	.62	1	.62	1.88	.178
VSE	.49	1	.49	1.50	.228
VSF	.00	1	.00	0.00	0.99
VEF	.00	1	.00	.00	.954
VSEF	.28	1	.28		
RV	.00	1	.00	0.00	.987
RVS	1.35	1	1.35	1.81	.185
RVE	.63	1	.63	0.84	.364
RVSE	.01	1	.01	0.01	.923
RVSF	.12	1	.12	0.16	.690
RVEF	.21	1	.21	0.28	.596
RVSEF	.06	1	.06	0.08	.782
Error	31.30	42	.74		

Appendix R (ii)

ANOVA for Bimovers Only for Reaction Times in LateralPresentation Task

Sex	19.93	1	19.93	1.62	.211
Emotion	25.64	1	25.64	2.09	.158
Finger	7.32	1	7.32	0.60	.445
SE	5.56	1	5.56	0.45	.506
SF	25.88	1	25.88	2.11	.156
EF	2.21	1	2.21	0.18	.674
SEF	33.08	1	33.08	2.70	.110
Error	404.83	33	12.27		
Response	36.28	1	36.28	16.91	.000**
RS	.06	1	.06	0.03	.870
RE	4.05	1	4.05	1.89	.178
RF	1.53	1	1.53	0.72	.404
RSE	.73	1	.73	0.34	.563
RSF	.09	1	.09	0.04	.839
REF	1.36	1	1.36	0.64	.431
RSEF	.32	1	.32	0.15	.700
Error	70.80	33	2.14		
Visual Field	1.33	1	1.33	2.17	.150
VS	.79	1	.79	1.28	.266
VE	4.08	1	4.08	6.62	.015*
VF	.08	1	.08	0.12	.729
VSE	2.38	1	2.38	3.87	.058
VSF	.80	1	.80	1.31	.261
VEF	4.86	1	4.86	7.88	.008**
VSEF	1.38	1	1.38	2.23	.144
Error	20.34	33	.62		
RV	.94	1	.94	1.14	.293
RVS	.21	1	.21	0.25	.619
RVE	.27	1	.27	0.33	.567
RVF	.02	1	.02	0.03	.870
RVSE	.32	1	.32	0.38	.54
RVSF	.00	1	.00	0.00	.963
RVEF	.41	1	.41	0.49	.487
RVSEF	.20	1	.20	0.24	.629
Error	27.19	33	.82		

Appendix R (iii)

ANOVA for Right Movers Only for Reaction Times in Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	2.55	1	2.55	0.15	.704
Emotion	.133	1	.13	0.01	.931
Finger	1.90	1	1.90	0.11	.743
SE	1.88	1	1.88	0.11	.745
SF	.00	1	.00	.00	.986
EF	22.68	1	22.68	1.31	.262
SEF	45.84	1	45.84	2.64	.115
Error	503.79	29	17.38		
Response	37.95	1	37.95	26.72	.000**
RS	1.75	1	1.75	1.23	.276
RE	.01	1	.01	0.01	.927
RF	.02	1	.02	0.02	.894
RSE	.09	1	.09	0.06	0.80
RSF	2.80	1	2.80	1.97	.171
REF	.94	1	.94	0.66	.423
RSEF	2.92	1	2.92	2.06	.162
Error	41.20	29	1.42		
Visual Field	.02	1	.02	0.02	.877
VS	1.01	1	1.01	1.30	.264
VE	.23	1	.23	0.30	.589
VF	.57	1	.57	0.73	.400
VSE	.34	1	.34	0.43	.515
VSF	.88	1	.88	1.12	.298
VEF	.06	1	.06	0.07	.788
VSEF	.03	1	.03	0.04	.838
Error	22.61	29	.78		
RV	.29	1	.29	0.97	.334
RVS	1.42	1	1.42	4.69	.039*
RVE	.55	1	.55	1.82	.187
RVF	.03	1	.03	.03	.747
RVSE	.12	1	.12	0.38	.541
RVSF	.04	1	.04	0.15	.703
RVEF	.17	1	.17	0.55	.463
RVSEF	.13	1	.13	0.44	.513
Error	8.78	29	.30		

Appendix R(iv)

