THE UNIVERSITY OF MANITOBA

PERCEPTION, HEMISPHERIC ASYMMETRY AND THE IDENTIFICATION OF FACIAL EXPRESSION DURING BRIEF EXPOSURE DURATIONS

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

DEPARTMENT OF PSYCHOLOGY
WINNIPEG, MANITOBA

AUGUST, 1980

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A thesis submitted to the Faculty of Graduate Studies of
the University of Manitoba in partial fulfillment of the requirements
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Acknowledgements

I would like to express my gratitude and appreciation for the support and encouragement I received during my work on this project. First and foremost I thank Dave Martin for his unfailing encouragement and valuable advice and criticism from this project's inception to completion. I thank Michel Janisse and Pat Churchland for their fresh, external points of view. Sincere thanks go to my colleagues and friends, Hans Beihl, Cliff Berrish, Terry Dushenko, Jaye Miles and Doug Tataryn for providing the intellectual climate necessary to clarify my research questions and ideas and for helping me run subjects during the many hours it took. I thank Ina Fraser and Dianne Rosin for having the time and perseverance to read my handwriting in producing such excellent typing.

Most importantly I thank my wife, Catherine, for providng me with the support and love needed to get me through the highs and lows that I encountered.

I would like to dedicate this thesis to a friend who was like a brother, Michael Beach, who tragically passed away when I was beginning this project. He is part of who I am now.

Abstract

Previous research has demonstrated cerebral hemispheric asymmetry (in favour of the right hemisphere) in the efficiency of processing emotional stimuli. The present study was designed to investigate such asymmetry and to examine whether it is maintained when the stimuli are presented such that they lie outside of reportable awareness. There is a substantial and diverse body of evidence that can be marshalled from the areas of binocular rivalry, retinal image stabilization, dichotic listening (fate of the unattended channel), and subliminal stimulation to collectively suggest that there are relatively high levels of processing of stimuli which lie outside of reportable awareness.

Using a tachistoscopic presentation paradigm 20 male, right-handed subjects were presented simultaneously with (1) a face expressing either positive, neutral or negative affect to the left or right visual field and, (2) the outline of the face containing visual noise, uncorrelated with the emotion but with equal density, to the opposite visual field. The visual field containing the face expressing emotion was randomized so that on average each visual field contained a face one half of the time. A range of stimulus presentation durations was used to sample above and below threshold processing.

On each trial subjects responded to two forced choice

questions: (1) Which side was the face on? and (2) What was the emotion expressed by the face? Threshold was determined by locating the stimulus presentation duration at which subjects were at a chance level of responding on the question asking which side the face was on.

The results revealed a left visual field advantage for locating the face supporting the contention that facial stimuli are processed with greater efficiency by the right hemisphere than by the left hemisphere. There was only suggestive evidence in favour of a right hemisphere superiority in the processing of facial expression *per se*. The most important finding was that when subjects' performance locating the face represented chance (i.e., there was no reportable awareness of stimulus cues needed to discriminate a face from a nonface), they were significantly above chance identifying the facial expression. Since a concurrent assessment of awareness was made, contrary to most subliminal stimulation research, this finding provides strong evidence for high levels of processing in the absence of reportable awareness.

The theoretical and methodological implications of these findings are discussed in the context of the emerging integration of current neuropsychological and information processing research.

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PERCEPTION, HEMISPHERIC ASYMMETRY AND THE IDENTIFICATION OF FACIAL EXPRESSION DURING BRIEF EXPOSURE DURATIONS

Over the past two decades there has been a proliferation of research which has demonstrated cerebral hemispheric asymmetry in the performance of diverse cognitive functions in humans (for comprehensive reviews see Dimond & Beaumont, 1974; Geffen, Bradshaw & Wallace, 1971; Kimura, 1966; Levy, 1974; Milner, 1971; Moscovitch, 1976; Pirozzolo, 1977; White, 1972). It is generally agreed that in the majority of right-handed people, the left hemisphere is superior in the processing of linguistically encodable material while the right hemisphere is specialized in processing material that needs spatial analysis.

Further, although speculative, it has been suggested that hemispheric asymmetries reflect hypothesized differences in cognitive style such that the left hemisphere has been typified as logical, analytic and sequential, while the right hemisphere has been described as holistic and parallel in processing (Cohen, 1973; Galin, 1974; Ornstein, 1972; Patterson & Bradshaw, 1975; Seaman & Gazzaniga, 1973). Recent evidence, however, is suggesting that hemispheric asymmetries are not simply a function of material to be processed _per se_ or the hypothesized dichotomy of cognitive style, but rather a consequence of complex interactions of "factors such as direct versus indirect access to specialized cortical locations, stimulus codability, perceptual orientation shifts and selective hemispheric interference" (Hellige & Cox, 1976, p.219; see also Cohen, 1979; Hellige, 1978; Hellige, Cox & Litvac, 1979).

Regardless of the mechanism(s) hypothesized to account for observed hemispheric asymmetries, the fact remains that the hemispheres have been shown to differ in their efficiency with which they process material on experimental tasks. Although most of the research on hemispheric asymmetry has been directed towards investigating the lateralization of cognitive abilities only "scant reference exists in the literature of the possible hemisphere specialization for emotional functions" (Ley & Bryden, 1979a, p.127). As both Ley and Bryden (1977, 1979a, 1979b) and Galin (1974, 1976) suggest, there is good reason to suspect that the hemispheres possess differing capabilities and efficiencies that may be implicated in the differential attending to, and processing of stimuli with substantial emotional components. In fact there is a considerable quantity of converging clinical and experimental data that does suggest that the right hemisphere is more efficient in dealing with emotional stimuli than the left hemisphere. This evidence is reviewed.

In overview, the interest here was in exploring hemispheric asymmetries in the processing of affective cues as they are represented in facial expression. The goal was primarily to examine such asymmetries when the facial stimuli and the emotions inherent in them were out of reportable awareness. In the broader view, it is of considerable clinical and theoretic significance in determining whether high levels of processing of affective information can occur where the representation of the stimulus is such that there is no reportable awareness of the actual stimulus presentation.

Hemispheric Asymmetries and Emotion

Research with Clinical Samples

Split brain research. In the early 1960's a small sample of neurosurgical patients underwent a radical procedure to effect a remission of intractable grand mal seizure disorder particularly that of status epilepticus. The procedure involved the surgical section of the corpus callosum, the anterior commissure and the hippocampal commissure. (For a complete description of the procedure and illustrative cases see Bogen & Gazzaniga, 1965). This resulted in a split brain preparation in that the left hemisphere was disconnected from the right hemisphere at levels higher than the brain stem.

The surgery proved effective in eliminating generalized convulsions and remarkably, there was an apparent lack of change in the patients' personality, intellect or overt behaviour. There were, however, intriguing findings when more detailed tests were administered which were specifically designed to detect impairment of interhemisphere integration. In the main, it has been demonstrated that each hemisphere of these patients is unable to know what the other is doing or perceiving (for reviews see Sperry, 1968; Sperry, Gazzaniga, Bogen, 1969). Most of this research has been aimed at investigating the dissociation of the hemispheres with regard to the visual, auditory and tactile systems and in terms of such functions as speech, writing and calculation.

Although there has been a lack of research with the split brain sample specifically directed to examine differential processing of emotional stimuli, Gazzaniga (1967), and Sperry, Gazzaniga and Bogen (1969) have provided some anecdotal evidence suggesting that the right hemisphere can independently generate an emotional reaction. For example, they embedded a picture of a nude woman in a series of stimulus presentations which were presented tachistoscopically to the hemispheres individually. When the nude was presented to the left hemisphere there was a reaction of embarrassment accompanied by the verbal identification of the picture. When the picture was presented to the right hemisphere there was a similar emotional reaction that was independent of any verbal mediation or recognition of what had been seen.

Although only suggestive, this evidence is strengthened by other split brain research (Gazzaniga, 1967)which demonstrates considerable right hemisphere cross-cueing of the left hemisphere by the use of emotional gestures.

Again the right hemisphere was independently generating emotional reactions.

Hysterical conversion neurosis research. Foregoing an analysis of the aetiology and genesis of hysterical conversion reactions, it would be fair to say that the disability results from intense emotional upset which manifests itself in apparent physical illness in the absence of any organic pathology. It has been speculated that if the right hemisphere is more efficient in the processing of emotional stimuli, the representation of emotions would be more fully developed in the right hemisphere than in the left hemisphere (Ley & Bryden, 1979b). Further, it has been posited that if this is the case, it would be expected that there would be differences in the side of the body in which the conversion symptoms would appear (Galin, Diamond & Braff, 1977; Ley & Bryden, 1979b).

Where clearly lateralized hysterical motor disturbances are found, it has been the clinical observation that they are present more frequently on the left side of the body (innervated by the right hemisphere) than on the right side of the body by a ratio of 2:1 (Fenichel, 1945; Janet, 1924).

Using a more systematic methodology Galin, Diamond, and Braff (1977), Stern (1977) and Ley (1978) validated the clinical findings by again finding a 2:1 ratio of left to right sided symptoms in retrospective analyses of hospitalized, hysterical, psychiatric patients' records.

Ley (1978) states that the magnitude of the disabilities incurred was such as to present equal difficulties to the patient regardless of the side of the disturbance. This argues against the alternate explanation that hysterics kept themselves from not being totally debilitated by rendering their dominant limb non-functional. Although only speculative and suggestive, this evidence points to greater right hemisphere involvement in dealing with emotional stimuli.

Research on patients with unilateral brain lesions. There are consistent differences in the emotional reactions to unilateral brain lesions dependent upon which hemisphere is damaged. Hecaen (1962) and Gainotti (1969) found a significantly higher incidence of catastrophic reactions (crying, swearing, anxiety reactions and aggressive behaviour) in patients with left hemisphere lesions than those with right hemisphere lesions and a significantly greater incidence of indifference reactions (explicit indifference and minimization) in patients with right hemisphere lesions than those with left hemisphere lesions. This suggests that there is hemispheric asymmetry in emotional reaction to lesions localized in either hemisphere.

Research with intracarotid injections of sodium amobarbytal. It has been observed that there are again consistent and different emotional reactions which accompany the dissipation of left and right-sided injections of sodim amobarbytal (Alema, Rosodini & Rossi, 1961; Rossi & Rosodini, 1967; Terzian, 1964). Similar to the findings of the hemispheric asymmetry in emotional reaction to lateralized brain damage, left hemisphere injections are characterized by "depressive-catastrophic" reactions, whereas, right hemisphere injections evidenced "euphoric-manical" reaction.

As Ley and Bryden (1979b) state,

> "...it is difficult to interpret the meaning of different affective reactions following unilateral amobarbytal injections. For example, depression may be seen and expected as a natural reaction to loss of speech as it may simply be that a mute patient seems more depressed...Other interpretive difficulties arise because the affective reaction occurs as the anesthetic is wearing off, rather than at the peak of the disability...Most importantly one cannot definitely conclude whether the observed affect is resulting from the injected side in response to the drug, or from the noninjected side as the cerebral balance shifts [when the drug effects are dissipating]" (p.26-27)

Even though there are these interpretive difficulties specific to amobarbytal injection, the fact that these data do complement those from the unilateral lesion research does support the contention that the two hemispheres have a different involvement in mediating emotional reactions.

Summary. Although there are interpretive difficulties, the data derived from clinical samples support the contention that there is hemisphere asymmetry in emotional reactivity. Although the data from the hysterical conversion literature suggest that the right hemisphere plays a more intimate role in emotional expression, the data from work involving lateralized hemispheric invasion (by lesion or amobarbytal) suggest that both hemispheres are involved by in different ways. As will be seen, however, the evidence from studies involving normal subjects consistently demonstrates that the right hemisphere is specifically involved in the detection and recognition of emotions, while the left hemisphere plays a lesser role.

A caveat is in order here. There is considerable danger in extrapolating directly from observations gleaned from clinical samples in developing models of normal brain function. In attributing the emotional reactions observed to the hemisphere in which there is some pathological organic process operating (as in lateralized brain damage and amobarbytal injection by virtue of the fact that in the vast majority of cases the procedure is performed diagnostically before neurosurgery), we are assuming a simplistic and unitary model of brain function. We are overlooking the compensatory activity of the surviving cortex and the disinhibition which occurs both within and across hemispheres (see Kinsbourne, 1974 and Moscovitch, 1976, for a full discussion of these issues). This suggests that even if a particular lateralized lesion is targeted, it is by no means conclusive that any subsequent emotional reaction can be attributed to the site or side of such a lesion. For example, the emotional reaction to left hemisphere invasion may be a by-product of the concomitant language disturbances and hence essentially artifactual. As Ley and Bryden (1979a) state, "if this is the case, a predominantly right-hemispheric mediation of emotional processes might be indicated" (p.128). Although there is a lack of evidence specifically addressing this hypothesis, Ley and Bryden suggest that the literature with normal subjects supports such an interpretation.

