RIGHT HEMISPHERE DECLINE IN THE PERCEPTION OF EMOTION AS A FUNCTION OF AGING

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(ABSTRACT)

The hypothesis that the right cerebral hemisphere declines more quickly than the left cerebral hemisphere in the normal aging process was tested in two studies using a facial recognition and a response time task. In Study 1, subjects (N=60) were asked to identify facial affect from 50 standardized photographs of 5 affective categories: Happy, Neutral, Sad, Angry, and Fearful, and were asked to rate the intensity of each photograph. The results of the analysis indicate that the elderly group was significantly less accurate at identifying negative and neutral affective expressions than the younger group, with no significant differences seen between groups in the identification of positive affect. The results also indicate that the elderly rated the affective expressions as being significantly more intense than the younger group.

Study 2 (N=60) investigated response times for the recognition of the affective stimuli as a function of visual field of presentation and valence of the stimuli, using the same subject population. The results of this analysis reveal that the elderly show an increase in cerebral lateralization in comparison to the younger group. The elderly exhibited increased response times to negative affect presented to the left hemisphere. The results of this study also indicate that both groups had faster response times to positive affect, and that both groups had a response bias in favor of positive affect when neutral facial affective slides were presented to the left hemisphere.

The results are interpreted as partially supporting the right hemi-aging theory. The elderly showed a diminished ability to identify negative affect across both studies, suggestive of lowered right hemisphere functioning. However, the increased rather than decreased cerebral asymmetry in the response time task, and slower response times to negative affect presented to the left hemisphere are suggestive of bilateral changes in affective processing for the elderly. Overall, these findings suggest that the elderly have more difficulty processing negative affect, while their ability to process positive affect remains intact. This finding has implications for research using facial affective paradigms designed for use with younger subjects, and suggests the need for more studies of emotional aging processes in normal populations.

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Research into the functioning of the human brain has become increasingly sophisticated over the past one hundred years. Techniques used to study the brain have improved dramatically, permitting the more precise study of what Paul Broca first proposed one hundred years ago: that the two cerebral hemispheres of the human brain are specialized for different functions. The earliest and most dramatic evidence of these functional asymmetries came from patients with brain damage, and were first noted by the ancient Greeks. The first scientific inquiry into the area of functional asymmetry was in 1836 when a French neurobiologist, Marc Dax, presented a paper at a medical conference, detailing his observations that damage to the left hemisphere of a patient often preceded loss of speech for that patient. While Dax's paper was basically ignored, Broca's similar findings about 30 years later aroused the interest of his colleagues and the first scientific inquiries into brain functioning and cerebral lateralization of function were begun.

Although many people think of the brain as one structure, it is actually divided into two halves, the two cerebral hemispheres. These hemispheres are packed together inside the skull and linked by several distinct bundles or tracts forming the corpus callosum, which act as a channel of communication between them (Springer and Deutsch, 1985). Each hemisphere appears to be approximately a mirror image of the other. Control of the body's basic movements and sensations is about evenly divided between the two hemispheres following the principle of decussation: the right hemisphere controls the left side of the body, while the left hemisphere controls the right side of the body. However, this left-right physical symmetry of the brain and the body does not imply that the right and left sides are equivalent in all respects. For example, most people have a dominant hand, and the side of this dominance in most cases will predict a great deal about the organization of higher mental functions in that individual. In right-handers it is almost always found that the hemisphere that controls the dominant hand (typically the left hemisphere) also controls propositional speech for that person.

Research indicates that this functional asymmetry is present at least at the time of birth (Davidson & Fox, 1982; Fox & Davidson, 1986; Mehler, 1989). Auditory evoked potentials in infants indicate heightened left hemisphere activation during speech presentation and elevated right hemisphere activation during musical stimuli (Molfese, Freeman, & Palermo, 1975), although there has been some disagreement about the age at which this is present (Vargha-Khadem & Corballis, 1979). According to a study done by Chi, Dooling, and Giles (1977), asymmetry of the planum temporal is visible already at 31 weeks of fetal age.

Although the reason for functional asymmetry of the brain is speculative, many brain researchers believe that the brain has evolved in this direction to allow for greater cognitive and language flexibility and complexity than other mammals. Lateralization of function has been noted for nonhumans as well, including primates, mice, chicks, and songbirds (Denenberg, 1986).

In the human brain, researchers have shown that the two cerebral hemispheres differ in their ability to handle stimuli and in the manner in which they process information. Because most sensory and motor pathways in the human body are crossed, stimuli presented on the right will project initially to the left hemisphere, while stimuli presented on the left will project initially to the right hemisphere. Investigators can therefore somewhat selectively present information to either the right or the left hemisphere.

The left hemisphere appears to be specialized for language, detailed analysis, refined motor activity, symbolic meaning, and temporal relationships (Levy, 1983; Bryden, 1982). The right hemisphere appears to be specialized for processing visuospatial material, and has been characterized as processing information in a more holistic, integrative, and less sequential manner than the left hemisphere (Bryden, 1982). The left hemisphere bias for processing verbal information and the right hemisphere bias for the processing of visuospatial information has been well-accepted. Recent research has shown that emotional processing is also lateralized in humans.

Emotion is not an easily definable phenomenom. Neuropsychologists often measure emotional behavior in terms of subjective mood or feeling and related observable behaviors, autonomic components of emotion, physiologic reactivity, and cognitive processing of affective stimuli (Silberman and Weingartner, 1986). There are many ways in which emotion is conveyed. One of the most common, and most important for the purposes of the present research, is through facial expression. The neuropsychology of facial expression is based on two assumptions. First, that facial movements express emotional states, and second, that the two cerebral hemispheres are differentially involved in the expression and interpretation of facial expression. It appears that an intact right hemisphere is essential not only for the expression of emotion or affect, but also for the comprehension of these emotions (Heilman, Scholes, and Watson, 1975).

According to Paul Ekman (1990), one of the prominent theorists in the field of facial expression and emotion, each emotion is characterized by unique patterns of expressive behavior and physiological reactivity, which can be measured in the laboratory. Ekman (1975) hypothesizes that primary facial reactions and controlled voluntary facial movements correspond to distinct aspects of emotional expression. Ekman calls his theory the "neuro-cultural theory of emotion." Neuro refers to the facial affect program-e.g., the relationships between particular emotions and the contraction of a particular pattern of facial muscles. The cultural part of the theory refers to the facial program being submitted to facial display rules learned during childhood and shaped by culture. A common assumption in Ekman's theory and other theorists of emotion, including Charles Darwin and William James, is that emotional behavior, including facial expressions, is part of the adaptive behavior patterns inherited through phylogeny (Feyereisen, 1986).

These theorists suggest that emotions serve a function in the evolution of man, such that expressed negative emotions are important in withdrawal behaviors, while expressed positive emotions initiate approach behaviors. Davidson, Ekman, Saron, Senulis, and Friesen (1990) hypothesize that the two hemisphere's differ in their ability to facilitate approach and withdrawal behavior, such that the right hemisphere is involved in the more negative aggressive or withdrawal behaviors, while the left hemisphere subserves positive affect and approach behaviors.

It has been shown that the right hemisphere is specialized for modulating cortical arousal levels, and is posited as being more involved in arousal in general than the left hemisphere. Heilman (1979) suggests the importance of a corticothalamic-reticular arousal loop in the right hemisphere, the primary cortical representation of which is in the dorsolateral frontal cortex. Heilman and Van de Allan (1979)found that warning stimuli projected to the right hemisphere are associated with shorter reaction times than those projected to the left hemisphere, and Howles and Boller (1975) found that individuals with right hemisphere lesions have slower reaction times than individuals with left hemisphere lesions.

Properties of the right hemisphere which would appear to make it more suitable for the processing of emotionally significant material include the fact that elementary functions are more diffusely represented in the right than the left hemisphere (Semmes, 1969). Secondly, a higher ratio of white to gray matter exists in the right hemisphere (Gur and Gur, 1980). Both findings imply that the right hemisphere is better equipped than the left hemisphere to integrate information across modalities (Silberman & Weingartner, 1986). It has been suggested that this type of organization is especially suited to emotional processing, which may involve integration of simultaneous inputs from external and visceral sources (Safer & Levanthal, 1977, Tucker, 1981).

Three basic approaches to research have been utilized in the study of hemispheric specialization for affect. First is the study of emotional processing in normals. These studies typically measure performance when information is presented to one hemisphere or the other by means of tachistoscopic (visual), dichotic (auditory), dichaptic (tactile), or other paradigms. Data are provided about the lateralized processing of affectively-laden information. The second approach involves clinical research on patients with brain lesions localized within one hemisphere. These studies investigate subsequent changes in mood and affect, or deficits in emotional processing related to the side of the lesion. The third approach involves the study of affectively ill patients to identify whether disordered mood states are associated with dysfunction of one or the other hemisphere.

There is some question among researchers as to exactly what the right hemisphere's role in emotion is. Three hypotheses are currently being investigated. First, that the right hemisphere is superior for recognizing emotional aspects of information. Secondly, that the right hemisphere is hypothesized to be superior in regulating mood and affect. Finally, it is hypothesized that the recognition and regulation of emotion are bilaterally represented, but that the right hemisphere is specialized for processing negative emotions, while the left hemisphere is specialized for processing positive emotions.

A theoretical challenge in all of the studies investigating emotional processing is that of disentangling the effects of emotion per se from other right hemispheric functions. Since the right hemisphere has been shown to be superior in the recognition of visuospatial patterns, it is important to control experimental studies so that what is being studied is emotional processing and not general pattern recognition, recognition of faces, or tonal aspects of speech. This issue will be addressed further.

Research with Normal Populations

Wada Test

Early evidence for lateralized affective processing came from patients undergoing a Wada test. The test is typically used by surgeons to determine which hemisphere contains language. The test involves injecting one carotid artery with sodium amytal, causing a temporary depression of activity in that hemisphere. Injections into the left side of the brain often produce a catastrophic reaction consisting of crying, pessimistic statements, guilt, despair, and worries about the future. Right-sided infusions generally produce euphoric reactions consisting of laughing, joking, optimism, and a sense of well-being. Lee, Loring, Meader, and Brooks (1990) injected patients with sodium amobarbital prior to surgery for epilepsy. Thirty-three emotional reactions occurred in the 26 patients, 44% of the reactions following right hemisphere injection, 32% after left hemisphere injection. Laughter and elated mood was statistically more frequent following right hemisphere injection, while crying was statistically associated with left hemisphere injections. The authors note that these reactions were not related to level of dosage, sex, bilateral hemispheric inactivation, general cognitive status, or side of seizure onset. These results support the hypothesis of differing specialization of emotional expression in the right and left cerebral hemispheres and their subcortical connections.

If it is true that the right hemisphere is implicated in processing negative affect, then why would we expect to see indifference or euphoria as a result of injury to the right hemisphere? Researchers hypothesize that if the right hemisphere is non-functional, only the left hemisphere is available for processing affect. The left hemisphere is released from contralateral control by the right hemispace and the person experiences euphoria. Thus, the right hemisphere, with suppression of the left, would produce dysphoria.

Dichotic Listening

Dichotic listening tasks have been used extensively to investigate functional asymmetries in both normal and brain-damaged populations. This experimental method involves the simultaneous presentation of two different and competing auditory signals, one to each ear. These asymmetries are then measured by comparing the accuracy of identification or the latency of reaction time. The direction of an ear advantage may be altered by manipulating the category of stimulus material presented. For example, emotional stimuli would be expected to produce a left ear advantage if the hypothesis of right hemisphere advantage for emotional stimuli were true.

Left ear advantage, implying right hemisphere specialization, has been shown in the recognition of non-verbal aspects of language, such as emotional tone in spoken sentences and in laughter and crying (Kimura, 1964; Hall & Goldstein, 1968, Haggard & Parkinson, 1971; Carmon & Nachson, 1973) . Mahoney and Sainsbury (1987) presented pairs of emotional non-speech sounds dichotically in a forced-choice paradigm. While they found a left ear advantage (right hemisphere) for the emotional sounds, this advantage was pronounced only after practice. The authors hypothesize that the right hemisphere advantage occurred only after sufficient attention was given to the task, thus supporting the hypothesis that the right hemisphere is also involved in arousal mechanisms.

In a study which was concerned with right hemisphere processing of words, Ely, Graves, and Potter (1989) had subjects respond either verbally or manually by pressing a response button. For manual responders, abstract words elicited a significantly greater right-ear advantage than did concrete words, while emotional words elicited a non-significant left-ear advantage. Verbal responders showed no significant difference in the size of the right-ear advantage across stimuli. The authors suggest that both response modality and stimulus type are important variables for dichotic listening paradigms seeking evidence of semantic processing.

Safer and Leventhal (1977) found that the emotional tone of sentences is judged by verbal content when heard by the right ear, but by tone of voice when heard by the left ear. Subjects who viewed cartoons and heard spoken cartoons and laughter in either the left or right ear found the cartoons funnier when the laughter was heard in the left ear (DeWitt, 1978). This would imply that specific emotional content of language was better appreciated when heard in the left ear, implying right hemisphere advantage, since subjects were presumably able to recognize the sound patterns as as laughter when heard in the right ear, but did not have as intense an emotional reaction.

Some of the subject variables which are thought to influence dichotic listening results include handedness, age, and sex. As with all research done to determine laterality, left-handers in the past have often been excluded because of heightened variablility in lateralized language processing. Generally, subjects participating in laterality research will be tested for handedness by using a questionnaire or behavioral sample. They might also be questioned for family sinistrality. Traditionally, only strongly right-handed individuals have been used as subjects, although there have been several recent reports of laterality using left-handed populations.