ANOVA for Yes Trials Only for Reaction Time in Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	9.71	1	9.71	0.86	.357
Emotion	12.05	1	12.05	1.06	.305
Finger	2.47	1	2.47	0.22	.642
CLEM	23.21	2	11.60	1.02	
				.363	
SE	1.12	1	1.12	0.10	.754
SF	8.33	1	8.33	0.73	.394
EF	.06	1	.06	0.01	.943
SC	7.28	2	3.64	0.32	.726
EC	14.83	2	7.42	0.65	.522
FC	7.39	2	3.69	0.33	.723
SEF	62.39	1	62.39	5.50	.021*
SEC	2.04	2	1.02	0.09	.914
SFC	13.23	2	6.62	0.58	.560
EFC	28.85	2	14.42	1.27	.285
SEFC	4.71	2	2.35	0.21	.813
Error	1179.72	104	11.34		
Visual Field	2.81	1	2.81	4.61	.034*
VS	.42	1	.42	0.68	.411
VE	2.75	1	2.75	4.51	.036*
VF	.76	1	.76	1.24	.268
VC	.51	2	.25	0.42	.660
VSE	.09	1	.09	0.15	.701
VSF	.53	1	.53	0.87	.353
VEF	1.18	1	1.18	1.93	.167
VSC	.15	2	.07	0.12	.883
VEC	.02	2	.01	0.02	.980
VFC	.23	2	.13	0.21	.813
VSEF	.05	1	.05	0.08	.779
VSEC	1.06	2	.53	0.87	.420
VSFC	.69	2	.35	0.57	.570
VEFC	3.16	2	1.58	2.59	.080
VSEFC	.64	2	.32	0.53	.591
Error	63.39	104	.61		

Appendix R(v)

ANOVA for No Trials Only for Reaction Time in Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	11.47	1	11.47	1.32	.254
Emotion	3.72	1	3.72	0.43	.515
Finger	.19	1	.19	0.02	.882
CLEM	34.98	2	17.49	2.01	.139
SE	7.30	1	7.30	0.84	.362
SF	7.48	1	7.48	0.86	.356
EF	.03	1	.03	0.00	.953
SC	4.35	2	2.17	0.25	.779
EC	2.69	2	1.34	0.15	.857
FC	1.99	2	.99	0.11	.892
SEF	40.69	1	40.69	4.67	.033*
SEC	1.06	2	.53	0.06	.941
SFC	6.18	2	3.09	0.35	.702
EFC	13.64	2	6.82	0.78	.460
SEFC	1.93	2	.97	0.11	.895
Error	905.98	104	8.71		
Visual Field	.15	1	.15	0.26	.612
VS	.76	1	.76	1.31	.255
VE	.74	1	.74	1.27	.262
VF	.36	1	.36	0.61	.436
VC	.70	2	.35	0.60	.550
VSE	1.00	1	1.00	1.72	.192
VSF	.70	1	.7	1.21	.275
VEF	.32	1	.32	0.55	.459
VSC	3.38	2	1.69	2.90	.060
VEC	2.64	2	1.32	2.27	.108
VFC	.01	2	.00	0.01	.991
VSEF	.42	1	.42	0.71	.400
VSEC	1.40	2	.70	1.20	.305
VSFC	.12	2	.06	0.10	.905
VEFC	1.08	2	.54	0.93	.397
VSEFC	1.02	2	.51	0.88	.418
Error	60.62	104	.58		

Appendix S

Table 24

Reaction Times for Sex x Emotion x Finger Pattern Interaction in Lateral Presentation Tachistoscopic Face Recognition Task

Males

		Emotional	Neutral
Index Condition	Mean	620.32	565.22
	(SD)	(315.40)	(172.32)
	N	(16)	(16)
Middle Condition	Mean	541.75	576.44
	(SD)	(202.16)	(244.50)
	N	(16)	(16)

Females

		Emotional	Neutral
Index Condition	Mean	579.64	604.44
	(SD)	(151.76)	(149.86)
	N	(16)	(16)
Middle Condition	Mean	655.23	562.52
	(SD)	(231.82)	(123.13)
	N	(16)	(16)

Appendix T

Table 25

Reaction Times for Visual Field x Emotion x Finger Pattern Interaction on Lateral Presentation Tachistoscopic Task for Bimovers Only

