# IDENTIFICATION OF FACIAL EXPRESSIONS BY EPILEPTIC AND NON-NEUROLOGICAL SUBJECTS



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# IDENTIFICATION OF FACIAL EXPRESSIONS BY EPILEPTIC AND NON-NEUROLOGICAL SUBJECTS

by

(c) H. Wishart, B.A.

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## Abstract

The first goal of this thesis was to determine whether previous findings regarding facial expression processing among non-neurological subjects could be replicated with a modified experimental set-up. The second goal was to determine if there were any difficulties on the task unique to epileptics, subgroups of epileptics, or chronically ill patients.

Epileptics, chronic illness control subjects (diabetics) and non-patient control subjects identified facial expressions, and their accuracy and latency were measured. Expressions were presented for 150 ms to one visual hemifield at a time. The presentation format was designed to detect the subjects' style of processing, that is whether or not they processed the emotional expressions independently of the non-emotional facial characteristics. Subjects were tested following both neutral instructions and instructions intended to provoke anxiety.

Previous related findings with non-neurological subjects were replicated in part with the present experimental set-up. A tendency toward a right hemisphere (left visual field) superiority emerged independently of potential interacting factors such as expression valence, subject gender and group. The expressions, in order of decreasing accuracy, were surprised, happy, sad and fearful. In order of increasing latency they were happy, surprised and sad. It was impossible to analyse latency data for fearful expressions. Non-neurological subjects appeared to use both independent

and dependent styles of processing the expression with respect to the face dimension.

There were not enough epileptics with well-defined foci to form subgroups based on lateralization and nature of the focus. Thus epileptics were subclassified according to seizure type (complex partial versus primary generalized) and according to whether they scored like a comparison group of psychiatric patients (PSY) or of non-psychiatric subjects (NonPSY) on the Personal Behavior Inventory. Groups differed in age and years of education so the effect of these variables was removed using analysis of covariance. No abnormalities in hemispheric asymmetry, accuracy, latency or style (e.g. independence versus dependence) of expression identification could be attributed to epileptics, epileptic subgroups or chronically ill people. However the groups appeared to react differently to the anxiety induction. Non-patients, diabetics and NonPSY epileptics maintained or improved their accuracy of identifying happy expressions, whereas PSY epileptics' accuracy decreased. No differences between seizure type subgroups emerged. Thus it may be more useful to group epileptics according to Personal Behavior Inventory scores than according to seizure type when trying to isolate those vulnerable to the effects of anxiety on the processing of facial affect information.

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Prologue

Certain interictal changes in emotion, behavior and thought have been attributed to the subgroup of epileptics who have complex partial seizures (CPS). Although this attribution is controversial, there has been some consensus that epilepsy in general is characterized by a high incidence of some emotional problems. The main purpose of the present study is to examine the performance of epileptic and control subjects on a facial expression identification task. Facial expression is one of the most important channels of nonverbal communication (Ekman & Freisen, 1975). As Frijda (1986) states, "the process of recognizing facial expressions .... touches upon the general problems of knowing other minds and of social communication" (p.319). Given the possibility that epileptics or subgroups of epileptics have emotional difficulties, these difficulties may manifest themselves as a disturbance in identifying emotional facial expressions. The experiments in this thesis were designed to test this possibility.

An adequate examination of this idea should consider how people free of neurological problems process facial affect. Issues to consider include: (a) hemispheric asymmetry for the task, (b) the particular facial expressions used as stimuli, (c) facial expression processing style, or the relationship of processing emotional facial expressions to processing the non-emotional characteristics of faces, and (d) the impact of internal mood on perception of others' emotions. Once the characteristics of normal

facial expression identification have been established, the performance of the epileptics and epileptic subgroups can be compared to that of the non-neurological subjects, including a medical control group, to determine whether they have any deficit in their ability to identify facial expressions.

Hemispheric asymmetry of emotional expression identification

Studies examining the question of hemispheric asymmetry have inferred its existence when monohemispherically presented stimuli are processed faster or more accurately by one side of the brain than the other. In that case one hemisphere has been said to show an advantage over the other. Generally the research to be discussed in the following paragraphs indicates the right hemisphere is superior to the left in processing facial expressions, although there may be significant interactions with gender, handedness and expression valence.

Some researchers have found no significant hemispheric asymmetry among non-neurological subjects on tasks involving facial expression stimuli (Hirschman & Safer, 1982; Thompson, 1983). They argue that various methodological factors may account for the lack of significant findings.

A number of studies have shown an overall right hemisphere advantage in the intact human brain for processing facial expressions with

a variety of same-different tasks (Hansch & Pirozzolo, 1980; Landis, Assal & Perret, 1979; Ley & Bryden, 1979; Strauss & Moscovitch, 1981; Suberi & McKeever, 1977). It has been hypothesized that one hemisphere may process negative expressions better whereas the other hemisphere processes positive expressions better (Reuter-Lorenz & Davidson, 1981). Valence specificity of hemispheric superiority was examined in three of the above studies, but not supported in any of them (Ley & Bryden, 1979; Strauss & Moscovitch, 1981; Suberi & McKeever, 1977).

Further support for the specialization of the right hemisphere for the processing of facial expressions has come from studies of subjects with lateralized brain disorder using various experimental tasks (Cicone, Wapner & Gardner, 1980; DeKosky, Heilman, Bowers & Valenstein, 1980; Kolb & Taylor, 1981; Prigatano & Pribram, 1982). The possibility of valence specificity of hemispheric superiority was investigated in two of these studies. Prigatano & Pribram (1982) found no support for valence specificity, whereas Cicone et al. (1980) found that right hemisphere damage was associated with an elevated number of mistakes with happy expression stimuli.

Conflicting evidence concerning valence specificity was found in two studies carried out by Reuter-Lorenz and colleagues (Reuter-Lorenz & Davidson, 1981; Reuter-Lorenz, Givis & Moscovitch, 1983). They used an expression detection paradigm which, as Ley & Strauss (1986) noted, was

unique in the literature of facial expression processing. In these experiments, subjects were briefly and simultaneously shown an expressive (happy or sad) face in one visual field and a neutral face in the other. Subjects were asked to identify the side on which the expressive face appeared. At least among right handers the reactions times for correct responses were faster to left visual field presentations of sad faces and right visual field presentations of happy faces. Given that this effect is opposite to that found by Cicone et al. (1980), and that several studies have yielded no support for the valence specificity hypothesis, the relationship between hemispheric superiority and expression valence remains in question.

In summary, although there is uncertainty about some issues regarding the hemispheric asymmetry of facial expression processing, some consistencies have also been found. When expression detection paradigms were used, evidence for valence-specific hemispheric superiority emerged. In most studies using other paradigms (including same-different paradigms), a general right hemispheric superiority emerged, even when valence specificity was investigated.

Other issues regarding the hemispheric asymmetry of facial expression processing have not yet been resolved. For example, debate has continued as to whether any overall superiority of the right hemisphere for facial expression processing is dependent on its superiority for processing other non-emotional characteristics of faces (DeKosky et al., 1980; Hansch

& Pirozzolo, 1980; Ley & Bryden, 1979; Safer, 1981; Strauss & Moscovitch, 1981; Suberi & McKeever, 1977).

There have also been mixed findings on sex differences in hemisphere superiority for facial affect identification. Ladavas, Umilta and Ricci-Bitti (1980) found a right hemisphere superiority among females and no hemisphere difference among males in speed of matching expressions to previously presented expression labels in a go-no go paradigm. On the other hand Safer (1981) found a right hemisphere superiority among males and no hemisphere difference among females in accuracy of verbally identifying expressions as "same" or "different" from target when subjects were given verbal priming instructions.

Some debate has also continued regarding the hemispheric asymmetry of verbal emotional functions. It has been shown that left hemisphere damage decreases comprehension of the emotional content of words (Cicone et al, 1980; Kolb & Taylor, 1981), whereas right hemisphere damage decreases understanding of emotional tones of voice (Heilman, Scholes & Watson, 1975; Tompkins & Mateer, 1985). However Hansch & Pirozzolo (1981) found no significant differences in hemispheric asymmetry for recognition memory of neutral versus emotional words with a same-different task. Also Schlanger, Schlanger & Gerstman (1976) found no hemispheric superiority with emotional vocal tone stimuli. Thus even within experiments using similar types of stimuli, disagreement has

continued as to which verbal emotional functions can be attributed to each hemisphere.

In summary, there has been some agreement that valence specificity emerges when expression detection paradigms are used. Right hemisphere superiority emerges, regardless of expression valence, when other paradigms (including same-different paradigms) are used. Debate has continued as to gender differences in hemispheric asymmetry of facial expression processing, the hemispheric asymmetry of verbal emotional functions, and the relationship between processing of facial expression and processing of other facial characteristics.

Identification of particular facial expressions

It has been found that certain expressions are identified faster and more accurately than others when presented to the center of the visual field, that is to both hemispheres simultaneously. It has been found that the order of decreasing accuracy and increasing latency of identification for the following expressions is as follows: happiness, surprise, sadness and fear, although the differences were not necessarily significant (Hirschman and Safer, 1982; Kirouac and Doré, 1983). Mandal and Palchoudhury (1985) found a similar pattern except that fear was identified more accurately than surprise. The above facial expressions are those used in the present

study. The potential interacting factor of subject gender has been found to have no effect on the rank order of accuracy and/or latency in which the expressions are identified (Hirschman & Safer, 1982; Kirouac & Doré, 1983, 1984; Mandal & Palchoudhury, 1985).

Facial expression processing style

Ekman and Friesen (1975) described the face as a multimessage system, communicating such information as age, sex, character and intelligence, as well as emotion. In the present thesis the word "expression" refers to the emotion the face portrays and the word "face" refers to the rest of the information the face conveys. Moreover Ekman and Friesen (1975) characterized perception of facial expression as a process of selective attention. Processing of facial information has been investigated from a selective attention perspective by Etcoff (1984). She adapted Garner's (1976) selective attention paradigm from the spatial perception literature to the question of the independence of facial identity processing and facial expression processing. There were three conditions in the design. In the constant condition (CON), one stimulus dimension remained constant while the other varied; that is, one face portrayed all the expressions. In the correlated condition (COR), the two dimensions covaried. For example, one face portrayed happiness and another face portrayed sadness. In the

orthogonal condition (O). dimensions were counterbalanced for each subject; that is, each face portrayed each expression.

Figure 1 depicts five of Garner's (1976) condition effect patterns. These patterns reflect five different dimension interaction types (here called processing styles): separable (here called independent, after Etcoff, 1984), integral, configural, optional separable (here called optionally independent), and asymmetric separable (here called asymmetrically independent). All the processing styles, except optionally independent, are empirically based. Garner investigated these processing styles using various non-face stimuli. Etcoff (1984), using face stimuli, found that non-neurological subjects used an independent processing style. The other processing styles have not yet been demonstrated with face stimuli among non-neurological subjects. Because Etcoff's adaptation of Garner's paradigm is useful for understanding the relationship of face processing and expression processing, it will be described in detail in the following paragraphs. Etcoff's paradigm uses two dependent measures (accuracy and latency) and face stimuli. In the examples below, facial expression is the target dimension and face is the non-target dimension.

The basic assumption of independent processing is that one can attend to the target dimension without attending to the non-target dimension. Thus neither degree of variation in the non-target dimension (face) nor degree of covariation of the two dimensions (face and facial

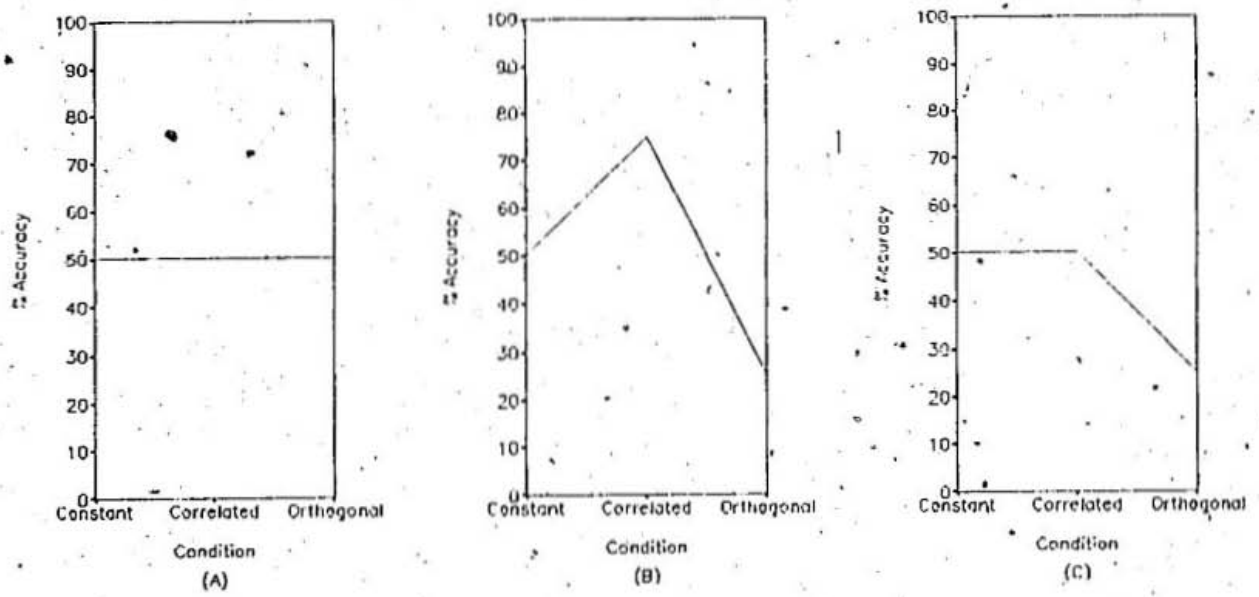


Figure 1. Processing styles: (a) Independent, (b) Integral, (c) Configural

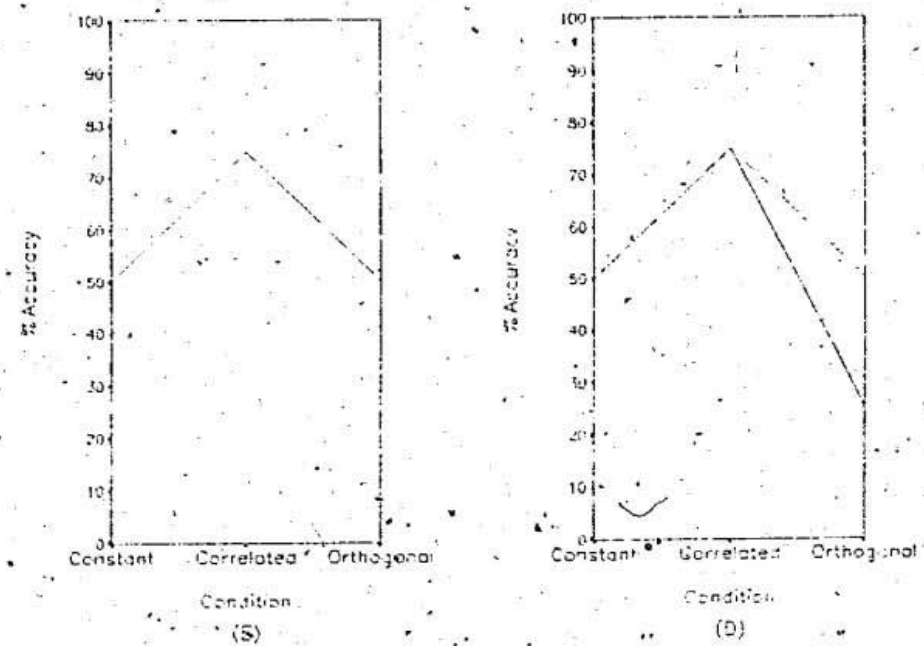


Figure 1 Continued. Processing styles: (d) Optionally Independent, (e) Asymmetrically Independent

expression) affects performance. With independent processing, accuracy and latency are equal across constant, correlated and orthogonal conditions.

The basic assumption of integral processing is that when one attends to the target dimension, one also attends to the non-target dimension. That is, the facial stimuli are processed as wholes. If integral processing is used, performance in the correlated condition is facilitated or improved relative to that in the constant condition, and performance in the orthogonal condition deteriorates relative to that in the constant condition. This may arise, if the stimuli are processed as wholes, because the variation among expressions imposed by variation in the faces differs across conditions. Degree of variation among expressions refers to how different each expression is from the others, that is the discriminability of the expressions. The more discriminable the expressions, the easier they are to identify. Greatest discriminability of expressions is achieved in the correlated condition, if the stimuli are processed as wholes, because each expression is portrayed on a unique face. For example the face which portrays the happy expression may have a large mouth and dark eyebrows whereas the sad face may have a small mouth and blonde eyebrows; the physical features of the faces increase the difference between the expressions that they portray. Contrast this high level of discriminability to that in the constant condition, in which the same face portrays all

expressions. The zero variation in the face dimension imposes no variation on the facial expression. In the constant condition then, information in the face dimension neither increases nor decreases the discriminability of the expressions, when the stimuli are processed as wholes. Therefore it is more difficult with such a processing style to discriminate and identify the expressions in the constant condition than in the correlated condition. It is most difficult to discriminate and identify the expressions in the orthogonal condition, when processing the stimuli as wholes, because the variation in the face dimension imposes error variation on the expression dimension. In this condition each of the faces presents each of the expressions. For example a young man with small eyes and an old woman with large eyes might each portray happy and sad expressions. If subjects are processing the stimuli as wholes, then the happy and sad expressions portrayed by the man are more similar than usual by virtue of being on the same face. Thus the error variation in the expression dimension, imposed by its orthogonal variation with the face dimension when the stimuli are processed as wholes, decreases the discriminability of the expressions. With an integral processing style, performance is best in the correlated condition, intermediate in the constant condition and poorest in the orthogonal condition.

With configural processing, when one attends to the target dimension, one also attends to the non-target dimension, as with integral

processing. The difference is that with configural processing the covariation of information in the correlated condition is not used to increase stimulus discriminability, and performance is not facilitated. Orthogonal variation of face and facial expression information still causes interference with ability to identify the expressions, and therefore still causes poor performance in the orthogonal condition as with integral processing. No explanation of configural processing has been advanced. To be sure that processing is configural and not integral, it should be clear that the lack of facilitation in the correlated condition is not a ceiling effect.

Garner (1976) discussed several theoretically possible processing styles, including the optionally independent style. The basic assumption of optionally independent processing is that the subject uses information in the non-target dimension only when it helps his performance. Covariation of information in the correlated condition is used to facilitate performance, but for neither dimension does orthogonal interference occur. Though he had no empirical evidence that this style exists, he noted that it would be an ideal style because it would provide for optimal performance across conditions.

With asymmetrically independent processing, performance in the correlated condition is facilitated by the increase in stimulus discriminability afforded by the covariation of information in the dimensions. Performance is not affected by orthogonal variation of

information with one of the target dimensions (facial expression, for example). However when the other dimension (face, for example) is the target, orthogonal interference occurs. Thus when dimension 1 is the target, the style of processing is like optionally independent processing. When dimension 2 is the target, the processing style is integral.

In the present thesis the term "processing style" was substituted for Garner's term "dimension interaction". Garner's term seems to imply that "integral", "configural", etc. are unchanging properties of the stimuli, however it may be that they are characteristics of the processing style. To illustrate, the Stroop Test contains two orthogonally varying dimensions. Boyden and Gilpin (1978) found that, at least among males, errors on the Matching Familiar Figures Test correlated significantly with errors on the Stroop Test, suggesting that males with higher impulsivity attended to the non-target dimension more than those with lower impulsivity, even when doing so disrupted their performance. Thus it seems reasonable to suggest that performance on a task such as Garner's depends more on the individual's processing style than on the stimulus. Garner's terms were changed to accommodate the possibility that individuals might differ in their method of dealing with the stimuli.

The styles of processing can be ranked in order of their favorableness with respect to optimizing performance across conditions. The styles, in order of decreasing favorableness are optionally independent,

asymmetrically independent, independent, integral and configural. When investigating facial expression identification, it is useful to determine whether subjects use an optimal or less than optimal style of processing. Also, if facial expression can be processed independently of the face dimension, this would lend credence to the idea that research into facial expression processing tells us something about emotion processing in general. If not, it would appear that expression processing is a spatially linked process, from which generalizations to emotion processing would be more difficult.