Although a variety of evidence suggests that age and sex play a role in patterns of hemispheric asymmetry, the exact nature of those relationships is unclear. While most research shows patterns of laterality in infants, it is also believed that these processes are not fully developed until the age of 10-12. Very few dichotic listening studies besides the early work of Kimura (1964) have looked at children for this reason.

In terms of sex differences, it is claimed that adult right-handed men are more completely lateralized than adult right-handed women, especially for verbal functions (McGlone, 1980). The hypothesis that women are less lateralized than men is partly based on findings from brain-injured individuals (McGlone, 1978) and partly on evidence from normal populations using laterality paradigms (Lake and Bryden, 1976). Current research using dichotic listening tasks to evaluate hemispheric asymmetry indicate that many of the earliest studies which found greater laterality for men have failed to be replicated, while Annett (1980) has noted that only 3 of the 14 dichotic listening tasks cited by McGlone (1980) actually showed a greater right-ear advantage for males than females. Hiscock and MacKay (1985) failed to find a significant sex difference in a series of five consecutive dichotic listening experiments, even when the data from all five studies were pooled. In a more recent study, Hiscock and Hiscock (1988) found a significant difference in the direction opposite to what would be expected if females were less lateralized, i.e., they found a greater right ear advantage in females. In another recent dichotic listening study which tested only whether males were more lateralized than females, Wexler and Lipman (1988) administered a word task in which subjects heard 15 different single syllable word pairs presented to both ears, while being aware of hearing only one word. Each pair of words was presented twice in a 30 trial block, the second time to the ear opposite that of the first presentation. Laterality was then computed by subtracting total left ear responses from correct right ear responses, and dividing the result by the sum of the correct left and right ear responses. Males showed significantly greater right ear advantages than did women during the first 30 trials. This sex difference decreased during the second 30 trials, and by the last 60 trials, the sexes were indistinguishable. The authors hypothesize that males respond to the novelty of a new task with relative left hemisphere activation, while females respond with relative right hemisphere activation.

Tachistoscopic Studies

The tachistoscopic paradigm is used to investigate laterality effects by presenting brief visual stimuli in either the right or left visual field. The stimulus interval is brief enough to prevent saccadic eye movements, and thus, stimuli may be restricted to one visual field. Studies which compare the processing of emotional stimuli with nonemotional stimuli show right hemisphere superiority for the recognition of emotional faces (Landis, Assal, & Perret, 1979). Other studies indicate a left visual field superiority for recognition of faces when the faces have emotional rather than neutral expressions (Suberi & McKeever, 1977), and that how high the subjects rate the emotionality of the face will affect the degree of right hemisphere advantage (McKeever & Dixon, 1981).

Right hemisphere superiority for the ability to perceive affect emerges in these studies as a consistent finding despite differences in the stimuli used (e.g., cartoon faces, profile of faces, full face photographs), and the particular emotion chosen, although all studies cited used at least one positive and one negative facial expression.

Experimental research using normal subjects strongly indicate that while the perception and expression of emotion is primarily a function of the right hemsiphere, there is also a bias for the right hemisphere to respond more quickly to negative rather than to positive affective stimuli. In other words, negative emotional stimuli presented to an individual will generally be recognized more quickly in the left visual field or in the left ear, suggesting right hemisphere involvement. For example, Suberi and McKeever (1977) found that sad faces are easier to recognize when they are presented to the right hemisphere (RH), whereas happy faces were associated with left hemisphere (LH) advantage. Other research using a visual field paradigm showed that negative emotions were more easily recognized when presented to the right hemisphere (Sackeim & Gur, 1978). Films projected to the right hemisphere were rated as more unpleasant than those presented to the left hemisphere; and subjects reported experiencing more happiness in response to faces presented to the left hemisphere, as compared to the identical faces presented to the right hemisphere (Dimond & Farrington, 1977).

Mandal and Singh (1990) presented stimuli consisting of four negative facial expressions using a tachistoscope presentation to 90 subjects. The subjects made decisions about the type of emotion being expressed. Task manipulations included visual field, hemiface composition (a normal representation of a face, or one with two right or left sides of the faces joined in a split-half presentation), and task (matching labelling). In the labelling condition, subjects were asked to identify each of the four emotional conditions, plus a neutral condition. The authors found a left visual field superiority for identifying the facial emotions; with sad emotion being identified with increased accuracy. This study was unique in its inclusion of both the normal representation of faces and split-half faces, although the normal facial representations were identified with greater accuracy than the composite faces. While the preceeding studies strongly indicate that emotion is recognized more effeciently in the right hemisphere, research concerning the recognition of facial expression also suggests that the left side of the face is more prominent in emotional expression by normal right-handers.

The evidence for the hypothesis that emotions are expressed more strongly on the left side of the face, also suggests right hemisphere involvement (Sackeim & Gur, 1978; Borod & Canon, 1980). The most problematic feature of these studies is that they more often have used posed rather than spontaneous facial expression, and therefore may not represent actual feeling states of the subjects. Some investigators have failed to find comparable asymmetries in spontaneous facial expression, while others have found posed as well as spontaneous expressions to be stronger on the left side (Moscovitch & Olds, 1982; Borod, Koff, & White, 1983). In a study which assessed the perception of emotion across the lifespan, Levine and Levy (1986) found that there was a significant bias for the perception of emotion to occur when the perceiver views the left side of the face, regardless of the age group. In a tachistoscope study of the same hypothesis, Davidson, Mednick, Moss, & Saron (1987) presented faces with either happy or sad expressions. Subjects were required to rate the intensity of the expression and their emotional reaction to each slide on a 7 point Likert scale. They found that subjects reported more happiness in response to stimuli in the left hemisphere compared to the identical slide presented to the right hemisphere.

A recent study by Schiff and MacDonald (1990) had subjects perform an easy or difficult verbal antonym task while being videotaped. Subjects were unaware that they were being photographed, thus the expressions were spontaneous. Subjects who performed the difficult task reported unpleasant emotions, tested high on state anxiety and showed greater changes in left than right-sided composites when compared to the relaxed state. Subjects who performed the easy version of the same task reported positive emotions, tested significantly lower on state anxiety, and showed greater changes in right-sided composites. The results of this study support the hypothesis for lateralization of function for positive and negative emotions.

Studies which induce emotion as part of the testing situation have shown that emotion per se affects performance. Ladavas, Nicoletti, Umilta, & Rizzolatti (1984) measured simple reaction times to lateralized visual targets during neutral and sad emotional states. Compared to the control condition, the sad mood led to a slight delay in responding to targets presented to the right hemisphere. The authors concluded that the left visual field delay arises from the sad mood's activation of the right hemisphere, with this activation perhaps interfering at a premotor level the translation of left visual field input into a motor response. Derryberry

(1989) extended this line of reasoning into three experiments which investigated the influence of success-related emotional states on lateralized visual targets. Using a video game technique, Derryberry manipulated emotion by means of success and failure feedback. Under neutral conditions involving no feedback, subjects showed a right visual field advantage. When emotional value was added to the task, the right visual field advantage increased following failure and decreased following success feedback.

In a study which manipulated emotional arousal without tachistoscopic presentation, Mueller, Heesacker, Ross, and Nicodemus (1983) required some subjects to judge photographs in a personality feature that had been judged as arousing an emotional reaction (e.g., attractiveness), while other subjects judged a nonemotional feature (e.g., punctuality). Subjects who made the emotional decisions generally performed better on the subsequent recognition task. To the extent that emotional processing activates the right hemisphere, the advantage for emotional orienting tasks during an experimental study is consistent with the general picture of right hemisphere dominance in face memory obtained by other methods.

Recent research in the area of facial expression examines the possibility that cognitive style and other personality variables may mediate an individual's use of emotional processing. For example, Gur and Gur (1980) have noted that individuals differ in their cognitive styles in a way that makes predominant use of the processing capacities of one hemisphere or the other, particularly when the task in question favors the involvement of a specific hemisphere. In a series of studies designed to test this hypothesis, Zenhausern and collegues (Zenhausern & Nickel, 1979) designed and tested a paper and pencil test to determine subjects who prefer a "right-hemisphere" style of thinking (e.g., thinks in pictures, holistic, parallel, etc.) from those who prefer a left hemisphere cognitive style (e.g., thinks with words, sequential. etc).

In one study, Zenhausern and Nickel (1979) found that subjects with a right-hemisphere cognitive style were better at maze learning when blindfolded than subjects with a left-hemisphere style, consistent with the notion that such maze learning required visualization, an ability usually associated with the right hemisphere. Zenhausern, Notaro, Grosso, and Schiano (1981) presented right and left hemisphere cognitive style subjects with auditory messages conflicting in verbal content and emotional tone, and found that subjects with a right preference responded more to emotional inflection than left-preference subjects, whereas the left-hemisphere cognitive style subjects responded more to verbal content. Finally, Coleman and Zenhausern (1979) examined processing speed with lateralized visual presentation for subjects with left and right cognitive styles, and found that input field and preference interacted, with preferred style actually leading to larger differences than input field.

Thompson and Mueller (1984) tested this right versus left cognitive style in a task which required subjects to make an emotional decision about photographs of faces. Their results supported the hypothesis that those subjects who self-reported that they had a more right hemisphere spatial memory bias remembered more of the photographs. The study also tested whether a person's personality style of extraversion would affect performance, but found no relationship.

Other findings from research investigating facial recognition support the previous findings that there may be individual differences in the utilization of right hemisphere processes in the recognition of faces. In a series of studies designed to further specify the elements of facial recognition, Levine, Banich, & Koch-Weiser (1988) have found that certain right-handed individuals have an arousal asymmetry in favor of the right hemisphere, and make greater use of the specialized processes of the right hemisphere when asked to recognize complex visuospatial stimuli, such as faces, than do those individuals whose arousal asymmetry favors the left hemisphere.

In a further test of the hypothesis of individual differences in arousal asymmetry, Wirsen, af Klineberg, Levander, & Schalling (1990) first measured cerebral asymmetry on a chimeric face task. The subjects were divided into groups on the dimension of right vs. left visual field bias. The subjects were then shown a series of chimeric face photographs. As expected, faces with left-sided smiles were judged as looking happier than those with right-sided smiles. However, there were individual differences in the direction and the extent of the bias, which were systematically related to reaction time, right visual field-biased subjects being slower. Differences in lateral bias as well as reaction time are assumed by the authors to reflect individual patterns of hemispheric arousal, whereas the lateral bias in face recognition appears to reflect right hemisphere specialization for processing facial emotion.

The idea that individuals have a preference for right or left hemisphere processing of information has been termed "hemisphericity" This construct was tested by Nestor and Safer (1990), who tested sixty-six right-handed subjects on a variey of self-report personality measures, dichotic listening, tachistoscopic emotion recognition, verbal ability and spatial ability tasks. Specifically, they were interested in whether some individuals process information analytically and others holistically, and whether these individual differences reflect characterictic preferences or strategies for left and right hemisphere processing, respectively. Although some of the hemisphericity measures exhibited moderate reliability over testing sessions, they generally did not correlate significantly with each other or with measures of personality. However, a composite hemisphericity index indicated that right hemisphericity was modestly correlated with the tendency to express emotion and left hemisphericity with the tendency to inhibit emotions.

Another hypothesis about the possible function of the right hemisphere in emotion suggests that while the right hemisphere surpasses the left hemisphere in interpreting and communicating emotion, the right hemisphere's threshold for experiencing negative emotion is lower than that of the left hemsiphere, whereas the left hemisphere's threshold for experiencing positive emotion is lower than that of the right hemisphere (Burton & Levy, 1989). This explanation would integrate the two prominant views of right hemisphere functioning. Natale, Gur, and Gur (1983) decomposed subjects' responses to laterally presented emotional faces into discrimination scores, which indicated how well subjects could accurately identify different emotional expressions, plus bias scores, which indicated the extent to which subjects were biased to interpret emotions as either positive or negative. They found a general right hemisphere superiority in the discrimination scores, but also a positive bias for stimuli presented to the left hemsiphere. In a more recent study, Burton and Levy (1991) found that in a free-vision chimeric facial emotion task, when subjects were split into groups of fast vs. slow responders, the fast responders made significantly faster judgements when stimuli were presented to the right hemisphere than to the left hemsiphere. They also found that the fast responders showed a bias for choosing the faces with the left-sided smile as happier, and found that these subjects all showed a leftward bias on a free-vision task.

While individual differences may enable some subjects to respond to right hemisphere tasks more efficiently, the issue of sex differences must also be taken into account. Psychological investigations have shown that women are more expressive than men and better understand emotional situations, as indicated by their superiority in identifying the affective implications of tone of voice and in understanding emotional information (Buck, Savin, Miller, Caul, 1972). In a review of 72 studies of nonverbal communication, Hall (1978) reported that a significant majority showed a female superiority.

McKeever and Dixon (1981) found that female subjects, but not male subjects, had a right hemsiphere superiority in recognizing previously memorized faces that were learned in association with negative affective imagery. Strauss and Moscovitch (1981) found a right hemisphere advantage in females for recognizing facial emotion. However, Harrison, Gorelczenko, and Cook (1990) found that left visual field presentations resulted in faster overall response times irrespective of affective valence of the stimuli or the sex of the subject. Overall, better recognition was found for the positive emotions than for the negative emotions. Males and females in this study were comparable in response times. However, males showed superior emotional identification in the left visual field, which was seen as supporting the idea of more diffuse lateralization of females.

Also supporting this finding is the research of Harrison and Gorelczenko (1990), who found that happy faces were identified more quickly than angry faces and that emotional valence was identified more quickly when presented to the left hemisphere. Males showed superior response times to stimuli presented to the right hemsiphere, while no effect was found for females.