		Emotional		Neutral	
		Index Condition	Middle Condition	Index Condition	Middle Condition
LVF	Mean	653.73	613.66	575.60	562.52
	(SD)	(1.15)	(1.25)	(1.21)	(1.19)
RVF	Mean	602.62	601.90	605.28	548.78
	(SD)	(1.20)	(1.26)	(1.18)	(1.18)
	N	(8)	(11)	(10)	(12)

Appendix U

Table 46

Emotion Ratings for Sex x Emotion x CLEM Interaction of Target Tachistoscopic Facial Stimuli

Male

		Left Movers	Bimovers	Right Movers
Emotional	Mean	9.25	8.70	8.20
	(SD)	(1.48)	(2.00)	(3.08)
	N	(12)	(10)	(10)
Neutral	Mean	6.77	6.00	7.38
	(SD)	(1.92)	(1.95)	(1.30)
	N	(13)	(11)	(8)

Female

		Left Movers	Bimovers	Right Movers
Emotional	Mean	8.85	7.78	10.10
	(SD)	(2.88)	(2.95)	(2.47)
	N	(13)	(9)	(10)
Neutral	Mean	7.08	7.00	5.56
	(SD)	(2.84)	(2.61)	(2.01)
	N	(12)	(11)	(9)

Appendix V(i)

Table 48

Emotion Ratings of Nontarget Tachistoscopic Facial Stimuli for Sex x Emotion x Finger Pattern Interaction

		Males	
		Emotional	Neutral
Index	Mean	8.56	7.25
Condition	(SD)	(2.03)	(2.35)
	N	(16)	(16)
Middle	Mean	8.31	6.56
Condition	(SD)	(2.27)	(2.68)
	N	(16)	(16)

		Females	
		Emotional	Neutral
Index	Mean	10.56	7.00
Condition	(SD)	(1.93)	(2.28)
	N	(16)	(16)
Middle	Mean	8.12	7.19
Condition	(SD)	(1.09)	(2.04)
	N	(16)	(16)

Appendix V(ii)

Table 49

Emotion Ratings of Combined Tachistoscopic Facial Stimuli for Sex x Emotion x Finger Pattern Interaction

Males

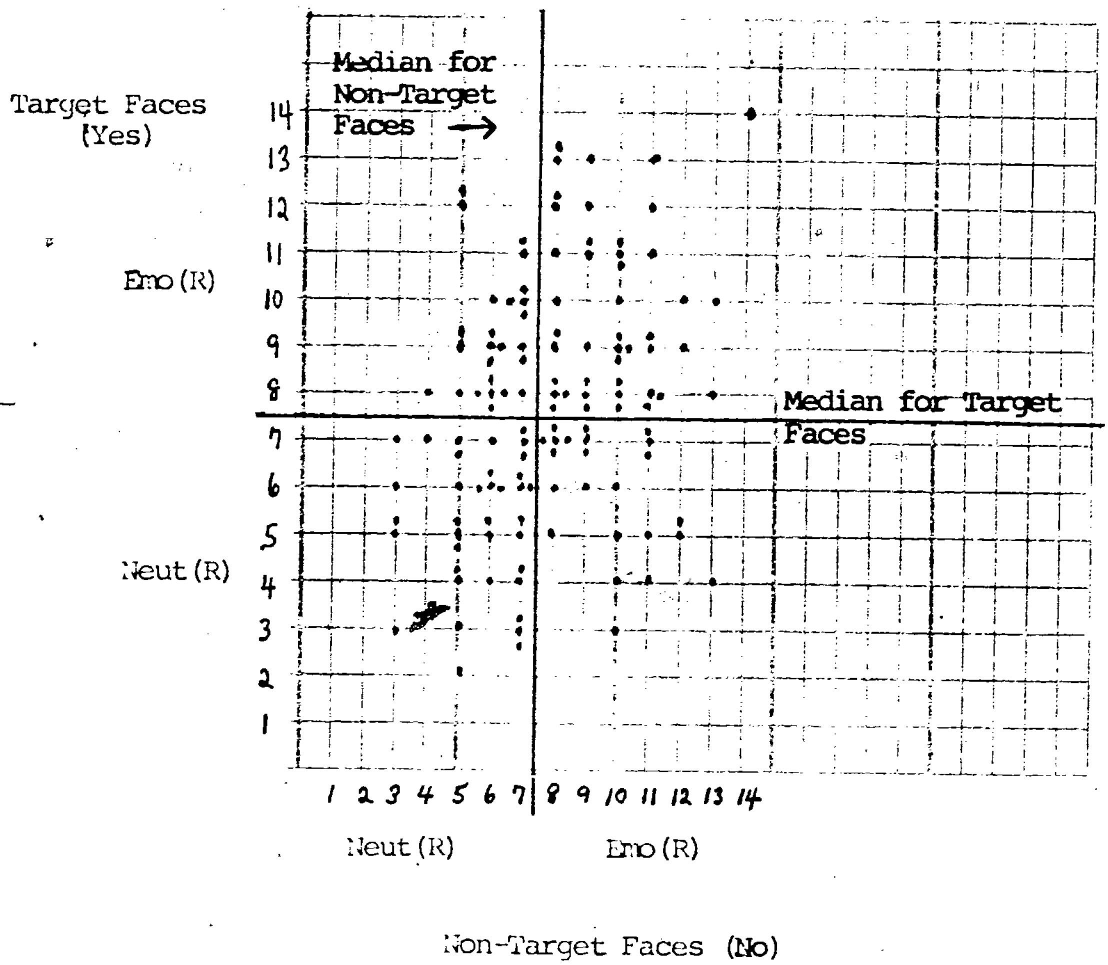
		Emotional	Neutral
Index Condition	Mean	17.19	13.88
	(SD)	(2.48)	(3.63)
	N	(16)	(16)
Middle Condition	Mean	17.19	13.25
	(SD)	(3.08)	(3.49)
	N	(16)	(16)