The impact of mood on performance

Bower (1981) reported a set of experiments which showed the effect of hypnotically-induced mood on reactions to stimuli, especially ambiguous stimuli. For example, he hypnotically induced either anger or happiness in subjects, and then asked them to free associate to stimulus words in one experiment, and to create stories about Thematic Apperception Test cards in another experiment. Two independent judges rated the associates and stories as angry or happy, and these ratings correlated significantly with the induced mood of the subjects in both studies. Since many methodological details are missing from the report, it is impossible to critically evaluate the experiments. Extrapolating from

Bower's (1981) findings, the induction of a negative mood such as anxiety may increase the number of anxiety-related or negative interpretations of stimuli such as facial expressions.

Alternatively, if the increase in anxiety is very great, it may interfere with performance (Hebb, 1964). Blatt (1964) noted that efficient performance of both simple and complex tasks was associated with elevated arousal as measured physiologically. He suggested that when arousal reached very high levels (such as panic), performance would deteriorate significantly. However he could not ethically test this hypothesis in an experiment.

Certain subjects may respond more than others to imaginally induced anxiety, particularly those who are anxiety prone. They may show a greater increase in negative interpretations of stimuli than that predicted for comparison subjects on the basis of Bower's (1981) mood congruency hypothesis. Alternatively they could show greater performance interference than that predicted for comparison subjects on the basis of the inverted U hypothesis (Hebb, 1964), but only if their anxiety becomes very high.

Effects of seizure focus on hemispheric asymmetry

Little information exists regarding the effects of epilepsy on processing of facial information within the context of the issues described above. Nevertheless evidence does exist for the alteration of other psychological abilities by seizure disorders. This evidence is presented in the following sections.

Findings from several studies suggest that unilateral temporal damage impairs processing of verbal and nonverbal auditory stimuli presented to the contralesional ear, regardless of the normal hemispheric asymmetry found for these tasks. This phenomenon is known as the lesion effect (Kimura, 1961; Mazzucchi and Parma, 1978; Schulhoff and Goodglass, 1969). Epileptics with unilateral brain damage evident using computerized tomography, electroencephalography and clinical history are said to have a lesional focus, and show a lesion effect even if the focus site is non-temporal (Mazucchi et al., 1985). Epileptics without such evidence of brain damage, but with clear electroencephalographic evidence of unilateral epileptic focus, are said to have a nonlesional focus (Mazzucchi et al., 1985). Among such epileptics, some functions normally performed by the focus hemisphere are facilitated, and functions normally performed by the non-focus hemisphere are performed better by (or "attracted" to) the focus hemisphere. This has been called the paradox effect (Mazzucchi et al., 1985). The paradox and lesion effects have been demonstrated among epileptics with temporal and

non-temporal focus sites on measures of speed and accuracy of response in attentional and perceptual tasks using simple visual, auditory and cutaneous stimulation (Blinkov & Moskatova, 1967; Mazzucchi & Parma, 1978; Mazzucchi et al., 1985). Jacobs (1980) and Hunter, Maccabe and Ettlinger (1976) reported paradox-like effects in vision and learning respectively. The paradox effect has not yet been investigated with emotional stimuli. When examining facial expression identification among epileptics, the impact of seizure foci on the normal hemispheric asymmetry for the task deserves examination.

Effects of seizure focus on style of processing facial expressions

Etcoff (1984) compared non-neurological control subjects to patients with either left or right brain damage. Subjects were asked to sort pictures of two women quickly according to identity on some trials and according to facial expression (happy versus sad) on other trials. The patients with right hemisphere damage found it hard to attend only to face or only to expression in the orthogonal condition, as evidenced by the decrease in their accuracy and speed in this condition. This was not a general problem with selective attention since even the right hemisphere patients sorted geometric figures with equal speed and accuracy according to color and shape across conditions. Etcoff inferred that right brain

damage could cause interference between the processing of faces and expressions. She concluded that among the non-neurological subjects in her study, face identification and expression identification were independent processes, and that right brain damage impaired this selective processing. Thus when examining facial expression identification among epileptics, the effect of seizure foci on processing style deserves investigation.

Some emotional characteristics of epileptics and their relationship to identifying facial expressions

Various emotional and behavioral problems have been attributed to epileptics and subgroups of epileptics. It is possible that such disturbances in psychological well-being may manifest themselves in disturbances in social communication (such as interpretation of facial expressions). Thus a link may exist among epilepsy, emotional and behavioral problems, and deficits in facial expression processing. Epileptics' difficulties in processing expressions may manifest themselves in their accuracy, latency or style (optimal versus sub-optimal) of facial expression identification, or in the effect of a mood induction procedure on their performance.

Hermann and Whitman (1984) reviewed reports of numerous emotional and behavioral disturbances which have been rightly or wrongly

attributed to epileptics in general or to CPS patients in particular. They identified six problem types: "sexual dysfunction, psychosis, aggression, personality change, affective disorder and ... general psychopathology ..." (p.452). General psychopathology covered disturbances evidenced for example by presence of a psychiatric diagnosis or abnormal scores on psychological tests such as the Minnesota Multiphasic Personality Inventory or the Fear Questionnaire.

These problems, if they do characterize some or all epileptics, may be related to physical factors intrinsic to epilepsy or to extrinsic social and physical factors linked with epilepsy. The potential extrinsic factors in the development of emotional and behavioral problems among epileptics and/or CPS patients include medications, the lifestyle limitations imposed by the presence of a chronic medical disorder (including unemployment), loss of control over one's own body and the social stigma attached to epilepsy. Potential intrinsic factors include presence of structural brain damage, degree of seizure control, age at onset of epilepsy, duration of the disorder and seizure type (Hermann & Whitman, 1984). Identification of psychologically vulnerable epileptics has often been attempted using seizure type. Given the purported role of the septum (a limbic structure), along with other brain regions, in affective behavior (Kolb & Whishaw, 1985), it has been hypothesized that epileptics whose seizures emanate from near this region of the brain would constitute the psychological risk group

(Stark-Adamec et al., 1985). These epileptics are usually identified by presence of CPS. However, as discussed below, this attribution is controversial because the relevant studies have often been disconfirmatory and/or methodologically weak.

The studies to be discussed in the following paragraphs used a variety of tests, two of which were specifically designed to examine the emotional and behavioral problems attributed to epileptics. These two tests, the Personal Inventory (Bear & Fedio, 1977) and the Personal Behavior Inventory (PBI; Stark-Adamec et al., 1985) will be described in some detail. The Personal Inventory covers 18 traits previously attributed to epileptics, including euphoria, sadness, anger, aggression, obsessionalism, paranoia, humorlessness, and circumstantiality. Subjects rate five items per trait as true or false, and higher trait scores indicate greater applicability of the trait to that person. Stark-Adamec et al. (1985) developed the PBI as a modification of the Personal Inventory. Cluster analysis showed the 91 test items on the PBI formed 11 categories with various numbers of items in each: (a) religiousity, (b) elation, (c) emotionality (including depression), (d) confusion, (e) dependence on others, (f) anger, (g) humorlessness, (h) decreased sexual activity, (i) compulsivity, (j) hypergraphia, and (k) feeling that one's own life story is important. These inventories are among the tests used to examine epileptics for psychological problems.

Depression and anxiety are thought to be common interictal associates of epilepsy, but their exact incidence is not known (Hermann and Whitman, 1984; Robertson, 1985). The incidence of depression among epileptics has been examined in at least four controlled studies. Almost 70 per cent of epileptics, as compared to just over 40 per cent of control subjects with locomotor disorders, had mean scores above the cut-off on the depression category of the Present State Examination (Standage and Fenton, 1975). Using the Personal Inventory, Mungas (1982) found no significant differences on the depression (sadness) subscale among CPS, psychiatric and neuropsychiatric patients. Stark-Adamec et al. (1985) compared the responses of epileptics (with various seizure types), patients with other medical problems, and healthy adult controls. On the "emotional" category, which contains items pertaining to depression, moodiness and guilt, the epileptics rated themselves higher than the comparison subjects. Korgeorgos, Fonagy and Scott (1982) classified epileptic and non-epileptic neurological subjects into psychiatric risk and non-risk groups using the 30-item General Health Questionnaire. The epileptics in the risk group scored significantly higher on the depression subscale (among other subscales) than did the epileptics in the non-risk group. The non-epileptics in the psychiatric risk group scored as low as the non-epileptics in the non-risk group on the depression subscale. In other words, epileptics who showed psychiatric risk were likely to have

depression among their problems. Thus at least some epileptics tend to show depression which exceeds that of comparison subjects on psychological testing.

In at least three studies, attempts were made to see if depression was specific to any subgroup of epileptics. Bear and Fedio (1977) found that depression, as measured on their Personal Inventory, characterized the CPS patients in their study. However without a seizure control group composed, for example, of primary generalized seizure (PGS) patients, no conclusions about the specificity of depression to CPS patients could be made on the basis of their study. Korgeorgos et al. (1982) found that focal epileptics were no more depressed than PGS patients. This however was not meant to be a true test of depression differences between CPS and other seizure patients because the focal group contained a small number with a non-temporal focus. Using the Present State Examination, Standage and Fenton (1975) found no evidence of specificity of depression to CPS patients as compared to patients with other seizure types (15 PGS and 3 non-temporal focal epileptics). Thus of three studies investigating subgroup specificity of depression, only one (Standage and Fenton, 1975) was methodologically equipped to deal with the question of specificity to CPS patients. The results of this study were disconfirmatory.

Anxiety is thought to be common among epileptics, and is often found in conjunction with depression (Currie, Heathfield, Henson and

Scott, 1971; Robertson, 1985). Brodsky and colleagues proposed that certain cases of intractable anxiety are due to subictal epileptiform activity. They successfully treated ten such cases of anxiety with anticonvulsant medications (Brodsky, Zuniga, Casenas, Ernstoff and Sachdev,1983). However anticonvulsants may reduce anxiety by some means other than reducing epileptiform activity, so this finding must be interpreted cautiously. In summary, there is some evidence for a connection of epilepsy with anxiety and depression.

Excessive emotional-responsiveness has been attributed to CPS patients in particular. According to Bear's (1979) hypothesis of sensory-limbic hyperconnection, stimulation (kindling) of limbic structures may lower their firing threshold, leading to increased limbic and therefore emotional responding (Bear, Schenk and Benson, 1981). Bear et al. (1981) found that CPS patients showed a larger electrodermal response to both neutral and emotional visual stimuli than a healthy adult control group. Bear & Fedio (1977) found that CPS patients scored significantly higher than healthy normal adults and patients with neuromuscular disorders on items pertaining to excessive emotionality on their Personal Inventory. Due to the lack of a control group with another seizure type in both studies by Bear and colleagues, specificity of the findings to CPS patients cannot be inferred. Bellur, Camacho, Hermann, Kempthorne and McCanne (1985) found no differences among their CPS group, epileptics without CPS (non-

CPS) and their healthy control groups in either heart rate or electrodermal response to an emotionally charged film. Differences among groups may have been obscured by the lack of a homogeneous epileptic control group and/or the use of a markedly emotional film. Thus because of methodological problems in these studies, the question of excessive emotional responsiveness among epileptics, or CPS in particular, remains open.

Bear and Fedio (1977) used their Personal Inventory, described earlier, in an attempt to delineate a CPS patient behavior syndrome. In their study, the CPS patients scored higher than patients with neuromuscular disorders and healthy adult control subjects on each of the 18 traits surveyed by the inventory. However the behavior syndrome they elucidated cannot be attributed to CPS patients in particular because they did not use an epileptic control group, composed, for example, of PGS patients. Using the same questionnaire, Mungas (1982) found no significant differences on any of the 18 trait scores among CPS patients, psychiatric patients and non-psychiatric patients. Again there was no investigation of another specific seizure type group, so specificity of the behavior syndrome to CPS patients cannot be inferred.

Stark-Adamec et al. (1985) administered the Personal Behavior Inventory (PBI) to a sample of 70 epileptics, 28 dialysis patients (a chronic illness control group), 92 psychiatry patients (with a range of diagnoses)

and 447 nonpatients. They found that a number of the characteristics supposed to comprise the epileptic or CPS patient behavior syndrome, actually characterized other medical patients as well. Using jackknife discriminant analysis they found that just over one-third of the seizure patients (here called group PSY) responded like the comparison group of psychiatry patients on the PBI. The subgroups based on seizure types of CPS, CPS with secondary generalization and PGS did not differ from each other on their scores on any of the inventory's 11 categories. These findings help refute the notion that epileptics in general or CPS patients in particular are characterized by an abnormal emotional/behavioral syndrome.

As the preceeding paragraphs suggest, controversy surrounds the use of seizure type diagnosis as a predictor of psychological problems among epileptics. Stark-Adamec et al. (1985) attempted to find a better predictor than seizure type for physiologically-based psychological risk among epileptics. Knowing the possible role of the septum, (a limbic structure) and other anatomically related structures in affective behavior (Kolb & Whishaw, 1985), and the fact that limbic kindling produces long-term behavior changes in animals (Adamec and Stark-Adamec, 1983), they agreed with other researchers that an indicator of limbic epileptiform activity was needed. In the search for a noninvasive indicator, they hypothesized that an aura or set of auras might characterize epileptics with

different degrees of limbic involvement in their seizures. Therefore they developed the Aura Questionnaire which consists of 33 descriptions of auras that have been reported in the literature. The broad a priori categories of auras on the questionnaire pertain to perceptual changes, bodily sensations, thoughts and emotions. They administered this questionnaire to the subjects of the study described above (Stark-Adamec et al., 1985). The PSY epileptic group was characterized by significantly higher scores than the other epileptics (NonPSY) on six auras, five of which have in fact been reproduced with stimulation of the human limbic system. These were (a) changes in the brightness of light, (b) perception of formed images, (c) changes in loudness, pitch or quality of sounds, (d) hatred as an emotion which comes "out of the blue", (e) dizziness, (f) mind becomes stuck on a single idea. Perry (1987) increased the sample sizes of the Stark-Adamec et al., (1985) study and found that again about one-third of epileptics scored like the comparison group of psychiatric patients on the PBI. These PSY epileptics were characterized by significantly higher scores than other epileptics on a different set of five auras, three of which have been reproduced in humans with limbic stimulation. These five auras were (a) perception of formed images, (b) jamais vu, (c) perception of time speeding up or slowing down, (d) irritability, and (e) perception of humming or buzzing sounds. The work of identifying definitive limbic auras is still in progress, and auras may prove to be good predictors of psychological disturbance among epileptics.

In summary some or most epileptics may be characterized by emotional and behavioral problems. Such problems have been attributed to epileptics as a group and to the subgroup of epileptics with CPS. Also the PBI has been used, in conjunction with the Aura Questionnaire, to identify the epileptics with such problems. If some or all of these groups have emotional or behavioral problems, the problems may manifest themselves as differences between these subjects and control subjects on the facial expression identification task. Differences could arise in their accuracy, latency or style of facial expression processing. Epileptics in these groups may show poorer accuracy or latency scores. Relative to control subjects, they may use a less favorable (that is, integral or configural) style of processing facial expression with respect to the face dimension. Differences among groups could also arise in the effect an anxiety induction procedure has on their performance. Given the possibility that they are more anxious and emotionally responsive, epileptics or certain subgroups of epileptics may be more affected by an anxiety induction procedure.

## Hypotheses

The first goal of this thesis is to ascertain how people free of neurological disorder identify facial expressions. Measures of hemispheric asymmetry, accuracy, latency and style of facial expression identification are obtained to determine whether previous related findings with such subjects can be replicated with the present experimental set-up. Hypotheses 1, 2 and 3 pertain to this first goal. The second goal of this thesis is to determine whether any difficulties in facial expression identification can be attributed to chronically ill people (diabetics and epileptics), to epileptics or to subgroups of epileptics. In addition to being examined on the variables above, they are also investigated for differences in the effect of a mood induction procedure on their performance. Hypotheses 4, 5, 6 and 7 deal with the second goal of the thesis.

Hypothesis 1: Hemispheric asymmetry of facial expression identification among non-neurological subjects

Based on the consensus in the literature, it is hypothesized that among right-handed non-neurological subjects there will be a right hemisphere advantage in accuracy and latency for identification of all expressions.

Hypothesis 2: Accuracy and latency of facial expression identification among non-neurological subjects

Accuracy is defined as the number of times a facial expression is correctly identified, and latency refers to the time taken to *accurately* identify facial expressions. On the basis of findings by Hirschman and Safer (1982) and Kirouac and Doré (1983, 1984), it is hypothesized that among non-neurological subjects certain expressions will be identified faster and more accurately than others. The expressions in predicted order of decreasing accuracy and increasing latency are happiness, surprise, sadness and fear.

Hypothesis 3: Facial expression processing style among non-neurological subjects

Based on the finding by Etcoff (1984) that healthy normal adults process the facial expression dimension independently of the other characteristics of the face (that is, of the face dimension), it is hypothesized that all non-neurological subjects will use an independent strategy in the present study. This means that speed and accuracy of expression identification will not significantly differ across constant, correlated and orthogonal conditions for these subjects.

Hypothesis 4. Group differences in hemispheric asymmetry of facial expression identification

It is hypothesized that paradox and lesion effects will be seen for expression identification among epileptics depending on the side and nature (lesional versus nonlesional) of their seizure focus. It is hypothesized that relatively greater right superiority in accuracy and latency will be obtained in the right nonlesionals and left lesionals than controls because of the paradox and lesion effects respectively. Relatively greater left superiority in speed and accuracy, or at least lower right superiority, will be obtained in the left nonlesionals and the right lesionals because of the paradox and lesion effects respectively. It is also hypothesized that, owing to unequal representation of epileptics with various focus types in the epileptic group and subgroups (e.g., CPS, PGS; PSY, NonPSY), these groups may differ in hemispheric asymmetry of facial expression identification.

Hypothesis 5: Group differences in accuracy and latency of facial expression identification

Given the attributions of emotional and behavioral problems to epileptics and certain epileptic subgroups (i.e., CPS and PSY), it is hypothesized that they will show lower accuracy and/or longer latencies for identification of some or all expressions when compared to control subjects.

Hypothesis 6. Group differences in expression processing style

Based on Etcoff's (1984) findings it is hypothesized that nonpatient controls, chronic illness controls, and some epileptics will use an independent style. Those epilepties with right lesional foci should perform as did the right damaged subjects in Etcoff's study. They should be slower and/or less accurate in selectively attending to the expression when the face varies orthogonally with expression.

Given the attributions of emotional difficulty to epileptics and certain subgroups of epileptics (i.e., CPS and PSY), it is hypothesized that these subjects, regardless of the site and nature of their focus, will use a less favorable processing style than comparison subjects. All comparison subjects should use an independent processing style.

Hypothesis 7: Group differences in response to anxiety induction

The anxiety induction may increase the use and speed of use of the fear label or both negative labels (fearful and sad), a prediction extrapolated from Bower's (1981) mood congruency findings. This would be associated with an increase in accuracy and decrease in latency for fearful and possibly sad expressions. There might also be an associated decrease in accuracy and increase in latency for happy and possibly surprised expressions.

Given the attributions of emotional difficulties and enhanced emotional responsiveness to epileptics and certain subgroups of epileptics (i.e., CPS and PSY), it is hypothesized that these subjects will show a greater effect of the anxiety induction than comparison subjects. It is hypothesized that this effect will be superimposed on their already lower accuracy and longer latencies in the absence of anxiety instructions. (See hypothesis 5.) It is further hypothesized that among epileptics or subgroups of epileptics, the anxiety induction procedure will be associated with higher accuracy and shorter latency for fearful and possibly sad expressions relative to their own performance in the absence of anxiety instructions and relative to the comparison subjects' performance. Similarly it is hypothesized that among these subjects, the anxiety induction will be associated with lower accuracy and longer latencies for happy and possibly surprised expressions relative to their own performance in the absence of anxiety instructions and relative to the comparison subjects' performance.