Burton and Levy (1989) presented either a word-face combination or a face-face combination in the left or right visual field and had subjects match the stimuli for same or different emotional stimuli being presented. They found that both males and females responded more quickly to negative rather than to positive emotional stimuli. Reaction times were faster for negative emotions presented to the right hemisphere and for positive emotions presented to the left hemisphere. Further, an interaction of Gender, Task, and Emotional Valence was found, such that the task had opposite effects for the two sexes. The task which involved matching faces appeared to inhibit the performance of the male subjects and to facilitate the performance of the female subjects using reaction time measures. The authors suggest that specifying the target emotion by an emotional face elicits a greater emotional response on the part of the subject than an emotional word, and that this emotional elicitation may result in reactive inhibition in the male subjects and in an elaboration in the female subjects. These results support previous sex difference findings by Natale et al (1983), who found that females were superior in discriminating facial expressions. Borod, Koff, and White (1983) found that both males and females show a left-face asymmetry in the expression of negative emotion, but the asymmetry is larger for women. David (1989) found a significant and reliable perceiver bias toward the left hemiface when judging facial expression for females and for right-handers, whereas no bias was found for left-handers. This bias was more pronounced in females, and was not affected by a mood induction procedure.

Research investigation sex differences in the perception and expression of emotion remain controversial, but suggest a few conclusions. First, that females are more emotionally expressive than males. Second, than females may be less lateralized than males, but that the task characteristics may influence the magnitude and duration of this effect.

Other research paradigms which support the hypothesis that the right hemisphere is preferentially involved with the processing of emotion, and which also support the idea that the right hemisphere is involved in negative and the left hemisphere involved in positive emotion, come from electroencephographic (EEG) and lateral eye movement studies.

It is commonly thought that the right posterior cortical regions of the right hemisphere (the right parietal region), are involved in the perception of emotion, particularly the perception of emotional faces (Davidson, 1984). The specialization of right posterior areas for affective perception is thought to apply to the perception of all valences of emotion, and this has been found in some EEG studies (Davidson & Schwartz, 1976). Basically, parietal EEG asymmetry does not differentiate between negative and positive emotion, but does show activation for both positive and negative emotional states. Two recent studies concerning parietal lobe processing of information (Smith, Meyers, Kline, & Bozman, 1987; Meyers & Smith, 1987), found that affective stimuli produce greater EEG activation at parietal sites than cognitive stimuli do, and that the right parietal sites had higher activation levels than the left parietal site.

Lateral eye movements (LEM) in response to questions requiring reflective thinking have been hypothesized to indicate activation of the hemisphere contralateral to the direction of the eye movement. Schwartz, Davidson, and Maer (1975) observed LEMs in response to emotionally laden and neutral questions. They found that normal right-handed subjects tended to shift their gaze to the left (RH) in response to questions which were emotionally laden. This effect was greatest for questions which involved both visuospatial and emotional material. While other studies have replicated this finding of left-biased LEM's in response to emotional stimuli (e.g., Ahern and Schwartz, 1979; Libby and Yaklevich, 1973; Schweitzer and Chacko, 1980), other studies have failed to find this result (e.g., Hatta, 1984, and MacDonald and Hiscock, 1985). Ahern and Schwartz (1979) added the dimension of emotional valence and found that leftward eye movements were more frequent in response to negative emotions and rightward eye movements were more frequent in response to positive emotions. Borod, Vingiano, and Cytryn (1988), had subjects generate emotional images of positive and negative valences in auditory, visual, and tactile modalities. Overall, subjects looked significantly more to the left than to the right in response to emotional images, but they found no effect for valence.

Methodologically, the above visual processing studies can be dimensionalized along three categories, which have implications for interpreting the results found in the studies. The first type of study involve making a same-different judgement with respect to the stimuli, and involve memory such that the subject is asked to remember the stimuli and to identify the stimuli presented as "same" or "different". These studies are specifically designed to evaluate recognition memory. Overall, these studies have found a right hemisphere superiority for processing both positive and negative affect (Suberi & McKeever, 1977; Strauss & Moscovitch, 1980; Kolb & Taylor, 1981). This fairly robust finding holds true for the majority of studies, but effects for the gender of the subject have also been reported (Safer, 1981). Safer's study indicates that males exhibit a right hemisphere superiority in accuracy, while a study by Ladavas, Umilta, and Ricci-Bitti (1981) found the exact opposite: a right hemisphere superiority for women. Other subject variables which may be affecting the results of these studies are cognitive style (Pizzamiglio et al, 1983) and memory (Strauss and Moscovitch, 1980). However, the overall results for these studies indicate a right hemisphere advantage for the processing of emotional information, regardless of any task or subject variables.

With respect to studies investigating right hemisphere dominance for emotional valence, the results are less clear. Early research by Reuter-

Lorenz and Davidson (1981) used a different research paradigm which required only the identification of the affect by pushing a response button, rather than the same/different paradigm which includes a memory component. This study finds a strong preference for the right hemisphere to be activated more quickly by negative affect, and the left hemisphere by positive affect. It is possible that these recognition/reaction time studies are tapping an early stage of processing of the stimuli. That is, differential lateralization for different emotional valences may be evident when subjects rely on more immediate emotional reactions rather than on their cognitve appraisal of the stimuli. The alternative explanation may be that the discrimination of happy and sad faces may be accomplished by using different cognitive strategies. Happy faces may be recognized by detecting a specific facial feature, such as the mouth, an analytic feature for which the left hemisphere is presumably specialized (Ley and Strauss, 1986). Identifying sad faces may require that information from various parts of the face be related to each other, a holistic process that presumably requires the right hemisphere.

Cerebral dominance is a construct that had been developed by scientists to organize the knowledge about the effects of lateralized brain lesions on behavior. The construct was later extended to normally functioning individuals. If the experimental tasks used to measure the construct are valid, then variations in performance on the tasks should support the hypotheses generated about the construct. Some of the threats to the validity of laterality paradigms, as stated earlier, include processing style, attention, handedness, and homogeneity of the groups.

Schwartz and Kirsner (1984) argue that behavioral measures of laterality are generally of low reliability and unknown validity, that intersubject differences are often large, and that a given subject may show marked change from test to retest with the same task. It is often true that the groups tested are heterogeneous, making it difficult to draw a clear association between group membership and specific patterns of lateral differentiation.

However, recent work has shown that certain stimulus materials and presentation techniques yield stable asymmetry indices (Speaks, Niccum, & Carney, 1982, Wexler & Halwes, 1983). It has also been shown that individual differences in laterality are often replicable (Lauter, 1982), and may possess statistically reliable associations with psychological traits (Ellis and Oscar-Berman, 1989). Levy (1983) and other researchers have made significant improvements in the evaluation of numerical laterality scores (Bryden & Sprott; 1983). Perhaps most importantly, according to Ellis and Oscar-Berman (1989), successful cross-validation of asymmetry measures by comparison with neurological data has been undertaken (Strauss, Lapointe, Wada, Gaddes, & Kosaka, 1987).

It appears that some of the difficulties remaining in laterality research have to do with task variables. For example, a task designed to measure purely emotional responses needs to be controlled so that it does not include verbal mediation of the emotional response. Studies which induce emotional responses and then measure the effects of the emotional response need a valid and reliable measure that the mood was, in fact, present. As the research into the question of laterality becomes more sophisticated and precise, the intervening variables will become more controlled.

For example, neuropsychologists (Levine, Banich, & Koch-Weiser, 1988) have asked whether faces are recognized as a special class of stimuli, or whether faces are recognized serially by the right hemisphere in the same way that other visuospatial information is recognized. The finding that faces are recognized more quickly by the right hemisphere even when inverted led to a series of experiments designed by Levine and her colleagues (1988). These studies were designed to assess whether the ability to recognize faces was qualitatively different from the ability to recognize other classes of stimuli. They found that subjects were equally accurate at identifying one other class of familiar visuospatial stimuli (e.g., houses), and suggest that any greater right hemisphere involvement in the recognition of faces is due to our expertise at recognizing faces as a specific stimulus class. An additional finding in this study was that the individuals who had an arousal asymmetry in favor of the right hemisphere were significantly more accurate at identifying the faces than those who had an arousal asymmetry for the left hemisphere.

Other variables which affect our ability to test and make hypotheses during facial processing include memory processing (e.g., are we asking a person to make a judgement based on same-different). This is particularly important with research using elderly subjects. Research has shown that the elderly retain their ability to make recognition judgements, but that they may have difficulty in novel decision-making situations.

One last group of task variables concern the mechanics of the task, i.e., the perceptual quality of the stimulus. In tachistoscopic presentations, some of the variables which affect the response are retinal eccentricity, stimulus size, luminance, contrast, blurring and degradation, and exposure duration (Sergent, 1986). In tachistoscope research, the stimulus characteristics have been manipulated in order to evaluate whether changes in the stimulus will affect the results of the study. One question asked, referred to as the spatial frequency hypothesis, is whether increases in retinal eccentricity, stimulus size, and blur/degradation, along with decreases in luminance and exposure duration (all of which reduce the availability of higher relative to lower spatial frequencies), will produce greater decrements in left hemisphere processing relative to that of the right hemisphere. In a review of 79 laterality studies published over the past 10 years, Christman (1989) reported that forty five of these studies produced results consistent with the predictions of the spatial frequency hypothesis. Twenty five of the studies showed no interactions, and nine showed interactions opposite to that predicted by the hypothesis. Christman concludes that moderate support was found for the spatial frequency hypothesis. Specifically, he reports that spatial frequency differences between the hemispheres are not present at early sensory levels, arise at intermediate processing stages where sensory codes are translated into more abstract perceptual codes upon which cognitive mechanisms operate, and may be overridden by the influence of other strongly lateralized processes (e.g., word identification).

Brain Injured Populations

Unilateral damage to the right hemisphere is associated with impaired processing (i.e., perception, comprehension, and expression) of emotional stimuli. Thus, patients with right hemisphere lesions have been shown to demonstrate impaired perception and expression of the affective intonations in speech (Kolb, 1981; Heilman, Scholes, & Watson, 1975). A series of experiments were designed to assess whether patients with right hemisphere focal damage can express emotionally-intoned speech (Tucker, Watson, & Heilman, 1981). Patients were asked to say semantically neutral sentences using a happy, sad, angry, or indifferent tone of voice. Typically, they spoke the sentences in a flat monotone. Ross and Mesulam (1979) describe patients who could not comprehend affective intonation but who could repeat affectively intoned speech and postulated that right hemisphere lesions may disrupt the comprehension, repetition, or production of affective speech in the same way that left hemisphere lesions disrupt propositional speech (Heilman & Valenstein, 1985).

Further evidence supporting the disruption of emotional processing following brain injury is shown in a study by Bihrle, Brownell, and Powelson (1986). Bihrle et al tested a group of stroke patients who had sustained either right or left-sided injury. The stimuli used were either a humorous cartoon or a non-humorous completion task. Their findings indicate that those patients with right-hemisphere damage performed more poorly on both tasks.

In an attempt to further study the difficulty right hemisphere patients have in drawing inferences and in understanding stories and jokes, Ostrove, Simpson, and Gardner (1990) had individuals with right hemisphere damage and a control group describe everyday situations involving a social dimension (reflecting presence or absence of interactions between characters) and an emotional dimension (reflecting a positive, negative, or neutral emotion felt by a protagonist in the situation). The subjects were asked to provide emotional characterizations of, and continuations to, the situational vignettes. Results indicate that those subject's with right hemisphere damage were more likely than control subjects to attribute a positive emotional state to a character in a neutral situation. There were no other significant differences between the groups, although the right hemisphere damaged group made significantly more factual errors in their continuations than the control subjects.

Damage to the left side of the brain is frequently associated with a depressive-catastrophic response, manifested by various combinations of dysphoria, fits of crying and feelings of despair, hopelessness, and anger. In contrast, damage to the right hemisphere is more often followed by an indifferent-euphoric response characterized by minimization or denial of deficits, general indifference, jocularity, and social inhibition. Gainotti (1972) found that three times as many left-sided lesioned patients as right-lesioned patients had "catastrophic" behaviors, while the reverse was true for indifference reactions.

Sackeim and his collegues (1982) reviewed the literature on pathological crying and laughing in patients with unilateral brain damage. Destructive lesions of the right hemisphere were associated with pathological laughter and mood change, while destructive lesions of the left hemisphere were associated with crying and negative mood change. These experimental results from brain-lesioned and normal populations undergoing a Wada test further support the role of the right hemisphere in negative affective processing.

Development of an appropriate emotional state may depend not only on perceiving and comprehending auditory stimuli, but also on perceiving and comprehending visual stimuli. Although both right and left hemisphere damaged patients have difficulty naming and selecting emotional faces, right hemisphere patients tend to be more impaired (Heilman at al, 1978). Heilman and his collegues propose that because patients with right hemisphere disease have difficulty comprehending affectively-intoned speech and recognizing affective facial expressions, these deficits may interfere with their ability to develop an appropriate cognitive state. Some research also shows that right hemisphere patients have more difficulty remembering facial expressions, when compared to left hemisphere patients. Weddell (1989) tested 49 brain-damaged and 15 control subjects on a test of memory for facial expression. His results suggest that right hemisphere patients were more impaired. Frontal lobe patients were also more impaired than those with posterior brain damage in the recall of emotional faces. There was, however, no significant difference between the group's ability to produce facial expression.

Post stroke depression is more common in patients with left than with right-sided lesions (Robinson, 1982). Robinson correlated depression in stroke patients with the location of the causative lesion and found that the more anterior the location of the stroke in the left hemisphere, the greater the degree of depression. Robinson proposes that depression following left hemisphere damage may be based on asymmetry of neurotransmitter pathways, with the left frontal area containing more noradrenergic neurotransmitters than the right frontal area. The greater tendency for depression after left hemisphere than right hemisphere stroke reaffirms the findings of Gainotti (1972) cited earlier.