Research with Normal Samples

Dichotic listening paradigm. King and Kimura (1971) demonstrated a left ear advantage (right hemisphere) in the identification of dichotically presented nonverbal sounds such as laughing and coughing. For a description of the dichotic methodology see Kimura (1961). Haggard and Parkinson (1971) reported a left ear advantage for the identification of emotional intonation when four emotional tones (anger, boredom, happiness, and distress) were factorally crossed with six sentences with differing verbal content. The sentences were presented dichotically with continuous babble. Both the King and Kimura study and the Haggard and Parkinson study confounded verbal processing requirements with emotion processing requirements by either having subjects verbally match the dichotic presentation with delayed binaural stimulus presentation (King and Kimura) or in Haggard and Parkinson's case, having the subjects process the verbal content as well as the emotional content.

In remedying this, Carman and Nachishan (1973) attempted to maximize the left ear advantage in the perception of emotional stimuli using a procedure that eliminated verbal contamination by making both the stimulus and response free from any apparent verbal components. They dichotically presented subjects with crying, shrieking and laughing of a child, of an adult female, and an adult male and had subjects point to a pictoral representation of the corresponding auditory stimulus. They again found a left ear advantage of equal magnitude as that found previously. This suggests that the verbal contamination of earlier studies was not systematically related to the right hemisphere superiority in identifying emotions.

Although not exactly using a dichotic paradigm, Safer and Leventhal (1977) presented subjects with monaural (either right or left ear) passages which had three levels of content (positive, negative and neutral) and three levels of tone (positive, negative and neutral). Even though subjects were not instructed about which cue to use, 29 out of 36 subjects who listened with their left ear used the tone of voice cue to rate the passages, while 21 out of 36 subjects who listened with their right ear used the content cue to rate the passages.

Tachistoscopic presentation paradigm. Although there are only a small number of studies using a tachistoscopic presentation methodology with which to examine the hemispheric asymmetry in processing emotional information, there is reason to believe that it could be a powerful strategy. The dichotic listening procedure is severely limited in the range and intensity of emotions which could be presented and recognized by subjects, whereas visual presentation permits greater flexibility. Further, because the human face is the primary communicator of affect (Ley & Bryden, 1979b; Sacheim & Gur, 1978), it seems that it would be most efficacious (and ecologically valid) to explore asymmetries in dealing with emotions as they are conveyed as a component of faces.

There is substantial literature with both clinical samples (DeRensi, Faglioni & Spinnler, 1968; Dricker, Butters, Berman, Samuels & Carey, 1978; Levy, Trevanthen, & Sperry, 1972; Warnington & James, 1967) and normals (Finlay & French, 1978; Geffen, Bradshaw & Wallace, 1971; Gilbert & Baken, 1973; Klein, Moscovitch & Vigna, 1976; Ley & Bryden, 1979; Marcel & Rajan, 1975; Moscovitch, Scullion & Christie, 1976; Patterson & Bradshaw, 1975; Young & Ellis, 1976) that overwhelmingly suggests that the right hemisphere is superior to the left in facial recognition. However,

> "The extensive tachistoscopic literature on face recognition is almost exclusively concerned with identifying the face per se and not emotional expression...Tachistoscopic research on face recognition has treated the face 'monolithically' and failed to distinguish the two primary purposes the face

serves, communication and identification". (Ley & Bryden, 1977, p.32).

As mentioned, there have been only a handful of studies reported in the tachistoscopic literature which have examined hemispheric asymmetry and the processing of emotional stimuli. Dimond and Farrington (1977) and Dimond, Farrington and Johnson (1976) used a procedure by which it was possible to present films directly to either the right or left hemisphere. They found that heart rate was significantly higher, as was subjective ratings of unpleasantness, when an unpleasant film was presented to the right hemisphere than when presented to the left hemisphere, or to both in a free vision situation. Conversely, a pleasant film produced no difference in heart rate regardless of which visual field it was presented to.

Suberi and McKeever (1977) had subjects study and memorize either emotional or nonemotional faces and judge as rapidly as possible whether a unilaterally presented face was a member of the memorized set. Reaction times favored the left visual field (right hemisphere) more strongly when the emotional faces were unilaterally presented than when neutral faces were presented. Although not demonstrating a left visual field superiority for the identification of emotional expression, the study indicates that faces are better identified in the left visual field when emotions associated with the faces are present in the memory set.

Ley and Bryden (unpublished, cited in Ley & Bryden, 1979a) report a pilot study in which they tachistoscopically presented cartoon drawings of human faces (a man, a woman, and a child), each expressing three different emotions (very happy, neutral, and very sad) to either the left or right visual field. The subject's task was to compare the laterally presented target face to a subsequent, centrally presented face and judge whether the emotion expressed was the same or different. A significant left visual field superiority for emotion recognition was obtained but the importance of this is minimized by the fact that the left visual field superiority may be a manifestation of the well documented right hemisphere advantage in facial recognition (see earlier discussion). This is mitigated, however, by Ley and Bryden's pilot finding that the left visual field effect was greater for the emotional stimuli than for neutral stimuli and by the published evidence (Ley and Bryden, 1979a) that the left visual field superiority for processing emotions is independent of the face recognition advantage.

Ley and Bryden (1979a) unilaterally presented subjects with a series of stimuli which consisted of five adult male cartoon drawings, each with five emotional expressions: extremely positive, mildly positive, neutral, mildly negative, and extremely negative. Each combination was presented either on the right or left visual field. The subject's task was to judge the similarity or difference for both emotional expression and the character of the visual field face and a subsequent centrally presented face. The results revealed that there was a left visual field superiority for both emotion and face recognition. Although there was a lack of significant visual field difference for the mildly positive, neutral, and mildly negative emotional expressions, there was a strong left visual field advantage for both the extremely positive and extremely negative emotional expressions. Further, both correlational and covariance analysis demonstrated that the left visual field (right hemisphere) effect for recognition of emotion was independent of the well established left visual field superiority for facial recognition. This finding is supported by the fact that the right hemisphere proves superior to the left in identifying and recognizing emotion in dichotic listening paradigms (eg. Carman & Nachishan, 1973) where the confounding due to facial analysis is precluded.

Summary. Although the evidence derived from clinical samples suggests that there is hemisphere asymmetry in emotional response (reactivity) with both hemispheres being involved in the expression of emotion in different ways, studies with normal subjects consistantly implicate the right hemisphere as being superior to the left hemisphere in the efficiency with which it processes emotional stimuli. Two interpretations may be offered in accounting for this. Lateralization may be different for the perceptual and expressive components of emotion. Here both hemispheres may be involved in the expression of emotion, whereas, the right hemisphere is primarily involved in recognition and identification of emotional stimuli (Ley & Bryden, 1979b; and Semmes, 1968, for varying elaborations of this interpretation). Alternatively, as previously mentioned, the finding of a characteristic (catastrophic) emotional reaction after left hemisphere invasion (by lesion or amobarbytal) may be a residual effect of the coexisting language disturbance and hence by artifactual (Ley & Bryden, 1979a).

Regardless of the resolution of this empirical discrepancy, the fact remains that there is hemispheric asymmetry in emotional reaction and that the right hemisphere has been shown to be more intimately involved in processing related the recognition and identification of emotional stimuli. The interest here was in replicating the Ley and Bryden (1979a) finding of left visual field superiority in the recognition of emotions and extending it by investigating whether the processing of emotions can still occur when the relevant stimuli are out of reportable awareness (in this case essentially the same stimuli as used by Ley & Bryden).

There is a substantial and diverse literature from the areas of binocular rivalry, retinal image stabilization, dichotic listening (fate of the unattended channel), and subliminal stimulation that collectively suggests that there are relatively high levels of processing of stimuli which lie outside of reportable awareness. These areas are briefly reviewed. It should be noted that this review is not exhaustive because its purpose is restricted to demonstrating that there is evidence that can be marshalled to support the controversial contention that processing can occur in the absence of awareness. Nisbett and Wilson (1977) state:

> "The basic question of whether people can respond to a stimulus in the absence of the ability to verbally report on its existence would today be answered in the affirmative by many more investigators than would have been the case a decade ago...The new acceptance rests on methodological innovations...and persuasive theoretical arguments that have succeeded in deriving the subliminal perception phenomenon from the notion of selective attention and filtering"(p.239).

Processing Stimuli which lie outside of Reportable Awareness

Binocular Rivalry

Binocular rivalry represents a paradigm in which two different stimuli are presented simultaneously and independently to the two eyes with the stipulation that the visual fields of the eyes, and the stimuli contained within them do not overlap. Typically, with relatively long exposure durations (i.e.:100 sec., Walker, 1975), such an arrangement yields a situation in which the two eyes alternate in being dominant in that at any one time the subject will be aware of the stimuli presented to the visual field of the 'dominant eye' but unaware of the stimuli presented to the other, 'suppressed' eye (see Walker, 1978, for a comprehensive review of the binocular rivalry literature). Further, Somelch and Wilding (1973) have demonstrated that by using the binocular rivalry methodology, it is possible to insure that one of the two stimuli will "always be completely suppressed when presented in the company of the other image, but still remain visible when presented alone" (p.339).

The interest in the current context is in the fate of the 'suppressed' stimulus. In his review Walker (1978) concludes that "binocular rivalry reflects central selective processes that take effect subsequent to the analysis of both monocular stimuli...Though peripheral responses such as changes in pupil diameter or accommodation may be correlated with rivalry suppression, they may not be held responsible for the suppression itself...the suppressed stimulus in rivalry is being fully analyzed and evaluated" (p.376). Although Blake and Overton (1979) concur with Walker's (1978) contention that central (cortical not retinal) processes are intimately involved in binocular rivalry, they suggest that rivalry does not involve such refined analysis of the suppressed stimulus as that implied by Walker.

There are several lines of evidence that suggest that the information contained in the phenomenally suppressed stimulus is being analyzed. Human visual evoked potentials have been recorded to the currently suppressed stimulus, and since these potentials are qualitatively equivalent in wave form and amplitude to those recorded where the stimulus is dominant, this suggests that some form of processing is taking place (Cobb, Morton, and Ettlinger, 1967; Riggs and Whittle, 1967). The perception of depth that is a consequence of retinal disparity can be observed despite the fact that there is a lack of reportable awareness of the suppressed stimulus in one of the monocular fields (Asher, 1953; Julesz, 1961; Kaufman, 1964).

In examining the temporal course of rivalry phenomenon Blake and Fox (1974), Levelt (1966), and Walker (1975) have demonstrated that the duration of dominance of the stimulus in one eye is independent of its strength but "dependent only upon the strength of the stimulus in the contralateral [suppressed] eye" (p.225, Levelt). This suggests that the physical features of the rivalry stimulus continue to be analyzed during its' suppressed phases.

Research also indicates that the meaningful content of the suppressed stimulus is analyzed. For example, Toch and Schulte (1961), Shelley and Toch (1962), and Berg and Toch (1966), using a procedure whereby they could ensure that only one of the two stimuli (scenes of violence vs neutral scenes) would be seen, found that policemen, institutionalized offenders and police cadets perceived the violent alternative more often than a matched group of liberal arts students. Further, Moore (1966) found that males perceived more violent stimuli than females and, for both sexes, the sensitization to violence was positively correlated with age. These authors suggest that the subjects' cognitive makeup and learning history determines which of the two rivalling stimuli emerge as the dominant one after the analysis of both. Consistent with this is the work of Rommetveit, Toch and Svendsen (1968a, 1969b) and Rommetveit, Berkley, and Brogger (1968) which also demonstrates the analysis of the meaningful content of the suppressed stimulus.

The above evidence supports the contention that, despite the lack of reportable awareness, the suppressed stimuli in binocular rivalry paradigms reaches the cortex and undergoes analysis both of it's physical and meaningful content.

Retinal Image Stabilization

Like binocular rivalry, retinal image stabilization represents a phenomenon where there is an absence of reported perception of a stimulus even though the stimulus elicits cortical evoked potentials. To achieve this, the methodology is such that the eye movements which normally effect shifting of the retinal image from one set of receptors to another are prevented. Thus, the stimulus falls on precisely the same area of the retina throughout the duration of its presentation. Subjectively, in the absence of retinal image movement, there is a gradual fading and complete disappearance of the stimuli.