It is also hypothesized that the anxiety induction will affect subjects' responses to neutral expressions. According to the mood congruency hypothesis, the anxiety induction will cause an increase in the use of fearful, and possibly sad, labels. It may cause a decrease in the use of happy, and possibly surprised, labels. It is also hypothesized that the anxiety induction will cause an increase in state anxiety, but not trait anxiety, on a standard test of these constructs. Again these effects may be exaggerated among epileptics or subgroups of epileptics.

# Method

## Subjects

Eighteen epileptics were compared to 12 diabetic control subjects (DC: the chronic illness control group) and 24 people free of chronic illness (the nonpatient control group; NPC). Diabetics were chosen for the chronic illness control group because they were available, and because both diabetes and epilepsy are chronic and debilitating diseases. Attempts were made to obtain all right-handed subjects with normal or corrected-to-normal vision, and to equate the groups on demographic variables.

With the cooperation of their physician, Dr. Farid, the diabetics were first contacted by the experimenter when they they came in for regular check-ups at the Health Sciences Center in St. John's, Newfoundland. The epileptics were first contacted by mail, with the cooperation of their physician, Dr. Sadler, also of the Health Sciences Center in St. John's. The NPC subjects were recruited through advertisements at Memorial University, the Y.M.C.A. and the Aquarena in St. John's. Subjects were given a brief description of the study and its purposes at the time of first contact. After they had informally agreed to participate, they were contacted by phone to arrange an appointment. All subjects were paid $3.75 per hour for their participation.

Measures

The seizure patients were asked to complete the PBI (appendix A) and the Aura Questionnaire (appendix B, Stark-Adamec et al., 1985) if they had not already done so as part of a previous study. The PBI data were used to subclassify the epileptics, as explained in the Statistical Analyses section of this thesis. The aura data for the resulting epileptic subgroups were compared as in previous studies (Perry, 1987; Stark-Adamec et al., 1985). The psychometric properties of these questionnaires have not yet been established.

The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushere, 1971) was used to help determine the effectiveness of the anxiety induction procedure. The 20-item A-Trait scale of the STAI is intended to measure trait anxiety, which is thought to be a stable personality characteristic. The 20-item A-State scale of the STAI is intended to measure state anxiety, the anxiety level at a particular time. (Hedberg, 1972). The STAI has been demonstrated to be a valid test of these two anxiety constructs, and its scales have high internal consistency. As expected, the A-Trait scale has high test-retest reliability whereas the A-State scale does not (Hedberg, 1972).

All subjects were asked to complete a personal background questionnaire developed for this study (appendix C) and the Edinburgh Handedness Inventory (Oldfield, 1971). On the handedness inventory, subjects state whether they perform each of 20 activities exclusively or sometimes with their left or right hand, or either hand. The subjects were also administered a set of tests to assess differences between groups with respect to anxiety and depression: the Beck Depression Inventory (BDI; Beck, Ward, Mendelsohn, Mock & Erbaugh, 1961), and the Social Avoidance and Distress Scale (SADS; Watson & Friend, 1969). The 21-item BDI has been demonstrated to have good concurrent validity, internal consistency and test-retest reliability, and it samples all the major signs of depression (Rehm, 1981). The 28-item SADS has high internal consistency. Test-retest correlation, calculated with a one month interval, was adequate. On self-report scales, high SADS scorers report that they are significantly more apprehensive and less talkative in a group situation than low SADS scorers (Watson & Friend, 1976).

Materials

The face stimuli were chosen from Ekman's *Pictures of facial affect* (1976). The photos were cropped to eliminate the identification number, leaving the head and most of the hair in the picture. The black/white contrast across slides was made as much the same as possible. Five other slides, used in the preliminary conditions, were made by the experimenter using Lettraset and a marker. Two Kodak slide projectors were situated immediately behind the subject, and a Bailey Controls Company Multi-Function Controller (MFC) ran a pre-established random sequence of left and right presentations.

Experimental set-up

Stimuli were presented 51 cm to the left or right of center, measuring from the central edge of the stimulus. Images measured 25.4 cm vertically by 17.8 cm horizontally on the screen. With subjects at an average viewing distance of 76.2 cm from the screen, the images subtended a visual angle of 6.6 degrees, and the nasal edge of the image fell about 36.1 degrees from the fovea. A response card listing the possible responses for the experimental condition was placed in the center of the screen midway between the lateral images, and served as the central fixation stimulus throughout the experiment. Side of presentation was randomized

such that the subjects could not predict the side on which the stimulus would appear next. The random left/right sequence in each condition was the same for each subject.

For each slide presentation, the Bailey MFC automatically turned on the projector light and simultaneously started a timer. The MFC also turned off the light after the predetermined interval. The timer could be shut off by either of two toggle switches, one on each arm of the subjects' chair. Subjects used one hand per condition to stop the timer, starting with either the left or right hand (according to random assignment), and alternating with each new condition. The timer could also be stopped and reset by the experimenter. The experimenter advanced the slides with manual controls.

Procedures

At the beginning of the experimental session, subjects were asked to read and sign a consent form (appendix D). Any preliminary questions were answered at this time. Subjects were then seated in a chair close to the projection screen, and were given the following instructions.

> You will be seeing a number of slides. The pictures will appear either on the left or right of the screen (experimenter points to the exact location). They will appear in random order so you won't be able to tell the side where the next picture will be. All the while I want you to look straight ahead at this little card.

> Keep looking straight ahead; don't look directly at the picture at the side of the screen. If you keep looking straight ahead, the pictures that fall on the left side of the screen will cross over and be processed on the right side of the brain. And the pictures that fall on the right side of the screen will cross over to the left side of the brain. That way I will be able to compare how well the two sides of the brain process these pictures. But it will only work if you keep your eyes straight ahead. If you happen to look over at the picture, please let me know. It's o.k. - it's quite natural for you to look over, because we are used to turning to look at things. But you will find that you can keep looking straight ahead with a little practice.
>
> I'm going to show you several different sets of slides, and I will give you more instructions when we get to each new set. Generally I will want you to tell me what each picture is, and to do so as quickly as you can. At the same time you say your answer, I want you to flick one of these switches. I will tell you which hand to use for each set at the time. Try flicking the switches a couple of times, just to get the feel of them. We will be going quite quickly. I would like you to give an answer for every slide. If you are not sure, guess. If you do miss an answer, it's o.k., just go on to the next one. Remember, say your answer as quickly as possible after you see the slide, and flick the switch at the same time you say your answer.

Instructions were repeated and clarified as needed to ensure that each subject understood. The specific instructions and procedures for the preliminary and experimental conditions are described below, with conditions listed in the order in which they were presented to the subjects. Subjects were given five-minute breaks between conditions, and longer breaks as needed.

Preliminary condition 1: Face identification

The main purpose of the first preliminary condition was to establish that subjects could perceive faces under the presentation conditions used in the experimental conditions. Five faces with neutral expressions were presented along with five black and white complex geometric designs. The faces were the same as those used in the experimental conditions. Each stimulus was presented twice to each visual hemifield for 50 ms and was followed by an interval of approximately five seconds. There were a total of 40 presentations.

The subjects were instructed:

> In this first set, you will be seeing pictures of faces and geometric designs. I want you to tell me whether you see a face or a design. Just say "face" if it's a face, and "design" if it's a design. If you're not sure, guess. Say your answer as quickly as you can, and flick this switch (points) at the same time that you say your answer. Remember all the while to keep looking straight ahead.

Preliminary condition 2: Gender identification

The second preliminary condition was included to establish that all subjects could perceive and label a dimension in faces other than expression. Two male and two female faces were presented twice to each visual hemifield for 50 ms. Each presentation was followed by an interval of approximately five seconds. Following the same basic framework of the

instructions in preliminary condition 1, subjects were asked to indicate the type of stimulus by saying either "male" or "female", and to flick the switch at the same time.

Preliminary condition 3: Color identification

This condition was included as another way of ensuring that subjects could perceive and label a dimension in facial stimuli other than expression. Four faces were presented twice, once in black/white and once in color (blue, red, green or yellow). Each stimulus was presented twice to each visual hemifield for 50 ms, and was followed by an interval of approximately five seconds. There were a total of 32 presentations. Using the same basic set of instructions as in preliminary condition 1, the subjects were instructed to indicate the type of stimulus by saying "color" or "black", and to simultaneously flick the switch.

Experimental conditions

The general purposes of the experimental conditions were to determine the hemispheric asymmetry, accuracy and latency, and processing style with which the subjects in the various groups identify various facial expressions, and to look for a differential effect of induced anxiety on accuracy and latency across groups.

Five faces each showing five expressions were presented. The stimuli appeared on the screen for 150 ms, and a new stimulus appeared approximately every five seconds. The five expressions were neutral, happy, sad, surprised and fearful. Faces appeared to the left or right of a card on which four emotion choices were listed vertically. The response choices were happy, sad, surprised and fearful. Neutral was not offered as a response choice. The response card remained in the center of the screen throughout the experiment.

Four conditions were given, corresponding to the presentation formats constant, correlated, orthogonal (neutral instructions) and orthogonal (anxiety instructions). In the constant condition, only one face (Ekman kit: PF) was presented; it showed each of the five expressions. In the correlated condition, each of the five expressions were on different faces (Ekman kit: C, JJ, NR, PF, WF). In the orthogonal condition, each of the five faces portrayed each of the five expressions.

Using the same basic set of instructions as in preliminary condition 1, the subjects were instructed:

> Choose the label on the response card which best fits the expression of the person in the picture. If the person looks happy, say "happy", and the same for sad, surprised and afraid. Before the orthogonal (neutral instructions; ON) condition, subjects were given the following extra instructions. "I want you to imagine that you are walking down your street one summer evening when you notice a group of people across the street.

> They are the people in these slides you will be seeing. You see that they are watching a dog. Try to imagine that the expressions you see on their faces represent their reactions to the behavior of the dog.

Before the orthogonal (anxiety instructions; OA) condition, subjects were given the following extra instructions.

> I want you to imagine that you are walking down your street one summer evening when you notice a group of people across the street. They are the people in these slides you will be seeing. You see that they are watching you. Try to imagine that the expressions you see on their faces represent their reactions to your behavior.

Completion of questionnaires

After completing the slide portion of the experiment, subjects filled out the questionnaires in the following order: Edinburgh Handedness Inventory, SADS, BDI, STAI, and, if appropriate, the PBI and Aura Questionnaire. Subjects were given help as required with these questionnaires. Subjects completed the STAI twice, once with anxiety instructions, and once with neutral instructions. The neutral and anxiety instructions from the slide portion were repeated verbatim with the introduction: "Remember, before, I asked you to imagine you were taking a walk. Well, now I want you to imagine the scene again, while you are filling out this questionnaire. Imagine you are walking down your street.... Answer this questionnaire as you would if you were in this situation." The

order of the neutral and anxiety STAI instructions was randomized across subjects. Subjects were debriefed after they finished the experiment.

## Methodological Considerations

The visual angles in the main experimental task were chosen because they produced an approximate accuracy level of 75 per cent among pilot subjects, a figure near that which Lord (1952) identified as giving the best discrimination among subjects on a four-choice task. It might have been better to use presentation angles closer to those used in other similar experiments, but then it would have been impossible to get the desired low accuracy level, at least with the available equipment. In these other studies, accuracy tends to be high because the main dependent variable is latency of accurate responses. In the present study accuracy is also of interest, and changes therein would be obscured by very high accuracy rates. The difficulty of the task is increased by widening the visual angle of presentation because that causes the images to fall nearer the periphery of the retina, where acuity is relatively low. An attempt was made to increase task difficulty by reducing the exposure time. However when the exposure time for the preliminary conditions was lowered to the minimum possible with the available equipment (50 ms), it was still impossible to decrease subjects' accuracy to the desired 75 per cent level.

It was originally proposed that a black circle would be presented to the center of the visual field during each inter-stimulus interval. For logistical reasons the response card had to serve as the

central fixation stimulus. It had also been proposed that central fixation checks would be used. A digit from one to nine was to have been presented to the center of the visual field for 150 ms. It was to have appeared randomly in lieu of a lateral stimulus presentation. If subjects could not identify the number, it would have been assumed that they were not maintaining central fixation. During the pilot study it became apparent that, contrary to what was expected on the basis of published reports (Kirouac and Doré , 1984), 150 ms offered subjects enough time to shift the eyes and look directly at the stimulus. That is, subjects could shift their eyes *after* the side stimulus had appeared. In view of this, the proposed central fixation checks were deemed inadequate. Instead subjects were asked to tell the experimenter when they looked directly at any of the stimuli.

It was impossible to directly measure physiological reactions to the anxiety instructions because of problems obtaining the necessary equipment. The STAI was not administered under the neutral and anxiety instruction conditions until after it was known that physiological recording equipment would be unavailable. Therefore there are incomplete STAI data under these conditions for the first 13 participants of the study (9 NPC, 3 DC, 1 E). A further three participants (2 NPC, 1 E) did not receive the STAI due to experimenter error. Because of a delay in obtaining the equipment to measure latency, the first 15 participants (10

NPC and 5 DC) have no latency data. The preliminary condition data for the first diabetic participant were not included in the analyses. That subject received the preliminary conditions with altered visual angles because the experimenter was trying to find a way to reduce accuracy on these conditions.

## Design Considerations

Table 1 lists the experimental variables. The order of presentation of the various experimental conditions was incompletely counterbalanced across subjects, complete counterbalancing being impossible. Hand order was also incompletely counterbalanced.

Subjects of each gender were included in an effort to maximize the generalizability of findings. Several expressions were presented for the same reason. Equal numbers of positive and negative expressions were presented in a random order so that if judgements about facial expressions were affected by previously viewed facial expressions (Thayer, 1980), they would not be biased in the positive or negative direction.

Etcoff's paradigm was included to examine the relationship of face processing to facial expression identification. If facial expression processing appeared to be independent of face processing in this experiment, then it would be more likely that the experiment tested emotional processing ability. On the other hand, if expression processing depended on face processing, then generalizations regarding emotional processing would be more difficult. Subjects in the present experiment were asked to identify facial expressions under constant, correlated and orthogonal conditions, but were not asked to identify faces. Therefore the task addressed the question of whether facial expressions could be

Table 1

Variables in the present experiment

| Dependent Variables: | Abbreviations |
|---|---|
| Accuracy | |
| Latency | |
| **Between Subjects Variables:** | |
| Group: Non-patient Control Subjects | NPC |
| Diabetic Control Subjects | DC |
| Epileptic Subjects | E |
| Gender of Subject: Male, Female | |
| **Within Subjects Variables:** | |
| Condition: Constant | CON |
| Correlated | COR |
| Orthogonal, neutral instructions | ON |
| Orthogonal, anxiety instructions | OA |
| Visual Field: | VF |
| Left, Right | LVF, RVF |
| Expression: Happiness | |
| Sadness | |
| Surprise | |
| Fear | |

processed independently of face identity, but not whether face identity could be processed independently of facial expression. On the basis of this experiment, inferences can be made about the independence of facial expression processing from face processing, but not about the independence of face processing from facial expression processing.

In the constant condition, inferences about expression processing may be limited because there is only one stimulus face. Inferences about expressions portrayed by that person are not necessarily applicable to expressions in general. In the correlated condition, expression is confounded by the face (and gender) of the person in the photograph. It would have been best to counterbalance various faces in the constant and correlated conditions across group by gender cells, however the reproduction cost was prohibitive. This problem is considered in analysing and discussing the results of analyses involving the condition factor. All hypotheses involving within subjects factors other than condition (e.g., visual field, expression) are evaluated using data from the orthogonal (ON) condition to make the results more generalizable and to free them of the face confound in the correlated condition. In the ON condition there are several faces (unlike CON) which vary independently of expression (unlike COR).

To control for the effect of the extra instructions given before the orthogonal (OA: anxiety instructions) condition, subjects received extra

instructions intended to have no effect on their anxiety level before the orthogonal (ON; neutral instructions) condition. In the CON and COR conditions, subjects received no such instructions, which creates a confound of condition (CON, COR versus ON) and instructions. However since subjects received instructions (regarding how to do the task) before every condition (CON, COR, ON, OA), it was felt that the presence of the instructions confound was the least objectionable of alternatives. The neutral instructions could have been administered before the CON and COR conditions, however in that case there would have been three sets of neutral instructions and only one set of anxiety instructions, creating another confound. More conditions could have been used. For example, all three conditions (CON, COR, orthogonal (O)) could have been administered with neutral and anxiety instructions, for a total of six conditions. Or the three conditions (CON, COR, O) could have been administered without anxiety instructions. Then two more O conditions could have been administered with neutral and anxiety instructions. However with this number of conditions, the experimental sessions would have exceeded two hours, and further counterbalancing problems would have arisen. Thus it was decided that the presence of the condition-instructions confound was the least objectionable of alternatives. The potential influence of this confound must be considered in discussing results of analyses involving the CON, COR and ON conditions.

Because neutral was not offered as a response choice, accuracy and latency of accurate responses for neutral expressions could not be obtained. Instead a count was kept of the number of times each subject used the happy, sad, surprised and fearful labels to describe a neutral expression. These data were examined for bias in the orthogonal (ON and OA) conditions. Responses to neutral expressions in the constant and correlated conditions were not analysed in the present experiment.

## Statistical Analyses

### General design and missing data

There were 32 within subjects cells defined by the four levels of condition, the two levels of visual field and the four levels of expression. The two dependent variables, accuracy and latency, were measured up to five times in each of the 32 within subjects cells. Reasons for missing values were, for example, that the subject blinked or looked at the stimulus. The reaction time for any trial was eliminated from the analyses if the flick of the switch preceeded or followed the vocal response by more than a half-second. Two per cent of trials were eliminated for this reason. Mean latency and percent accuracy were calculated for each subject for each of the 32 within subjects cells. Grand means were substituted for missing data, except when more than ten per cent of cells for a factor were empty. This case arose only for fear latency data. The value of twenty per cent of fear accuracy cells was zero. Since latency was calculated only for correct responses, twenty per cent of fear latency cells were empty. To run the analyses it would have been necessary to substitute means for these data, or omit subjects with empty cells from the analyses. The first option would lead to twenty per cent substituted data; the second would reduce the number of subjects to 16 (0 to 5 in each group by sex cell). Neither option was acceptable so the fear latency data were not analysed.

Patient Groupings

Each set of between subjects analyses (i.e., for hypotheses 4, 5, 6, and 7) was performed three times, with the levels of the group factor composed differently each time. In the first set of analyses the levels of group were NPC, DC and E. E refers to the complete group of epileptics.

In the second set of analyses the epileptic group was divided according to seizure type. There were five CPS patients and seven PGS patients. Six epileptics were excluded because they had mixed seizure types.

In the third set of analyses the epileptic group was divided on the basis of their responses on the PBI. Their PBI scores were added to the data set of a previous experiment (Perry, 1987), which included PBI scores of 114 epileptics, 91 psychiatric patients, 43 patients with a chronic illness (15 diabetics and 28 dialysis patients), and 100 nonpatient control subjects. A jackknife discriminant function analysis was performed, and each epileptic was classified as PSY (meaning that they scored like the comparison group of psychiatric patients) or NonPSY (meaning that they scored like the comparison groups of nonpatients and seizure patients). Perry (1987) found that the psychiatric comparison group scored higher than the other comparison groups on all item clusters, and therefore

represents the group with emotional and behavioral disturbance as measured by the PBI. Of the 15 epileptics who returned PBI data in the present experiment, four were classified as PSY, and the rest were classified as NonPSY.

It had been proposed that the epileptics would be subclassified on the basis of the side and nature (lesional versus nonlesional) of the seizure focus. This classification was made as far as possible on the basis of electroencephalography, computerized tomography and clinical history in collaboration with a neurologist (Dr. Mark Sadler). However it was impossible to obtain the proposed groups of left nonlesional, right nonlesional, left lesional and right lesional with ten subjects in each. Therefore no analyses examining the effects of lesions were done.

Background differences and Analysis of Covariance

Subjects were measured on several demographic and test variables as described in the Measures section. It had been decided that variance due to differences among the groups, as defined above, on appropriate demographic variables (i.e., age, education) would be removed by analysis of covariance. It would not have been appropriate to remove variance associated with differences on some of the other variables because these differences could be integral differences among groups (i.e., number

of recent hospitalizations, scores on the depression and anxiety tests). It was decided that differences on these variables would be addressed in the discussion.