The most consistent finding from studies of post-stroke depressive disorders is that lesion location is the single most important variable associated with mood disorder. The highest prevalence of major depressive symptoms is found in patients with left anterior brain lesions (Robinson & Lipsey, 1985). Researchers (Robinson & Benson, 1981) evaluating the effects of location of brain lesion within the left hemisphere by CT scan have suggested that depression is more severe in patients with anterior aphasias, and that proximity of injury to the frontal lobe is strongly associated with severity of depression. Frontal-lobe lesions have also been shown to impair both voluntary and spontaneous facial expression (Kolb & Taylor, 1981a).

The major problem with assessing brain function based on the findings of behavioral deficits is the uncertainty that the particular brain area included is the major site of localization for that function. As Lashley, Hunt, and other neuropsychologists recognized many years ago, loss of a behavior or the emergence of an abnormal behavior does not necessarily imply that the brain region affected is the primary, or even the most important, brain area involved in that function. Experimental evidence has demonstrated that a lesion on one side of the brain may release a behavior, which is really a function of the opposite hemisphere, by removal of inhibition. Similarly, a lesion may affect a chemical or neuronal system within the brain which only secondarily affects the behavior which is being examined (Robinson & Lipsey, 1985).

It is also important to note that depressive reactions following a stroke are not merely a depressive reaction to a serious illness. Folstein, Maiberger, & McHugh (1977) reported that 20 stroke patients were significantly more depressed than 10 orthopedic patients who were matched for severity of functional disability. They concluded that mood disorder is a more specific complication of stroke than simply a response to motor disability. Similarly, Finkelstein, Benowitz, and Baldessarini (1982) reported that the prevalence rate of moderate to severe depression was significantly higher in 25 stroke patients than in 13 control patients with disabling medical or surgical conditions who were matched for age, associated medical illnesses, and length of stay in the hospital.

Laterality Differences in Affective Disease

Researchers have recently begun to explore the possibility that some psychiatric disorders, particularly schizophrenia and depression, may be related to impaired functioning of the hemispheres in terms of cerebral laterality. In order to show that there are laterality differences between depressed and non- depressed individuals, a study would have to show evidence specifically of hemisphere overactivation or underactivation during depressive illness, rather than simply hemispheric dysfunction (Coffey, 1987).

There is growing evidence which suggests a right hemisphere involvement in depression. In general, depression is associated with increased right hemisphere activity relative to left hemisphere activity. This can either be a result of heightened right hemisphere activation, or by a decrease in left hemisphere activation. The hypothesis of left hemisphere underarousal is the most widely accepted by researchers, based on depressive reactions following damage to the left hemisphere. (Gainotti, 1972, Davidson, 1984).

Using an electrodermal orienting response measure, Gruzelier and Venables (1974) found diminished response measured at the left hand of schizophrenics and the right hand of depressives. Gruzelier and Venables interpreted their data to signify a left hemisphere dysfunction in schizophrenics and a right hemisphere dysfunction in depressives. However, a more recent GSR study failed to find any differences between depressed and non-depressed subjects (Toone, Cooke, & Lader, 1981). Another study found no asymmetries in recovered depressives (Bernstein et al, 1988). This suggests that, to the extent that such differences exist in GSR readings, they are related to the acute illness rather than being stable traits of depressive-prone individuals (Iacono & Tuason, 1983).

In a positron emission tomography (PET) study of patients with unipolar depression, metabolic asymmetries between the hemispheres were demonstrated (Baxter, Phelps, & Mazziotta, 1985). The authors were able to identify a subgroup of patients with unipolar depression with a lower left than right frontal cortical metabolic rate. Another study done by the same researchers (Phelps, Mazziotta, Baxter, & Gerner, 1984) showed that following treatment for depression, there was a return to normal glucose metabolic rate and the hemispheric asymmetry disappeared.

In work with temporal lobe epileptics, Flor-Henry (1969, 1976) found that depression was more common among patients with right hemisphere foci. Among psychiatric patients who had been screened for prior organicity, Flor-Henry found that patients with affective disorders had neuropsychological test performance indicative of right hemisphere lesions. Using the Halstead-Reitan neuropsychological assessment battery to study the effects of electroconvulsive shock (ECT), Goldstein, Filskov, and Weaver (1977) also found similarities among depressed psychiatric patients and patients with right hemisphere lesions. Kronfol, Hamsher, and Digre (1978) found decreased right hemisphere performance in depressed patients prior to ECT; that this right hemisphere dysfunction is related to the depressive affect itself is suggested by their observation that when ECT alleviated depression, there was an improvement on neuropsychological tests sensitive to right hemisphere function.

Right hemisphere dysfunction in depression has also been inferred from performance on neuropsychological tests, based on the finding that depressed patients show more deficits on standardized visuo-spatial than verbal tasks (Flor-Henry, 1983; Goldstein et al, 1977; Kronfol, 1977). Silberman, Weingartner, and Post (1983) found a pattern of errors in depressed subjects which resemble that of right lobectomized patients. A recent study by Richards and Ruff (1989) found that a group of clinically depressed subjects scored more poorly on the visuospatial measures of a standard neuropsychological test, but not on the verbal portion. This study was interesting in that the patients were medication free, while many of the studies mentioned above tested patients who were taking a variety of anti-depressant and neuroleptic medications which could potentially affect the results. The authors proposed that depression acts as a confounding variable in neuropsychological testing, showing up in novel tasks. Another recent study by Silverstein, McDonald, & Meltzer (1988) comparing task performance on the Luria-Nebraska Neuropsychological Battery found no differences between schzophrenics, schizoaffectives, and depressed patients. Other studies have shown no differences in neuropsychological test results between depressed and non-depressed subjects (Small, Small, Milstein, & Moore, 1972), and no differences between affectively ill patients and controls on a task comparing sequential (LH) vs. simultaneous (RH) tasks (Gur, 1979).

Cerebral Lateralization in the Elderly

Some researchers (Kaplan, 1983) have suggested that functional lateralization is not a static feature of the brain, but one that may change over the lifespan. One view of these changes is that of right hemisphere decline with age. In other words, certain right hemisphere skills are proposed to deteriorate more rapidly than those of the left hemisphere (Nebes, Madden, & Berg, 1983).

One popular line of reasoning used to support the view of differential decline in right hemisphere functioning is the consistent finding on the Weschler Adult Intelligence Scale (WAIS) that scores on the verbal subtests remain fairly constant, while those on the performance subtests decrease substantially with age. It has also been shown that many of the performance subtests require visuospatial abilities and are particularly difficult for patients with right hemisphere damage. Patterns of scores across the WAIS subtests seen in the elderly and in right hemisphere damaged subjects are very similar (Nebes et al, 1983). Klisz (1978) found that elderly subject's scores on a standard neuropsychological test battery were also very similar to patients with right hemisphere damage.

However, just because right-hemisphere damaged patients and elderly individuals find the same types of psychometric tests difficult does not necessarily mean that the elderly have dysfunctional right hemispheres. Since the tests are complex, the performance of different populations may be determined by different factors, including poor spatial skills for the brain-damaged, a fatigue factor for the elderly, or the novelty of the task for either group. In a recent study Mittenberg, Seidenberg, O'Leary, and DiGiulio (1989) report that deficits in elderly subject's performance could be shown to be more associated with general bilateral reduction in frontal lobe function. Moehle and Long (1989) administered the Halstead-Reitan Neuropsychological Battery to 86 normal subjects in six age ranges (15-24, 25-34, 35-44, 45-54, 55-64). They found a significant decline with aging in neuropsychological performance on all measures except the simple motor task of finger tapping, beginning as early as the 30's and 40's. These results were interpreted as supporting a model of differential decline of specific functions nested within a general decline model.

Therefore, in order to determine whether the functional efficiency of the two hemispheres does decline differentially with age, a more direct measure of relative hemispheric performance is needed, such as in the experimental lateralization paradigm. Typically, a right-handed individual would process visuospatial or emotional information faster and more accurately when it is presented within the left visual field. If, with advancing age, the right hemisphere does undergo a greater decline in processing efficiency than does the left, then in comparison to the young, the elderly should demonstrate a heightened visual half-field difference in the processing of verbal information and a diminished visual half-field difference in the processing of affective information (Nebes, 1983). This pattern would be expected because, in the young, the left hemisphere surpasses the right in verbal-linguistic processing; therefore, any loss of right hemisphere ability would augment an already existing lateral performance asymmetry. With spatial or emotional information, however, the right hemisphere processing superiority present in the young would be diminished or eliminated by right hemisphere decline in the elderly (Nebes et al, 1983).

Alterations in central nervous system functioning are commonly thought to underlie much of the decrease in cognitive performance found with advancing age. While signs of organic change are widespread in the aged brain, a number of reports (Lapidot, 1987; Goldstein & Shelly, 1981; Riege, Metter, & Williams, 1980) have suggested, on the basis of behavioral data, that the cognitive operations of the right cerebral hemisphere are disproportionately affected in comparison to those of the left. Lapidot (1987) for example, had young and elderly individuals perform a dual-process task, designed to engage right and left hemisphere functions. She found that an imagery task, thought to engage the right hemisphere, coupled with pursuit-eye movements, was significantly more difficult for the elderly subjects. There was no effect for the direction of eye movements. The results of this study support the hypothesis of asymmetry of brain aging with specific right hemisphere vulnerability to the aging process.

Trahan, Larrabee, and Levin (1986) found that visual recognition memory declines as a function of age, supporting earlier work done by Bartlett, Till and Levy (1977); Riege and Inman, 1981; Till, Bartlett, and Doyle (1982); and Trahan and Larrabee (1984). Nebes, Madden, and Berg (1983), however, used a verbal and non-verbal tachistoscopic task to study the speed with which young and elderly subjects identified stimuli presented to their right or left hemisphere. The results indicated an overall left hemisphere advantage for the verbal condition, and an overall right hemisphere advantage for the pictorial condition, but no effects for aging were found. Baron and Journey (1989) hypothesized that if an elderly person gave a verbal response rather than a manual one (i.e., reaction time), age differences would disappear. This study was designed to factor out the effect of general nervous system slowing as a function of aging. They found that when the subjects were asked to either give a verbal response to a matching task or to move a lever, that verbal response tasks were, in fact, slower than manual response tasks. While the authors were not certain why the verbal reaction times were slower, hypothesizing measurement artifact, they did note that the slopes for the responses for the elderly and younger subjects were similar. This suggests that verbal responding was more difficult for both groups, and not a function of aging itself.

In a study designed to examine memory strategies in normal elderly and patients with Alzheimer's Disease, Backman and Herlitz (1990) found that for the healthy elderly, the ability to recognize faces was related to their previous semantic knowledge store. More specifically, the normal elderly appear to utilize prior knowledge to enhance their memory performance. This finding supports similar findings in a series of experiments designed to clarify visuospatial encoding strategies of the elderly. This research is based on Craik and Simon's (1981) hypothesis that the elderly have difficulty remembering information because they encode the information at a general level and have difficulty in effectively using specific contextual information (i.e., the general encoding hypothesis). Park, Puglisi, and Smith (1986) and Park, Royal, Dudley, and Morrell (1988) reported that younger adults and the elderly do not differ across a variety of experimental conditions in the recognition of meaningful complex pictures-stimuli with rich visuospatial detail. Smith, Park, Cherry, and Berkovsky (1990) further tested the hypothesis that the failure to find age differences in the memory for complex pictures occurs at encoding and retrieval due to both the degree of visual detail (complex perceptual information) and the degree of propositional content (linguistic meaningfulness) that are represented in complex scenes. Pictures differing in visual detail (complex vs. simple) and propositional content (concrete vs. abstract) were shown to younger and elderly subjects. The results indicate that age differences in picture memory emerge if the pictures are either deprived of visual detail or reduced in propositional content. In a related study Park, Smith, Morrell, Puglisi, and Dudley (1990) found that an age difference in memory for visuospatial material is largest when there is a lack of good contextual information for the person to use to encode the target stimuli.

The present study is designed to examine age differences in the cerebral asymmetry for the processing of emotional information. While many studies have been done concerning right hemisphere decline with aging, only one study to date has been concerned with the affective processing capabilities of the right hemisphere and aging (Moreno, Borod, Welkowitz, and Alpert, 1990). This study assessed both the perception and expression of emotion as a function of age group. Young, middle-aged, and elderly women were asked to pose various emotions, and to also make intensity ratings after viewing photographs of chimeric faces. While the study found support for the right hemisphere emotional processing hypothesis, the hypothesis of age differences in cerebral asymmetry was not supported.

Based on Heilman's work with right hemisphere brain damaged individuals, it is expected that if the right hemisphere is differentially involved in aging, then older subjects will be less efficient in perceiving negative emotion than younger subjects. Related to this issue is the issue of affective vulnerability in the elderly. If the right hemisphere is, in fact, declining in relation to the left hemisphere with advancing age, this would have implications for the elderly individual's ability to efficiently process emotional information from their environments, and may lead to an altered vulnerability or predisposition to affective problems, such as depression.

To further test this hypothesis, this study will assess differences in affective perception among young and elderly subjects. Based on the hypothesized right-hemisphere decline with age, diminished ability of the elderly to perceive negative emotional cues is expected. What we would expect to see with the elderly would be more social-approach behaviors and intact verbal abilities, based on the fact that the left hemisphere is still functioning efficiently relative to the right hemisphere.