Riggs and Whittle (1967) and Lehman, Beeler, and Fender (1967) reported that there were no changes in either cortical or retinal evoked potentials recorded during stabilized or unstabilized viewing conditions. Kessy (1971) also observed evoked potentials to the 'faded' stimulus but found that they were of smaller amplitude than those present in the unstabilized condition. Together these results suggest that because cortical evoked potentials are found to stimuli in the absence of reportable awareness of their presence, there is some form of processing occurring.

The Fate of the Unattended Channel in Dichotic Listening

Theories of selective attention differ greatly in the level of analysis attributed to the stage in processing of incoming material after which preferential treatment is given to an attended message over an unattended message (Kahneman, 1973). As Shevrin & Dickman (1980) suggest however, all such theories assume that at least some part of the cognitive activity (the initial stages) related to attention occurs outside of reportable awareness. What is at issue here (and what primarily distinguishes theories of attention) is the degree to which material not attended to and, which lie outside of reportable awareness, is processed.

Dichotic listening paradigms provide a methodology by which it is possible to assess the fate of material which is not attended to and hence is not available to the subject's awareness. This is accomplished by having the subject attend to and shadow (repeat back) verbal material presented to one ear simultaneously with distracting verbal material presented to the other nonattended to ear. Depending on the specific manipulation and dependent measure used, it is possible to assess what level of processing the unattended material undergoes in the absence of any awareness of the content of that message.

With this as his goal, Lewis (1970) provided subjects with a dichotic listening task in which he assured that attention would be directed only to the attended channel by requiring relatively errorless shadowing of words presented at a rate of 1 word / 2/3 second. The unattended message words consisted of words associately related, semantically related, or unrelated to the attended message words. He reasoned that if the unattended message words were being processed, this would interfere with the processing of the attended message words because such processing already taxes the capacity of the subject. Further, the nature of the unattended processing could be inferred from the stimulus conditions which produced interference. The dependent measure was verbal reaction time to attended words as a function of the class of simultaneously presented unattended words. The results revealed that although subjects were unable to recall unattended message words while maintaining errorless shadowing, there were significant reaction time differences to the various unattended message word classes with semantically similar words producing the greatest interference. Lewis concluded that the unattended message is processed at a semantic level even though the content of the message cannot be reported by the subject.

Using a different dichotic listening methodology Corteen & Wood (1972) also conclude that there is "a fairly sophisticated degree of processing occurring without awareness" (p.312). These authors conditioned GSRs to city names using electric shock and then embedded the city names in material presented to the nonattended channel in a dichotic listening task. Although city names were no more likely to produce GSRs than any other nouns in the absence of conditioning, the results revealed that there were significantly more GSRs to shock-associated city names and nonshock-associated city names than to nonshock-associated control nouns. An elaborate three stage interview procedure was used to assess awareness of the unattended material and although only 5 subjects (out of 36) admitted hearing some words, no subject was aware of hearing any city names during the dichotic listening task. Thus, even though there was an absence of awareness of the material in the unattended channel, their results suggest that semantic ("word class") processing of material goes on.

Although Wardlaw and Kroll (1976) failed to replicate the Corteen and Wood (1972) finding despite "every attempt..., to follow the original procedure as closely as possible" (p.360), there are slight methodological differences which may account for their negative results. As Forster & Govier (1978) state, "careful study of both reports lead to the conclusion that the discrepancy may rest on the conditioning procedures of the two experiements" (p.293). Even though both reports indicate an equal number of CS (city) - US (shock) pairings were used (three per CS), there may have been large differences in the intensity of the shock used. Corteen and Wood report losing approximately one-third of their subjects because the shock level was higher than they were willing to tolerate, while Wardlaw and Kroll did not report such experimental attrition. Forster and Govier conclude that "Wardlaw and Kroll did not use a sufficiently large number of word-shock pairings for their comparitively low level of shock" (p.293).

This argument is strengthened by Forster and Govier (1978), and VonWright, Anderson, and Stenman's (1975) findings, using procedures similar to Corteen and Wood, of GSR's to the occurrence of the CS in the unattended channel and also to words acoustically similar to the CS and to synonyms of the CS. Because of the generalization of the conditioned GSRs from the actual target CS to words semantically similar (but different in acoustical properties - i.e., CS - Ships, synonym - Boats) Forster & Govier state that "the weight of experimental evidence from various areas of investigation now support the notion that complex linguistic material may be processed to the level of meaning without awareness of the subject"(p.294).

Subliminal Stimulation

The concept that stimuli which lie outside of reportable awareness can be processed receives its most vehement attack when it is embodied in the form that uses subliminal stimulation as its descriptor. The reasons for this may reside in the reactions to the sensational claims that have been made regarding the use such a phenomenon could be put to in the fields of advertising (for a review of these claims and the empirical data that suggests less dramatic and subtle effects see George & Jennings, 1975; Hawkins, 1970; Housepian & Quatiman, 1978; McConnell, Cutler, & McNeil, 1958; Oshikawa, 1970) and the fact that until recently (i.e. Dixon, 1971; Erdely, 1974; Watson, 1975), positive findings using stimuli which lie below threshold use various psychoanalytic notions (particularly a topographical unconscious) as explanatory devices (Blum & Barbour, 1979; Pine, 1964; Silverman, 1971, 1975, 1976). An example of this latter point is Erdely's (1974) development of an information processing model in which there are multiple loci of selectivity,only some of which are available to reportable awareness.

That the history of research on subliminal stimulation has been stormy and controversial is without doubt and is attested to by the methodological critiques that have appeared (for example see Adams, 1957; Bevan, 1964; Eriksen, 1960). The most cogent and parsimonious alternate explanation for the subliminal phenomena revolve around the manner in which thresholds are determined and the possibility that by not using the stringent forced choice methodology, partial cues are available which are not reported due to negative response bias (Guthrie & Wiener, 1966; Wiener & Kleespies, 1968). These partial cues are systematically related to particular stimuli such that in the absence of report, the illusion of subliminal stimulation is demonstrated.

This issue has been specifically addressed by Silverman (1968) and Silverman and Spiro (1967) who have shown that in a discrimination task administered after successful subliminal stimulation studies, using the same procedural parameters as in the experiments proper, there were no partial cues available to be used in discriminating experimental stimuli from neutral, control stimuli. In other words, experimental stimuli could not be discriminated from control stimuli. If, as the partial cue hypothesis suggests, there were structural cues available to subjects, it would be expected that discrimination between stimuli would be possible. This is strengthened by the demonstration that subjects were unable to discriminate between a blank slide presentation and a presentation of a slide with a stimulus on it even when monetary reward was offered for accurate performance. Further, the findings (summarized in Silverman, 1976; Silverman, Bronstein, & Mendelsohn,1976), demonstrating that the response to a subliminal stimulus is markedly different from one that is supraliminal, ran counter to what would be predicted by the partial cue hypothesis.

As Silverman (1976) states:

> "In the 1960's many subliminal stimulation experiments came under attack for methodological weaknesses. This had the salutory effect of stimulating the subliminal 'advocates' to tighten their experimentation so that such alternate explanations as 'partial cues' could be dispensed with. The success of these latter efforts is attested to by the fact that over the past years, while many papers have been written in which subliminal effects have been claimed, no papers, to my knowledge, have challenged the validity of subliminal phenomena. Thus, as Dixon (1971) in his exhaustive and scholarly book tracing research in this area has maintained, a careful review of all of the pertinent literature to date leads to the conclusion that subliminal registration has been demonstrated beyond any reasonable doubt"(p.624).

Similarly, Sackeim, Packer and Gur (1977) have concluded that "the weight of the evidence from experimental investigations firmly supports the view that registration of perceptual stimulation outside of conscious awareness does occur" (p.624). In support of this there is neurophysiological evidence which shows that subliminally presented stimuli are encoded by averaged evoked potentials (see earlier discussion and Martin, Hawryluk, & Guse, 1974; Shevrin, 1974; Shevrin, 1975; Shevrin, Smith & Fritzler, (1969). Shevrin (1974) has also provided data that suggests that the average evoked responses encode subliminal stimulus content in that the evoked potential to such stimuli differing in content can be reliably differentiated.

Despite attempts at systematic replication, Schwartz and Rem (1975) were unable to find evoked potentials that could discriminate stimuli differing in content. Although there is negative evidence for content being encoded in the evoked response, the finding of such potentials to subliminal stimuli is important in itself for it does suggest some form of processing in the absence of reportable awareness.

Although subliminal effects have been demonstrated in many different contexts (i.e. dreams, adaption level, verbal behaviour, and drive-related behaviour), this review will be restricted to recent studies investigating the possibility that subliminal stimulation can influence affect (for a comprehensive review and analysis of research on subliminal stimulation see Dixon, 1971).

Silverman and his colleagues (Silverman, 1971, 1975, 1976; Silverman, Bronstein, & Mendelsohn, 1976; Silverman, Martin, Ungaro & Mendelsohn, 1978) have completed over 20 studies (summarized in Silverman, 1976) in which what has been termed 'subliminal psychodynamic activation' has been used to investigate "the relationship between psychopathological behaviour and unconscious libidinal and aggressive wishes" (p.432, Silverman et al, 1978). Without attempting to deal with the validity of the interpretations of the evidence that this research group has generated, the data are very consistent in that they convincingly demonstrate that stimuli which lie outside of reportable awareness can influence affect.

The basic design of these studies is similar and entails a within subject analysis of pre- and post-test measures (behaviour rating scales, word association tests, story recall tasks, and inkblot tests) under two counter-balanced conditions (control and experimental). The studies are well controlled, making use of double-blind procedures and stringent forced choice detection criteria. Using a variety of samples (depressives, homosexuals, schizophrenics, stutterers, obese subjects, and insect phobics) it has been shown that presentation of the relevant drive-related subliminal stimuli (relevant as derived from psychoanalytic tenets) produce increased pathological reactions while no such increase appears after a subliminal presentation of neutral stimuli, or the supraliminal presentation of the drive-related stimuli.

Using a different approach O'Grady (1977) presented subjects both sexual and neutral pictures at one, two and three standard deviations below each subject's mean detection threshold and found significantly greater mean deflection in skin resistance following exposure to the sexual pictures than to the neutral pictures. The detection threshold was defined as that point at which subjects detected anything other than the white background that was provided. Hence, there is a very low probability that stimuli presented at speeds one, two and especially three standard deviations below mean detection threshold would be detected. This study replicates earlier reports (e.g. Dixon, 1958; Worthington, 1961) of skin resistance changes to emotionally charged stimuli presented subliminally and suggests that meaning and affective connotations of the stimuli can be abstracted in the absence of reportable awareness.

Using essentially a binocular rivalry paradigm, Somelch & Wilding (1973) presented an expressionless face to one eye and affect words (happy or sad) to the other eye. Although the words were visable when presented alone, the arrangement was such that they were completely suppressed when presented simultaneously with the face. That this was the case is attested to by introspective data collected after the completion of the experiment which revealed that 36 out of 40 subjects were unaware of <u>any</u> stimulus other than the target face. The results showed that the subliminal exposure of the words 'happy' and 'sad' influenced the affective judgements of the face in the appropriate direction.

In a similar study, Sacheim, Packer and Gur (1977) supraliminally presented subjects with an expressionless face on which was superimposed a subliminal happy or sad face. Subliminal exposure levels were determined for each subject by having five blocks of ascending trials in which the task was to indicate the point at which any change (new lines or shadows) was noted in the appearance of a neutral face. A subliminal neutral face was superimposed upside down at increasing luminances. The threshold for each subject was computed by averaging the values at which the last report of no change occurred for the five ascending blocks. The results demonstrated subliminal effects for left hemisphere dominant subjects who were encouraged to think in a logical, organized manner and for right hemisphere dominant subjects when encouraged to think in an intuitive and holistic way. There were no subliminal effects for the converse arrangement.

Summary

The above review of the experimental literature from the areas of binocular rivalry, retinal image stabilization, dichotic listening, and subliminal stimulation provides strong evidence which suggests that processing to the level of meaning does occur in the absence of awareness. Further, the Sacheim et al (1977) results demonstrating an interaction between hemisphericity and cognitive set are consistent with the earlier discussion regarding the mode of processing speculated to be specific to each cerebral hemisphere particularly with regard to the processing of emotional stimuli. These findings, together with Ley and Bryden's (1979a) results showing left visual field - right hemisphere superiority in the recognition of emotions, suggest that although both hemispheres can process emotional stimuli, they do so with different efficiencies.