Females

		Emotional	Neutral
Index Condition	Mean	20.56	13.50
	(SD)	(3.18)	(3.65)
	N	(16)	(16)
Middle Condition	Mean	16.00	13.94
	(SD)	(2.85)	(3.64)
	N	(16)	(16)

Appendix W

Graph of Target and Nontarget Emction Ratings



Appendix I

Table 55

Mean Errors (Two Blocks) for Response x Visual Field x Sex x Emotion(R) Interaction for Lateral Presentation Tachistoscopic Face Recognition Task

Males

	Emotional(R)	Neutral(R)
Yes		
LVF	1.38	.73
SD	(2.31)	(1.14)
RVF	.74	1.07
SD	(1.24)	(1.34)
No		
LVF	.88	.83
SD	(1.34)	(1.42)
RVF	1.50	.67
SD	(2.05)	(1.09)
N	(34)	(30)

Females

	Emotional(R)	Neutral(R)
Yes		
LVF	1.36	1.22
SD	(2.00)	(1.36)
RVF	1.15	.55
SD	(1.87)	(.89)
No		
LVF	1.06	1.55
SD	(1.73)	(1.86)
RVF	1.21	1.61
SD	(1.62)	(1.69)
N	(33)	(31)

Appendix Y(i)

Errors (Four Blocks) for Digit x Emotion(R) x CLEM Interaction

Emotional(R)

	Left Movers	Bimovers	Right Movers	Mean
Index Digit	5.65	8.21	8.32	7.25
SD	(4.37)	(7.28)	(6.54)	(6.08)
Middle Digit	7.92	6.74	8.00	7.61
SD	(5.81)	(6.25)	(8.13)	(6.69)
N	(26)	(19)	(22)	

Neutral(R)

	Left Movers	Bimovers	Right Movers	Mean
Index Digit	5.79	6.91	4.73	5.93
SD	(4.92)	(4.47)	(3.35)	(4.43)
Middle Digit	5.12	10.27	8.13	7.72
SD	(4.08)	(6.01)	(6.28)	(5.77)
N	(24)	(22)	(15)	

This table shows the largest effects for the bimovers and right movers in the neutral(R) condition. Both groups made fewer errors with the index finger. This pattern of lesser errors with the index finger is also apparent, though less striking, for the left movers, but with the emotional(R) rather than the faces rated as neutral. The basis of the marginally significant digit x emotion(R) interaction is also apparent from this table. Although in general fewer errors were made with the index finger, this is primarily due to the neutral(R) faces.