Study 1

Study 1 was designed to investigate the ability of young subjects and elderly subjects to accurately identify affective expressions. If there is right hemi-aging, we would expect the elderly to be less accurate than younger subjects in the identification of the affective expressions in a group of standardized photographs. We would also expect the elderly to vary in their estimates of affective intensity depicted in the facial stimuli in comparison with younger subjects. 60 subjects, 30 college-aged and 30 elderly, were tested on a facial identification task. Subjects were also asked to rate the intensity of the affect as expressed in a group of standardized photographs. It was hypothesized that the younger group would be the more efficient in identifying the affect and that they would rate the negative affective valence as more intense. Study 2 was a tachistoscope study designed to assess differences between the age groups in their response times to affect differentially projected to the right or left visual field.

Hypotheses for Study 1

1. Subjects in the younger group will be more accurate in identifying the affect of the photographs than the elderly subjects.
2. Due to the right hemi-aging hypothesis and the right hemisphere's role in negative emotion, the elderly will have the most difficulty identifying negative affective stimuli (e.g., sad, angry, and fearful pictures).
3. The subjects in the younger group will produce heightened ratings of

intensity when compared with the elderly group.

4. Following the hypothesis of right hemisphere decline, the elderly will rate the negative affective stimuli as less intense than the positive, while there will be no significant differences for the younger group.

5. Subjects with the highest scores on the Affect Intensity Measure (AIM) will rate the photographs as generally more intense than low-scoring subjects.

Method

Subjects

Subjects were 60 volunteers who were selected according to age. Thirty were college students, 15 males and 15 females, aged 18-24. The mean age of the college students was 19.47 (SD 1.43). The students were enrolled in Psychology classes at Virginia Tech and received course credit for their participation. Thirty subjects (15 male, 15 female) were elderly residents, ages 62-90, of two retirement villages located in southwestern Virginia who volunteered to participate. The mean age of the elderly subjects was 74.03 (SD 6.86).

The elderly were recruited through flyers which were put into their mailboxes. Further recruitment was necessary, due to the low response rate (16%). The management at both retirement centers provided the experimenter with a list of individuals felt to be most likely to participate. Individuals on this list were contacted with an 82% positive response rate. The population of the retirement centers consisted of a wide range of socio-economic groups, including retired college professors, white and blue-collar workers, and housewives.

All of the subjects were right-handed. Handedness was determined using a behaviorally validated questionnaire (See Appendix C) (Coren, Porac, & Duncan,1979). This questionnaire consists of 13 items which assess four types of lateral preferences (hand, foot, eye, and ear). Responses to the items were scored as +1 for right, -1 for left, and 0 for both right and left. The criterion for right-hand dominance and inclusion in the study was a total score of +6 or above out of a total possible score of +13.

Subjects were excluded who had a history of neurological disease, psychiatric disorder, disabling medical disease, alcohol or drug abuse. Subjects who were currently being medicated with a substance known to affect hormone levels or central nervous system functioning were not included in the study. Subjects were also screened for visual acuity to insure that they could see the visual stimuli adequately (20/40 corrected vision), using an eye chart published by Bates (1970).

Materials

All subjects were administered self-report questionnaires. The questionnaires were included in order to assess possible relationships between frequency and intensity of affect, depressive and anxiety symptoms and performance. These questionnaires included the Beck Depression Inventory (BDI, see Appendix D for all self-report questionnaires) (Beck, 1978) for the younger subjects, and the Geriatric Depression Scale (GDS,) (Brink et al, 1982) for the elderly. The Beck Depression Inventory is the most frequently used self-report measure in the depression literature (Shaw, Vallis, & McCabe, 1985), it possesses adequate test-retest reliability (Oliver & Burkham, 1979); internal consistency (Gallagher, Nies, & Thompson, 1982); and concurrent validity with the Diagnostic and Statistical Manual of Mental Disorders (DSM III-R; (Oliver and Simmons, 1984).

The GDS has been shown to be a more valid measure of the elderly individual's depressive states because it emphasizes depressive features of this population which are not confounded by normal aging or other disease processes (Yesavage et al. 1983; Bolla-Wilson, 1989), and has also been shown to have adequate internal consistency, convergent and discriminiant validity.

The state portion of the State-Trait Anxiety Scale (STAI) (Spielberger, 1970) was included as a means to assess state levels of anxiety during testing. The Affect Intensity Scale (AIM) was also administered as a means of measuring differences between how intensely the younger and elderly group typically experience emotions.

The AIM is a 40-item questionnaire that assesses the characteristic strength or intensity with which an individual typically experiences his or her emotions. The authors of this scale (Larsen and Diener, 1986) postulate that some individuals modulate the intensity of emotional stimuli such that they consistently exhibit stronger or more intense reactions to both positive and negative emotional stimuli. This definition emphasizes the distinction between the frequency of emotional experiences (e.g., I am happy quite often) and the intensity of experienced emotion (e.g., When I am happy the feeling is one of intense joy). The construct definition also emphasizes that affect intensity pertains to all emotions regardless of hedonic tone. Thus, individuals who typically experience strong positive affect typically also experience strong negative affect. Finally, the construct definition includes the notion that affect intensity should not only manifest in subjective experience but should also influence bodily responses, cognitive performance, and interpersonal relationships (Larsen et al, 1986). Psychometric analysis of the AIM has been undertaken with evidence for construct validity (Larsen, 1984). Specifically, the AIM correlates significantly with both resting Galvanic Skin Response and resting heart rate. The 1, 2, and 3 month re-test correlations were .80, .81., and .81, respectively.

All subjects were administered the Vocabulary and Block Design subtests from the Weschler Adult Intelligence Scale-Revised, as a means of assessing general cognitive functioning levels. The Vocabulary and Block Design tests were selected because they have been shown to correlate most highly with the overall Verbal and Performance I. Q. scores, respectively.

Affective Facial Stimuli

The stimuli utilized in this study were 50 (10 x 15 cm) photographs of faces representing standardized poses of fundamental emotions. These test stimuli were developed and standardized by Ekman and Friesen (1978).

The photographs (Ekman & Friesen, 1976) are of ten individuals posing one of five emotional poses: happy, neutral, sad, angry, and fearful, and were mounted in a booklet (30 x 30 cm).

Procedure

The college students were tested in the Neuropsychological Laboratory at Virginia Tech, while the elderly subjects were tested in a room specifically set aside for testing at the two retirement centers.

Each subject signed an informed-consent form. Each was asked health screening questions, and was checked on a standard eye chart (Bates, 1970) to assure that visual acuity criteria were met. The subject was then administered the Vocabulary and Block Design sub-tests from the Weschler Adult Intelligence Scale-Revised. The subject was told that he/she was participating in an experiment concerning the recognition of faces. The subject completed the self-report questionnaires, and was then given the following instructions:

> "We are interested in finding out how people identify facial expressions. What we would like for you to do is to look at this book of pictures. Each picture is of a person with a particular expression on his or her face. We would like you to rate each picture according to what emotion you see, and how strongly this emotion is being expressed. The choices of expressions are happy, sad, fearful, angry, and neutral. The intensity of the emotion is on a scale from 1 to 5; 1

meaning not intense at all, 5 meaning the emotion is being expressed very intensely. You will mark your answers on this rating scale." "Here are some practice pictures. For example, if I showed you this picture, what emotion would you say that this person is expressing?" (Person is given a picture of a happy person, and upon giving the correct response the experimenter replied "Good". If the person did not correctly identify 6 of the 10 practice photographs, they were excused from further participation.) When given a correct response,the experimenter replied, " Now please tell me how intensely that expression is being expressed, on a scale from1-5".

Since there are no right or wrong answers on intensity, the experimenter thanked the subject, and showed them how to record the answers on the rating scale. Each subject was given ten practice photographs, two photographs for each emotion. Three elderly subjects were excused from further participation for health reasons or for not meeting visual acuity requirements.

Upon completion of the task, the subject was debriefed and scheduled for the second part of the study.

Results

Separate analyses of variance (ANOVA's) were performed on the accuracy scores and the intensity measures. The data were subjected to a two-factor mixed design ANOVA with age as the between subjects factor (young and elderly), and with repeated measures on affect (happy, neutral,

Table 1

Means and Standard Deviations for Demographic and Self-Report Data: Study1

	Young Group			Elderly Group		
	Mean	S.D.	Range	Mean	S.D.	Range
Age	19.47	1.43	17-22	74.03	6.86	65-90
Handedness	11.63	1.03	8-13	11.26	.98	9-13
Vocab. (Age Correct)	10.90	1.44	8-15	12.43	2.38	9-18
B. Design (Age Correct)	13.10	2.60	8-16	11.90	2.26	8-16
B. D.I.	4.63	3.80	0-15			
G.D.S.				1.56	1.75	0-7
STAI	31.36	6.64	20-50	29.00	8.30	20-53
AIM	3.85	.38	3.2-4.4	3.70	.65	2.5-5.2

sad, angry, and fearful).

Self-Report and IQ Measures

Table 1 shows the means and standard deviations of the scores from the demographic, self-report questionnaires, and IQ measures. Simple effects ANOVAs were used to analyze the data. The elderly subjects scored reliably higher on the Vocabulary subtest of the WAIS-R, $F(1, 58) = 5.57$, $p < .02$. It is interesting to note that this finding was not significant, $F(1, 58) = .054$, $p < .464$, without the age correction. Post hoc analysis using Tukey's Least Significant Difference procedure indicates that without the age correction, the younger subjects showed a significantly higher score on the Block Design subtest, $F(1, 58) = 19.80$, $p < .0001$. No other significant differences were found between the two age groups.

Accuracy Data

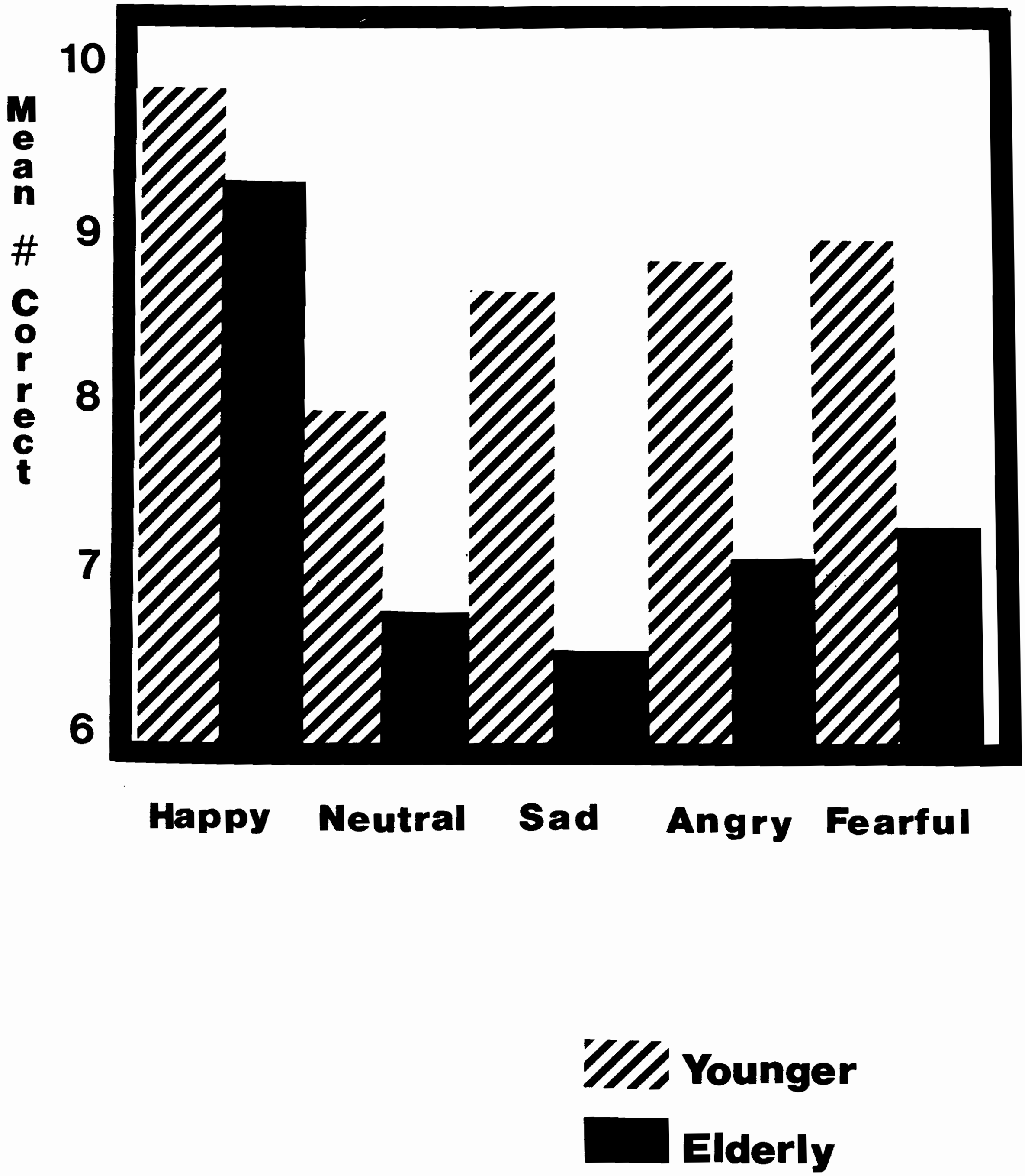
Accuracy responses for the identification of the 5 affective categories were summed for each subject within each affective category. Table 1, Appendix A, shows the means and standard deviations for the number of correct responses (maximum = 10) for each affect. A two factor mixed-design ANOVA with age as the between subjects factor and with repeated measures on affective category (Happy, Neutral, Sad, Angry, and Fearful) was performed on the accuracy data. The Group x Affect interaction was reliable, $\underline{F}$ (4, 232) = 2.51, $\underline{p}$ < .04. Within the elderly group there were significant differences in their accuracy of identification among the negative (sad, angry, fearful) and neutral affective categories, when compared to the identification of happy affect (See Figure 1).