Because Sacheim et al (1977) were investigating what they termed as "an enduring personality characteristic [hemisphericity] and situationally induced cognitive sets in the production of subliminal effects" (p.629), they did not examine hemispheric differences in the processing of subliminally presented emotional stimuli per se. For example, even though they identified whether subjects were right or left hemisphere activators by scoring conjugate lateral eye movements, they did not present stimuli to each visual field individually. Rather, they had long duration centre field presentations where stimuli have easy access to both hemispheres simultaneously.

As stated earlier, the present intent was to attempt to replicate the Ley and Bryden (1979a) finding of a left visual field superiority in the recognition of emotions as represented in facial expression and, extend it, by investigating whether the finding of lateralization is maintained when the stimuli lie outside of awareness. Further, the present study corrects what is considered to be a methodological flaw in the Ley and Bryden study and hence, provides a more stringent test of hemisphere asymmetry in the processing of emotions. Specifically this criticism is of Ley and Bryden's procedure of exposing the faces centered at 1^{o} of visual angle from the fixation point. Since their faces subtended 2^{o} of visual angle, the inside edge of the face was on the midline and the outside at a location 2^{o} off fixation. Using such a preparation the stimuli are accessible to both hemispheres although most of the information contained in the faces goes to the contralateral (to the side of presentation) hemisphere. As White (1972) has pointed out in his review of the tachistoscopic literature, because of the overlap of the visual fields, stimuli need to be positioned at a point such that the inside edge of the display subtend at least 2° of visual angle to insure that only the contralateral hemisphere initially receives the stimuli.

Experimental Design and Rationale

To achieve these ends this study was designed to be a varient of that carried out by Marcel (In Press) which Sacheim,Nordlie, and Gur (1979) describe as having "provided perhaps the most clear-cut demonstration of...the independence of visual processing from awareness of visual representation"(p. 480). Following what he termed as a 'crude hunting procedure' to get an idea where each subject's threshold was using a visual masking paradigm, Marcel presented words at the centre of fixation followed at various intervals by a visual mask. This enabled him to sample a range of target word-mask intervals from above threshold to well below it. On each trial, at the various target-mask intervals, subjects were required to make one of the following forced choice decisions which were randomly rotated for each trial: (a) whether or not a word had preceded the mask, (b) which of two words did it resemble graphically (e.g., present hill, test hilt and cigarette); or (c) which of two did it resemble in meaning (present hill, test mountain and machine). Results revealed that although all three questions were accurately responded to at long target-mask intervals, when the duration decreased the first judgement to reach chance was whether or not a word had appeared, followed by judgements of structural similarity, and finally, at substantially shorter target-mask intervals, by the semantic judgement. Thus, at target-mask intervals where subjects were at a chance level in deciding whether a word had been presented or not, they were above chance in judging structural and semantic similarity.

Using a design conceptually similar to Marcel (1980) this study presented subjects simultaneously with (1) a face expressing either positive, neutral, or negative affect to the left or right visual field and (2) the outline of the face containing visual noise, uncorrelated with the emotion but with equal density, to the opposite visual field. The visual field containing the face expressing emotion was randomized so that on the average each visual field contained a face one half of the time. A range of stimulus presentation durations was used which sampled both the above threshold and below threshold processing.

Masking was not used in the present study because of the complexity and unpredictable nature of masking functions (for a review see Fox, 1978). Further, although Marcel (1980) was able to demonstrate the masking of words, there is little data on the masking of complex visual-spatial stimuli such as faces while the literature using subliminal presentation of complex stimuli is vast (see earlier discussion).

On each trial subjects responded to two forced choice questions: (a) which side was the face on?, and (b) what was the emotion expressed by the face? Threshold was determined for each subject by locating the stimulus presentation duration at which a chance level of responding was noted for the question asking which side the face is on. It was felt that this form of forced choice threshold determination would be very stringent because it is such that if structural cues are available for the detection of emotions, then these would be used to answer what intuitively is the easier question of what side the face is on. That is, such structural cues, if available, would be used to discriminate a face from a non face. Further, it is thought that the choice of which side the face is on is one that could be made without any confidence and be perceived by the subject as simple guessing (i.e., is itself a subliminal phenomena). Using this reasoning, I felt confident that any degree of above chance accuracy in identifying the emotion expressed in the faces (when the location accuracy is at chance) would be evidence for processing outside of awareness.

Hypotheses

The following hypothese were advanced:

(1) The left visual field-right hemisphere will prove superior to the right visual field-left hemisphere in locating the face and identifying the expression (positive, neutral, or negative) on the face throughout the range of stimulus presentation durations.

(2) The left visual field superiority for the identification of expression will be greatest for the positive and negative emotional expressions.

(3) When the accuracy of decision on location is at chance, identification of the emotional expression on the face will be above chance for both visual fields.

No specific predictions were offered concerning the interaction of emotion presented (positive, neutral, or negative) with presentation duration or the interaction of emotion presented, visual field, and presentation duration.

Method

Subjects

The subjects were 21 volunteer male, right-handed intersession undergraduate students taking psychology courses at the University of Manitoba. Age ranged from 19 - 35 with a mean of 22.8 years. English was their first language. All had normal or corrected to normal vision in both eyes. Subjects attended one experimental session which lasted approximately 100 min. One subject was dismissed from participation for failure to attend to the experimental task.

Stimuli and Apparatus

The experimental stimuli were 15 of the 25 cartoon drawings of five adult faces used by Ley and Bryden (1979a). The faces representing the mildly positive and mildly negative emotional expressions were ommitted from the experiment proper because Ley and Bryden found no lateralization in the processing of them. The five adult faces expressed each of three emotions (positive, neutral, and negative; See Figure 1).

Insert Figure 1 about here

The faces expressing the mildly positive and negative emotion were used in a forced choice threshold determination procedure (See Figure 2).

Figure 1

Insert Figure 2 about here

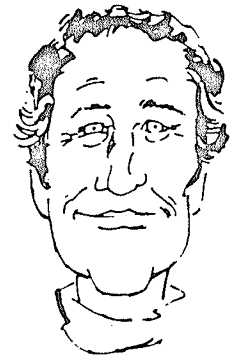
Isolated discriminable features such as hair, eyes, nose, facial lines, etc. were grossly similar for each face, as was the overall size, shape and general 'gestalt' of the head.

The outline of each facial stimulus was traced and copied and then visual noise was drawn in so that the density of the material enclosed by the traced outline was approximately equal to that of the face itself. The same configuration of visual noise was placed in each face outline so that there was no correlation with the emotion expressed by the faces. The hair was traced in also (See Figure 3) because pilot work has shown that there are marked

Insert Figure 3 about here

luminance differences between the outline of a face and one that contains the representation of hair. The faces expressing emotion and the outline of the corresponding face containing visual noise was affixed to 12.7 x 17.8 cm white cards for tachistoscopic presentation. The facial stimuli and the outlines were approximately 4.5 cm in height and 2.6 cm in width. Four sets of 30 cards (5 characters x 3 emotions x 2 visual fields) were used for the experiment proper and two sets of 20 cards (5 characters x 2 emotions x 2 visual fields) were used for threshold determination.

Figure 2



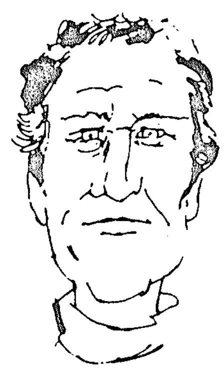
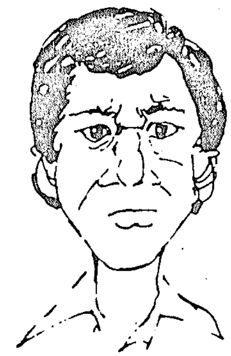
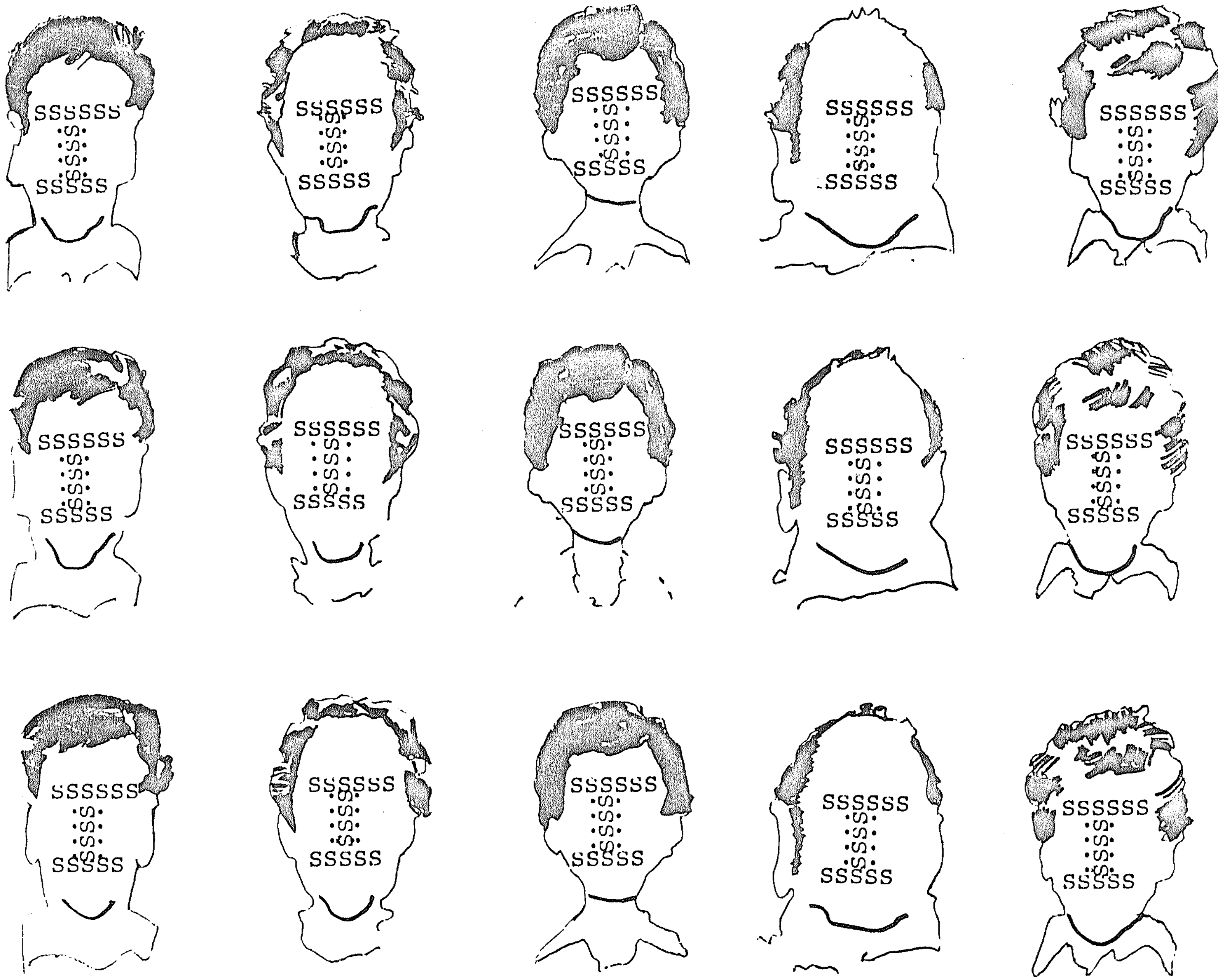




Figure 3



A face expressing emotion and an outline of a face containing noise was located on each card, either to the left or right of fixation. On one half of the cards the face expressing emotion was on the left with the outline on the right and on the other half the positions were reversed (See Figure 4 for a sample stimulus card). In each set

Insert Figure 4 about here

(experimental) of 30 cards, each emotion expressed by the five characters appeared five times on both the left and right side of the cards. Each character appeared three times on both the left and right of the cards.