Groups did not differ on most demographic and test variables, as shown in appendix E. Groups differed in number of recent hospitalizations, with all patient groups (diabetics, epilepties, CPS, PGS, PSY, NonPSY) having been hospitalized significantly more often than nonpatients. Since hospitalizations are characteristic of patients, it was not appropriate to use this variable as a covariate. CPS patients started having seizures when significantly younger than PGS patients ($t(11)=2.42$, $p<.05$), and they reported having significantly more seizures than PGS patients in the year preceeding the experiment ($t(9)=2.46$, $p<.05$). These differences may be integral to seizure type (Wilder and Schmidt, 1985), and so were not appropriate covariates.

Groups differed on two variables which were appropriate covariates, age and years of education (table 2). Therefore when group differences were analysed, these two variables were included as covariates in analyses of unstandardized residuals using the following factors and procedures. Accuracy and latency data were analysed separately in mixed model multivariate analyses of variance with repeated measures on condition, visual field and expression using the averaged tests of significance of the SPSSX MANOVA package. For totally within subjects

Table 2

Mean age and education for each group

| | NPC | | DC | | E | |
|---|---|---|---|---|---|---|
| Variable | M | SD | M | SD | M | SD |
| Age | 22.5 | 5.5 | 49.5 | 13.1 | 36.8 | 12.2 |
| Educ | 14.6 | 2.0 | 12.7 | 3.3 | 11.2 | 3.4 |

| | CPS | | PGS | |
|---|---|---|---|---|
| Variable | M | SD | M | SD |
| Age | 50.0 | 12.4 | 32.9 | 9.3 |
| Educ | 8.8 | 3.7 | 13.1 | 3.1 |

| | NonPSY | | PSY | |
|---|---|---|---|---|
| Variable | M | SD | M | SD |
| Age | 37.7 | 14.0 | 36.8 | 12.8 |
| Educ | 11.5 | 3.9 | 11.0 | 3.5 |

Note. There were significant differences among nonpatient control (NPC), diabetic control (DC) and epileptic (E) groups in age ($F(2,51)=30.75$, $p<.001$) and years of education (Educ, $F(2,51)=7.37$, $p<.005$). There were also significant differences among NPC, DC; complex partial seizure (CPS) patients and primary generalized seizure (PGS) patients in age ($F(3,47)=19.34$, $p<.001$) and education ($F(3,47)=3.84$, $p<.05$). Significant differences also arose among NPC, DC, PSY epileptics (who scored like a comparison group of psychiatry patients on the Personal Behavior Inventory) and NonPSY epileptics (who did not scores like the psychiatric group) in age and education (respectively $F(3,44)=28.95$, $p<.001$ and $F(3,44)=6.59$, $p=.001$).

analyses (e.g., hypotheses 1, 2 and 3), analysis of covariance was unnecessary. For such analyses, results using raw means were presented. For analyses involving between subjects factors (e.g., hypotheses 3, 4, 5, 6 and 7), the results of residuals analyses were presented. To investigate some of the a priori hypotheses, data were collapsed over levels of certain factors. That is, the mean of scores from different levels of a factor were used as the value for the factor.

Test assumptions

Mauchley's test revealed several violations of the sphericity assumption. The epsilon adjustments associated with the averaged tests of the SPSSX MANOVA package were employed automatically when necessary to correct as much as possible for the violations. Results of the averaged tests are thus presented here. The specific analyses used to investigate each hypothesis are described below, along with the results. MANOVA summary tables for each hypothesis are in appendix F.

## Results

Hypothesis 1. Hemispheric asymmetry of facial expression identification among non-neurological subjects

Raw accuracy and latency data obtained from non-neurological subjects (NPC and DC) in the orthogonal (ON) condition were pooled, after the three left-handed subjects were excluded. Data from only the orthogonal (ON) condition were used to avoid generalization and confound problems described above. Raw accuracy and latency means were analysed separately in three-way MANOVAs with gender, visual field and expression as the factors. Contrary to expectations, there were no significant visual field main effects or interactions involving visual field in either accuracy or latency among non-neurological subjects.

Hypothesis 2: Accuracy and latency of facial expression identification among non-neurological subjects.

Raw mean accuracy and latency data were obtained from all non-neurological subjects (NPC and DC) in the orthogonal (ON) condition. Data from the orthogonal (ON) condition were chosen to avoid confound and generalization problems discussed above. Data were collapsed across visual field of presentation and gender of subject, and entered into separate MANOVAs (for accuracy and latency) with one factor, expression.

A significant effect of expression emerged in accuracy ($F(3,105)=6.17$, $p<.005$) but not latency ($F(2,38)=.19$, $p>.05$). Using the Scheffé method of comparisons, it was found that accuracy for happy, sad and surprised expressions did not significantly differ from each other (table 3, page 70; all $F(1,105)$, $p>.05$). All three expressions were identified significantly more accurately than fearful expressions (table 3; happy versus fearful $F(1,105) = 13.5$, $p<.05$; sad versus fearful $F(1,105)=8.3$, $p<.05$; surprised versus fearful $F(1,105) = 13.7$, $p<.05$). Recall that latency data for fear expressions were not analysed due to missing data.

In keeping with other related studies, the means were also rank ordered. The expressions in order of decreasing accuracy were surprise, happiness, sadness and fear. In order of increasing latency they were happiness, surprise and sadness.

Hypothesis 3. Facial expression processing style among non-neurological subjects

Raw mean accuracy and latency data, obtained from non-neurological subjects (NPC and DC), were collapsed across visual field and gender of subject. Accuracy and latency were analysed separately in two-way MANOVAs with factors condition and expression.

Table 3

Identification of particular facial expressions by non-neurological subjects in the orthogonal (neutral instructions) condition

| | % Accuracy | | Latency (ms) | |
|---|---|---|---|---|
| Expression | M | SD | M | SD |
| Happiness | $62.06_a$ | 32.73 | 1794.78 | 1581.14 |
| Sadness | $58.63_a$ | 18.89 | 2075.40 | 1341.64 |
| Surprise | $62.36_a$ | 22.63 | 1894.45 | 1386.90 |
| Fear | $43.70_b$ | 27.63 | ---- | ---- |

Note. The non-neurological subjects were the nonpatient control and diabetic control subjects. Means with different subscripts are different at the $p<.05$ level using the Scheffé method of multiple comparisons.

Contrary to expectations, there was a significant main effect of condition ($F(2,70)=6.41$, $p<.005$), qualified by an expression by condition interaction ($F(6, 210)=3.17$, $p<.01$) among non-neurological subjects (pooled NPC and DC) in the accuracy data. The expression by condition interaction was due to the following (figure 2). Two-tailed t-tests showed that happy and sad expressions were identified with similar accuracy levels in the constant and orthogonal (ON) conditions (happy: $t(210)=.63$, $p>.05$; sad: $t(210)=.05$, $p>.05$). Accuracy in the correlated condition was significantly greater than that in the constant condition for happy ($t(210)=2.75$, $p<.05$) and sad expressions ($t(210)=2.09$, $p<.05$). Accuracy in the correlated condition was also significantly greater than that in the orthogonal (ON) condition for happy ($t(210)=3.38$, $p<.05$) and sad expressions ($t(210)=2.14$, $p<.05$). In contrast there were no significant differences in accuracy across conditions for the surprised and fearful expressions (all $t(210)$, $p>.05$).

Contrary to expectations, there was also a significant main effect of condition ($F(2,38)=4.24$, $p<.05$) in the latency data (figure 3). Two-tailed t-tests showed that non-neurological subjects correctly identified the expressions faster in the correlated condition than in the orthogonal (ON) condition ($t(38)=2.88$, $p<.05$). Latency in the constant condition was not significantly different from that in the correlated condition ($t(38)= 1.79$, $p>.05$) or the orthogonal condition ($t(38)=1.09$, $p>.05$). None of the other relevant effects were significant.

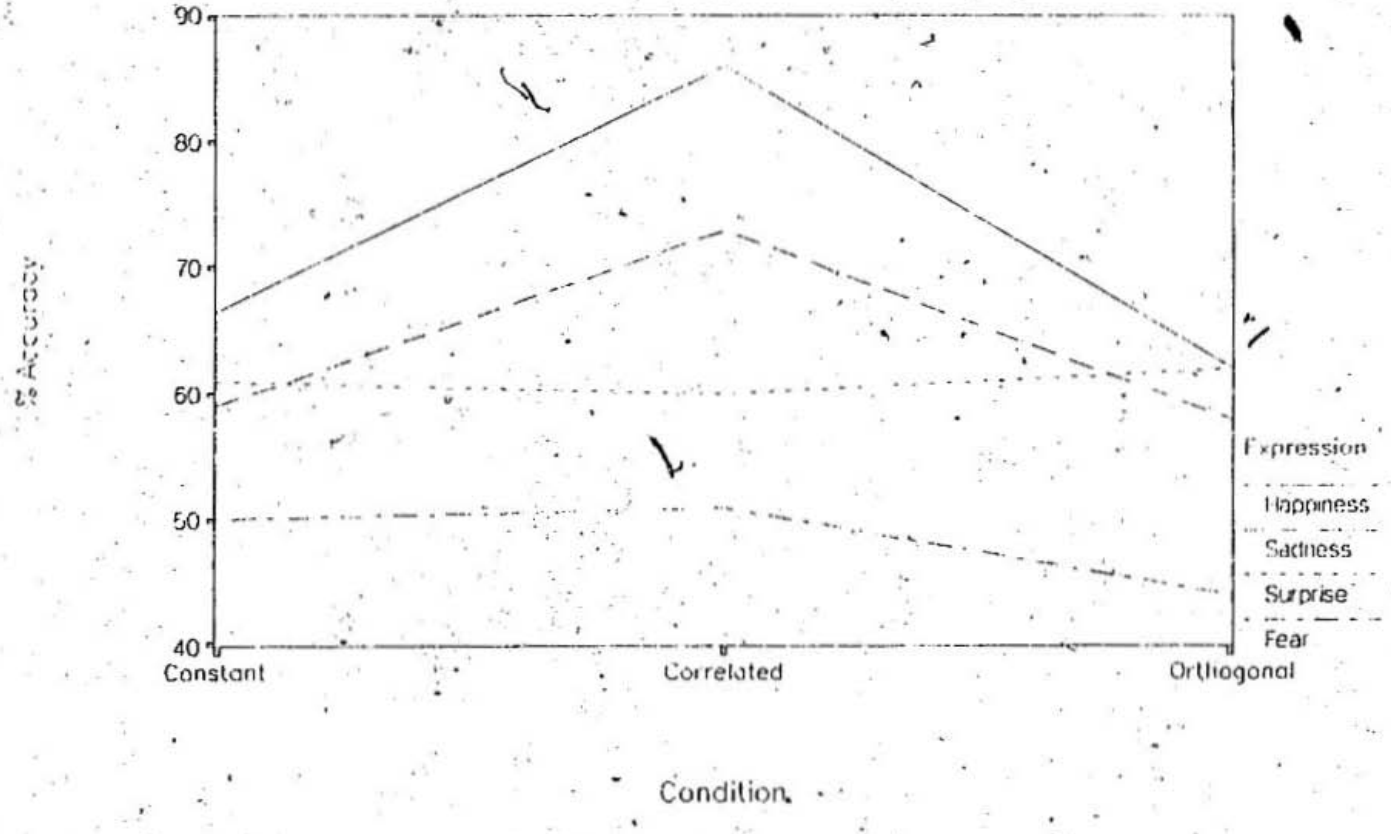


Figure 2. Accuracy across conditions for each expression among non-neurological subjects

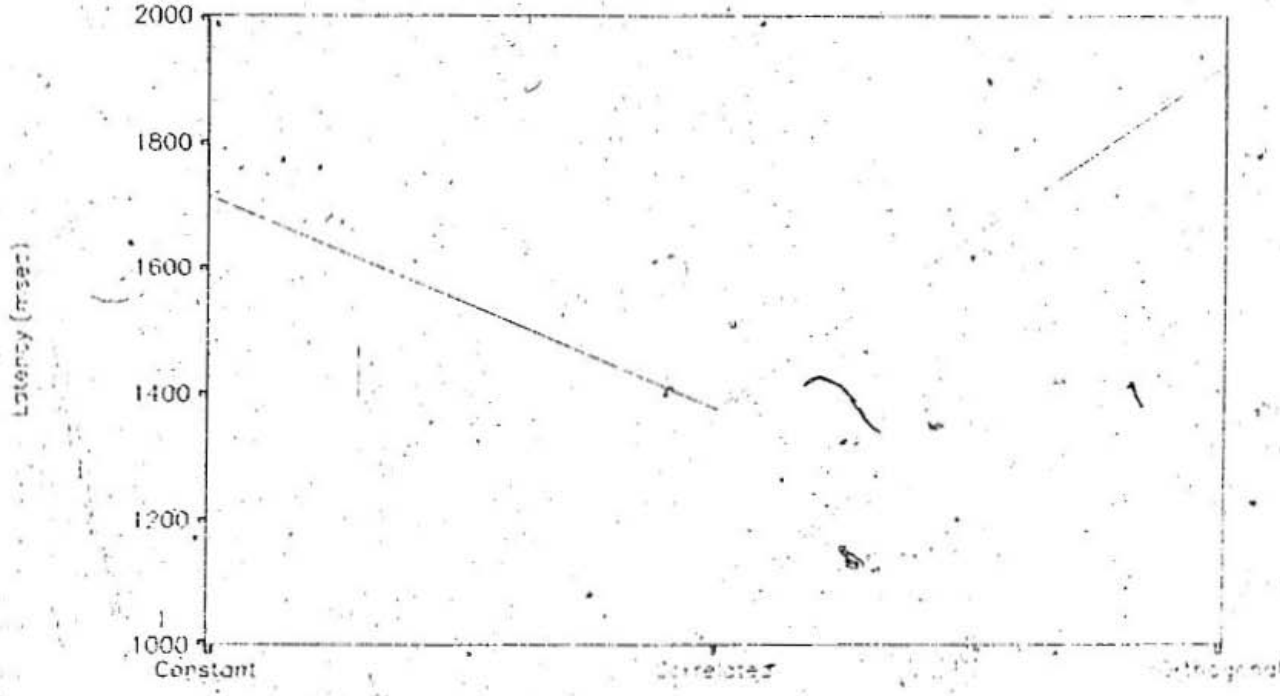


Figure 3. Latency across conditions among non-neurological subjects

Hypothesis 4. Group differences in hemispheric asymmetry of facial expression identification

It was impossible to evaluate facilitation and attraction hypotheses because of the lack of epileptics with well defined unilateral lesional and nonlesional foci. It was possible to evaluate the hypothesis that epileptics or other subgroups of epileptics would show unusual hemispheric representation of facial expression identification. The seven left-handed subjects including the three non-neurological left-handers were excluded from these analyses. Residual accuracy and latency data (i.e., with variance associated with age and education removed), obtained in the orthogonal (ON) condition, were analysed separately in four-way MANOVA's with factors gender, visual field of presentation, stimulus expression and group. Epileptics were included in the analyses, and compared to NPC and DC groups. Epileptics were grouped in three ways: (a) together as an epileptic group (E), (b) subclassified according to seizure type diagnosis (CPS and PGS), and (c) according to discriminant function classification (PSY and NonPSY). The analysis for hemispheric asymmetry was therefore performed three times.

With the inclusion of the epileptics in the analyses, no effects involving groups emerged. So epileptics and diabetics do not differ from

nonpatient controls with respect to hemispheric asymmetry of facial expression identification. With this larger number of subjects, a nearly significant main effect of visual field emerged ($F(1,42)=3.88$, $p=.055$). Expressions presented to the left visual field (right hemisphere) were identified more accurately than those presented to the right visual field (left hemisphere; $t(42)=1.97$, $p<.05$). There were no other significant main effects or interactions involving visual field in either accuracy or latency.

Hypothesis 5. Group differences in accuracy and latency of facial expression identification

Residual accuracy and latency scores (i.e., with variance due to age and education removed), obtained from all subjects in the orthogonal (ON) condition, were collapsed over visual field and gender of subject. They were then entered into separate two-way MANOVAs with factors group and expression. Data from only the orthogonal (ON) condition were used to avoid generalization and confound problems described above. These analyses were performed three times, with the three different subject groupings described above.

With group levels NPC, DC and E, analysis of accuracy and latency residuals revealed no significant group or group by expression

effects. The same was true when epileptics were subclassified on the basis of seizure type and PBI classification.

Hypothesis 6. Group differences in facial expression processing style

To evaluate style differences across groups, residual accuracy and latency scores (i.e., with variance due to age and education removed) obtained from all subjects were collapsed over visual field and gender of subject, and analysed in separate three-way MANOVAs with factors expression, condition (CON, COR, ON) and group. These analyses were performed three times, with the three different subject groupings described above. Group differences in processing style should appear as significant group by condition or group by condition by expression interactions. Neither effect was found for any of these analyses. Thus the groups did not differ in processing style.

Hypothesis 7. Group differences in response to anxiety induction

Self reported anxiety: State-Trait Anxiety Inventory results.

Residual scores (i.e., with variance due to age and education removed) on each STAI subscale (A-State, A-Trait) were analysed separately in MANOVAs with two factors: instruction condition (neutral, anxiety) and group. Analyses were done three times with the three subject

groupings described above. There were no significant main effects or interactions on either scale.

Responses to neutral faces.

Since neutral was not offered as a response choice, responses to presentations of neutral expressions could be happy, sad, surprised or fearful. The number of each of these responses by each of the subjects were converted into residual scores (i.e., with variance associated with age and education removed), and entered into separate MANOVAs for each expression. The factors in each MANOVA were instruction condition (ON, OA) and group. These analyses were performed with each of the three subject groupings described above looking for significant two-way interactions. None were found.

Analyses for differences in accuracy and latency.

Residual accuracy and latency data (i.e., with variance associated with age and education removed), obtained from all subjects, were collapsed over visual field and gender of subject, and analysed separately in two-way MANOVAs with factors condition (ON, OA) and group. The data for each expression were analysed separately to prevent obscuring of the predicted expression-specific results. Analyses were performed three times using the three subject groupings described above. The group by condition interactions are pertinent to the question of

whether the anxiety induction procedure differentially affected the performance of epileptics or certain subgroups of epileptics. Significant interactions were further analysed with one-tailed and two-tailed t-tests as appropriate with respect to the specific hypotheses. One-tailed tests were used to evaluate changes in the predicted direction.

Differences in accuracy and latency among NPC, DC and E.