The elderly group was significantly less accurate overall in their identification of facial affective category than the younger group, $\underline{F}$ (1, 58) = 32.25, $\underline{p}$ < .0001. The overall accuracy scores declined from a mean of 8.75 in the young group to a mean of 7.21 in the elderly group.

Accuracy also varied across the affect categories irrespective of group, as evidenced by the main effect of affect, $\underline{F}$ (4, 232), = 40.44, $\underline{p}$ < .0001. The negative and neutral affective categories were identified reliably less accurately than the happy affective category.

Overall, the mean accuracy declined from 9.96 for positive affect in the young group to 9.30 for the elderly group; from 8.63 for sad affect in the young group to 6.56 for the elderly; from 9.03 in the young group for angry affect to 7.30 for the elderly; from 9.03 in the young group for angry

Figure 1: Mean Accuracy Scores by Group for Each Affective Category


Mean # Correct
10
9
8
7
6
Happy
Neutral
Sad
Angry
Fearful
Younger
Elderly

affect to 8.30 in the elderly group; and from 8.03 in the young group for neutral affect to 6.73 in the elderly group (See Table 2).

The elderly group was most accurate in identifying happy, followed by fearful affect. There was no significant difference in the elderly group's ability to identify sad and neutral faces, and they identified these categories significantly less accurately than fearful faces. There was also a reliable difference in the elderly group's ability to identify sad faces when compared to angry and fearful faces.

The younger group was reliably more accurate in the identification of happy affect in comparison with the neutral and negative affective categories of sad, angry, and fearful. The younger group was least accurate in the identification of stimuli within the neutral category, but there was not a significant difference between the accuracy of neutral and sad responses.

Table 5, Appendix A shows the Pearson Correlation Coefficients between the self-report questionnaires, self-report variables, and accuracy scores by group. The correlations indicate that Vocabulary and Block Design are highly correlated for both groups. Since there were significant group differences on scores of the Vocabulary subtest, and

Table 2

Means and Standard Deviations of the Number of Correct Responses for Each Affective Category

	Happy	Sad	Angry	Fearful	Neutral
Young	9.96 (.18)	8.63 (1.67)	9.03 (.99)	9.06 (.82)	8.03 (1.9)
Elderly	9.30 (1.0)	6.56 (1.88)	7.30 (1.8)	8.30 (1.5)	6.73 (2.2)

Tukey's Minimum Significant Difference = .69

Table 3

Means and Standard Deviations of the Intensity Rating Scores for Each Affective Category, Correct Responses Only

	Happy	Sad	Angry	Fearful	Neutral
Young	3.92 (.43)	2.32 (.63)	3.43 (.59)	3.51 (.42)	3.18 (.68)
Elderly	4.03 (.57)	3.13 (.74)	3.49 (.49)	3.59 (.56)	3.34 (2.4)

Tukey's Minimum Significant Difference = .24

since the Block Design subtest was significantly related to the Vocabulary subtest (see Table 5, Appendix A), an analysis of covariance (ANCOVA) was performed on the accuracy data. The results of these analyses indicate that when the Vocabulary and Block Design subtests are covaried out, the effect for group remains (See Tables 11, 12, Appendix A). This suggests that the reliable differences seen between the group's ability to correctly identify the pictures are not primarily related to the factor of general intelligence, as measured by the Vocabulary and Block Design subtests.

Affect Intensity Ratings

Table 2, Appendix A, shows the means and standard deviations for the intensity ratings of each affect by group, computed on the correct responses only. A General Linear Model (GLM) ANOVA which has the capacity to analyze data in the presence of missing values was used for this analysis. The Group x Affect interaction was significant, $\underline{F}(4, 232) = 6.72$, $\underline{p} < .0001$. The mean intensity rating overall was 3.51 for the elderly, while for the younger group it was 3.28. The finding of higher intensity ratings for the elderly was opposite to what had been predicted. Post hoc analyses reveal that the elderly rated the happy affect as being expressed significantly more intensely than the other affective categories.

Figure 2. Mean Intensity Rating Scores by Group for Each Affective Category

Mean Intensity
4.5
4.0
3.5
3.0
2.5
2.0
Happy
Neutral
Sad
Angry
Fearful
Younger
Elderly

The sad and neutral faces were rated as being expressed as least intense, and are not significantly different from each other, followed by angry and fearful. The angry and fearful and angry and neutral faces were also not seen by the elderly as being different in intensity level. (See Figure 2).

For the younger group, the happy stimuli were also rated as being expressed more intensely than the other affective categories. The younger subjects rated the sad stimuli as least intense, followed by neutral, angry, and fearful. The neutral stimuli were seen as significantly less intense than the angry and fearful stimuli, which were not seen as different in intensity level.

An examination of the Pearson Correlation Coefficients revealed a significant relationship between the mean intensity ratings and scores on the Affect Intensity Measure and the state portion of the State/Trait Anxiety Inventory for the younger subjects. Since the factors of Affect Intensity and State anxiety were significantly correlated with the intensity rating scores (see Table 6, Appendix A), an analysis of covariance was performed on the data using these factors as co-variates. The analyses, seen in Tables 13 and 14, Appendix A, indicate that when the effects for Affect Intensity and State anxiety are removed from the analysis, a significant group difference in intensity ratings remains.

The Affect Intensity Questionnaire

The scores on the Affect Intensity Measure (AIM) were rank ordered into high (Mean = 4.26), medium (Mean = 3.86), and low (Mean = 3.18) scores. A series of simple effect ANOVA's were performed to investigate whether individuals who typically experience their emotions more intensely are more accurate at identifying facial affect. In addition, the use of the questionnaire as a predictor of the intensity ratings was evaluated.

The results indicate that subjects in both the younger and the elderly groups who scored in the highest AIM category also scored significantly higher on the state portion of the State/Trait Anxiety Inventory than subjects who scored in the lower categories, $F(2, 54) = 4.79$, $p < .01$. There was no effect for AIM in the accuracy, $F(2, 316) = .31$, $p < .73$, or intensity analysis, $F(2, 342) = .26$, $p < .77$.

Discussion

As hypothesized, the younger group was significantly more accurate at identifying affective expressions in a group of standardized photographs than elderly subjects. Also, as hypothesized, the diminished ability of the elderly to identify facial affect was seen across all negative affective categories and the neutral category. The elderly were significantly less accurate at identifying sad, angry and fearful photographs than the younger group. The elderly group was also significantly less accurate at identifying neutral pictures.

Also as hypothesized, the younger subjects had the most difficulty identifying neutral faces, although the accuracy scores on neutral faces for the younger group did not differ significantly from their accuracy scores on sad faces. An examination of the responses from both the younger and the elderly groups revealed that within the sad affective category, the majority of errors involved identifying the sad faces as being neutral. This was true, in reverse, for the neutral cateory, where the majority of errors involved seeing neutral faces as sad.

There were, however, no significant differences between groups in their ability to identify happy affective expressions, although there was a non-significant trend in that direction. If the elderly subjects' inability to recognize the affective expressions were due to age differences in facial affective processing, per se, (e.g., a general slowing of the nervous system or visual acuity deficits), then their ability to make judgements across the five affective categories would have been equally affected. This was not the case, however, since the elderly had a mean accuracy score of 9.30 (maximum =10) for the happy faces, which was not significantly different from the mean of 9.96 for the younger group. Thus, the two groups were equally accurate in making judgements about the happy faces, but significantly different with respect to the negative and neutral faces.

It is possible that a ceiling effect in the happy category prevented a significant difference to emerge between the two group's ability to identify happy faces. However, since the trend was non-significant, the finding that there were no significant differences between groups in their ability to identify happy affect supports the right hemi-aging hypothesis. The elderly were as accurate in identifying positive affect as the younger subjects, but were significantly less accurate at identifying negative affect. Because the right hemisphere is hypothesized as preferentially processing negative affective information, while the left is hypothesized to process positive affective information, the right hemi-aging hypothesis would predict age differences in the ability to identify negative vs. positive affect, as was found.

These results can be interpreted as supporting in part recent work done by Levenson, Carstensen, Friesen, and Ekman (1991) who found that while there are no significant differences between young and elderly subjects' performance on a series of emotional tasks, the elderly subjects exhibited a decrease in magnitude of change of autonomic nervous system (ANS) among different negative affective stimuli measures when compared to the younger group. The groups were equally able to perform a task of inducing emotional responses to emotional stimuli, but the elderly showed less differentiation of change in ANS reactivity among the negative affective categories (anger, fear, sadness, and disgust). In other words, the elderly were able to perform the task, but their level of arousal, as measured by blood pressure and finger temperature, to each different negative affective category did not vary, when compared to the younger group.

Taken together, the present study and the Levenson et al (1991) study suggest that the elderly retain the ability to make distinctions among negative affective categories, but that this ability is decreased in comparison with younger subjects, as would be predicted by the hemi-aging hypothesis. Because the present study had only one positive affective category, it is difficult to draw a conclusion with respect to relative differences between groups in their ability to discern positive emotion, and this was not addressed in the Levenson study.

Limitations of the present study, with respect to the accuracy ratings, include the fact that while there was only one category for happy faces, there were three categories for negative faces. This fact may have decreased the accuracy of the responses, since the subjects had to choose from among three possibilities and thus, were more likely to make mistakes. In both the young and the elderly group, performance was poorer in the negative affective categories. This suggests that within the negative affective categories, identification was more difficult. For identification of the happy faces the task was to decide if the face was happy. For the negative faces the decision then had to be made concerning what kind of negative face it was. Thus, the task itself was more difficult and may have resulted in increased errors. Heightened difficulty here may have contributed to the interaction of age and affect, thus confounding the right hemi-aging hypothesis with the generalized decline hypothesis (Moehle & Long, 1989).

One possible remedy for this problem and the problem of a ceiling effect would be to replicate the study using only three affective categories, and more faces per category. Because in the present study fearful faces were identified more accurately than the other negative affective categories, the categories would logically be happy, fearful, and neutral. Consequently, there would be fewer choices in the negative affective categories and an equal number of choices within each affective category.

Adding an intermediate age group, such as ages from 30-60, would also be helpful in determining if any of the differences in groups were caused by a cohort effect, due to non-specific differences in how the elderly identify and express emotions, compared to younger adults.

With respect to the intensity ratings of the photographs, and opposite to what had been predicted, the elderly rated the pictures as more intense than the younger group did. Overall, both groups rated the happy faces as most intense, followed by fearful, angry, neutral, and sad, as the least intense. The major difference between groups was that the elderly rated the sad and neutral faces as significantly more intense than the younger subjects did.

The hypothesis that the elderly would rate the negative affective categories as less intense than happy and neutral categories was only partially supported. Based on the right hemi-aging hypothesis, decreased intensity ratings for negative affect would be expected because the elderly would be less able to discriminate negative affect, and thus, would see it as being expressed less intensely.

What was found was that the elderly saw the sad affect as being expressed least intensely, but the younger group also rated the sad affect as least intense. A possible explanation for this is that the stimuli for sad faces were the most difficult to discriminate, and thus, the most difficult to rate for intensity. In terms of accuracy, the elderly group was least accurate with the sad faces. The younger group was less accurate at neutral than sad faces. It would appear likely that the happy faces were rated as being expressed most intensely because they were the easiest to identify, for both groups. It appears that the intensity ratings were directly related to the accuracy scores; the greater the accuracy, the greater the intensity rating. It would appear that the more confident the subject was in identifying the affect, the higher intensity rating he or she gave it.

In order to clarify the issue of the independence of the intensity measures, this study should be replicated, using the same Ekman and

Friesen faces. However, the subject would be told which affect was being expressed, and asked only to rate it for intensity. Differences among intensity ratings would then be independent of the subject's confidence level in making a judgement about the nature of the affect, and the subject could concentrate on merely rating the intensity of the affect.

Affect Intensity Findings

The finding that the high scorers on the AIM also scored higher on the state portion of the State/Trait Anxiety Inventory suggests that either the two questionnaires are measuring the same phenomena, or that individuals who typically experience their emotions strongly also experience higher anxiety than others. The finding that high scorers on the AIM also scored in the high scoring group for the STAI was true for both age groups. This is not true for scores on the two depression inventories, whose scores did not correlate highly with the AIM. Thus, either the AIM also measures anxiety, or high scorers on the AIM are more likely to be anxious than low scorers. Further research on this topic is needed to address the relationship between the two constructs of response intensity and anxiety.

The fact that there was no significant relationship between the AIM and the intensity measures, as hypothesized, may be due to several factors.

First, there may not be a clear relationship between the intensity with which one typically experiences emotion and the ability to perceive emotions in other people. For example, even though a person scores high on the AIM and would hypothetically be a person who typically experiences his or her emotions strongly, that person may not be skilled at reading other people's emotional cues, particularly when seen in a photograph. Second, the demands of the experiment may not have been sufficiently stimulating. The subjects may not have been putting forth their best effort in identifying the pictures or how strongly the expressions were being expressed. A better way to design a study to look at intensity ratings might be to use video equipment and have models in real-life situations expressing emotions within a context, rather than still photographs. The context would provide the subjects with enough information so that they would know what the emotion is, and be able to make intensity judgements with more confidence.

Study 2

Study 2 was designed to assess cerebral asymmetry for the processing of emotional stimuli as a function of age. Hemispheric processing of affective stimuli was assessed using a tachistoscopic task.

Based on prior research (Harrison & Gorelczenko, 1990; Harrison, Gorelczenko, & Cook, 1990) differences were expected in response time as a function of affective valence and the visual field of presentation. Specifically, right hemisphere superiority in emotional face processing was expected. It was also hypothesized that response times to angry faces would be reduced with presentation to the right hemisphere. In contrast, minimal functional asymmetry was expected in the response times to happy faces.