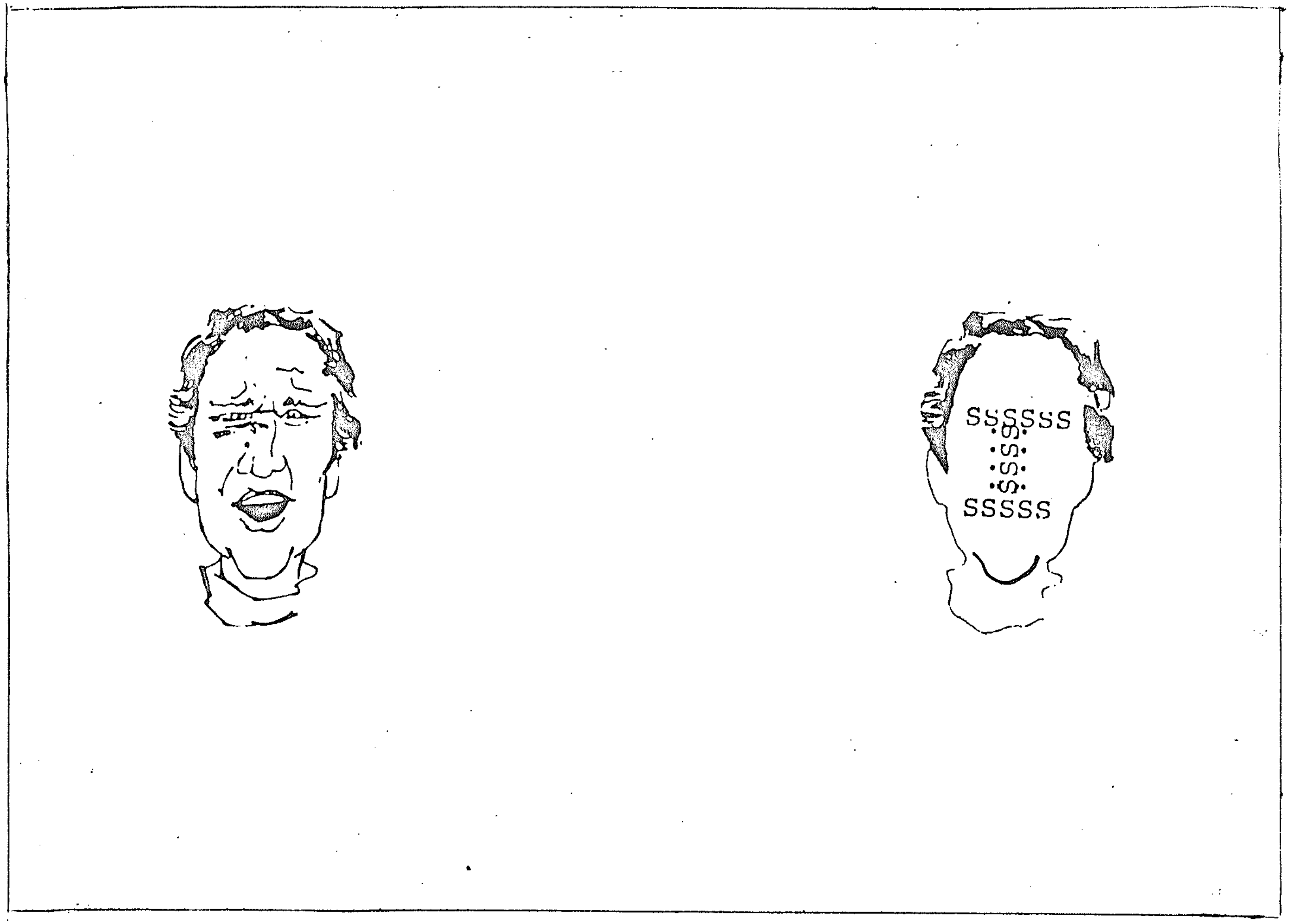
The stimuli were positioned such that the inside edge of the face or outline was 3.98 cm to the left or right of fixation. Stimuli were presented in a three field Scientific Prototype tachistoscope (Model GB) at a viewing distance of 114.30 cm. When exposed the inside edge of the stimuli was 2^{o} of visual angle from the central fixation point.

Procedure

Upon entering the laboratory and being seated at the tachistoscope each subject was read the following instructions.

> "This is an experiment looking at the identification of emotions expressed by faces when the faces are presented at very fast speeds. What you are going to be asked to do is look through the viewer and when I say 'ready', fix

Figure 4


SSSSSS
SSSSS

your eyes on the 'X' which will be presented in the middle of the screen for 1.5 sec. Immediately after the 'X' disappears a card similar to this one will be flashed very quickly [Experimenter will show subject a stimulus card from the threshold determination set]. Notice on this card, as on all the cards I will present you, there is a cartoon face expressing emotion on one side and the outline of the face with some lines in it on the other side. What we are going to do first is determine how fast I will have to present the cards to you. I am going to present cards to you at various speeds starting at a speed where you most likely will not know what side the face is on. On each presentation I want you to tell me if you can determine which side the face is on and, if so, what side it is on. This will be a difficult task because the side the face is on will be randomly determined so that your best strategy is to look at the center of the viewer at the 'X' because you won't be able to predict which side the face will be on. Any questions? [if so, experimenter will clarify]."

In this threshold determination procedure the cards with the mildly positive and negative emotion were used. The order of presentation was random with a face appearing on each side one half of the time. The first card was presented at 5 msec duration and the presentation time was increased by 3 msec steps until the subject was able to discriminate which side the face is on. The rest of the cards was then presented at one increment (3 msec) below the point at which the subject stated that he could discriminate and was correct on the first card until a criterion of less than 60% accuracy (over at least 10 trials) was met for each visual field. This occasionally entailed either increasing or decreasing the exposure duration by 3 msec increments until the criterion was met at a specific exposure duration. This served as a crude threshold determination in that it allowed the presentation of a range of presentation durations both above and below that determined. When the procedure resulted in accurate discrimination in either visual field at exposure durations of 11 msec the procedure was terminated and the 10 msec exposure duration was used as the point about which the exposure durations ranged. Because it was thought that threshold may wander during the course of the experiment in unknown ways due to the interaction of practise and fatigue, the threshold initially determined was used just as a guide to indicate where, for each subject, to place a range of presentation durations which spaned both above and below threshold processing.

The exposure durations used in the experiment proper were 10 msec above the point where the subject had less than 60% accuracy over at least 10 trials for each visual field, at that point, 5 msec below it, and finally 10 msec below it. For those subjects who were discriminating accurately in either visual field at 11 msec, the exposure durations used in the experiment proper were 20 msec, 10 msec, 5 msec, and 1 msec. Pilot testing has shown that accuracy at 5 msec and at 1 msec is at a chance level. The presentations at the four exposure durations were randomized so that on average two sets of 30 cards were presented at each duration. The 120 cards were presented twice with the random order reversed for the second presentation. Thus for each exposure duration there were 60 trials with 30 to each visual field. Over the total 240 trials subjects were exposed to each of the emotional expressions 10 times in each visual field at each exposure duration.

The following instructions were used to introduce the experiment proper.

> "Good. 'Now we will begin the experiment. As mentioned I am interested in your identification of the emotional expression in faces. What we will now be doing is essentially the same as before. Briefly, you will be looking through the viewer and when I say 'ready', fix your eyes on the 'X' which will be on for 1.5 sec. When it disappears a card similar to the ones you have been viewing will appear again with the face expressing emotion either to the left or right of centre. I will be changing the speed of presentation throughout the experiment so some trials will be more difficult than others. Because you will not be able to predict which side the face will be on it is essential that you look directly at the 'X' when it appears in preparation for the face presentation. This is especially important now because I am most interested in your perception of the emotions. After each presentation your task will be to indicate on your response sheet what side the face is on and what emotion is expressed by it. Some of the cards will be flashed very quickly so you will have to guess to answer the questions. In these cases just answer the questions in the way that feels best or that intuitively seems right. This sheet shows you the emotions which will be shown [Subject is shown a sheet, Figure 1, with 5 different characters expressing the three emotions]. The top line of faces is designated positive, the middle neutral, and the bottom negative. Do you have any questions?' [Experimenter clarifies if need be].

There was a five minute rest period after the first 120 trials. Upon completion subjects were debriefed and told about the nature of the study.

Results

As an initial step, seperate analyses were performed on the accuracy of judgements for the location and facial expression dependent measures. The number of correct judgements were used as the data points in these analyses. Correct judgements for both dependent measures were defined as a correspondence between the response the subjects made and the stimulus conditions actually presented. For each dependent measure, the absence of a response was regarded as an error. These accounted for four out of the 9600 data points (0.042%).

As a validity check for both analyses, a 4 (Presentation Duration) X 3 (Facial Expression) X 2 (Visual Field) X 2 (Trial Block-Trials 1 - 120, Trials 121 - 240) repeated measures analysis of variance was performed. In both analyses, consistent with expectation, the main effect and interactions (single and higher order) involving the Trial Block factor were not significant (most Fs < 1.0 and all ps $> .25$). Consequently, the Trial Block factor was not used in further analyses and will not be included in discussion since it seems that accuracy on both dependent measures is not effected in this analysis by the combination of practice and fatigue.

Judgements of Location Analysis

Table 1 reveals the results of the 4 (Presentation

Insert Table 1 about here

Table 1

4 (Presentation Duration) X 3 (Facial Expression) X 2 (Visual Field) Repeated Measures Analysis of Variance for the Accuracy of Location Judgements

Source	*df*	*MS*	*F*	*p*
PD	3	87.772	23.60	.00001
Error	57	3.507		
FE	2	66.202	12.66	.0001
Error	38	5.231		
VF	1	99.008	3.73	.0684
Error	19	26.530		
PD X FE	6	10.491	4.09	.0009
Error	114	2.566		
PD X VF	3	3.203	0.68	.5702
Error	57	4.736		
FE X VF	2	20.227	5.88	.006
Error	38	3.440		
PD X FE X VF	6	2.638	1.12	.3547
Error	114	2.354		

NOTE: PD, Presentation Duration; FE, Facial Expression; VF, Visual Field.

Duration) X 3 (Facial Expression) X 2 (Visual Field) repeated measures analysis of variance on accuracy of location judgements. Consistent with prediction, the Visual Field main effect approached significance (F (1, 19) = 3.73, p < .0684) indicating that faces were identified more accurately when presented to the left visual field (mean accuracy, 65.46%) than when presented to the right visual field (mean accuracy, 56.37%).

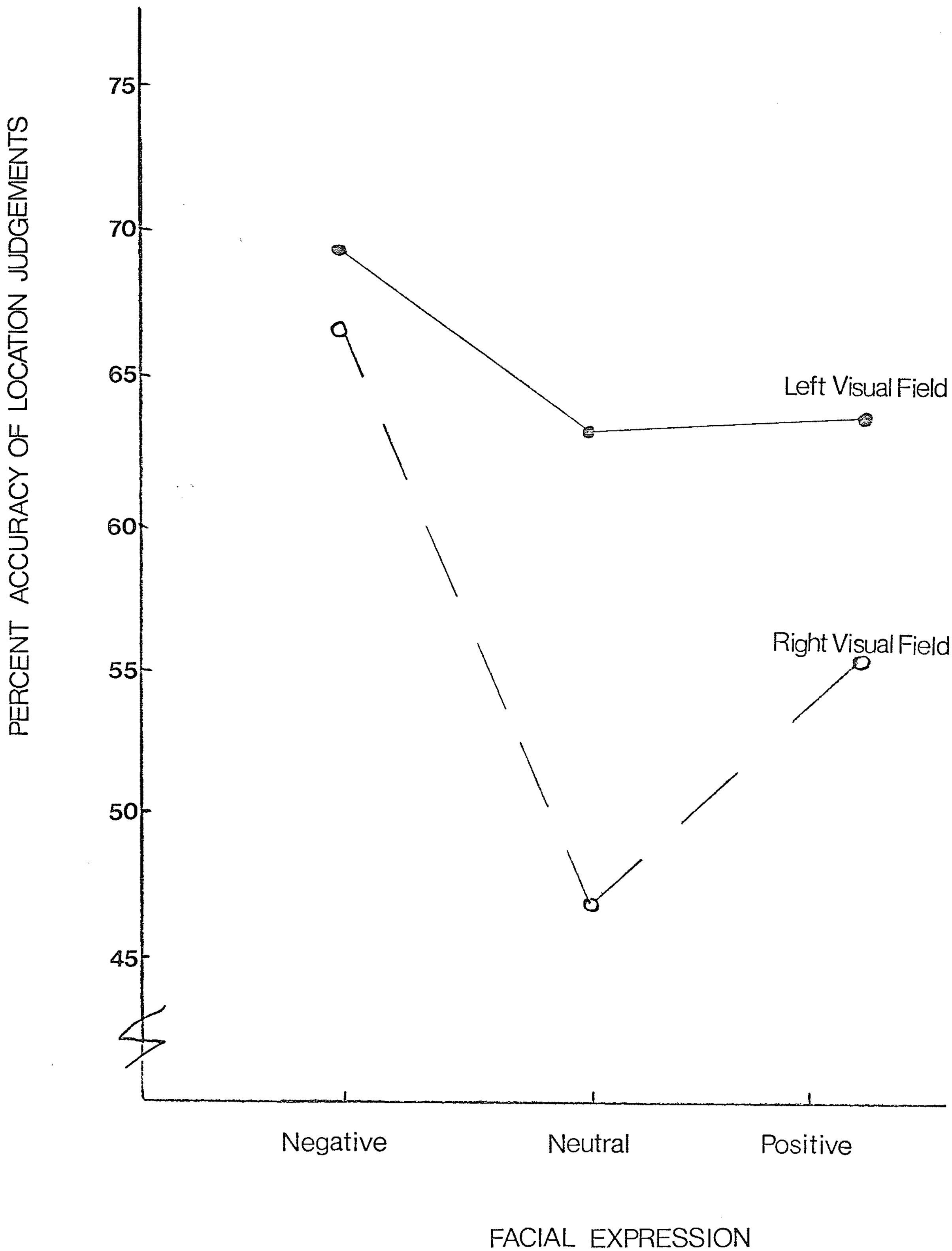
The interpretation of this main effect is mitigated however by the significant Visual Field X Facial Expression interaction (F (2,38) = 5.88, p <.006) which is illustrated in Figure 5. Post hoc Scheffe multiple comparisions revealed

Insert Figure 5 about here

that although faces were located more accurately in the left visual field when the facial expression was positive (F (2,38) = 7.68, p < .05) or neutral (F (2.38) = 32.14, p < .001), there was no visual field asymmetry when the expression was negative (F (2.38) = 0.73). Further, there was no difference in the visual field asymmetry between neutral and positive facial expressions for locating the face (F (2.38) = 4.20, p > .10).