On analysis of accuracy residuals, with group levels NPC, DC and E, a significant group by condition interaction emerged for identification of happy expressions ($F(2,51)=4.32$, $p<.05$). The first question is whether any of the groups showed evidence of a mood congruency effect, that is, lower accuracy of identification for happy expressions in the anxiety instructions (OA) condition relative to the neutral instructions (ON) condition. As shown in figure 4a, there was an unpredicted increase in accuracy among NPC after the anxiety instructions ($t(51)=2.88$, $p<.05$, two-tailed test). DC's accuracy did not change ($t(51)=.51$, $p>.05$) and epileptics' accuracy decreased in the OA condition relative to the ON condition ($t(51)=2.95$, $p<.05$). The second question is whether there were any group differences in accuracy of identification of happy expressions in either the ON condition or the OA condition. In the ON condition, DC and E did not differ from each other ($t(51)=.19$, $p>.05$), and together were unexpectedly more accurate than the NPC

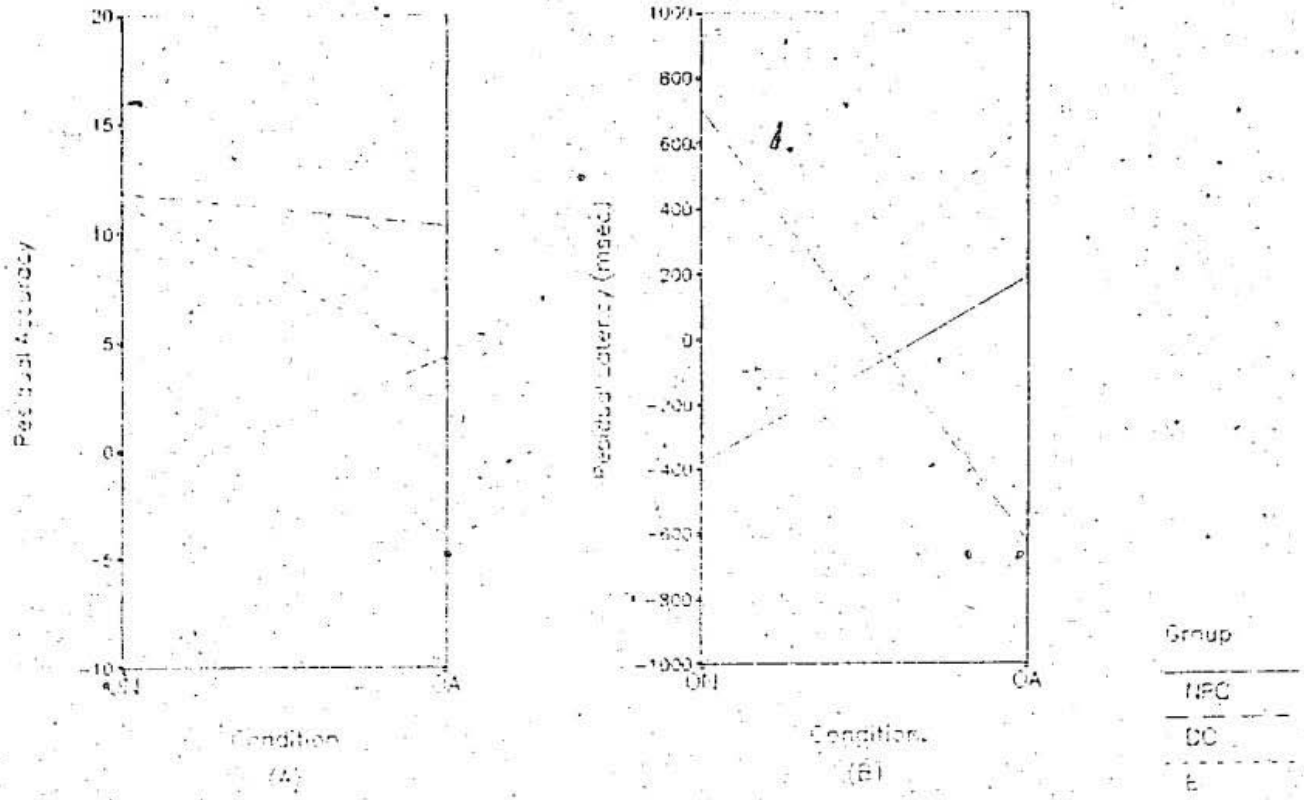


Figure 4. Identification of happy expressions by NPC, DC and E groups in the orthogonal conditions with neutral (ON) and anxiety (OA) instructions

(t(51)=6.69, p<.05, two-tailed test). In the OA condition, NPC were unexpectedly less accurate than DC (t(51)=2.35, p<.05, two-tailed test). E were significantly less accurate than DC (t(51)=2.27, p<.05). NPC and E did not differ significantly from each other (t(51)=.06, p>.05).

Analysis of latency residuals, with group levels NPC, DC and E, also revealed a significant group by condition interaction for identification of happy expressions (F(2,35)=5.21, p<.05). Again the first question is whether there was evidence of mood congruency among any of the groups, that is, longer latencies for identification of happy expressions in the OA condition relative to the ON condition. As shown in figure 4b on page 79, NPC showed a predicted increase in latency after the anxiety instructions (t(35)=1.79, p<.05), as did the E (t(35)=3.61, p<.05). Diabetics identified happy expressions faster after anxiety induction, a significant effect which was not predicted (t(35)=3.08, p<.05, two-tailed test). The second question is whether there were any group differences in latency of identification of happy expressions in either the ON or OA condition. In the ON condition the DC were significantly slower than the NPC (t(35)=2.86, p<.05). Unexpectedly they were also significantly slower than the E (t(35)=2.80, p<.05, two-tailed test). The NPC and E did not differ significantly from each other (t(35)=.25, p>.05). In the OA condition the DC were significantly faster than the E (t(35)=3.42, p<.05). Unexpectedly the DC were also significantly faster than the NPC

(t(35)=2.15, p<.05. two-tailed test). The NPC and E did not differ significantly from each other in this condition (t(35)=1.63, p>.05).

Differences in accuracy and latency among NPC, DC, CPS and PGS.

Analysis of accuracy residuals, with the epileptic group divided on the basis of seizure type revealed no significant effects. There was a significant group by condition interaction for happy expressions in the residual latency data however (F(3,28)=3.08, p<.05; figure 5). The data for each group were examined for evidence of a mood congruency effect; that is longer latencies for identification of happy expressions in the OA condition relative to the ON condition. The NPC showed a significant increase in latency after the anxiety induction (t(28)=1.82, p<.05), as did the CPS (t(28)=2.01. p<.05). The DC showed an unexpected decrease in latency after the anxiety instructions (t(28)=3.15, p<.05, two-tailed test). The PGS showed no significant difference in latency across instruction conditions (t(28)=1.69, p>.05). The data within each condition were examined for group differences. In the ON condition, the NPC were faster than the DC (t(28)=3.52, p<.05). Unexpectedly the PGS were also faster than the DC (t(28)=2.69, p<.05, two-tailed test). DC and CPS did not differ in latency (t(28)=1.66, p>.05). In the OA condition, the NPC were unexpectedly slower than the DC (t(28)=2.66, p<.05, two-tailed test). The PGS were also unexpectedly slower than the DC (t(28)=2.15, p<.05. two-

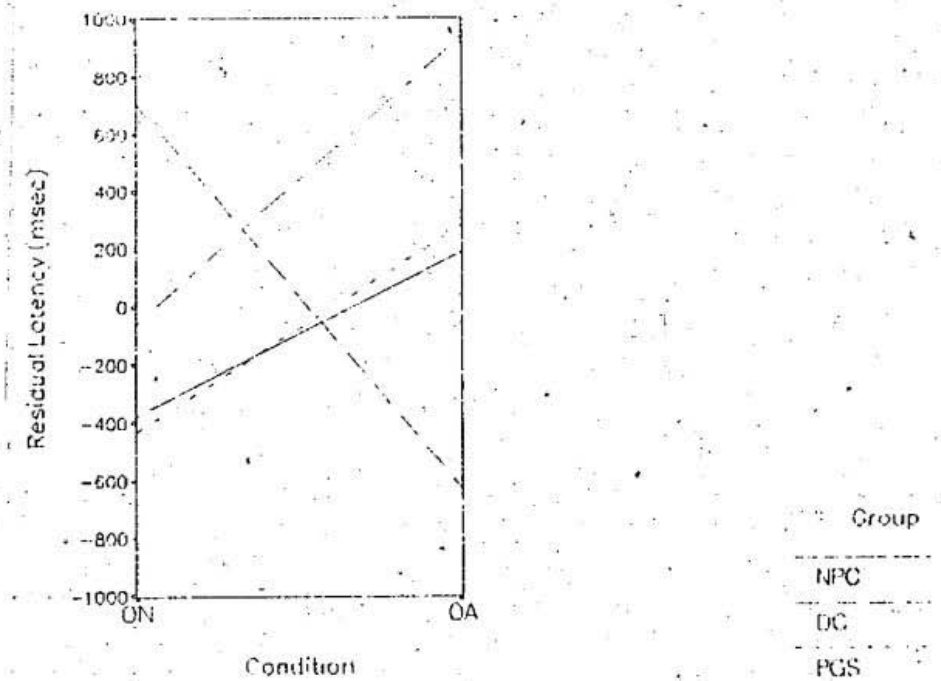


Figure 5. Identification of happy expressions by NPC, DC, PGS and CPS groups in the orthogonal conditions with neutral (ON) and anxiety (OA) instructions.

tailed test). As predicted the CPS were also slower than the DC ($t(28)=3.38$, $p<.05$). Thus the DC responded differently than the other subjects to the anxiety induction by identifying happy expressions faster, according to this set of analyses. This finding will not be further discussed because it does not relate to any of the patient groups who were targeted for investigation of possibly abnormal results (chronically ill people [DC and E], epileptics and epileptic subgroups [CPS and PSY]).

Differences in accuracy and latency among NPC, DC, NonPSY and PSY.

Analysis with the epileptic group defined according to their PBI classification revealed a significant group by condition interaction for identification of happy expressions for both residual accuracy ($F(3,47)=3.62$, $p<.05$) and residual latency ($F(3,31)=3.82$, $p<.05$). The accuracy of each group was compared across instruction conditions, looking for evidence of a mood congruency effect. As shown in figure 6a, NPC subjects unexpectedly identified happy expressions more accurately after the anxiety instruction ($t(47)=2.85$, $p<.01$, two-tailed test). DC subjects and NonPSY epileptics showed no change in accuracy across neutral and anxiety instruction conditions (respectively $t(47)= 0.40$, $p>.05$, and $t(47)=1.04$, $p>.05$). PSY epileptics identified happy expressions significantly less accurately after anxiety induction as predicted ($t(47)=4.23$, $p<.001$). So it is the PSY subgroup of epileptics which

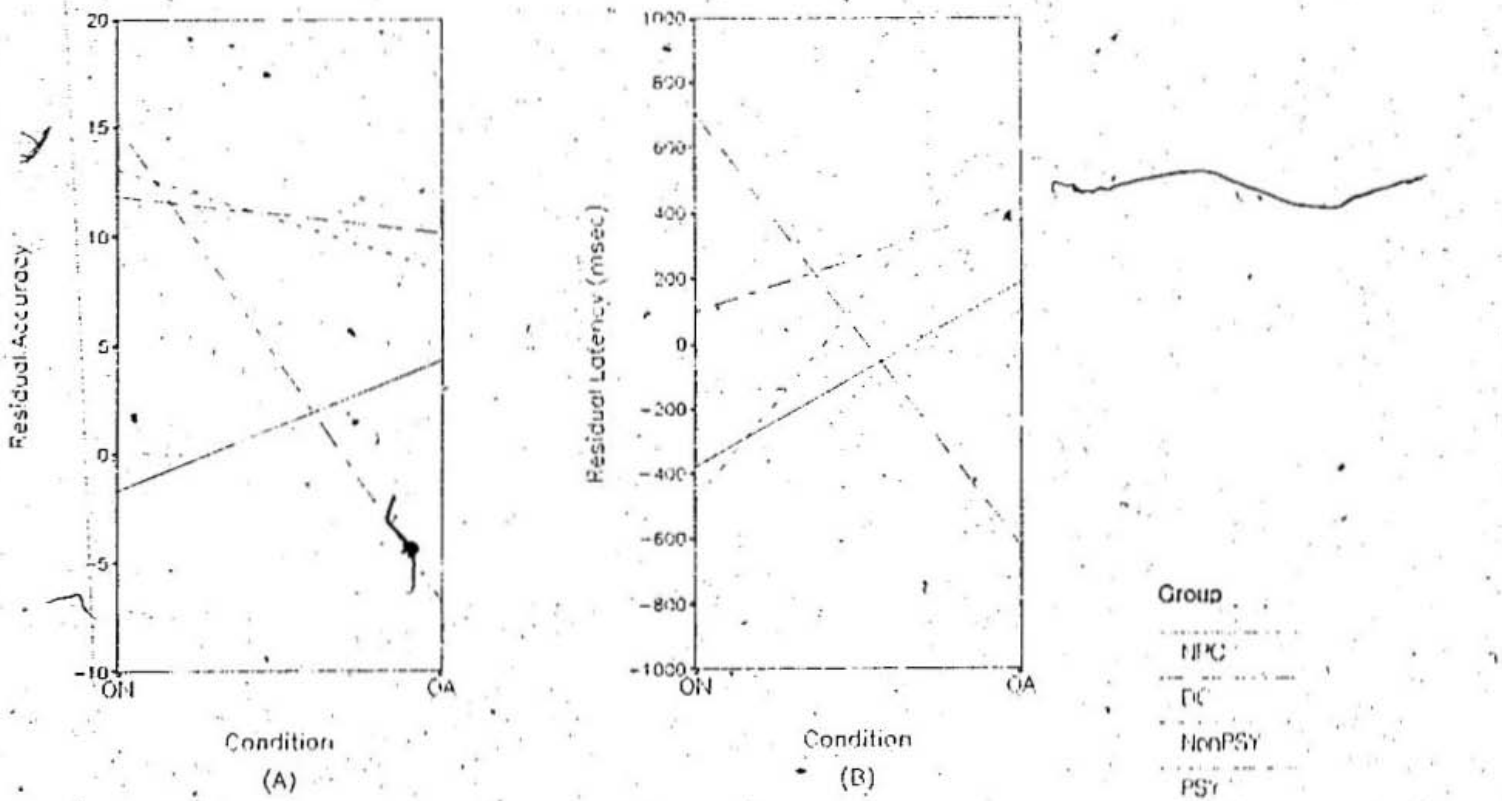


Figure 6. Identification of happy expressions by NPC, DC, PSY and NonPSY groups in the orthogonal conditions with neutral (ON) and anxiety (OA) instructions

accounts for the accuracy decrease presented above for epileptics considered as a group (figure 4a; page 79).

The groups' accuracy levels within each instruction condition were compared. In the ON condition, the NPC were unexpectedly less accurate than the DC ($t(47)=5.22$, $p<.001$, two-tailed test). DC did not differ in accuracy from NonPSY ($t(47)=.38$, $p>.05$) or PSY epileptics ($t(47)=.77$, $p>.05$). NonPSY and PSY did not differ from each other ($t(47)=.49$, $p>.05$). Patients' data were pooled (DC, NonPSY, PSY), and it was found that, counter to predictions, patients were more accurate than NPC ($t(47)=7.30$, $p<.001$, two-tailed test).

In OA, PSY were significantly less accurate than NPC ($t(47)=2.82$, $p<.05$), DC ($t(47)=4.00$, $p<.05$), and NonPSY ($t(47)=3.60$, $p<.05$). The NPC were unexpectedly less accurate than the DC ($t(47)=2.24$, $p<.05$, two-tailed test). DC did not differ from NonPSY ($t(47)=.56$, $p>.05$).

With respect to latency, the first question is again whether any of the groups showed evidence of a mood congruency effect, that is, longer latencies for identification of happy expressions in the OA condition relative to the ON condition. As shown in figure 6b on page 84, NPC subjects and PSY epileptics showed no change in latency of identification of happy expressions across anxiety instruction conditions (respectively $t(32)=1.25$, $p>.05$ and $t(32)=.40$, $p>.05$). Unexpectedly the DCs' latency

decreased after the anxiety instructions ($t(31)=2.15$, $p<.05$, two-tailed test). NonPSY epileptics were slower after anxiety induction ($t(32)=2.47$, $p<.05$).

The second question is whether the groups differed from each other in either of the instruction conditions. In the ON condition, NPC were significantly faster than DC ($t(31)=1.99$, $p<.05$). The DC were unexpectedly slower than NonPSY ($t(31)=2.12$, $p<.05$, two-tailed test) but not significantly different from PSY ($t(31)=.83$, $p>.05$). The PSY did not differ significantly from the NonPSY ($t(31)=.86$, $p>.05$). The NPC did not differ significantly from the PSY ($t(31)=.72$, $p>.05$) or the NonPSY ($t(31)=.20$, $p>.05$).

In the OA condition, NPC and DC did not differ from each other ($t(31)=1.50$, $p>.05$). Together they did not differ from NonPSY ($t(31)=1.10$, $p>.05$). These groups combined (NPC, DC and NonPSY) did not differ from PSY epileptics ($t(31)=.54$, $p>.05$). It should be noted that whereas the NonPSY epileptics' latency increased with the anxiety instructions, they were not slower than the other groups in the OA condition. Since this cannot be considered a clear instance of deficient performance it will not be further discussed.

Further analyses.

In view of accuracy results from the analyses of hypothesis 7, some further analyses were performed to examine for bias in the incorrect identifications of happy expressions. The number of incorrect identifications of happy as sad, surprised or fearful in the ON and OA condition were entered into a MANOVA with factors, expression, instructions condition (ON, OA) and group. This analysis was performed using each of the three subject groupings, and variance associated with age and education was removed for each analysis. The results were examined for significant group by expression by condition interactions, but none were found.

It is possible that the specificity of the accuracy findings with groups NPC, DC, NonPSY and PSY to happy expressions might be some effect of a greater potential of happy expressions to discriminate among groups. Therefore further analyses were performed to determine whether all expressions had equal potential to discriminate among groups. To be equally good discriminators, mean accuracy should not differ across expressions when the data are collapsed over the relevant between subjects factors. Residual accuracy data from the ON condition, obtained from all subjects in groups NPC, DC, NonPSY and PSY, were collapsed over group and gender, and entered into a MANOVA with one factor, expression. The same was done for residual accuracy data from the OA condition.

In the ON condition there was a significant main effect of expression ($F(3,150)=9.06$, $p<.001$). Since a high false negative rate made a Scheffé test undesirable for this particular analysis, accuracy for the expressions was compared using simple t-tests (table 4). This analysis showed that happy, sad and surprised expressions did not significantly differ in accuracy of identification. Fear was identified significantly less accurately than each of the other expressions, happiness ($t(150)=4.40$, $p<.001$, two-tailed test), sadness ($t(150)=3.04$, $p<.005$, two-tailed test) and surprise ($t(150)=4.19$, $p<.001$, two-tailed test). Thus mean accuracy of identification did not differ significantly among happy, sad and surprised expressions in the ON condition. In the OA condition there was also a significant main effect of expression ($F(3,150)=16.73$, $p<.001$). T-tests showed that accuracy levels for happy and surprised expressions did not significantly differ from each other, and were significantly higher than those for sad and fearful expressions. Accuracy levels for sad and fearful expressions did not differ significantly from each other. Thus happy and surprised expressions did not differ in accuracy of identification in the OA condition. These findings suggest that happy, sad and surprised expressions had equal potential to discriminate among groups in the ON condition, and that happy and surprised expressions had equal potential to discriminate among groups in the OA condition.

Table 4

Residual accuracy for each expression in the orthogonal conditions (N = 51)

| | ON | | OA | |
|---|---|---|---|---|
| Expression | M | SD | M | SD |
| Happiness | $3.5_a$ | 31.2 | $3.7_c$ | 27.2 |
| Sadness | $-3.8_a$ | 20.9 | $-12.0_d$ | 18.9 |
| Surprise | $2.5_a$ | 22.7 | $4.0_c$ | 21.4 |
| Fear | $-15.4_b$ | 27.6 | $-17.1_d$ | 26.0 |

Note. Subjects were from the nonpatient control group (NPC), the diabetic control group (DC) and and two epileptic subgroups. Epileptics were subgrouped according to whether they scored on the Personal Behavior Inventory like a comparison group of psychiatry patients (PSY) or unlike the psychiatry patients (NonPSY). Groups differed in age and education so variance associated with these variables was removed using analysis of unstandardized residuals. Mean data were collapsed over the group factor and were compared within Orthogonal-Neutral (ON) and Orthogonal-Anxiety (OA) instruction conditions. Means with different subscripts differed significantly from each other at $p < .05$.

Preliminary conditions

Residual accuracy data (i.e., with variance associated with age and education removed) were analysed separately in MANOVAs with one factor, group. These analyses were performed three times for each preliminary condition, with the three subject groupings described above.

There were no significant differences among groups in preliminary condition 1. This shows that subjects were equally able to differentiate faces from geometric designs at the angles and durations of presentation used in the experimental conditions.

In preliminary condition 2, with group levels NPC, DC, PSY and NonPSY, there was a nearly significant main effect of group ($F(3,44)=2.70$, $p=.057$). This indicates that one or more groups were somewhat less accurate in discriminating males from females with 50 ms exposures in the present experimental set-up. Thus if a deficit in identifying all expressions were to appear among these groups in the experimental conditions, it could be attributed to visual discrimination problems. Such an attribution would have to be qualified because of the difference in exposure duration between the preliminary and experimental conditions. As will become evident, the situation did not arise in which such an attribution would be made. No other group main effects approached significance in preliminary condition 2.