Based on the right hemi-aging hypothesis, an age-related decrement in the processing of affective information for the elderly was expected. Specifically, the elderly were expected to show decreased ability to process affective information presented to the right cerebral hemisphere.

This study also included the presentation of neutral slides in a forced-choice paradigm. The groups were told that they were to identify either happy or angry faces corresponding to the response manipulanda. The neutral slides were included to evaluate affective bias (rather than processing speed, per se). The elderly were expected to show a positive affective bias, based on the right hemi-aging hypothesis.

Hypotheses for Study 2

1. The younger group will identify the correct affect more quickly than the elderly group.
2. Facial affect will be identified more quickly when projected to the right hemisphere than to the left hemisphere.
3. Angry faces will be recognized more quickly when projected to the right hemisphere. Happy faces will be recognized more quickly when presented to the left hemisphere.
4. The elderly will show reduced right hemisphere activity, and reduced cerebral asymmetry on negative affect measures.

Method

Subjects

The same subjects participated in Study 2, 30 college students and 30 elderly individuals. All subjects were re-administered the self-report questionnaires. These included the Beck Depression Inventory (BDI); (Beck et al, 1961) for the younger subjects, and the Geriatric Depression Scale (GDS) (Brink et al, 1982) for the elderly, and the STAI (Spielberger, 1970).

Stimuli and Apparatus

Ten happy, ten angry, and ten neutral expressions were randomly selected from among Ekman and Friesen's (1978) pictures of facial affect. These slides were reproduced and remounted with the permission of the publisher, with the stimulus appearing in either the right visual field (RVF) or the left visual field (LVF). The stimuli were mounted with the inside of the edge of the picture three degrees from center and the outside edge 12 degrees from center (see Sergent, 1982). In all, 60 slides consisting of 10 faces (10 RVF happy, 10 LVF happy, 10 RVF neutral, 10 LVF neutral, 10 RVF angry, and 10 LVF angry) were used.

Subjects were tested in a sound-attenuated room. All time-based and event recording were performed using automated programming equipment located in a separate room. The subject was monitored through an observation window and prompted using an intercom. Stimuli were presented using a Constant Illumination Tachistoscope (Layafette Model 42011) onto a screen at a distance of 2.67 meters and 1.35 meters in front of the subject. The center of the screen was marked with a black dot positioned 1.47 meters above the floor. Luminance level was 4.5 candellas per m2 reduced to 2.5 candellas during presentation of a slide. Trial onset was signalled by a 2000 Hz, 55 dB (A-scale) tone located behind the subject. The manipulanda consisted of two "soft touch" trip switches flush mounted on the midline of a right-handed student desk, 58.5 cm. from the back of the chair. The switches were separately labeled "happy" and "angry" and were counterbalanced across subjects.

Procedures

The procedures were approved by the Institutional Review Board and Human Subjects Committee, informed consent was obtained on all the subjects. Subjects were seated and administered the BDI or GDS, and the STAI, and were given the folllowing instructions:

> "In this part of the study you will have to make decisions concerning faces which you will see on the screen. The presentation of the faces will be brief and either to the left or to the right of the black dot. The presentation will be preceded by the tone (the tone will be sounded). We ask that, upon hearing the tone, you focus on the black dot because the face will be presented about three seconds after the tone. Your task is to choose whether the face you see is happy or angry. We ask that you use your right index finger to choose whether the face is happy or angry. Please keep your index finger raised above and between the two switches. After the presentation of the face, please make your selection by pressing the switch labelled "happy" or "angry". Please respond as quickly and as accurately as possible. To get you used to the procedure, practice trials will be provided. Also, we will inform you when the practice trials have ended and the study will begin. There is an intercom behind you if you need to contact me. We will remind you to fixate on the black dot during the testing. Any questions?"

After having read the instructions, the practice trials, consisting of only 10 happy and 10 angry slides, were initiated. A one second duration tone signalled the impending presentation of an affective face. Three seconds after the tone, the slide was shown for 250 msec. Subject identification of the affective valence of the face stimuli occurred using a two-choice accuracy paradigm. Subjects were required to make their decision within a 15 second intertrial interval. Subjects were required to correctly identify eight consecutive slides within the first three replications of the practice slides for inclusion in the study.

The same presentation process was used for the test phase as was described for the practice phase. The only difference was that the slide set consisted of 10 neutral as well as 10 happy and 10 angry slides. Thus, a restricted (3 affects, 2 response alternatives) forced-choice accuracy paradigm was used. The subject was reminded to focus on the fixation point at the center of the screen after every 18 slides to improve the integrity of stimulus presentation within either visual field. The location of the response keys were counterbalanced across subjects to eliminate position effects. Also, randomized orders of slide presentation were used to control for order effects. When an incorrect response was made, the slide was repeated at the end of the 60 slides.

Results

Self-Report Measures

Self-report questionnaires were re-administered on the second testing date, to again monitor possible effects for level of depression and anxiety of subjects on testing day. A comparison of the Beck Depression Inventory, Geriatric Depression Scale, and the state version of the State/TraitAnxiety Scale (STAI) data taken at the second testing session indicate that there was a significant difference between the groups on the STAI, $F (1, 58) = 4.81$, $p < .03$, with the young group scoring higher than the elderly group. There were no other significant differences between groups on self-report questionnaires on the second testing day. Pearson Correlation Coefficient tables for the variables and the reaction time data are seen in Tables 9 and10, Appendix A.

Response Time Measures

A four-factor mixed design ANOVA was used with age as the between subject's factor, and with repeated measures on affect (Happy and Angry); visual field (LVF and RVF); and trial (10). Separate analyses were performed using the reaction time data from the neutral affect category. Table 4 presents the mean reaction times by group, affect, and visual

Table 4

Mean Reaction Times in Milliseconds by Group, Affect, and Visual Field

Group	Affect	Left Visual Field	SD	Right Visual Field	SD
Young	Happy	.726	.20	.719	.17
	Angry	.813	.17	.792	.18
Elderly	Happy	1.077	.20	.950	.19
	Angry	1.107	.23	1.211	.25

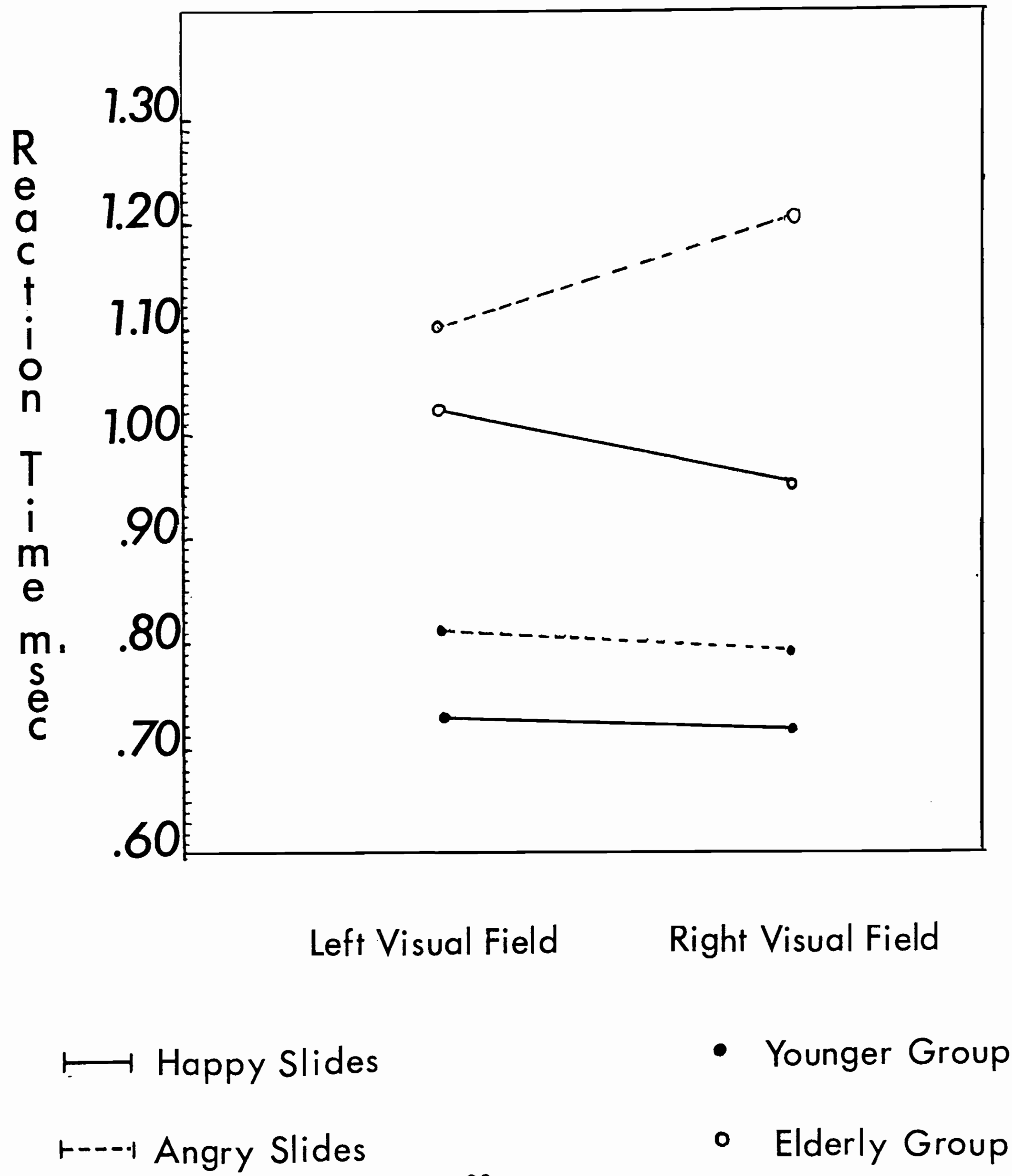
field.

In order to control for inflated Type I error rate often found with the repeated measures design (Vasey and Thayer, 1987), conservative degrees of freedom were used (Greenhouse and Geiser, 1959) to determine the significance of the main effects and interactions. Only the adjusted degrees of freedom are reported.

The data were first analyzed using the happy and angry reaction time data. This ANOVA revealed a reliable Group x Affect x Visual Field interaction, $\underline{F}$ (1, 58) = 7.15, $\underline{p}$ < .01. The analysis also showed a significant interaction of Affect x Visual Field, $\underline{F}$ (1, 58) = 6.03, $\underline{p}$ < .02; and a significant interaction of Group x Affect, $\underline{F}$ (1, 58) = 10.32, $\underline{p}$ < .002.

Visual field of presentation had its primary impact on the elderly. In comparison with the younger group, the elderly showed increased asymmetry (See Figure 3). There was no significant difference in response time by visual field for the younger group for either happy or angry affect. In other words, the younger group responded to the different affective categories with the same relative speed, regardless of visual field presentation.

Figure 3. Mean response time in milliseconds for the young and elderly groups as a function of visual field and affective valence.



Reaction Time m. sec
1.30
1.20
1.10
1.00
.90
.80
.70
.60
Left Visual Field
Right Visual Field
Happy Slides
Angry Slides
Younger Group
Elderly Group

For the elderly, Tukey's Least Significant Difference analyses indicated significantly faster response to slides of angry faces when the angry faces were presented to the left visual field (right hemisphere), while their reaction time to positive faces was faster when they were presented to the right visual field (left hemisphere). Thus, the elderly showed an apparent increase in cerebral asymmetry, compared to the younger group. Overall, both groups responded more quickly to happy affect than to angry affect, as seen in the main effect for affect, $\underline{F}(1, 58) = 63.03$, $\underline{p} < .0001$.

Examination of the Pearson Correlation Coefficient matrix indicated a signficant relationship between scores on Block Design and mean reaction time for the elderly (See Table 10, Appendix A). When Block Design was entered into an analysis of covariance, it was found that the significant differences between groups on reaction time remained after the effects of Block Design were covaried out (See Table 12, Appendix A).

Response Bias Analysis

The response time and affective response bias data from the neutral slides were analyzed separately, using a two factor mixed (ANOVA) design with group as the between subjects factor and repeated measures on visual field. The response time data for the neutral slides revealed no significant differences between groups other than a main effect for group, $F_{(1, 58)}$ = 25.50, $p < .001$. The young group was significantly faster in responding than the elderly.

The response bias slides revealed a main effect for visual field, $F_{(1, 58)}$ = $p < .01$. Both groups were more likely to identify the neutral/ambivalent faces as "happy" following presentation to the right visual field.

Discussion

Response Time

The elderly group's response times were significantly slower than the younger group's. However, since this finding is what would be expected due to general nervous system slowing in the elderly, it will not be discussed directly.

The major findings were as follows: The elderly showed heightened cerebral asymmetry compared to the younger group, opposite to what had been predicted. Specifically, the elderly responded more quickly to angry stimuli when it was presented to their right hemisphere than when it was presented to their left hemisphere. This finding is diametrically opposite to their response times for happy stimuli, which are processed more quickly with presentation to the left hemisphere. This finding can be interpreted as supporting the general hypothesis of differential processing for positive and negative affect by the right and left cerebral hemisphere (Silberman & Weingartner, 1986).

The finding of quicker response times to angry stimuli presented to the right hemisphere does not support the hypothesis of right hemisphere decline in the elderly. If the right hemisphere is less efficient at processing negative affect, there should have been a decrement in the response times to stimuli presented to the right hemisphere relative to the young group, and decreased rather than increased cerebral asymmetry. As can be seen in Figure 3, the elderly subjects responded more slowly to angry stimuli when it was presented to their left hemisphere, and more quickly to happy stimuli presented to their left hemisphere.