The significant Presentation Duration main effect (F (3.57) = 23.60, p < .00001) indicated that accuracy in locating the face decreased as the presentation duration of the stimuli gets shorter. Post hoc orthogonal contrasts reveal that accuracy was greater "10 msec above threshold'[1]

Figure 5


PERCENT ACCURACY OF LOCATION JUDGEMENTS
75
70
65
60
55
50
45
Left Visual Field
Right Visual Field
Negative
Neutral
Positive
FACIAL EXPRESSION

(mean accuracy, 69.75%) than the average of 'at threshold', '5 msec below threshold' and '10 msec below threshold' (mean accuracy, 57.97%) ($\underline{F}$ (1,57) = 35.59, $\underline{p}$ < .001); accuracy 'at threshold' (mean accuracy, 66.17%) was greater than the average of '5 msec below threshold' and '10 msec below threshold' (mean accuracy, 53.87%) ($\underline{F}$ (1,57) = 34.46, $\underline{p}$ < .001); but accuracy '5 msec below threshold' (mean accuracy, 54.91%) was no different than accuracy '10 msec below threshold' (mean accuracy, 52.84%) ($\underline{F}$ (1,57) = 0.74). As will be seen and as suggested by these results, the true threshold was at the point designated '5 msec below threshold' (see later discussion).

The significant Presentation Duration X Facial Expresion interaction ($\underline{F}$ (6,114) = 4.09, $\underline{p}$ < .0009) is illustrated in Figure 6. Poct hoc Scheffe multiple comparisions reveal that the overall decrease in accuracy locating the face was

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Insert Figure 6 about here

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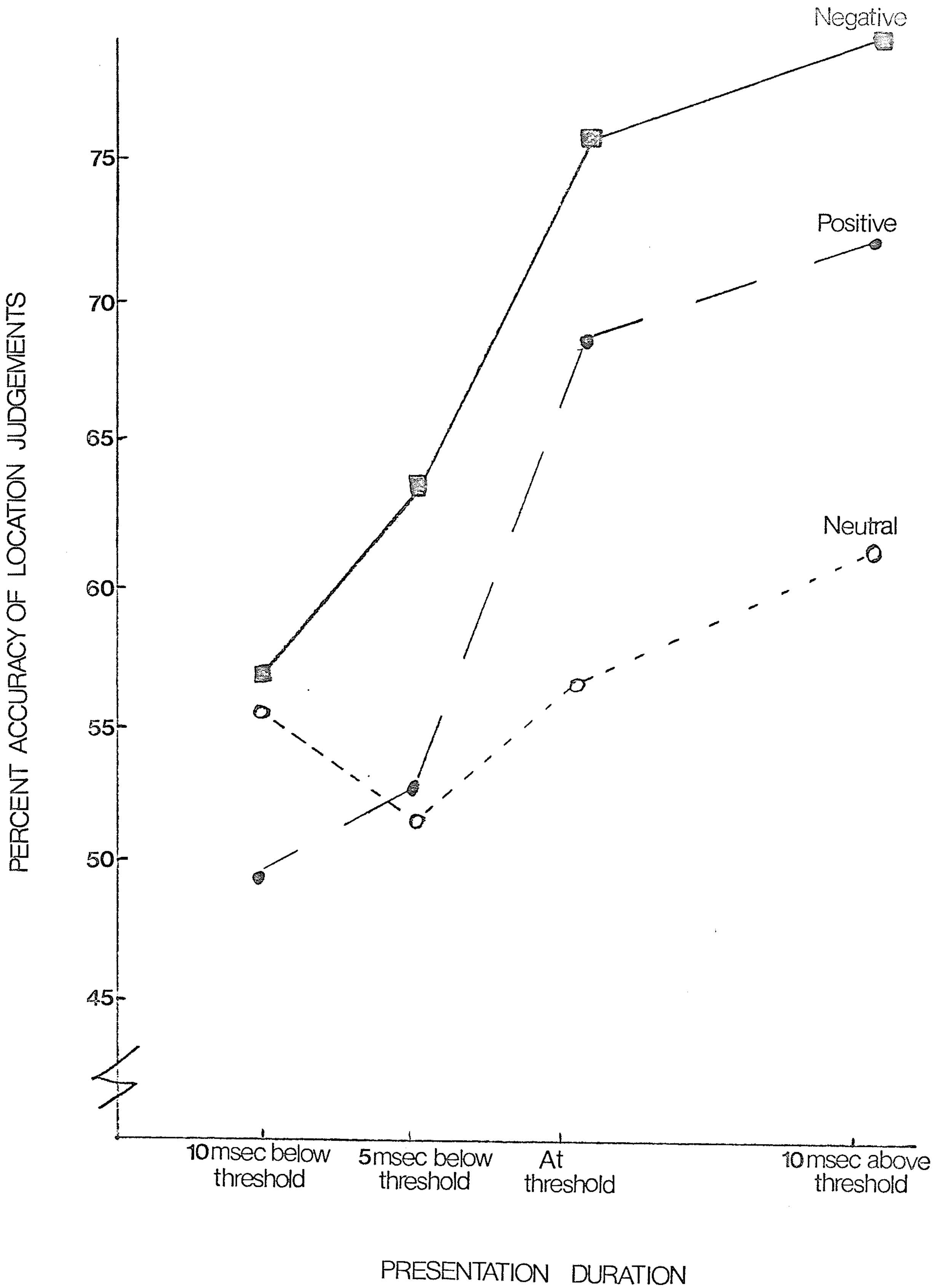
greater when the facial expression was positive or negative than when neutral ($\underline{F}$ (6, 114) = 15.91, $\underline{p}$ < .025). There was no difference in the overall decrease in accuracy when the facial expression was positive as compared to negative ($\underline{F}$ < 1.0). Further, accuracy locating the face was greater '10 msec above threshold' and 'at threshold' when the facial expression was negative ($\underline{F}$ (6, 114) = 55.53, $\underline{p}$ < .001), and positive ($\underline{F}$ (6, 114) = 21.52, $\underline{p}$ < .01) rather than neutral. There was no difference in accuracy when the facial expres-

Figure 6



Negative
Positive
Neutral
75
70
65
60
55
50
45
PERCENT ACCURACY OF LOCATION JUDGEMENTS
10 msec below threshold
5 msec below threshold
At threshold
10 msec above threshold
PRESENTATION DURATION

sion was positive as compared to negative (F (6, 114) = 7.913, P > .1) at these presentation durations. Accuracy in locating the face was also greater '5 msec below threshold' when the facial expression was negative as compared to positive and neutral (F (6, 114) = 14.35, p < .05).

Judgements of Facial Expression Analysis

Inspection of the data on accuracy of facial expression judgements (see Table 2) revealed that a marked response bias was operating such that on trials where subjects were

Insert Table 2 about here

presented with stimuli at or below the facial expression threshold (i.e., at '10 msec below threshold where the number of correct judgements, regardless of facial expression, was not different from that expected by chance responding - 33.3%), they had a tendency to respond that the face presented had a neutral expression rather than one of the extremes (either positive or negative). As Table 2 indicates, this had the result of artifactually inflating the accuracy of judgements of the neutral facial expression because subjects had disproportionately responded neutral over positive or negative (Scheffe F (6, 114) = 31.52, p < .001), even though overall accuracy represented a chance level of responding (Scheffe F (6, 114) = 0.07). When the overall accuracy represents chance responding, it would be expected that unbiased subjects would respond to each of the three facial expression categories with equal frequency. Further,

Table 2

Percentage Accuracy of Facial Expression Judgements and Mean Number of Responses to each of the Facial Expression Categories.

Facial Expression	Presentation Duration: 10 msec above threshold		At threshold		5 msec below threshold		10 msec below threshold	
Left Visual Field								
Positive	59.0	(11.8)	50.0	(11.8)	46.5	(11.2)	33.0	(8.65)
Neutral	48.0	(7.95)	43.5	(8.8)	50.0	(12.25)	57.0	(16.15)
Negative	51.5	(10.2)	39.0	(9.1)	32.5	(6.5)	18.5	(5.15)
Overall accuracy	52.8		44.2		43.3		36.2	
Right Visual Field								
Positive	54.5	(10.55)	48.5	(12.4)	41.0	(10.55)	24.0	(8.25)
Neutral	44.0	(7.6)	37.0	(7.75)	48.5	(12.25)	54.0	(16.4)
Negative	54.5	(11.9)	38.5	(9.95)	32.5	(7.2)	20.0	(5.35)
Overall accuracy	51.0		41.3		40.7		32.7	

Note 1. Numbers in parentheses indicate the mean number of facial expression judgements. There were 10 stimulus presentations for each cell for every subject.

Note 2. Overall accuracy is mean number of correct judgement regardless of facial expression. Chance performance is 33.3% accuracy.

although overall accuracy represented chance performance, accuracy for the negative facial expression was significantly below the chance level in both visual fields (for the left visual field, t (114) = 3.13, $p < .005$; for the right visual field, t (114) = 2.81, $p < .005$). Again, this reflects the operation of a sizable response bias.

To remove the unwanted effects due to the response bias, a 4 (Presentation Duration) X 3 (Facial Expression) X 2 (Visual Field) repeated measures analysis of covariance was performed with accuracy of facial expression judgements as the dependent variable and number of responses to each of the facial expression categories as the covariate. This analysis removed from the variance in the accuracy of facial expression data, the variance attributable to, and hence predictable from disproportionate responding to the facial expressions.

Table 3 summarizes the results of this analysis. Contrary to prediction, there was no Visual Field main effect (F (1, 18) = 1.81, $p < .1956$) nor was the Visual Field X Facial Expression interaction significant (F (2.37) = 0.05). Thus, there was no difference in accuracy of facial expression judgements between the visual fields, or difference in visual field asymmetry among the three facial expressions.

The main effect of Facial Expression approached significance however (F (2, 37) = 3.07, $p < .0585$) and post hoc orthogonal contrasts reveal that there was a trend for accuracy to be greater when the facial expression was neutral

Table 3

4 (Presentation Duration) X 3 (Facial Expression) X 2 (Visual Field) Repeated Measures Analysis of Covariance for Accuracy of Facial Expression Judgements with Number of Responses to the Facial Expression Categories as the Covariate.

Source	df	*MS*	*F*	*p*
PD	3	60.226	12.74	.00001
Error	56	4.726		
FE	2	4.109	3.07	.0585
Error	37	1.340		
VF	1	11.995	1.81	.1956
Error	18	6.506		
PD X FE	6	1.138	1.21	.3080
Error	113	0.943		
PD X VF	3	0.149	0.06	.983
Error	56	2.693		
VF X FE	2	0.056	0.05	.955
Error	37	1.238		
PD X VF X FE	6	0.977	1.27	.275
Error	113	0.767		

Note. PD, Presentation Duration; FE, Facial Expression; VF, Visual Field.

(mean accuracy 44.1%) rather than positive (mean accuracy, 42.3%) or negative (mean accuracy, 41.8%) (F (1, 37) = 3.23, p < .08).