In preliminary condition 3, with group levels NPC, DC, PSY and NonPSY, there was a significant main effect of group ($F(3,44)=3.62$, $p<.05$) One-tailed t-tests showed that NPC were significantly more accurate than DC ($t(44)=2.68$, $p<.01$). DC and NonPSY did not differ from each other ($t(44)=1.43$, $p>.05$), however the DC were more accurate than the PSY ($t(44)=2.86$, $p<.005$), and NonPSY were also significantly more accurate than the PSY ($t(44)=3.91$, $p<.001$). The findings suggests that the people with a chronic illness were less able to discriminate colored from black and white slides with the present experimental set-up. The PSY epileptics in particular performed more poorly than all the other groups. Thus if a deficit in identifying all expressions were to appear among the chronically ill subjects or PSY epileptics in the experimental conditions, it could be attributed to visual discrimination problems. Such an attribution would have to be qualified because of the difference in exposure duration between the preliminary and experimental conditions. As will become evident, the need to make this type of attribution did not arise. There were no other significant group main effects in condition 3.

## Discussion

Hypotheses 1 and 4. Hemispheric asymmetry of facial expression identification among non-neurological and epileptic subjects

The epileptics and epileptic subgroups did not differ from the non-neurological subjects in hemispheric asymmetry for facial expression processing, suggesting that their neurological abnormalities were insufficient to affect performance on that variable. With the inclusion of the epileptics' data in the analyses, the predicted superiority of the right hemisphere emerged, probably because of the larger sample size and/or decreased variability. It is probably reasonable to accept the right hemisphere superiority as characteristic of the general populations from which the subjects were chosen.

The finding of a right hemisphere superiority for facial expression processing with the present experimental set-up, is in keeping with the consensus from the literature. The lack of significant interaction between visual field and expression supports the idea that the right hemisphere is superior for identifying both positive and negative facial expressions. As Ley and Strauss (1986) point out, most studies showing valence specificity (Reuter-Lorenz and Davidson, 1981; Reuter-Lorenz et al., 1983) have used a unique expression detection paradigm.

Although evidence of right hemispheric superiority emerged, it was not a robust finding. There are a number of possible reasons for the weakness of the finding. It might be suggested that the visual field main effect was obscured because the subjects moved their eyes after stimulus presentation, thus exposing the stimulus to both hemispheres; however this is probably not the case. Although the exposure duration of 150 ms afforded subjects in this study enough time to look directly at the stimulus, they appear to have done so only occasionally. As requested, subjects reported occasions when they looked directly at the stimulus, and data from those trials were eliminated from the analyses. Bryden also reports (personal communication in Strauss and Moscovitch, 1981) that subjects usually do not move their eyes after stimulus presentation. Even if they do look at the stimulus directly and fail to report it, the test of hemispheric advantage is probably still valid. As Strauss and Moscovitch (1981) note, the stimulus is still presented initially to one hemisphere only.

Use of a verbal response mode of expression labelling may have diluted the right hemisphere superiority. Thompson (1983) and Hirschman and Safer (1982), who found no significant hemispheric asymmetry, noted that this may have been the cause. In fact, in several studies in which visual field effects emerged, nonverbal (key press) or categorization (same-different) response modes were used (Hansch and Pirozzolo, 1980; Ladavas et al., 1980; Reuter-Lorenz and Davidson, 1981; Reuter-Lorenz et al., 1983; Safer, 1981; Suberi and McKeever, 1977).

Alternatively, the weakness of the visual field effect may be due to involvement of the left hemisphere in the task in analyzing the stimuli. Some subjects said that they saw or attended to only the eyes or mouth, whereas others said that they performed the task by forming a general impression. Analytic strategies may be prompted among some subjects because the difficulty level of this particular task is especially high due the extreme visual angles of presentation. Unable to appreciate the complete stimulus, some subjects may resort to single feature analysis. Patterson and Bradshaw (1975) suggested that difficult same-different judgements about faces (though not necessarily facial expressions) are performed better by the left hemisphere, probably with an analytic strategy, and that easy same-different judgements were performed better by the right hemisphere, probably with a gestalt matching strategy. Thus the subjects' different strategies (analytical/holistic) may have obscured the overall right hemisphere advantage. If so, then similar experiments may produce a strong right hemisphere advantage because the difficulty of perception is low compared to that in the present experiment, and this permits impressionistic or holistic processing by the majority of subjects. This implies that the right hemisphere advantage in the accurate processing of facial affect represents a preference rather than a necessity, and that the choice of strategy depends on the difficulty of the task.

The lack of visual field findings in the latency data may be due to insensitivity of latency, as measured in this study, to hemispheric differences. Findings of hemispheric superiority in other studies rested on differences in latency of several hundred milliseconds on left versus right presentations. Thus the superiority is very subtle. In the present method of latency measurement, the time interval presumably reflects time for identification rather than recognition as in other studies. Maybe the longer latencies obscured a subtle hemispheric difference.

In conclusion the present results do not contradict the idea that the right hemisphere is superior for identifying facial expressions, regardless of the positive or negative valence of those expressions and regardless of subject gender. The weakness of the visual field effects may be due to contamination of the facial expression processing with verbal and/or analytical processing. The nonsignificance in the latency data may result from insensitivity of the particular latency measurement procedure used in the present study. There are apparently no differences in hemispheric asymmetry of facial expression identification among epileptics, subgroups of epileptics (CPS, PSY) or medical patients (DC and E) relative to appropriate control subjects.

Hypothesis 2. Accuracy and latency of facial expression identification among non-neurological subjects

In the present study, the order of decreasing accuracy for the expressions was surprise, happiness, sadness and fear; the order of increasing latency was happiness, surprise and sadness, though the differences were not significant in all cases. These findings conform in part to those of previous studies. One common finding in other studies is that happy expressions are identified most accurately and/or most quickly (Hirschman and Safer, 1982; Kirouac and Doré 1983; Ladavas et al., 1980; Mandal and Palchoudhury, 1985; Strauss and Moscovitch, 1981; Thompson, 1983). In the present experiment accuracy and latency for happy expressions were not markedly better than that for other expressions. Better accuracy and latency with happy expressions may have been prohibited by ceiling and floor effects respectively, imposed by the extreme visual angles of presentation used. With these visual angles, images fell on a part of the retina which has relatively low acuity. Therefore the present accuracy and latency levels may represent maximal performance.

In the present study, expressions of fear were identified significantly less accurately than other expressions. Kirouac and Doré (1983, 1984), Hirschman and Safer (1982) and Ladavas et al. (1980) also found that fear expressions were more difficult to identify than the three other expressions, though the differences were not necessarily

statistically significant. Mandal and Palchoudhury (1985) alone found that surprise was identified less accurately than fear, though again the difference was not statistically significant. It appears that identification and recognition of fear is relatively difficult, regardless of the particular experimental procedures used.

In summary the present findings are consistent with previous ones in part. The failure of subjects to identify happy expressions with higher accuracy may be explained as a ceiling effect. Rank ordering of mean latencies reveals the expected superiority for happy expressions. Fear was identified significantly less accurately than any other expression, as in most other studies.

Hypothesis 3. Facial expression processing style among non-neurological subjects

The observed pattern of accuracy across conditions among non-neurological subjects for happy and sad expressions is like Garner's (1976) optionally independent or asymmetrically independent styles. (Compare figure 1 and figure 2). Accuracy levels in the constant and orthogonal conditions were not significantly different from each other and were low relative to performance in the correlated condition. This is a style of processing in which covariation of dimensions can be used to facilitate

performance with respect to the constant condition, whereas orthogonal variation of dimensions has no effect. Since face was never used as the target dimension in the present thesis, it is impossible to say how faces would have been processed with respect to facial expressions. That is, it is impossible to say whether the style is actually optionally independent or asymmetrically independent. Therefore the style will be called optionally/asymmetrically independent in this discussion.

To be confident of the optionally/asymmetrically independent explanation, the low accuracy in the CON condition must not be spurious. It might be suggested that the low accuracy in the CON condition was due to some peculiarity of the particular face used in that condition. However all photographs obtained from Ekman's (1976) kit have been found to be reliably identifiable. Ekman (1976) found an accuracy rate of 93 to 100 per cent for identifying the expressions on the face used in constant condition of the present study. Therefore there is no good reason to suspect that the low accuracy derived from the face stimulus used.

In addition, to be confident of the optionally/asymmetrically independent explanation, lack of orthogonal interference must not be a floor effect. That is, the condition must not be so easy that motivated subjects necessarily perform well. There is some suggestion that there is no floor effect because of the fact that the subjects showed lower accuracy in the ON condition for fearful expressions, however this does not necessarily

mean they could have been less accurate with happy or sad expressions. Also, in view of the confounding of instructions and condition, the interpretations involving the ON condition can only be tentative.

Although other explanations are not precluded, the accuracy data suggest that happy and sad expressions were processed with an optionally/asymmetrically independent style. It may be speculated that such a style reflects use of an integral processing style combined with a performance limit on processing the non-target dimension (i.e., face in this case). Presumably the performance limit becomes evident only when complexity in the non-target dimension passes a critical level. This level may be attained in the orthogonal condition in the following way. Assume that when one attends to face information, one also attends to facial expression information, and vice versa. In other words, the stimuli are processed as wholes. Presumably then, the complexity of the stimuli is determined by the number of dimensions and the number of levels of each dimension. In the constant condition there are four expressions and one face, so the stimulus processing load is relatively small with only four levels. In the correlated condition there are four faces with one expression per face, so again there are only four levels and the stimulus processing load is quite small. In the orthogonal condition, assuming the stimuli are processed as wholes, the stimulus processing load is relatively high with four levels of face and four levels of facial expression for a total of sixteen

levels of the stimuli. It may be that with complexity of this magnitude non-target information is not processed efficiently; it is effectively ignored. Therefore orthogonal interference decreases from that expected for an integral processing style. That is, subjects are better able to identify the affect in the orthogonal condition than an integral processing strategy would normally allow. Facilitation still occurs in the correlated condition because with only four levels there is not enough stimulus complexity to create a performance limit on face processing. Facilitation emerges as the normal effect of redundancy with an integral processing style. This performance limit could explain how the optionally/asymmetrically independent style might arise.

The reason for the absence of facilitation of accuracy for surprised and fearful expressions in the correlated condition is not readily apparent. Since surprised and fearful expressions appear to have been identified with an independent style with respect to the face dimension, it may be that style of processing depends at least in part on the facial expression. However since the latency data suggest that all expressions were processed with a dependent style, it may be that some unknown factor prevented the emergence of evidence of a dependent style for these two expressions.

The results of the latency analysis for non-neurological subjects suggest that they used an integral strategy for all expressions. These

results are not inconsistent with the idea derived from the accuracy analysis that processing of facial expression and face dimensions may have been dependent in some manner on processing of the face, at least for some expressions. Given the confounding of instructions and condition, it is impossible to state with certainty the type of processing used.

Etcoff (1984) found that happy and sad expressions can be processed with an independent style, however this is not necessarily always the case. Possibly the style of processing varies depending on external factors such as method of presentation, given the differences in method between Etcoff's (1984) study and the present one.

These findings are hard to interpret due to the confounding of instructions and condition. In summary, however, the results suggest that non-neurological subjects can use independent, optionally/asymmetrically independent and integral styles of processing facial expression in relation to the face dimension. The style may depend on the method of presentation of the stimuli (i.e., card sort versus unilateral slide presentations), the expression portrayed by the face and/or the dependent measure (accuracy or latency).

Hypotheses 5 and 6. Group differences in accuracy, latency and style of facial expression processing

There was no evidence of abnormalities in accuracy or latency of facial expression identification among epileptics, subgroups of epileptics (i.e., CPS, PSY), and chronically ill people (DC and E) relative to appropriate control subjects. As mentioned above, neither was there any evidence of abnormal hemispheric representation of facial expression identification among these groups. Though the particular style used by the subjects in the present study cannot be definitely identified, there were no group differences in style. It is impossible to know whether group differences would have emerged, had there been no confounding of condition and instructions.

The present findings suggest that epileptics and subgroups of epileptics can interpret this form of social communication as well as others, at least with the present experimental set-up. Further, they do not differ from comparison subjects in hemispheric representation or processing style in the present study. There is some suggestion that epileptics in one subgroup in the present study were experiencing a measure of depression. Although the groups' BDI scores did not differ, four of the epileptics were classified as scoring like a comparison group of psychiatric patients on the PBI, and Perry (1987) found that PBI items relating to depression are the most powerful discriminators of psychiatric and non-psychiatric groups. In

view of these findings, the lack of abnormality in facial expression processing suggests that depression and social rejection among epileptics probably does not arise from any basic abnormality in their ability, style, or hemispheric representation of facial expression identification. However some epileptics do show evidence of facial expression processing difficulty under certain conditions, as described below.

Hypothesis 7. Group differences in response to anxiety induction

In identifying happy expressions, NPC subjects were more accurate after the anxiety instructions, though their latency did not change. Diabetics' latency decreased, though their accuracy did not change. Thus both control groups improved their performance on one measure, and showed no change on the other. The epileptics showed a significant decrease in accuracy of identifying happy expressions in response to the anxiety instructions, however in neither the ON nor OA condition was their accuracy significantly lower than that of appropriate control groups. Thus no clear accuracy deficit can be attributed to the epileptic group as a whole or to chronically ill people (DC and E). The epileptics showed a significant increase in latency, however their latency was not significantly different from that of NPC or DC in the ON condition, and was not significantly different from that of NPC in the OA condition. Therefore the

epileptic group and chronically ill people (DC and E) showed no clear abnormality of identification of happy expressions in response to the anxiety induction in either accuracy or latency.

Was there any disruption of performance among epileptic subgroups? It has been suggested that CPS patients are more likely than other seizure patients to have enhanced emotional responsiveness and other emotional problems. If so then it was hypothesized that they might be more susceptible to the anxiety induction procedure. However CPS patients showed no effect of the anxiety induction on either the expression identification task or the STAI A-State scale. This supports the notion that it would be unjust to attribute to CPS patients any special vulnerability to the experimental anxiety instructions. It is still tenable that epileptics with limbic epileptiform activity are more prone to emotional difficulties, including anxiety vulnerability. It may be that those with limbic epileptiform activity are not accurately identified by seizure type. Thus the epileptics were grouped according to PBI scores, and a discussion of the results of these analyses follows.

A decrease in accuracy following the anxiety induction was found for epileptics, but it was actually due to a decrease in accuracy among the PSY subgroup. The NonPSY epileptics showed no change in accuracy in response to the anxiety induction, whereas the PSY epileptics became significantly less accurate after the anxiety induction, and their

accuracy in the OA condition was significantly lower than that of the comparison groups combined (NPC, DC, NonPSY). This can be considered a clear instance of impaired performance among the PSY epileptics. Thus subdivision of the epileptic group on the basis of PBI scores reveals that the PSY subgroup may be particularly vulnerable to the effects of anxiety induction on accuracy of identification of happy facial expressions, and that this vulnerability should not be attributed to the epileptic group as a whole.

It may be that the instructions generated more anxiety among PSY epileptics than among comparison subjects, or that the comparison subjects were better able to function under the stress condition. Since the STAI A-State scores did not increase, it may be that the anxiety induction did not work. However there are other possibilities. As Weinberger, Schwartz and Davidson (1979) noted, people may show high anxiety-related arousal on physiological measures, even though they say they are not anxious on self-report tests. Also the anxiety instructions were first given just before subjects started to identify expressions in the relevant conditions. They were repeated just before subjects completed the STAI. It may be that anxiety produced by the first instruction inoculated the subjects against further upset. It is possible that the anxiety instructions induced some mood other than anxiety, such as sadness or anger. However if sadness

were induced one might expect to find a sadness bias to incorrect identifications of happy expressions, and this was not apparent. Simultaneous physiological recording would have provided a more immediate and cognition-free test of the emotional state at the time of slide presentation.

It is unlikely that the specificity of the PSY epileptics' difficulty to happy expressions is spurious. Analyses suggested that the potential of happy expressions to discriminate among groups was equalled by at least one other expression in each of ON and OA conditions. Since the PSY epileptics were able to identify these expressions (and others) as accurately as other subjects in both instruction conditions, the difficulty they showed with happy expressions is probably truly an expression-specific effect. This suggests that the problem with happy expressions is not due to drugs, drowsiness or other external variables which would produce a more general depression of performance. It also suggests that the anxiety instructions did not increase arousal enough to disrupt performance generally, an effect predicted by the inverted U hypothesis.

The expression specificity may reflect a real deficit among PSY epileptics in identifying smiling reactions to themselves. They can identify happy expressions as accurately as comparison subjects when the expressions are not supposed to be reactions to them. Since incorrect responses to happy expressions showed no bias towards fearful or sad and

fearful responding among PSY epileptics, it is probably not the case that the increase in errors is caused by enhanced (anxious or negative) mood congruency among PSY epileptics. The decline in accuracy for happy expressions is not likely a product of an anxiety level which is so high that it interferes with performance. To substantiate such an explanation the decline in performance would again have to be more general.

It is possible that the PSY epileptics' failure to identify smiling faces reflects a tendency on their part to fail to perceive pleased reactions to themselves. Mittan and Locke (1982) found that 67 per cent of their sample of 147 epileptics reported that others' reactions contributed greatly to their social problems, even more than the seizures themselves. Forty-one per cent of epileptics said that others made them feel different. Since epileptics report that others react negatively to them, they may develop expectations of negative reactions. This would concur with the idea that when the PSY epileptics in the present study were asked to imagine the expressions represented reactions to them, they did not perceive the happy faces accurately.

In any case it appears that among PSY epileptics, but not comparison subjects, the anxiety instructions disrupted accuracy of interpreting a specific instance of positive social communication. If the subjects' reactions in the experimental situation reflect their behavior in real social situations, this finding could suggest a potential source of

disturbance in the social interactions of PSY epileptics. They may become more anxious in response to perceived evaluation by others in social situations, and their anxiety may disrupt their responses to some instances of positive social communication. This could cause them to make inappropriate responses to positive nonverbal communication, and cause others to evaluate them more negatively (a self-fulfilling prophecy). The PSY epileptic may eventually avoid some social situations, which may lead to more social anxiety and depression.

It appears that those epileptics who responded like the comparison group of psychiatric patients on the PBI are more vulnerable to the effects of anxiety on performance of a facial expression identification task. The PSY epileptics may be those with greater greater emotional problems and possibly greater limbic involvement in their epileptiform discharge. It has previously been proposed that frequency and intensity ratings of certain auras may prove good indicators of limbic epileptiform activity, and hence emotional problems among epileptics (Perry, 1987; Stark-Adamec et al., 1985). However the PSY epileptics tested in this study rated their experience of these auras with equal or slightly (non-significantly) greater frequency and intensity levels relative to the NonPSY epileptics (table 5). This suggests that "limbic" auras are not predictive of an anxiety induced reduction in accuracy of identification of happy expressions. However with such a small number of PSY epileptics (N=4), the hypothesis cannot be dismissed on the basis of these results.

Table 5

Ratings of selected auras by PSY and NonPSY epileptics

| Set 1 | Frequency | | Intensity | |
|---|---|---|---|---|
| | M | SD | M | SD |
| PSY | 1.9 | 1.3 | 3.1 | 1.1 |
| NonPSY | 1.5 | 1.2 | 2.6 | 1.4 |

| Set 2 | Frequency | | Intensity | |
|---|---|---|---|---|
| | M | SD | M | SD |
| PSY | 1.6 | 1.1 | 2.7 | 0.7 |
| NonPSY | 1.6 | 1.2 | 2.3 | 1.1 |

Note. Epileptics were classified according to whether they scored like a comparison group of psychiatric patients (group PSY) on the Personal Behavior Inventory or unlike the psychiatric patients (NonPSY) using discriminant analysis. They rated their experience of auras on five-point scales, with higher numbers representing greater frequency and intensity. Sets of key auras have been defined by Stark-Adamec et al. (1985; set 1) and Perry (1987; set 2) as characteristic of epileptics who score like psychiatric patients on the Personal Behavior Inventory. The auras in set 1 were (a) changes in the brightness of light, (b) perception of formed images, (c) changes in loudness, pitch or quality of sounds, (d) hatred as an emotion which comes out of the blue, (e) dizziness, and (f) mind becomes stuck on a single idea. The auras in set 2 were (a) perception of formed images, (b) jamais vu, (c) perception of time speeding up or slowing down, (d) irritability, and (e) perception of humming and buzzing sounds. The numbers in the table represent mean frequency and intensity across all auras in each set for the 14 epileptics who returned aura data. In the present experiment there were no significant differences between the groups on either set of auras.