Appendix Y(ii)

Errors (Four Blocks) for Visual Field x Emotion(R) x Finger Pattern x CLEM Interaction

	Left Movers	Emotional(R) Bimovers	Right Movers
Index Pattern			
LVF	7.07	8.67	7.15
SD	(5.66)	(7.57)	(6.50)
RVF	6.27	5.56	7.31
SD	(4.77)	(5.96)	(6.25)
N	(15)	(9)	(13)
Middle Pattern			
LVF	6.18	8.50	10.44
SD	(4.98)	(7.40)	(7.65)
RVF	7.73	7.10	8.78
SD	(3.82)	(4.70)	(6.14)
N	(11)	(10)	(9)

	Left Movers	Neutral(R) Bimovers	Right Movers
Index Pattern			
LVF	6.00	8.56	8.28
SD	(2.45)	(6.02)	(4.27)
RVF	7.00	8.22	5.86
SD	(5.29)	(5.12)	(4.38)
N	(11)	(9)	(7)
Middle Pattern			
LVF	4.69	9.62	5.25
SD	(4.53)	(3.59)	(4.50)
RVF	4.54	7.85	6.50
SD	(3.48)	(3.13)	(4.41)
N	(13)	(13)	(8)

This four way interaction appears to have been primarily due to the bimovers and right movers. For the bimovers, in the emotional(R) condition, the overall greater accuracy from the RVF is more extreme in the index condition. With the neutral(R) faces, however, the overall RVF superiority is greater in the middle condition. For the right movers, in the emotional(R) condition, there is a RVF superiority in the middle condition in contrast to negligible visual field differences in the index condition. The situation is the reverse for the neutral(R) faces, where there is a considerable RVF superiority in the index condition with a small trend in the other direction with the middle condition.

Appendix Z

Table 58

Reaction Times for Response x Sex x Emotion(R) x CLEM Interaction for Lateral Presentation Task

			Yes		
			LM	BI	RM
Males	EMO(R)	Mean	595	545	532
		SD	1.41	1.25	1.31
	NEUT(R)	Mean	479	541	638
		SD	1.18	1.30	1.29
Females	EMO(R)	Mean	518	533	569
		SD	1.16	1.10	1.18
	NEUT(R)	Mean	562	630	644
		SD	1.26	1.26	1.20

			No		
			LM	BI	RM
Males	EMO(R)	Mean	616	587	653
		SD	1.34	1.19	1.27
	NEUT(R)	Mean	522	612	638
		SD	1.16	1.19	1.30
Females	EMO(R)	Mean	597	614	628
		SD	1.20	1.11	1.16
	NEUT(R)	Mean	620	670	672
		SD	1.27	1.21	1.09

Appendix AA(i)

ANOVA for Males Only for Errors (Two Blocks) Using Rated Emotion on Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Emotion-R	10.59	1	10.59	2.58	.114
Finger	.49	1	.49	0.12	.731
CLEM	2.55	2	1.28	0.31	.734
EF	.38	1	.38	0.09	.763
EC	8.73	2	4.37	1.06	.353
FC	18.22	2	9.11	2.22	.119
EFC	12.88	2	6.44	1.57	.218
Error	213.56	52	4.11		
Response	.29	1	.29	0.09	.768
RE	1.30	1	1.30	0.39	.534
RF	3.04	1	3.04	0.92	.342
RC	4.13	2	2.06	0.62	.540
REF	4.43	1	4.43	1.34	.253
REC	8.10	2	4.05	1.22	.303
RFC	1.58	2	.79	0.24	.79
REFC	5.36	2	2.68	0.81	.452
Error	172.51	52	3.32		
Visual Field	.12	1	.12	0.10	.750
VE	.01	1	.01	0.01	.934
VF	.02	1	.02	0.02	.893
VC	2.96	2	1.03	0.92	.405
VEF	.01	1	.01	0.01	.915
VEC	4.55	2	2.28	2.03	.141
VFC	.30	2	.15	0.14	.874
VEFC	.36	2	.18	0.16	.853
Error	58.25	52	1.12		
RV	1.78	1	1.78	1.12	.296
RVE	10.35	1	10.35	6.48	.014**
RVF	2.31	1	2.31	1.44	.235
RVC	.32	2	.16	0.10	.904
RVEF	.50	1	.50	0.31	.579
RVEC	4.30	2	2.15	1.35	.269
RVFC	.65	2	.32	.20	.817
RVEFC	1.24	2	.62	0.39	.681
Error	83.05	52	1.60		