The significant Presentation Duration main effect (F (3,56) = 12.74, p < .00001) demonstrated that the accuracy of facial expression judgements decreased as the presentation duration got shorter. Post hoc orthogonal contrasts show that accuracy was greater '10 msec above threshold' (mean accuracy 51.79%) than the average of 'at threshold', '5 msec below threshold', and '10 msec below threshold' (mean accuracy, 39.71%) (F (1, 56) = 27.78, p < .001); there was a trend such that accuracy 'at threshold' (mean accuracy 42.74%) was greater than the average of '5 msec below threshold' and '10 msec below threshold' (mean accuracy, 38.20%) (F (1,56) = 3.496, p < .10); and accuracy '5 msec below threshold' (mean accuracy, 41.90%) was greater than accuracy '10 msec below threshold' (mean accuracy, 34.50%) (F (1, 56) = 6.98, p < .025).

Processing Outside of Reportable Awareness Analysis

To examine whether there was above chance accuracy judging facial expression when judgements of location were at chance, multiple t-tests were used to compare the observed accuracies to those expected if the subjects were at threshold where chance performance prevailed. This involved comparing the observed accuracies for location and facial expression judgements in each of the 4 (Presentation Duration) X 3 (Facial Expression) X 2 (Visual Field) cells to that expected under threshold conditions (50% accuracy for location judgements and 33.3% for facial expression judgements) to determine if the observed values represented chance performance. Because use of multiple *t*-tests without correction of the comparison-wise error rate results in unacceptably high overall error rates for families of comparisons, it was decided to divide an acceptable family-wise error rate ($p < .05$) into 24 equal components ($p < .002$). Thus, for each dependent measure (location and facial expression), 24 comparisons were performed, each with a Type 1 error rate of less than .002. This preserved the Type 1 error for each set of 24 comparisons at less than .05.

Table 4 presents the percentage accuracy for location judgements and the adjusted percentage accuracy for facial expression judgements (i.e., response bias covaried out) as well as a summary of the results of the multiple *t*-tests. As indicated in Table 4 and consistent with prediction, when

Insert Table 4 about here

accuracy of location judgements was at chance, accuracy of facial expression judgements was significantly above chance. In the left visual field, at '5 msec below threshold', where accuracy on location decisions was at the chance level for the positive, neutral and negative facial expressions, accuracy was significantly above chance for judgements of the three facial expressions (see Table 4). There was no difference in accuracy of facial expression judgements among

Table 4

Percentage Accuracy for Location Judgements and Adjusted Percentage Accuracy for Facial Expression Judgements (Response Bias Covaried Out)

Facial Expression	Left Visual Field Presentation Durations				Right Visual Field Presentation Durations			
	+10	0	-5	-10	+10	0	-5	-10
				Location Accuracy				
Positive	72.50[a]	72.50[a]	56.50	53.50	69.50[a]	63.50	46.50	43.00
Neutral	69.00[a]	67.50[a]	59.50	58.00	51.00	43.50	41.50	51.50
Negative	81.50[a]	78.00[a]	62.50	54.50	75.00[a]	72.00[a]	63.00	56.50
				Adjusted Facial Expression Accuracy				
Positive	52.74[b]	42.74[b]	41.81[b]	38.12	53.06[b]	40.17	39.56	30.50
Neutral	55.53[b]	47.60[b]	42.69[b]	35.22	51.24[b]	45.72[b]	42.72[b]	32.36
Negative	50.77[b]	41.56[b]	44.04[b]	35.20	47.40[b]	38.63	41.23	35.51

Note. There were 10 stimulus presentations for each cell for every subject. +10 is '10 msec above threshold', 0 is 'at threshold', -5 is '5 msec below threshold' and -10 is '10 msec below threshold'.

[a]Differs from chance performance (50%), $p < .002$ ($df = 114$). All other cell accuracies for location represent chance performance ($p > .002$).

[b]Differs from chance performance (33.3%), $p < .002$ ($df = 113$). All other cell accuracies for facial expression represent chance performance ($p > .002$).

the facial expressions ($ts < 1.0$) in the left visual field at this exposure duration. In the right visual field accuracy of location judgements was at chance and accuracy of facial expression judgements significantly above chance only for the neutral facial expression. As shown in Table 4, this occurred '10 msec above threshold', 'at threshold', and '5 msec below threshold'.

To demonstrate the dissociation of accuracy of location judgements from accuracy of facial expression judgements more fully, additional analyses of covariance were performed. When the influence of location accuracy variance was removed (i.e., location accuracy was the covariate and facial expression accuracy the dependent variable), all the significant main effects and interactions of the facial expression analysis were maintained. When the facial expression variance was removed from the location accuracy data all significant main effects and interactions were maintained except for the Visual Field main effect. The Visual Field main effect, which was previously $p < .0684$, disappeared ($p < .1513$). It appears that the significant Visual Field main effect for location accuracy may be caused in part by effects due to facial expression.

Further, when a similar analysis as that performed previously comparing observed accuracy to chance performance for both dependent measures was carried out on adjusted location accuracy (i.e., variance attributable to facial expression accuracy removed) and on adjusted facial expression accuracy (i.e., variance attributable to location accuracy and response bias removed), results comparable to the earlier set prevailed. Again, the comparison-wise error rate was set at .002. Table 5 provides the adjusted accuracies for both dependent measures and a summary of the analysis. As shown, the main finding of above chance performance on

Insert Table 5 about here

facial expression judgements when location judgements were at chance was maintained even though the influence of location accuracy was removed from the facial expression data. This clearly demonstrated the independence of the facial expression accuracy from performance on judgements on location and strongly suggests that above chance accuracy for facial expression judgements was not a function of conditions where stimuli were actually seen and correctly located (even though location accuracy was not significantly different from chance).

Ancillary Analysis

As is evident from Tables 4 and 5, at the exposure durations which had been labelled 'threshold', above chance performance on location accuracy was found. To demonstrate that this finding was not a function of an inflation of location accuracy due to the fact that for eight subjects threshold was not found during the threshold determination procedure, but only nominally designated at '10 msec (i.e., was below 11 msec), location accuracy for the 12 subjects

Table 5

Adjusted Percentage Accuracy for Location Judgements (Facial Expression Accuracy Covaried Out) and Adjusted Percentage Accuracy for Facial Expression Judgements (Location Accuracy and Response Bias Covaried Out)

Facial Expression	Left Visual Field Presentation Durations				Right Visual Field Presentation Durations			
	+10	0	-5	-10	+10	0	-5	-10
	Adjusted Location Accuracy							
Positive	70.14[a]	71.44[a]	55.96	54.91	67.79[a]	62.66	46.75	45.72
Neutral	68.23[a]	67.39[a]	58.44	55.93	50.82	44.33	40.66	49.86
Negative	80.23[a]	78.54[a]	63.99	58.02	73.29[a]	72.61[a]	64.48[a]	59.80
	Adjusted Facial Expression Accuracy							
Positive	52.31[b]	42.31[b]	42.00[b]	38.40	52.73[b]	40.10	40.13	31.19
Neutral	55.19[b]	47.32[b]	42.77[b]	35.42	51.61[b]	46.39[b]	42.99[b]	32.81
Negative	49.95[b]	40.88	43.93[b]	35.40	46.86[b]	38.19	41.01	35.63

Note. There are 10 stimulus presentations for each cell for every subject. +10 is '10 msec above threshold', 0 is 'at threshold', -5 is '5 msec below threshold', and -10 is '10 msec below threshold'.

[a]Differs from chance performance (50%), $p < .002$ ($df = 113$). All other cell accuracies for location represent chance performance ($p > .002$).

[b]Differs from chance performance (33.3%), $p < .002$ ($df = 112$). All other cell accuracies represent chance performance $p > .002$.

for whom threshold was found was analyzed. Here the observed accuracy on location judgements was compared to that expected under threshold conditions (50% accuracy) to examine whether a similar pattern of results was obtained as that found when the entire sample of 20 subjects was used (see Table 4). Table 6 provides the percentage accuracy for location judgements and summarizes the results of this analysis. The Type 1 error rate for each comparison was set at .002. As seen, the results from the subjects for whom threshold was found do approximate those found when the entire sample was used. In the left visual field, for both analyses, performance on location judgements was significantly above chance 'at threshold' for all three facial expressions. In the right visual field, for both analyses, performance on location judgements was significantly above chance 'at threshold' for the negative facial expression. The fact that there was not a complete correspondence between the analyses (i.e., '10 msec above threshold', positive facial expression for both visual fields) was thought to arise because of the decreased power of the test due to the smaller sample size.

Table 6

Percentage Location Accuracy for Subjects (n = 12) for Whom Threshold was Found

Facial Expression	Left Visual Field Presentation Durations				Right Visual Field Presentation Durations			
	+10	0	-5	-10	+10	0	-5	-10
Positive	65.83	74.17[a]	56.67	56.67	65.83	65.0	50.83	40.00
Neutral	78.33[a]	73.33[a]	60.83	65.00	53.33	40.83	43.33	53.33
Negative	80.83[a]	76.67[a]	63.33	61.67	70.00[a]	68.33[a]	65.83	51.67

Note. There were 10 stimulus presentations for each cell for every subject. +10 is '10 msec above threshold', 0 is 'at threshold', -5 is '5 msec below threshold', and -10 is '10 msec below threshold'.

[a]Differs from chance performance (50%), $p < .002$ ($df = 66$). All other cell accuracies represent chance performance ($p > .002$).

Discussion

In overview, although the results of the present experiment support the contention that the right hemisphere processes facial stimuli more efficiently than the left hemisphere, it failed to replicate previous research (e.g. Ley & Bryden, 1979a) that has demonstrated a right hemisphere superiority in the processing of facial expression *per se*. The most important result of this study was the finding that when subjects demonstrated no reportable awareness of the facial stimuli, they were able to identify the facial expression at a level significantly greater than the chance base rate. Since a concurrent assessment of awareness (rather than one taken before the test task) was used, this demonstration provides strong support for the contention that high levels of processing occur in the absence of reportable awareness. Further, data from the awareness analysis provide suggestive evidence for a hemisphere assymetry (in favor of the right hemisphere) in the processing of facial expression.

Judgements of Location

The finding that subjects were more accurate locating the face (discriminating it from a nonface) when the face was presented to the left visual field than when presented to the right visual field replicates extensive research with both clinical samples and normals (e.g., Benton, 1980; DeKosky, Heilman, Bowers, & Valenstein, 1980; Levy, Trevanthen, & Sperry, 1972; and see earlier discussion). This work has shown that facial stimuli presented to the left visual field, which projects directly to the right hemisphere, is processed with greater accuracy and speed than when presented to the right visual field which projects directly to the left hemisphere. Marzi and Berlucchi (1977) state that "one of the best documented lateral asymmetries in normal human perception attributable to functional hemispheric asymmetry between the hemispheres is the superiority of the left visual field-right hemisphere for speed and accuracy of facial discrimination" (p.751).

The left visual field advantage in locating the face was present when the facial expression was either positive or neutral but absent when the expression was negative. These findings are difficult to interpret because Ley and Bryden (1979a), using the same facial stimuli in a character discrimination task, found that the left visual field advantage was greatest for the negative facial expression. Although their character discrimination task (judging the similarity of a visual field character and a subsequent, centrally presented character) was different from the task used here, this empirical discrepancy does point to the limitations that should be imposed upon generalizations made when a specific outcome is realized under a circumscribed set of stimulus parameters and task requirements.

A recent discrimination study by Hansch and Pirozzolo (1980) further demonstrates this point. Subjects were required to attend to an orally presented cue word (i.e. "happy") and make a same-different judgement as to whether a visual field stimulus presentation (i.e. happy face) matched the cue word. Results revealed that there was a left visual field advantage in reaction time when the stimuli were "emotional" (i.e., happy, angry and surprised) and when "neutral"; the visual field asymmetries were equivalent. Unfortunately, there was no separate analysis of visual field asymmetry for the different "emotions". Thus, although the present study and studies by Ley and Bryden (1979a) and Hansch and Pirozzolo (1980) are examining the same construct, hemispheric asymmetry in the processing of faces as a function of facial expression, markedly different results, and hence, conclusions, have been reached. At this stage it is not known whether the different results are a function of 'real' differences in the phenomenon being examined, differences due to artifacts arising from the various manipulatinns, or whether the differences reflect 'real' differences in differerent phenomena (e.g., when verbal processing requirements are introduced into the task).

What this does suggest is that since research in this area has escalated from the simple demonstration of functional hemispheric asymmetry to examination of relationships of degrees of asymmetry and investigations of process (Cohen, 1979; Hellige, Cox, & Litvac, 1979; Moscovitch & Klein, 1980; Simion, Bognaro, Bisiacchi, Roncato, &

Umilta, 1980), attention should be paid more closely to the stimulus conditions and task demands from which the data are generated. That this is important is shown by demonstrations that task demands can reverse hemispheric asymmetries (Cohen, 1973; Hellige, 1978; Hellige & Cox, 1976; Seamon & Gazzaniga, 1973).