It has been suggested (Hermann & Whitman, 1984) that some of the other variables shown in appendix E, may provide the basis for discrimination of epileptics with and without psychological risk. CPS and PGS patients differed significantly on two of these: age at which the disorder started and number of seizures in the preceding year. Since no clear difference between seizure type subgroups appeared on the facial expression identification task, it is suggested that these two variables have no relevance to performance on the experimental task.

In summary, although the anxiety induction did not disrupt the performance of control subjects (NPC and DC), it apparently decreased epileptics' accuracy of identifying happy expressions. Division of the epileptic group on the basis of PBI scores revealed that PSY epileptics accounted for most of the decline in accuracy, and that the accuracy of NonPSY epileptics, like that of NPC and DC, did not decline after the anxiety induction. Division of the epileptic group on the basis of seizure type revealed no split in performance. That is, CPS and PGS patients appear to have been similarly affected by the anxiety instructions. It may be that those epileptics with limbic epileptiform activity are identified better by scores on the PBI, than by seizure type diagnosis. In any case those epileptics vulnerable to the effects of anxiety induction on facial expression identification may best be identified with this questionnaire.

## Conclusions

On the basis of the present study several suggestions about facial expression identification among nonpatient control, diabetic control and epileptic subjects can be made. First, the right hemisphere superiority which emerged independent of subject gender, group, and emotional valence of the stimulus expression supports the idea that the human right hemisphere is specialized for identifying facial expressions of both positive and negative valence. The particular methods of the present experiment may have obscured a stronger right hemisphere superiority.

Non-neurological subjects identified some expressions less readily than others. In the present study fearful expressions were identified less accurately than happy, sad and surprised expressions. The high difficulty level of the present task may have created a ceiling effect, inhibiting the predicted superiority for accuracy of identifying happy expressions. In future it would be best to make such a task easier for the subjects, possibly by decreasing the visual angles. Happy expressions were identified faster than surprised expressions, which were identified faster than sad expressions, though not significantly so. These findings of the present study are not inconsistent with those of previous related studies.

The present findings, combined with those of Etcoff (1984), suggest that non-neurological subjects use independent, optionally/asymmetrically independent and integral styles of processing

facial expression with respect to the face dimension. The style which emerges in an experiment may depend on the stimulus expression, the method of stimulus presentation and/or the dependent measure.

Because of the lack of defining data, it was not possible to evaluate the effect of side and nature of the seizure focus on hemispheric asymmetry, accuracy, latency and style on facial expression identification. No significant differences in hemispheric asymmetry, accuracy, latency or style of facial expression identification could be attributed to epileptics or subgroups of epileptics defined by seizure type and PBI classification, suggesting that they have no problem in interpreting facial expressions as a form of social communication.

However the groups differed in their ability to identify happy expressions after the anxiety instructions. Nonpatient controls and diabetic controls either increased or maintained their accuracy after anxiety induction, whereas epileptics' accuracy decreased. CPS patients were as impaired as PGS patients, suggesting that it would be wrong to attribute difficulty on this particular task specifically to CPS patients. The rationale for such an attribution may still be tenable. Given the role of the human limbic system in emotion and other relevant findings, those epileptics with limbic epileptiform activity may be most vulnerable to emotional difficulties, and hence to problems on the present task. It may be that the method of identifying epileptics with limbic activity according to

seizure type is at fault, not the underlying rationale itself. The epileptics were subgrouped on the basis of PBI scores in an attempt to directly identify those with emotional problems. Certain epileptics were classified as scoring like a comparison group of psychiatric patients according to discriminant analysis (the PSY group), and others were classified as scoring lower than the psychiatric patients (NonPSY). The PSY group accounted for the decrease in accuracy observed for the whole epileptic group, and their accuracy was significantly lower than that of other subjects in the OA condition. NonPSY epileptics maintained their accuracy in the range of control subjects despite the anxiety induction. Thus identification of those epileptics vulnerable to the effects of anxiety induction on interpretation of specific instances of social communication may be accomplished better using PBI scores than seizure type diagnosis.

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# Appendix A

Personal Behaviour Inventory

We are studying the relationship between certain medical disorders and personal habits, preferences, feelings and beliefs. We are now asking for your help in this study.

On the following pages there are statements of personal attitudes and opinions. For each statement there is a corresponding 7-point scale for your response. Please indicate, on the scale, the extent to which each statement applies to you.

**Example Statement** a) "I never read the newspaper." If this statement is true, that you NEVER read the newspaper, then you would put your mark in the EXTREMELY CHARACTERISTIC space like this:

```
NOT AT ALL                              EXTREMELY
APPLICABLE                              CHARACTERISTIC
 (UNTRUE) ___:___:___:___:___:___:_X_   (TRUE)
```

If, on the other hand you always read the newspaper, then you would put your mark in the NOT AT ALL APPLICABLE space as the statement is completely untrue of you, like this:

```
NOT AT ALL                              EXTREMELY
APPLICABLE                              CHARACTERISTIC
 (UNTRUE) _X_:___:___:___:___:___:___   (TRUE)
```

If you read the newspaper about 50% of the time, then you would put your mark in the middle space, halfway between NOT AT ALL APPLICABLE and EXTREMELY CHARACTERISTIC, like this:

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:_X_:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

and so on.

**Example Statement**

b) "My weight has changed in the past six months."

If you have lost or gained A LOT of weight in the past six months, then you would put your mark in the EXTREMELY CHARACTERISTIC space.

If this statement is NOT TRUE of you, if your weight has been steady for the past six months, then you would put your mark in the NOT AT ALL APPLICABLE space.

If you have lost or gained a VERY LITTLE then you could put your mark here:

NOT AT ALL APPLICABLE (UNTRUE) ___:_X_:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

There are no "right" or "wrong" answers to this Inventory; what is most important is the honesty of your answers.

Because some of the items deal with highly personal areas, we can assure you of the confidentiality of your responses. Each form will be given a computer code number and will be processed statistically without your name.

We plan to share with the medical community any findings from this study that would be helpful in future treatment. We hope that in this way your participation will prove rewarding for you and other patients with similar illnesses in the future.

Below the rating scales for each statement in the questionnaire are four choices:

SAME. MORE LESS NOT APPLICABLE

If you feel that the statement was more characteristic of you before you started to have seizures, then circle "MORE".

If you feel that the statement was less characteristic of you before you started to have seizures, then circle "LESS".

If you would have answered the question in the same way you did now, then circle "SAME".

If for any reason you feel that you cannot make a judgement of "SAME", "MORE", or "LESS", then circle "NOT APPLICABLE".

# PERSONAL BEHAVIOUR INVENTORY

1. I think people would learn a lot from the story of my life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

2. I have stronger feelings of happiness than most people.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

3. I feel like a pawn in the hands of others.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

4. I can never forgive myself for some of the things I have done.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

5. I have a habit of counting things.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

6. It makes good sense to keep a detailed diary.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

7. Recently more of my thoughts have something to do with sex.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

8. I never get angry.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

9. For me, feelings often take the place of thinking.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

10. Things which never attracted me before have become sexually attractive.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

11. I think that I have a special mission in life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

12. I interpret things more deeply than most people.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

13. My religious beliefs have undergone major changes.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

14. I am more sensitive to distractions than most people.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

15. I have gotten people angry by asking them to do so much for me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

16. I never gossip.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

17. Powerful forces outside my control are working with my life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

18. I keep a diary.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

19. It makes me personally furious to see people disobeying the law.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

20. Little things make me angrier than they used to.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

21. If things are not just right, it upsets me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

22. Fate appears to be working against me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

23. Almost everything triggers some emotional reaction in me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

24. The Bible has special meaning which I am beginning to understand.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

25. My temper has gotten me into trouble.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

26. Sometimes I get terribly confused by little details.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

27. Powerful forces are acting through me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

28. I seem to depend on other people for many things.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

29. Few things are really funny.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

30. My table manners are just as good at home as when I am out in company.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

31. Often I get into such a good mood that I do foolish things.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

32. I am sure there is a significant meaning behind my suffering.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

33. I have had periods of weeks or months when I could not get going.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

34. I am open to attack from many sides.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

35. I cannot get off the point sometimes.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

36. I am losing control of my temper more frequently.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

37. Nothing is more important than trying to understand the forces that govern this world.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

38. Life is a strain for me much of the time.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

39. Sometimes I feel so helpless that I want people to do everything for me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

40. I never put off until tomorrow what I ought to do today.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

41. Often I am the only one to stand up for what is right.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

42. Sometimes my mind gets stuck on so many different ideas that I cannot make a decision or do anything.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

43. When I get angry, I often explode.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

44. Once I start to talk to someone, I have trouble breaking off.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

45. People do not seem to appreciate me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

46. I spend a lot of time thinking about the origins of the world and life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

47. At elections I never vote for men or women about whom I know very little.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

48. I have had some very unusual religious experiences.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

49. Almost every day I am infuriated by cases where justice has not been done.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

50. It is useless to tell someone something without giving them all the details.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

51. I have come to place my faith in astrology, meditation or other spiritual ways of relating myself to the universe.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

52. My sexual activity has decreased.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

53. I write down or copy things.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

54. Emotions control my life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

55. Much of the time I feel as if I have done something wrong or harmful.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

56. My feelings of hatred can be very intense.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

57. I like everyone I know.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

58. Before I make a decision, I need to know every detail.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

59. Sometimes I feel so good that ideas come into my mind faster than I can handle them.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

60. Sometimes my mind gets stuck on one idea so that I cannot make a decision or do anything.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

61. I have not lived the right kind of life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

62. I try to keep track of special details about my life and thinking.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

63. People tend to take advantage of me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

64. I always tell the truth.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

65. I have had periods when I felt so good that sleep did not seem necessary for several days.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

66. People should think about the points of many jokes more carefully instead of just laughing at them.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

67. I need more details than most people before I understand something.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

68. I have a tendency to break things or hurt people when I get angry.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

69. I am subject to big shifts in mood - from very happy to very sad.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

70. When I accidently hurt someone's feelings, I cannot forgive myself for a long time.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

71. I tend to get bogged down with little details.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

72. Finally I am beginning to understand the real meaning or nature of this world.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

73. I really am down in the dumps most of the time.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

74. I never laugh at a dirty joke.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

75. I would go out of my way to make sure the law is followed.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

76. I have more of a feeling than most people for the order and purpose of life.

NOT AT ALL APPLICABLE (UNTRUE) : : : : : : : EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

77. I am strongly attracted to members of my own sex.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

78. Sometimes I keep at a thing so long that others may lose their patience.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

79. Sometimes without any reason or even when things are going wrong I feel excitedly happy, or top of the world.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

80. I really make myself suffer after even a small mistake.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

81. People sometimes tell me that I have trouble getting to the point because of all the details.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

82. I would like to rip some people to shreds.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

83. I despise people who try to break the rules.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

84. I have trouble becoming sexually aroused.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

85. I have often felt so bad that I was close to ending my life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

86. I read every editorial in the newspaper every day.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

87. The thought of revenge burns inside me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

88. Most jokes do not seem funny to me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

89. My emotions have been so powerful that they have caused trouble.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

90. Sometimes a particular thought will run through my mind and bother me for days.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

91. I am often said to be hotheaded.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

_____ SAME MORE LESS NOT APPLICABLE

92. The future seems hopeless to me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

93. I am fortunate to receive so much help from people around me.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

94. I am very religious (more than most people) in my own way.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

95. I never feel like swearing.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

96. When I think of some of the things people have done to me, it makes me absolutely furious.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

97. Sometimes I think an illness has been given to me so that I would meet certain people at the right time.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

98. I would like to write a book about my life.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

99. Religion and God are more personal experiences for me than for most people.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

100. There is too much foolishness in the world these days.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

101. I have trouble getting a good night's sleep.

NOT AT ALL APPLICABLE (UNTRUE) ___:___:___:___:___:___:___ EXTREMELY CHARACTERISTIC (TRUE)

SAME MORE LESS NOT APPLICABLE

Thank you for your honest and patient completion of the Inventory.

Would you please check to be sure that all questions were answered.

# Appendix B

## Aura Questionnaire

On the following pages are listed various perceptual changes which some individuals experience 'just prior to ' or 'at the onset of' seizure activity. For some people these serve as a cue or a warning that a seizure is going to happen. For each of these 33 statements there are two 5-point scales indicating the FREQUENCY and INTENSITY of your experiences, respectively.

First, we would like you to indicate the FREQUENCY (ranging from NEVER to ALWAYS) with which you personally experience each of the perceptual changes. And then, for those sensations which you experience 'just prior to' or 'at the onset of' seizure activity, we would like you to indicate the intensity of each sensation on a scale ranging from VERY MILD to VERY INTENSE. Obviously, for those experiences which you never have just prior to a seizure you will not have to indicate the intensity.

Example Statement for FREQUENCY:

a) The perception of dark clouds

If you NEVER experience the perception of dark clouds just before your seizures, then you would put a check mark or an X in the space marked NEVER on the FREQUENCY scale.

FREQUENCY ___X___:_____:_____:_____:_____
never rarely sometimes often always

If, on the other hand, you ALWAYS experience the perception of dark clouds just before seizure activity, then you would put your mark in the ALWAYS space of the FREQUENCY scale, like this

FREQUENCY _____:_____:_____:__X__
rarely sometimes often always

In those cases where you have experienced the perceptual change either 'rarely', 'sometimes','often', or 'always', we would like you to indicate the INTENSITY of your experience on the INTENSITY scale.

Example Statement for Intensity:

b) The odour of roses

Assuming that you experience the odour of roses ' rarely', 'sometimes', 'often', or 'always' prior to seizure activity, then indicate the strength or vividness of this experience on the INTENSITY scale.

If the smell is very strong or vivid you would place your mark in the VERY INTENSE space like this

INTENSITY _____:_____:_____:_____:__X__
very mild mild moderate intense very intense

If, on the other hand, the smell is typically mild, then you would place your mark on the MILD space of the INTENSITY scale, like this

INTENSITY _____:__X__:_____:_____:_____
very mild mild moderate intense very intonse

## VISION CHANGES

1. Changes in the appearance of objects. For example, just before a seizure things appear to grow larger or smaller, appear to become nearer or farther away, or the shape of things appears to be distorted.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

2. Changes in the brightness of light. Just before a seizure things appear to be brighter or darker than they were previously.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

3. Perception of whirling, moving, and/or coloured lights just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

4. Perception of formed images (e.g. geometric shapes, humans, plants, objects, etc.) which actually aren't there, just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense

**********

HEARING CHANGES

1. Alterations in the loudness, pitch, or quality of sounds just before a seizure. Sounds may appear louder or fainter; sounds may appear to rise or fall in pitch (e.g. a low hum rising to a high scream; a high whistle dropping to a low roar and then rising again); sounds may take on an echoing quality.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense

**********

2. Perception of humming or buzzing sounds just before a seizure. The sounds may have no apparent environmental source.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense

**********

3. "Hearing" voices or music just before a seizure. The voices and/or music have no apparent environmental source.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

CHANGES IN SMELL

1. Sudden change or strengthening of an odour just before a seizure. The smell is originating from an identifiable source, but it is unusually strong, has an unusual quality or is inappropriate.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

2. The sensation of a PLEASANT smell, which may be either familiar or unfamiliar, just before a seizure. The smell cannot be attributed to anything in the immediate surroundings.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

3. The sensation of an UNPLEASANT smell, which may be either familiar– or unfamiliar, just before a seizure. The smell cannot be attributed to anything in the immediate surroundings.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

EMOTIONS WHICH COME "OUT OF THE BLUE"
JUST BEFORE A SEIZURE

1. Fear

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

2. Pleasure/well-being

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

3. Sadness/depression

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

4. Anger

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

5. Unpleasant feelings/complex, indescribable unpleasant emotions

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

6. Anxiety/tension

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

7. Hatred

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

8. Irritability

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

## CHANGES IN TASTE

1. Sudden changes in the taste of food just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

2. While not eating or drinking, experiencing a PLEASANT taste, which may be either familiar or unfamiliar, just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

3. While not eating or drinking, experiencing an UNPLEASANT taste, which may be either familiar or unfamiliar, just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

STOMACH SENSATIONS JUST BEFORE A SEIZURE

1. Feelings of nausea; feeling the need to vomit.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

## BODILY SENSATIONS

1. Changes in the feeling of body parts just before a seizure. For example, an arm or a leg may feel 'larger' or 'smaller' than usual; a limb may feel detached from the body

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

2. Tingling or numbness in part or all of the body just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

## BALANCE CHANGES/SENSATION OF MOVEMENT

1. Dizziness just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

2. Just before a seizure, a sensation of rotation, sensation of 'floating' or sensation of moving forward/backward or sideways (in the absence of any such movement).

FREQUENCY _____: _____: _____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

THOUGHTS AND/OR MEMORIES

1. Deja vu (a new experience feels as if it has somehow occurred before) just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

2. Jamais vu (a familiar scene suddenly becomes strange or unfamiliar) just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

3. A sense of strangeness or unreality although the surroundings remain familiar; a sense of remoteness; a sense of detachment from all that is happening, just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

4. A sudden reminiscence or remembering of past experiences, just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

5. Mind becomes stuck on a single idea, just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

6. A 'flood of ideas' pouring through the mind, just before a seizure.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

7. Just before a seizure time appears to be speeded up or slowed down.

FREQUENCY _____:_____:_____:_____:_____
never rarely sometimes often always

INTENSITY _____:_____:_____:_____:_____
very mild mild moderate intense very intense
**********

NAME: _____
(Note: Your name will be removed when the questionnaire is returned and a computer number has been assigned to your questionnaire)

# Appendix C

## Personal Background Questionnaire

Subject No._____

Age_____

Sex 1.Male 2.Female

Education _____

Occupation _____

Father's Occupation _____

Please answer each question. All information will be kept completely confidential.

Marital Status 1.married 2.living together
3.divorced 4.separated 5.widowed 6.single

With whom do you live? 1.alone 2.with spouse
3.with parents 4.with room-mates
5.other:_____

Where do you live? 1.in the country 2.small town
3.city

Have you received psychological/psychiatric help?
1.yes, in the past 2.yes, presently 3.never

Have you had a problem with alcohol?
1.yes, in the past 2.yes, presently 3.never

Have you had a problem with drugs?
1.yes, in the past 2.yes, presently 3.never

Have you been in trouble with the police?
1.yes, in the past 2.yes, presently 3.never

If yes, what type of trouble was it?
1.against person 2.against property
3.other_____

Do you have any medical condition? 1.yes 2.no
If yes, what is the condition?_____

How many times have you been hospitalized over the past two years?_____

What medical treatments did you receive when you were hospitalized?_____
_____

Please list any drugs (prescription or non-prescription) which you are currently taking.
_____

FOR PATIENTS ONLY

How old were you when your medical problem started?
_____

How long have you had the problem?_____

Is the condition controlled? 1.yes 2.no
If yes, how long has it been controlled?_____

FOR SEIZURE PATIENTS ONLY

What medications are you presently taking for epilepsy? dilantin (phenytoin) _____
tegretol (carbemazepine) _____
phenobarbitol _____
mysoline (primidone) _____
depakene (valproic acid) _____
zarontin (ethosuximide) _____
other:_____

Were you taking any of the following medications six months ago? dilantin (phenytoin) _____
tegretol (carbemazepine) _____
phenobarbitol _____
mysoline (primidone) _____
depakene (vaiproic acid) _____
zarontin (ethosuximide) _____
other. _____

About how many seizures have you had over the past month? _____

About how many seizures have you had over the past Year? _____

# Appendix D

Consent Form

I understand that my participation in this study is completely voluntary. I understand that I may withdraw from the study at any time if I so wish. I realize that my participation in the study will take about two hours of my time.

I will allow the researchers to obtain biographical data (such as age, education, etc.). This permission is given on the understanding that the information will be kept confidential.