Appendix AA(ii) ANOVA for Females Only for Errors (Two Blocks) Using Rated Emotion of Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Emotion-R	.14	1	.14	0.03	.874
FInger	.06	1	.06	0.01	.919
CLEM	12.95		6.48	1.20	.310
EF	16.22	1	16.22	3.00	.089
EC	7.19	2	3.60	0.67	.518
FC	14.46	2	7.23	1.34	.271
EFC	7.53	2	3.76	0.70	.502
Error	280.69	52	5.40		
Response	4.45	1	4.45	2.43	.125
RE	13.41	1	13.41	7.31	.009**
RF	1.91	1	1.91	1.04	.312
RC	2.28	2	1.14	0.62	
				.541	
REF	5.96	1	5.96	3.25	.077
REC	1.37	2	.686	0.37	.690
RFC	.14	2	.07	0.04	.962
REFC	20.22	2	10.06	5.50	.007**
Error	95.32	52	1.83		
Visual Field	.83	1	.83	0.64	.427
VE	1.11	1	1.11	0.86	.358
VF	.16	1	.16	0.13	.724
VC	2.42	2	1.21	0.94	.398
VEF	2.68	1	2.68	2.08	.156
VEC	.80	2	.40	0.31	.733
VFC	937	2	4.69	3.63	.033*
VEFC	2.87	2	1.43	1.11	.337
Error	67.11	52	1.29		
RV	2.33	1	2.33	1.05	.309
RVE	.40	1	.40	0.18	.670
RVF	2.93		2.93	1.33	.255
RVC	6.33	2	3.17	1.43	.248
RVEF	.69	1	.69	0.31	.579
RVEC	.87	2	.44	0.20	.822
RVFC	11.70	2	5.84	2.64	.081
RVEFC	7.77	2	3.88	1.76	.183
Error	114.99	52	2.21		

Appendix AA(iii) ANOVA for Emotion(R) Only for Errors (Two Blocks) Using Rated Emotion

Source	SS	DF	MS	F	Prob.
Sex	.18	1	.18	0.03	.867
Finger	6.85	1	6.85	1.06	.307
CLEM	16.75	2	8.38	1.30	.280
SF	1.62	1	1.62	0.25	.618
SC	6.39	2	3.20	0.50	.611
FC	9.29	2	4.64	0.72	.490
SFC	41.44	2	20.72	3.22	.048*
Error	353.80	55	6.43		
Response	.00	1	.00	0.00	.972
RS	2.74	1	2.74	0.86	.358
RF	.53	1	.53	0.17	.685
RC	4.14	2	2.07	0.65	.526
RSF	.13	1	.13	0.04	.841
RSC	8.14	2	4.07	1.28	.287
RSC	7.12	2	3.56	1.12	.335
RSFC	6.62	2	3.31	1.04	.361
Error	175.46	55	3.19		
Visual Field	.04		.04	0.03	.857
VS	.00	1	.00	0.00	.961
VF	1.06	1	1.06	0.85	.360
VC	2.17	2	1.09	0.87	.425
VSF	1.13	1	1.13	0.91	.345
VSC	6.55	2	3.28	2.62	.082
VFC	5.00	2	2.50	2.00	.144
VSFC	4.65	2	2.32	1.86	.165
Error	68.70	55	1.25		
RV	7.76	1	7.76	4.07	.049*
RVS	3.50>	1	3.50	1.84	.181
RVF	2.96	1	2.96	1.55	.218
RVC	3.25	2	1.62	0.85	.432
RVSF	.70	1	.79	0.41	.523
RVSC	.90	2	.45	0.24	.790
RVFC	6.34	2	3.17	1.66	.199
RVSFC	14.58	2	7.29	3.82	.028*
Error	105.00	55	1.91		

Appendix AA(iv) ANOVA for Neutral(R) Only for Errors (Two Blocks)