It is in this light that the finding that accuracy was greater locating the face '10 msec above threshold' and 'at threshold', regardless of visual field, when the face had a positive or negative facial expression (as compared to when neutral) is interpreted. What this suggests is that there is something more salient about a positive or negative facial expression that renders discriminations with a nonface easier. Similarily, for the neutral facial expression, there is an absence of a salient feature(s) and hence discriminations were harder and accuracy was lower than when positive or negative. These results contradict those obtained by Hansch and Pirozzolo (1980) who found that response latency for "neutral" faces was faster than that to "emotional" faces suggesting that the discrimination between the cue word and the visual field face was easier when the face was neutral. Again, this difference may be accounted for by the difference in task requirements and stimulus parameters.

Judgements of Facial Expression

The absence of a left visual field advantage for the identification of facial expression is surprising in light of the fact that a right hemisphere advantage for processing of affective material has been found across sensory modalities in both dichotic listening (e.g. Carman & Nachson, 1973) and tachistoscopic paradigms (e.g. Hansch & Pirozzolo, 1980; Ley & Bryden, 1979a). It is thought that this failure to find a left visual field advantage was not a function of any 'floor effect' in operation for right visual field presentations (this would work to underestimate any left visual field advantage) because neither the Visual Field x Presentation Duration interaction nor the Visual Field x Presentation Duration x Facial Expression interaction was significant. Because accuracy identifying the facial expression was above chance (the 'floor') in both visual fields at the '10 msec above threshold' presentation duraction (See Table 4) for the three facial expressions, at least one of the above mentioned interactions would be significant if the 'floor effect' could be used as a reasonable explanation for the failure to find a significant Visual Field main effect.

It may be that the task required of subjects forced a more verbal processing strategy, in that contrary to Ley and Bryden's (1979a) emotion discrimination procedure, subjects here had to classify the visual field stimuli into one of three discrete categories of facial expression. Similar to their character discrimination task, Ley and Bryden's "emotion" discrimination task required less verbal mediation in that subjects had to discriminate a visual field face from a subsequent, centrally presented face on the basis of "emotion" expressed by making a simple yes-no response. Thus, the additional verbal processing the present subjects were required to do in transforming the visual representation of the facial stimuli into a verbal code (positive, neutral or negative) representing it's facial expression may have worked to minimize any left visual field advantage. One likely mechanism for this is suggested by the Hellige (1978) and Hellige and Cox (1976) findings that activation of the left hemisphere by requiring a verbal memory load or priming, by presentations of verbal stimuli, increases the left hemisphere's performance on what is typically a task (recognition of complex visuospatial forms) which leads to right hemisphere advantage. In the present case, the demand for verbal processing could have activated the left hemisphere and hence increased the left hemisphere's processing of the facial expressions. At best this would lead to the minimization of a right hemisphere advantage and in the extreme, a left hemisphere advantage. The latter is what Hellige and Cox (1976) found. If this is a correct interpretation of the mechanism responsible for the absence of a visual field advantage in favour of the left field, then the degree of visual field asymmetry for location judgements is also attenuated because subjects were required to code their response in a verbal, but less complex manner (i.e., left or right) in combination with the verbal coding needed for the facial expression judgement.

Processing Outside of Reportable Awareness

The most important result of this study was the finding that when subjects judgements of the location of the face were at chance, they were able to judge the facial expressions with accuracy significantly above chance. As discussed previously, when accuracy judging the location of the face is at chance, it is logically correct to assert that subjects are demonstrating an absence of reportable awareness for any structural cues of the stimuli which could be used to differentiate a face from a nonface. Simply, if subjects demonstrate no reportable awareness for where the face is, processing of the facial expression, if it occurs, happens in the absence of reportable awareness. This being the case, in the absence of reportable awareness of cues needed for the discrimination, above chance accuracy identifying the facial expression is evidence for processing outside of reportable awareness.

This result is particularly important because it represents the first time (to my knowledge) that a concurrent assessment of awareness had been made in a subliminal presentation paradigm (Marcel's (1980) study used a concurrent assessment of awareness in a visual masking paradigm). This is noteworthy because, as the ancillary analysis reveals, the 'threshold' as found in the threshold determination procedure performed before the experiment proper began was not the same as that found during the course of the experiment. Although both thresholds were forced choice for judgements of location, the threshold found before the experiment proper used the mildly positive and mildly negative facial expression stimuli while the experiment proper used the extremely positive, neutral, and extremely negative facial expression stimuli. Further, task demands were changed in that in the threshold determination procedure only judgements of location were required but, in the experiment proper, both judgements of location and facial expression were required. The purpose here is just to document that there were both stimulus and task differences between the two determinations of threshold which resulted in different estimations of threshold. George and Jennings (1975) have discussed how estimations of threshold can differ dependent upon changes in task demands.

If this experiment had chosen to forgo the concurrent assessment of awareness and taken as true the threshold as determined by the threshold determination procedure, it would have overestimated the effects of processing outside of reportable awareness (See Table 4 for Facial Expression Accuracy and use the "0" point as representing the threshold for Judgements of Location). In light of the concurrent assessment of reportable awareness, clearly this would have been erroneous. As noted, researchers of subliminal stimulation have not typically used a concurrent assessment of awareness and, in fact, have based their determinations of threshold on different tasks and stimuli than those used in their demonstration of processing outside of awareness.

For example, Charman (1979), O'Grady (1977) and Sackeim, Pacher, and Gur (1977) used different stimuli and changed the task demands between their threshold determinations carried out before their experiments and their test tasks. Although Silverman (summarized in Silverman, 1976) used the same stimuli, the task demands were changed between the determination of threshold before the experiment and the test task.

Although the present results point to the importance of a concurrent assessment of awareness when attempting to unequivocally demonstrate the phenomenon of processing outside of reportable awareness, they do not necessarily call into question previous subliminal research. In the studies mentioned above and those cited earlier (See section on Subliminal Stimulation), a dominant theme was that although processing outside of reportable awareness was demonstrated, subjects were unable to report on their perceptual experience. The important issue is that since these researchers are claiming processing outside of reportable awareness, it is important (if not necessary) for them to demonstrate that, at the time when processing is occurring outside of awareness, the relevent stimuli <u>are</u> outside of awareness. This has only been done indirectly by these researchers by showing that before the test task the stimuli were outside of reportable awareness. This weakness is compounded by the stimulus and task demand changes.

In this study, by virtue of the fact that a concurrent assessment of awareness was obtained, it was not only possible to demonstrate above chance accuracy judging facial expression at the same time as accuracy judging location of the face was at chance (holding stimulus and task factors constant), but also to assess whether awareness of the location of the face, on any one trial, was systematically related to accuracy of judgements of facial expression. If this had been the case, that is, if when subjects correctly located the face they also tended to correctly judge the facial expression, this would argue against the case being made for processing outside of reportable awareness because subjects would have been aware of the face (i.e., correctly located) when they accurately judged the facial expression.

The covariance analyses performed argue against this interpretation by showing that accuracy judging facial expression was independent of location accuracy. Further, when the adjusted cell means were used in comparisons to assess processing outside of reportable awareness, subliminal effects were maintained. Surprisingly, accuracy of location judgements were not completely independent of facial expression accuracy. It seemed that the Visual Field main effect for location accuracy was dependent in part on effects due to facial expression. This suggests that although there was no visual field difference for judgements of facial expression, facial expression accuracy was somehow implicated in the greater accuracy locating the face when presented to the left visual field. That is, faces were more often correctly located when presented to the left visual field than the right visual field especially when the facial expression was also identified. Also, if Table 4 is examined, it appears that left visual field presentations yield more occurences of above chance performance for facial expression judgements (left visual field, 9 cells; right visual field, 5 cells) despite the absence of a significant visual field difference. Although the reasons for this discrepancy between this data and the finding of no visual field difference are unknown, other than the fact that this data may be a more sensitive measure at these fast presentation durations, this provides weak support for the contention (i.e. Ley & Bryden, 1979a) that the right hemisphere is more efficient in processing affective information as expressed in faces.

Implications

The present study has supported the position that high levels of processing do occur in the absence of reportable awareness. Using an experimental paradigm modeled on Marcel's (1980) work which demonstrated structural and semantic processing outside of reportable awareness, the present research has provided evidence that the processing of affective information in faces does also occur in the absence of reportable awareness. In doing so it supports subliminal stimulation research (i.e. O'Grady, 1977; Sackeim, Packer, & Gur, 1977; Silverman et al, summarized in

Silverman, 1976) that has shown processing of below threshold presentations of affective material.

Although there is no solid theoretical structure or empirical data base upon which to build explanations to account for the phenomenon of processing in the absence of reportable awareness, it may be that now, because of the vast array of converging evidence, the time is right to go beyond simple demonstrations of the phenomenon's existence to learning about the nature of the processing.

Dixon (1971) has proposed that the current level of neuropsychological knowledge can accommodate the phenomenon of processing outside of reportable awareness. In fact, more recent work examining the components of evoked potentials argues even more strongly in favor of the phenomenon. Naatanen and Michie (1979) state:

> "Evoked potential research on the neural basis of selective attention has not revealed any such attentional mechanism which could selectively operate without each individual stimulus contacting the memory system. There are no facts speaking in favor of the existence of any kind of selective neuronal filtering system, neither at the peripheral nor at the central level, on which the phenomenon of selective attention could be based...This is tantamount to saying that a selectively attentive subject has at least to some extent to process each stimulus in terms of comparisons with existing memory representations (e.g., neuronal models on templates) of the stimuli involved"(p.130).

Other converging lines of evidence for processing in the absence of reportable awareness come from the areas of visual search, picture identification, and preference research. Duncan (1980) has concluded that in the visual search paradigm, where subjects are required to discriminate target stimuli from an array of nontarget stimuli, nontargets are rejected on the basis of meaning by early, parallel, "unconscious processes" while only targets pass through the limited capacity system leading to awareness. He states that "since nontarget words can be rejected on the basis of meaning, stimuli must be fully identified before the limited capacity system" (p.272). Using a picture identification strategy McCauley, Parmelee, Sperber and Carr (1980) found that pictures could be named faster if primed by semantically related prime pictures as opposed to unrelated prime pictures when pictures were presented at "exposure durations too brief for conscious identification of the prime to occur" (p.265). They conclude that "semantic processing of a picture occurs with substantially shorter viewing time than a conscious identification...it appears that naming a picture depends on pictorial information reaching a state of conscious activation even though semantically encoding the picture imposes no such requirement for conscious processing" (p.273). Zajonc (1980) has summarized evidence showing that the 'exposure effect' ("the phenomenon of increasing preference for objects that can be induced by virtue of mere repeated exposure" p.160) can occur even when subjects had no awareness of having been exposed to the stimuli previously. He argues that the discrimination between new and repeated stimuli must be made at a level not accessible to subject reportable awareness.

It seems that Shevrin and Dickman's (1980) suggestion that psychological theories would profit from the use of "the concept of unconscious psychological processes" (p.432) is finding support from diverse areas of research. Since the present study found evidence for processing of affective material in the absence of reportable awareness and suggestive evidence for a possible hemispheric asymmetry of such, a profitable line of enquiry would be to examine the nature of the processing in the absence of reportable awareness in the context of hemispheric asymmetries. In this light it is notable that Moscovitch and Klein (1980), in attempting to integrate current neuropsychological data with information processing theory, found that they had to postulate that subjects processed an unattended stimulus "without the subjects' awareness or attention" (p.598) in order to account for the effects of a stimulus which subjects were not aware of. Thus it appears that a promising new research area is opening which is attempting to ground new ideas and speculations about information processing in the context of functional neuropsychology.

Footnote

[1]Unless otherwise specified, the term 'threshold' is used throughout the results section to specify the threshold as determined in the actual threshold determination procedure carried out before the experiment proper began. This procedure used the mildly positive and mildly negative facial expression stimuli. This threshold was a forced choice one for the above mentioned facial expressions on location accuracy. For those subject (n = 8) for whom threshold was below 11 msec, the 10 msec point was nominally designated as 'threshold' and presentation durations ranged around that point. It was thought that this was defensable because pilot testing has shown that accuracy '5 msec below threshold'(i.e., at 5 msec) and '10 msec below threshold' (i.e., at 1 msec) is at chance. The results of this experiment support this (see Table 4). As will be seen however, this 'threshold' (actually found or designated at 10 msec) was not the same as the true threshold found during the course of the experiment proper which used the extremely positive, neutral and extremely negative facial expressions as stimuli (see Ancillary Analysis).

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