I understand that the study involves psychological testing. I understand that my results will be confidential. They will be communicated to other professionals in a manner that prevents identification of the individual participant. I understand that I will not see my individual results, but that I will have access to the general results of the experiment.

---

(signature)

# Appendix E

Demographic information and test scores

The variables measured were number of hospitalizations in the two years preceeding the experiment (hosp), handedness as measured on the Edinburgh Inventory (hand), Beck Depression Inventory scores (BDI), Social Avoidance and Distress Scale scores (SADS), State Trait Anxiety Scale scores (A-State and A-Trait scales) under neutral instructions, and the ratio of males to females (M/F). Other variables measured only among epileptics were age at which the disorder started (age start), duration of the disorder (duration), whether the seizures are presently controlled (control), duration of seizure control (dur ctl), number of seizures in the month preceeding the experiment (sz month), number of seizures in the year preceeding the experiment (sz year), whether the present medications (meds) included dilantin or dilantin plus another drug (dil) or whether dilantin was not among the drugs being administered (not dil), and whether the number of present medications (# meds) was one or two.

There were significant differences among nonpatient controls (NPC), diabetic controls (DC) and epileptics (E) in number of recent hospitalizations ($F(2, 43)=4.30$, $p=.020$). UC had been recently hospitalized significantly less often than DC ($t(26)=4.85$, $p<.0005$) and E ($t(37)=2.48$, $p=.018$); patient groups did not differ on this variable. There were no significant groups differences in scores on the Edinburgh Inventory

(Hand), the Beck Depression Inventory (BDI), or the Social Avoidance and Distress Scale (SADS).

The age at which CPS patients first started having seizures was significantly older than that for PGS patients ($t(11)=2.42$, $p=.040$). CPS patients reported having significantly more seizures than PGS patients during the year preceeding the experiment ($t(9)=2.46$, $p=.040$). There were no other significant differences between CPS and PGS patients on any of the variables.

Epileptics who scored like psychiatric patients on the Personal Behavior Inventory (PSY) did not differ on any of the variables from those who did not score like psychiatric patients (NonPSY). Notably Personal Behavior Inventory classification was unrelated to seizure type (Yates corrected $Chi^2(1)=0.0$, $p>.05$)

| | UC | | DC | | E | |
|---|---|---|---|---|---|---|
| Variable | M | SD | M | SD | M | SD |
| Hosp | 0.0 | 0.2 | 0.9 | 0.7 | 0.0 | 0.7 |
| Hand | 57.0 | 38.2 | 78.2 | 36.1 | 60.0 | 53.4 |
| BDI | 5.9 | 6.8 | 4.9 | 4.3 | 7.5 | 8.8 |
| SADS | 8.0 | 8.1 | 5.7 | 8.5 | 9.7 | 7.7 |
| A-State | 29.3 | 6.6 | 28.0 | 10.9 | 31.2 | 9.6 |
| A-Trait | 35.9 | 9.9 | 34.1 | 13.9 | 35.6 | 13.7 |
| M/F | 12/12 | | 5/7 | | 9/9 | |

| | CPS | | PGS | |
|---|---|---|---|---|
| Variable | M | SD | M | SD |
| Hosp | 1.0 | 1.4 | 0.6 | 1.5 |
| Hand | 56.3 | 62.3 | 61.5 | 44.8 |
| BDI | 4.2 | 3.3 | 8.4 | 13.0 |
| SADS | 9.3 | 10.5 | 8.6 | 6.4 |
| A-State | 26.3 | 6.6 | 28.8 | 10.9 |
| A-Trait | 35.9 | 9.9 | 34.1 | 13.9 |
| M/F | 1/4 | | 5/2 | |
| Age Start | 33.0 | 17.4 | 15.6 | 7.1 |
| Duration | 16.8 | 10.0 | 17.3 | 10.4 |
| Control (yes/no) | 3/7 | | 2/0 | |
| Dur Ctl | 1.2 | 0.8 | 5.0 | 6.0 |
| Sz Month | 1.3 | 2.3 | 0.0 | 0.0 |
| Sz Year | 23.0 | 26.0 | 0.9 | 1.9 |
| Meds (Dil/ Not Dil) | 4/1 | | 4/3 | |
| # Meds (one/two) | 3/4 | | 2/3 | |

| | NonPSY | | PSY | |
|---|---|---|---|---|
| Variable | M | SD | M | SD |
| Hosp | 0.6 | 1.0 | 0.0 | 0.0 |
| Hand | 58.3 | 60.0 | 41.7 | 52.6 |
| BDI | 4.9 | 5.8 | 12.8 | 13.8 |
| SADS | 10.1 | 6.2 | 11.3 | 12.4 |
| A-State | 29.3 | 6.6 | 28.8 | 10.9 |
| A-Trait | 35.9 | 9.9 | 34.1 | 13.9 |
| M/F | 4/7 | | 2/2 | |
| Age start | 19.4 | 14.7 | 21.5 | 17.0 |
| Duration | 18.4 | 8.6 | 15.0 | 12.1 |
| Control (yes/no) | 9/2 | | 2/2 | |
| Dur Ctl | 4.3 | 6.4 | 9.5 | 10.6 |
| Sz Month | 0.2 | 0.7 | 1.3 | 2.3 |
| Sz Year | 7.9 | 16.9 | 5.0 | 8.7 |
| Meds (Dil/Not Dil) | 6/4 | | 3/1 | |
| # Meds (one/two) | 7/1 | | 4/3 | |
| Sz Type (CPS/PGS) | 3/3 | | 2/2 | |

# Appendix F

## MANOVA Tables

**Hypothesis 1. Hemispheric asymmetry of facial expression identification among non-neurological subjects**

Accuracy

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 444.87 | 1 | 444.87 | .77 | .333 |
| Gender x VF | 40.63 | 1 | 40.63 | .09 | .768 |
| VF x Expression | 1666.97 | 3 | 555.66 | 1.27 | .289 |
| Gender x VF x Expression | 1006.12 | 3 | 335.37 | .77 | .516 |

Latency

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 449727.79 | 1 | 449727.7 | .32 | .581 |
| Gender x VF | 286700.03 | 1 | 286700.0 | .20 | .659 |
| VF x Expression | 3352162.07 | 2 | 1676081.0 | .80 | .459 |
| Gender X VF x Expression | 138405.13 | 2 | 69202.6 | .03 | .968 |

Hypothesis 2. Accuracy and Latency of facial expression identification among non-neurological subjects

Accuracy

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Expression | 16537.19 | 3 | 5512.4 | 6.17 | .001 |

Latency

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Expression | 1619045.32 | 2 | 809522.7 | .19 | .825 |

Hypothesis 3. Facial expression processing style among non-neurological subjects

Accuracy

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Condition | 19284.39 | 2 | 9642.2 | 6.41 | .003 |
| Condition x Expression | 16944.03 | 6 | 2824.0 | 3.17 | .005 |

Latency

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Condition | 18270813.82 | 2 | 9135406.9 | 4.24 | .002 |
| Condition x Expression | 3371670.47 | 4 | 842917.6 | .38 | .824 |

Hypothesis 4. Group differences in hemispheric asymmetry of facial expression identification

Accuracy

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 1435.75 | 1 | 1435.75 | 3.88 | .055 |
| Gender x VF | 52.32 | 1 | 52.32 | .14 | .709 |
| Group x VF | 1190.48 | 2 | 595.24 | 1.61 | .212 |
| Gender x Group x VF | 1491.68 | 2 | 745.84 | 2.02 | .146 |
| VF x Expression | 1433.92 | 3 | 477.97 | 1.14 | .334 |
| Gender x VF x Expression | 1906.24 | 3 | 635.41 | 1.52 | .212 |
| Group x VF x Expression | 1445.14 | 6 | 240.86 | .58 | .748 |
| Gender x Group x VF x Expression | 4396.37 | 6 | 733.06 | 1.75 | .114 |

Hypothesis 4, Accuracy, Continued

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 693.21 | 1 | 693.21 | 1.75 | .195 |
| Gender x VF | 3.74 | 1 | 3.74 | .01 | .923 |
| Group x VF | 1273.39 | 3 | 424.46 | 1.07 | .374 |
| Gender x Group x VF | 1831.08 | 3 | 610.36 | 1.54 | .221 |
| VF x Expression | 2628.85 | 3 | 876.28 | 2.08 | .107 |
| Gender x VF x Expression | 2697.12 | 3 | 899.04 | 2.13 | .100 |
| Group x VF x Expression | 3457.42 | 9 | 384.16 | .91 | .519 |
| Gender x Group x VF x Expression | 6220.37 | 9 | 691.15 | 1.64 | .113 |

Hypothesis 4, Accuracy, Continued

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 523.58 | 1 | 523.58 | 1.41 | .242 |
| Gender x VF | .12 | 1 | .12 | .00 | .986 |
| Group x VF | 1221.09 | 3 | 407.03 | 1.10 | .362 |
| Gender x Group x VF | 1299.30 | 3 | 433.10 | 1.17 | .335 |
| VF x Expression | 1037.16 | 3 | 345.72 | .79 | .503 |
| Gender x VF x Expression | 1380.44 | 3 | 460.15 | 1.05 | .375 |
| Group x VF x Expression | 2582.13 | 9 | 286.90 | .65 | .749 |
| Gender x Group x VF x Expression | 4627.22 | 9 | 514.14 | 1.17 | .321 |

Hypothesis 4 Continued

Latency

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 122344.72 | 1 | 122344.72 | .10 | .750 |
| Gender x VF | 22141.47 | 1 | 22141.47 | .02 | .892 |
| Group x VF | 872428.04 | 2 | 436214.02 | .37 | .696 |
| Gender x Group x VF | 2098965.81 | 2 | 1049482.9 | .89 | .424 |
| VF x Expression | 5298073.75 | 2 | 2649036.9 | 1.75 | .183 |
| Gender x VF x Expression | 1503918.95 | 2 | 751958.48 | .50 | .611 |
| Group x VF x Expression | 8370834.81 | 4 | 2092708.7 | 1.39 | .252 |
| Gender x VF x Group x Expression | 8783254.92 | 4 | 2195813.7 | 1.45 | .230 |

Hypothesis 4. Latency, Continued

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 149243.76 | 1 | 149243.76 | .12 | .730 |
| Gender x VF | 68152.15 | 1 | 68152.15 | .06 | .815 |
| Group x VF | 2987799.96 | 3 | 995933.32 | .82 | .499 |
| Gender x VF x Group | 1542642.98 | 3 | 514214.33 | .42 | .739 |
| VF x Expression | 3791873.38 | 2 | 1895936.7 | 1.17 | .321 |
| Gender x VF x Expression | 793583.16 | 2 | 396791.58 | .24 | .784 |
| Group x VF x Expression | 8281585.04 | 6 | 1380264.2 | .85 | .539 |
| Gender x Group x VF x Expression | 8857139.22 | 6 | 1476189.9 | .91 | .497 |

Hypothesis 4, Latency, Continued

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| VF | 108026.69 | 1 | 108026.69 | .08 | .780 |
| Gender x VF | 172198.77 | 1 | 172198.77 | .13 | .724 |
| Group x VF | 621684.83 | 3 | 207228.28 | .15 | .926 |
| Gender x Group x VF | 3771342.80 | 3 | 1257114.3 | .93 | .443 |
| VF x Expression | 4466269.95 | 2 | 2233135.0 | 1.33 | .276 |
| Gender x VF x Expression | 323822.30 | 2 | 161911.15 | .10 | .908 |
| Group x VF x Expression | 4642725.52 | 6 | 773787.59 | .46 | .832 |
| Gender x Group x VF X Expression | 13734265.2 | 6 | 2289044.2 | 1.36 | .254 |

Hypothesis 5. Group differences in accuracy and latency of facial expression identification

Accuracy

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 332.33 | 2 | 166.17 | .05 | .950 |
| Group x Expression | 4228.01 | 6 | 704.67 | 1.15 | .336 |

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 5760.98 | 3 | 1920.33 | .64 | .593 |
| Group x Expression | 5396.12 | 9 | 599.57 | .98 | .455 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 2142.69 | 3 | 714.20 | .22 | .883 |
| Group x Expression | 6288.08 | 9 | 698.68 | 1.13 | .348 |

Hypothesis 5 Continued

Latency

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 3265935.40 | 2 | 1632967.7 | .63 | .537 |
| Group x Expression | 5155219.43 | 4 | 1288804.9 | 1.58 | .189 |

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 6863909.20 | 3 | 2287969.7 | .88 | .462 |
| Group x Expression | 6002894.75 | 6 | 1000482.5 | 1.15 | .343 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 4888125.56 | 3 | 1629375.2 | .62 | .607 |
| Group x Expression | 7275172.73 | 6 | 1212528.8 | 1.34 | .254 |

Hypothesis 6. Group differences in expression processing style

Accuracy

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | 2624.37 | 4 | 656.09 | .93 | .448 |
| Group x Expression x Condition | 5052.27 | 12 | 421.02 | 1.00 | .448 |

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | 4396.45 | 6 | 732.74 | 1.10 | .370 |
| Group x Expression x Condition | 7704.48 | 18 | 428.03 | .98 | .480 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | 3811.44 | 6 | 635.24 | .95 | .466 |
| Group x Condition x Expression | 7734.60 | 18 | 429.70 | 1.01 | .452 |

Hypothesis 6 Continued

Latency

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | 7703776.65 | 4 | 1925944.2 | 2.23 | .074 |
| Group x Expression x Condition | 7183755.57 | 8 | 897969.45 | 1.01 | .434 |

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | 7176406.92 | 6 | 1196067.8 | 1.30 | .269 |
| Group x Expression x Condition | 8443569.13 | 12 | 703630.76 | .80 | .652 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | 9072541.89 | 6 | 1512090.3 | 1.50 | .195 |
| Group x Expression x Condition | 8470614.30 | 12 | 705884.52 | .71 | .736 |

Hypothesis 7. Group differences in response to anxiety induction

Self reported anxiety: State-Trait Anxiety Scale

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| State Scale | | | | | |
| Group | 137.81 | 2 | 68.91 | .28 | .759 |
| Condition | 5.39 | 1 | 5.39 | .06 | .803 |
| Group x Condition | 41.30 | 2 | 20.65 | .24 | .786 |
| Trait Scale | | | | | |
| Group | 111.33 | 2 | 55.66 | .23 | .794 |
| Condition | .02 | 1 | .02 | .00 | .982 |
| Group x Condition | 7.80 | 2 | 3.90 | .12 | .885 |

Group levels: NPC, DC, NonPSY, PSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| State Scale | | | | | |
| Group | 489.23 | 3 | 191.10 | .64 | .593 |
| Condition | 14.74 | 1 | 14.74 | .16 | .688 |
| Group x Condition | 8.67 | 3 | 2.89 | .03 | .992 |
| Trait Scale | | | | | |
| Group | 1196.89 | 3 | 389.96 | 1.89 | .178 |
| Condition | 3.85 | 1 | 3.85 | .20 | .659 |
| Group x Condition | 39.39 | 3 | 13.13 | .68 | .573 |

Hypothesis 7 Continued

Self reported anxiety, continued

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| State Scale | | | | | |
| Group | 343.01 | 3 | 114.34 | .44 | .729 |
| Condition | .82 | 1 | .82 | .01 | .924 |
| Group x Condition | 303.82 | 3 | 101.27 | 1.13 | .350 |
| Trait Scale | | | | | |
| Group | 157.97 | 3 | 52.66 | .20 | .896 |
| Condition | .01 | 1 | .01 | .00 | .982 |
| Group x Condition | 56.81 | 3 | 18.94 | .63 | .599 |

Hypothesis 7 Continued

Differences in response to neutral expressions

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 1.19 | 2 | .59 | .32 | .731 |
| Sadness | 3.39 | 2 | 1.69 | .79 | .458 |
| Surprise | 2.38 | 2 | 1.19 | 1.10 | .340 |
| Fear | .71 | 2 | .36 | .36 | .697 |

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 3.26 | 3 | 1.09 | .58 | .632 |
| Sadness | 2.96 | 3 | .99 | .46 | .712 |
| Surprise | 1.83 | 3 | .61 | .53 | .661 |
| Fear | 2.02 | 3 | .67 | .79 | .505 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 3.11 | 3 | 1.04 | .52 | .668 |
| Sadness | 11.00 | 3 | 3.67 | 1.87 | .149 |
| Surprise | 3.26 | 3 | 1.09 | .92 | .441 |
| Fear | 2.06 | 3 | .69 | .68 | .571 |

Hypothesis 7 Continued

Differences in accuracy

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 914.06 | 2 | 457.03 | 4.32 | .018 |
| Sadness | 223.80 | 2 | 111.90 | .60 | .551 |
| Surprise | 469.58 | 2 | 234.79 | 1.05 | .358 |
| Fear | 230.16 | 2 | 115.08 | .58 | .562 |

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 1174.60 | 3 | 391.53 | 3.62 | .020 |
| Sadness | 359.10 | 3 | 119.70 | .61 | .610 |
| Surprise | 662.97 | 3 | 220.99 | .98 | .409 |
| Fear | 550.61 | 3 | 183.54 | .93 | .435 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 482.73 | 3 | 160.91 | 1.40 | .255 |
| Sadness | 304.53 | 3 | 101.51 | .54 | .657 |
| Surprise | 812.93 | 3 | 270.98 | 1.18 | .328 |
| Fear | 310.14 | 3 | 103.38 | .75 | .526 |

Hypothesis 7 Continued

Differences in latency

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 13674650.40 | 2 | 6837325.2 | 5.21 | .010 |
| Sadness | 4607776.15 | 2 | 2303888.1 | 2.14 | .133 |
| Surprise | 418769.73 | 2 | 209384.87 | .18 | .832 |

Group levels: NPC, DC, PSY, NonPSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 15412407.25 | 3 | 5137469.1 | 3.82 | .019 |
| Sadness | 4654828.14 | 3 | 1551609.4 | 1.28 | .298 |
| Surprise | 282736.37 | 3 | 94245.46 | .08 | .970 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Condition | | | | | |
| Happiness | 11638445.39 | 3 | 3879481.8 | 3.08 | .043 |
| Sadness | 5131251.26 | 3 | 1710417.1 | 1.50 | .237 |
| Surprise | 1625532.70 | 3 | 541844.23 | .40 | .756 |

Hypothesis 7 Continued

Further analyses

Bias in incorrect identifications of happy expressions

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Expression x Condition | 7.98 | 4 | 1.99 | 1.32 | .269 |

Group levels: NPC, DC, NonPSY, PSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group x Expression x Condition | 7.38 | 6 | 1.23 | .75 | .608 |

Group levels: NPC, DC, CPS, PGS

| | | | | | |
|---|---|---|---|---|---|
| Group x Expression x Condition | 9.94 | 6 | 1.66 | 1.16 | .338 |

Hypothesis 7 Continued

Further analyses continued: Potential of the expressions to discriminate among groups

Orthogonal-Neutral (ON condition)

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Expression | 13269.29 | 3 | 4423.10 | 10.41 | .000 |

Orthogonal-Anxiety (OA condition)

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Expression | 17823.45 | 3 | 5941.15 | 16.73 | .000 |

Preliminary condition 1

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 153.37 | 2 | 76.69 | 1.61 | .210 |

Group levels: NPC, DC, NonPSY, PSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 173.73 | 3 | 57.91 | 1.13 | .347 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 196.10 | 3 | 65.37 | 1.46 | .238 |

Preliminary condition 2

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 328.25 | 2 | 164.12 | 2.90 | .065 |

Group levels: NPC, DC, NonPSY, PSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 450.64 | 3 | 150.21 | 2.70 | .057 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 250.43 | 3 | 83.48 | 1.55 | .216 |

Preliminary condition 3

Group levels: NPC, DC, E

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 239.64 | 2 | 119.82 | 1.19 | .312 |

Group levels: NPC, DC, NonPSY, PSY

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 939.13 | 3 | 313.04 | 3.62 | .020 |

Group levels: NPC, DC, CPS, PGS

| Source | SS | DF | MS | F | p |
|---|---|---|---|---|---|
| Group | 396.66 | 3 | 132.22 | 1.23 | .311 |