Using Rated Emotion on Lateral Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	9.79	1	9.79	3.42	.071
Finger	4.18	1	4.18	1.46	.233
CLEM	9.87	2	4.94	1.72	.189
SF	4.52	1	4.52	1.58	.215
SC	.18	2	.08	0.03	.970
FC	1.75	2	.87	0.31	.737
SFC	2.86	2	1.43	0.50	.610
Error	140.46	49	2.87		
Response	6.41	1	6.41	3.40	.071
RS	9.71	1	9.71	5.15	.028*
RF	14.05	1	14.05	7.45	.009**
RC	4.32	2	2.16	1.15	.326
RSF	.00	1	.00	0.00	.996
RSC	.40				
			.20	0.11	.898
RFC	11.99	2	5.99	3.18	.050*
RSFC	2.62	2	1.31	0.70	.503
Error	92.37	49	1.88		
Visual Field	.57	1	.57	0.49	.487
VS	1.37	1	1.37	1.18	.282
VF	.53	1	.53	0.46	.501
VC	.18	2	.09	0.08	.924
VSF	.23	1	.23	0.20	.658
VSC	1.96	2	.98	0.85	435
VFC	2.80	2	1.40	1.21	.301
VSFC	.33	2	.16	0.14	.867
Error	56.66	49	1.15		
RV	.02	1	02	0.01	.919
RVS	3.90	1	3.90	1.21	.276
RVC	1.68	2	.84	0.44	.645
RVSF	.43	1	.2.93	1.54	.875
RVSFC	.10	2	.05	0.03	.973
Error	93.04	49	1.90		

Appendix BB(i)

ANOVA Using Rated Emotion on Errors for Central Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	.81	1	.81	1.08	.301
Emotion-R	.03	1	.03	0.05	.830
Finger	.01	1	.01	0.01	.912
CLEM	5.09	2	2.54	3.43	.036*
SE	.07	1	.07	0.10	.751
SF	.09	1	.09	0.12	.725
EF	.10	1	.10	0.14	.711
SC	5.18	2	2.58	3.49	.034*
EC	3.62	2	1.81	2.44	.092
FC	.16	2	.07	0.11	.900
SEF	1.30	1	1.30	1.76	.188
SEC	.50	2	.25	0.34	.714
SFC	2.12	2	1.06	1.42	.245
EFC	1.25	2	.62	0.84	.433
SEFC	.10	2	.05	0.07	.933
Error	76.51	103	.74		
Response	2.31	1	2.31	2.87	.093
RS	.00	1	.00	0.00	.998
RE	.40	1	.40	0.51	.479
RF	.68	1	.68	0.85	.359
RC	.78	2	.39	0.49	.615
RSE	.01	1	.01	0.02	.891
RSF	2.25	1	2.25	2.81	.010
REF	.35	1	.35	0.44	.510
RSC	.33	2	.16	0.21	.814
REC	.52	2	.26	0.32	.725
RFC	2.20	2	1.10	1.37	.259
RSEF	1.96	1	1.96	2.43	.122
RSEC	.02	2	01	0.01	.987
RSFC	1.80	2	.90	1.12	.330
REFC	6.96	2	3.48	4.32	.016*
RSEFC	.42	2	.21	0.26	.768
Error	82.90	103	.80		

Appendix BB(ii)

ANOVA using Rated Emotion on Reaction Time for Central Presentation Task

Source	SS	DF	MS	F	Prob.
Sex	3.57	1	3.57	0.72	.399
Emotion-R	212.55	1	212.55	0.00	.948
Finger	2.45	1	2.45	0.49	.485
CLEM	54.16	2	27.08	5.43	.006**
SE	3.96	1	3.96	0.80	.374
SF	.01	1	.01	0.00	.956
EF	7.29	1	7.29	1.46	.229
SC	.49	2	.24	0.05	.952
EC	24.47	2	12.23	2.45	.091
FC	.09	2	.05	0.01	.991
SEF	1.32	1	1.31	0.26	.609
SEC	12.79	2	6.40	1.28	.282
SFC	.27	2	.14	0.03	.973
EFC	1.57	2	.78	0.16	.854
SEFC	11.38	2	5.69	1.14	.324
Error	513.79	103	4.99		
Response	46.43	1	46.43	58.09	.000**
RS	1.39	1	1.39	1.74	.190
RE	>96	1	.96	1.20	.276
RF	2.06	1	2.06	2.58	.111
RC	2.64	2	1.32	1.65	.196
RSE	.64	1	.64	0.80	.374
RSF	1.59	1	1.59	1.99	.162
REF	.10	1	.10	0.12	.726
RSC	.27	2	.14	0.17	.844
REC	1.40	2	.70	0.88	.419
RFC	2.01	2	1.01	1.26	.288
RSEF	2.62	1	2.62	3.28	.073
RSEC	1.21	2	.60	0.75	.473
RSFC	1.67	2	.84	1.05	55
REFC	1.21	2	.61	0.76	.471
RSEFC	1.62	2	.81	1.01	.368
Errors	82.34	103	.80		