For the younger group, there was no significant difference between presentation of stimuli to the left or right hemisphere, regardless of valence. Interestingly, the proposed finding of quicker response times to angry stimuli in the right hemisphere was not found for the younger subjects, nor was affect recognized more quickly when projected to the right hemisphere. It is unclear why this effect was not found for the younger group, especially in light of the same finding being present for the elderly group.

In previous studies using a similar research paradigm and research apparatus (Harrison & Gorelczenko, 1990; Harrison, Gorelczenko, & Cook, 1990) reliable effects for visual field of presentation and valence were found. In the present study, the younger subjects did not show the expected right hemisphere superiority for affective processing. It is possible that the younger group remembered the stimuli from the previous study, and responded based on previous learning. Since the stimuli in both studies were Ekman and Friesen standardized faces, the younger subjects may have recognized the faces and responded more quickly than the elderly, regardless of valence and visual field. This finding would replicate other studies which investigated differences in facial recognition as a function of aging (see Trahan et al, 1986 for review), and which generally find that both recall and recognition memory decline with age and that the elderly learn at a slower rate than younger groups do.

The present study should be replicated using the same Ekman and Friesen faces with a group of subjects who have not been exposed to the pictures previously. While previous work with these stimuli in the same laboratory (Harrison and Gorelczenko, 1990; Harrison et al, 1990) have found results which support the differential processing of negative and positive emotion, an elderly sample has not been used. Therefore, an elderly sample who has not been exposed to the stimuli would help to clarify issues related to the effects of aging on the processing of affect.

Overall, both groups responded more quickly to happy rather than angry stimuli, replicating earlier studies by Harrison and Gorelczenko (1990) and Harrison et al (1990). This finding of quicker response times to positive faces can be extended to Study 1, which found that positive faces were recognized significantly more accurately than negative faces. Better recognition for positive affect has also been found cross-culturally (Ekman & Friesen, 1971).

Response Bias

With respect to the response bias data, the results indicate that both groups were more likely to identify the neutral slides as happy when they were presented to the left hemisphere, as would be predicted by the hypothesis of left hemisphere mediation for positive affective processing. This finding is similar to a finding by Davidson et al (1987) who found that subjects reported that they experienced more happiness to slides presented to the left hemisphere, than to the identical slide in the right hemisphere.

General Discussion

While research on the elderly and the aging process is still in its infancy, converging lines of evidence from neuropsychological studies support the notion that certain cognitive, memory, and motor skill changes are inevitable in the aging adult (Moehle & Long, 1989; Mittenberg et al, 1989). Research regarding changes in affective processing is scarce, as are hypotheses used to guide the research (Nebes, 1983; Lapidot, 1983). In interpreting the results from the current study, several factors need to be considered.

First, no consensus has been reached among researchers concerning the cause of general decline in function'ing among aging individuals. The hypothesis that age differences are strictly due to decrements in speed of processing for the elderly have not been borne out. Heron and Chown (1967), and more recently Salthouse, Kausler and Saults (1988) showed that sensory-motor speed cannot account for all age-related declines in cognitive performance. The changing environment theory hypothesizes that age-related differences in scores are caused by changes in the physical environment such that successive generations of people perform better on the same tests. An aspect of this hypothesis which is important, and may influence the current study, is that of the novel environment and the effects on test performance. It is well known that the elderly do not perform as well in an unfamiliar environment, and this fact should be taken into consideration when interpreting the results of the present study (Mittenberg, 1989). Also, although the present study was designed to measure right hemisphere non-cognitive operations, aspects of cogntive operations such as speed of processing and ability to learn new information may have influenced the results.

Results of the two studies provided partial support for the hypothesis of right hemi-aging. First, the finding of relative stability of scores on the Vocabulary subtest of the WAIS-R with the decline in the Block Design scores for the elderly replicated previous studies (Botwinick,1977). This discrepency among scores on the WAIS-R for the elderly has been interpreted by theorists as evidence of lateralized degenerative change in right hemisphere function (Klisz, 1978).

Second, the fact that the elderly appear to be able to identify positive affect as well as the younger subjects, but had significantly more difficulty with negative affect would suggest that right hemisphere-mediated skills are affected more than left hemisphere-mediated skills in the aging adult. This finding supports the recent work of Levenson et al (1991) who found that measures of physiological reactivity differed less for negative emotions among the elderly when compared to younger subjects when viewing negative affective stimuli.

However, in the second study the results indicate a slowing of the left hemisphere in processing affect. In order to accept fully the right hemi-aging hypothesis, a decrement in the response time for angry stimuli presented to the right hemisphere should have been seen. What was seen instead was an increase in the differences normally expected between right and left hemisphere processing of affect. In fact, the results of this study would indicate that the elderly had more difficulty processing angry affect in the left hemisphere.

In the forced-choice paradigm, in order to support the right hemi-aging hypothesis, the elderly subjects should have seen the neutral stimuli as angry. This, however, was not the case. Both groups saw the neutral stimuli as more likely to be happy when it appeared to the left hemisphere, supporting the hypothesis of differential processing of affect for the two hemispheres rather than the right hemi-aging hypothesis.

Thus, while partial support for the hemi-aging hypothesis was found, partial support was also found for the general decline model, which states that loss in functioning ability of the elderly occurs equally in both cerebral hemispheres (Mittenberg et al, 1989). Future research in this area should be designed to delineate more clearly right from left hemisphere functions in healthy aging subjects. For example, the current study was designed to study right hemisphere processing of affect, but other cognitive processes such as learning and memory, appear to have affected the results. While it appears possible that the right hemisphere is declining more quickly than the left hemisphere, this decline is nested within an overall system that is declining with age, making it difficult to study the differences between the two.

Continued use of research paradigms which attempt to measure speed of processing before the information is cognitively processed would appear to be the most fruitful research direction (e.g., tachistoscopic, dichotic listening tasks). One way to study not only left vs. right processing of information, but also differences between young and elderly subjects, is through that of attentional processes. Since attention is hypothesized to be a more basic process than either affect or cognition, studying differences in the ability of each group to actively attend to information which would be either affective or cognitive could possibly yield interesting information about group differences. While the same experimental constraints would be present (i.e., the problems of a novel environment and general decline of the nervous system for the elderly, and controlling for general level of education, health, etc.), a task could be designed which would measure just the ability to attend to affective vs. cognitive stimuli, thus yielding information about right vs. left hemisphere functioning.

The most striking finding of the present research suggests that the elderly do develop and maintain a strong preference and ability to process positive affective information, as seen by their ability to identify positive affect across both studies. This finding has potential interest regarding the question of depression in the elderly, and can be seen as supporting the contention that the elderly are not more prone to depression than younger adults.

Right hemisphere-mediated visuospatial and affective abilities may decline as a function of age, although it is difficult to separate facial recognition skills from strictly visuo-spatial skills. This decline may predispose the elderly to show age-related impairment in processing negative affect, leading them to an impaired ability to deal with daily stressors, etc. This bias would suggest that the elderly are not more predisposed to depression, but instead, may be more vulnerable to deficits in processing negative affective information, such as anger, sadness, and fear. It would appear, based on the present study and Levenson et al (1991) that the elderly have more difficulty differentiating between negative affective categories, and may explain the finding that the elderly had increased latency of response to negative stimuli in the left hemisphere. The elderly can identify negative affect but it takes them longer to differentiate between types of negative affect.

Generally, it also would appear that the elderly have greater difficulty learning new information, not just verbal information, but also affective and particularly negatively-toned information. This may be due to a slow learning curve for negative information and the increased difficulty in differentiating between types of negative affect, and may be due to decreased right hemisphere processing capabilities. However, based on this study, it appears that the reduction in functioning involves not just right hemisphere-mediated functions, but also involves memory and motor skills.

A study to clarify these issues should include components of memory processing, better controlled than the present study. For example, if the elderly subject's decreased performance in accuracy was due to a slower acquisition curve for affective information, then a study designed to factor out what was difficult about learning the information would be helpful. It would be interesting to study the differences in learning ability for affective vs. non-affective information, and then further, positive vs. negatively valenced information. Studies with elderly subjects have also shown that the elderly do not learn as quickly when they are in a novel situation (Mittenberg et al, 1989). This important consideration, which was not controlled for in the present study, should be controlled for in future studies. Testing the elderly in their own environments when possible may lead to a more accurate estimate of their abilities.

More research with the elderly that factors out the effects of general motor slowing would also be helpful. In the present study it is difficult to know precisely what group effects were actually due to a difference in processing, and what effects were due to a slower response time. The fact that scores on the Block Design task were highly correlated with reaction time scores is further evidence that these two factors are interacting with each other.

The results of this study indicate that emotional processing of facial affective cues as studied with younger groups may not be generalizable to elderly populations. This finding is potentially useful for individuals who work closely with the elderly, and may help to clarify issues related to affective disturbances. A recent study by Malatesta, Izard, Culver, and Nicolich (1987) highlights this finding. They found that there were significant differences among different age groups in their abilities to accurately judge the emotional expression of elderly individuals. They found that as individuals age, a group of raters had increased difficulty decoding the elderly's expressions, and were more likely to see them as sadder than they were. A peer effect was found, suggesting that the more familiar the person was to the rater, the easier it was to accurately judge the emotion.

Very little is known about changes in emotional processing for the elderly, either from a neuropsychological or a personality variable perspective. The little work that has been done in the area of affect and neuropsychological functioning in the elderly has been almost entirely devoted to whether the elderly are more depressed than younger adults. While most researchers now agree that the elderly are not more depressed than younger adults, treatment issues and related concerns about the co-existance of depression and dementia take precendence in the current literature.

What we do not know, and what the results of this study leave in doubt, is what normal emotional functioning is for an adult age 65 or older. Old age has been described by early theorists as a time of pensive self-focus and dampened emotional intensity (Buhler, 1968; Erikson, 1959). Research done by Schultz (1982) finds that age differences in the central nervous system suggest a possible tendency toward greater instability, overreactivity, and higher levels of arousal with slower return to baseline. Stress has been shown to produce longer periods of autonomic nervous system (ANS) reactivity in the elderly relative to the young (Bondareff, 1980). In the Levenson et al (1991) study, the authors propose that while the basic emotional "machinery" is still intact in old age, old people may nonetheless appear to be less emotional in the natural environment because of lowered levels of social activity.

Yet other studies report that the emotional experience continues to play a crucial role in the elderly individual's life. Studies have demonstrated that those people who have strong social ties have lower morbidity and mortality (Blazer, 1982) and that there are no differences between the importance placed on emotions and the prominence of negative emotions between younger and older adults (Malatesta and Kalnok, 1984). In the current study, on a self-report measure of anxiety and depression, it was the younger group who scored significantly higher on these measures.

In general, the literature in aging supports the notion that the elderly see themselves as happier and more satisfied with life in general than younger adults (Malatesta and Kalnof,1984; McRae and Costa, 1982). This tendency to see themselves as happy fits well with the results of this study. The elderly group in this study appeared, both in their responses and in their behavior in the testing situation, to be well-adjusted. Their low scores on the Geriatric Depression Scale further attest to their general satisfaction with life at this time. Further research in this area should include multiple physiological and neuropsychological measures in order to adequately sample the range of emotional parameters of the elderly adult.

Better normed tests for the healthy elderly are also a high priority for researchers in the area of aging and emotion. Most importantly, research into a wide variety of emotional experiences of the elderly need to be undertaken.

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Appendix A: ANOVA Tables

Table 1

Repeated Measures ANOVA for Mean Accuracy Scores

Source	Sum of Squares	df	F	$p <$
Group	176.33	1	32.25	.0001
SN(Group)	317.15	58	.	.
Affect	302.98	4	40.44	.0001
Group x Affect	18.83	4	2.51	.04

Table 2

Repeated Measures ANOVA for Mean Intensity Scores

Source	Sum of Squares	df	*F*	*p* <
Group	4.56	1	4.02	.05
SN(Group)	63.57	56	.	.
Affect	51.05	4	57.56	.0001
Group x Affect	6.72	4	6.72	.0001

Table 3

Repeated Measures ANOVA on Mean Reaction Time by Visual Field, Affect, and Group

Source	Sum of Squares	df	F	p <
Group	5.71	1	45.64	.0001
SN(Group)	7.26	58		
Affect	1.004	1	63.03	.0001
Group x Affect	.164	1	10.32	.0021
Affect*SN(Group)	.924	58		
Visual Field	.003	1	.44	.51
Group x Visual Field	.017	1	2.00	.16
Affect x Visual Field	.092	1	6.03	.02
Group x Affect x Visual Field	.097	1	7.15	.01

Table 4

Repeated Measures ANOVA on Neutral Slides: Reported Affect

Source	Sum of Squares	df	F	p
Group	.494	1	3.92	.05
SN(Group)	7.30	58		
Visual Field	.184	1	6.91	.01
Group x Visual Field	.036	1	1.38	.24

Table 5

Pearson Correlation Coefficients for Self-Report Questionnaires, WAIS-R Scores, and Accuracy Scores for Study 1.

Younger Group (N= 30)

		VOC	BD	BDI	GDS	AIM	STAI	ACCUR
VOC	r=	1.00	.36	-.01	0.00	-0.26	-0.21	.06
	p=	.00	.05	.95	1.00	.15	.24	.77
BD	r=	.36	1.00	-.20	0.00	.14	-.11	.02
	p=	.05	0.00	.29	1.00	.44	.43	.90
BDI	r=	-0.01	-0.20	1.00	0.00	.23	.22	.30
	p=	.95	.28	0.00	1.00	.21	.16	.12
AIM	r=	-0.26	0.15	.24	0.00	1.00	.35	-0.05
	p=	.16	.44	.21	1.00	0.00	.06	.80
STAI	r=	-0.21	-0.11	.22	0.00	.35	1.00	.06
	p=	.24	.43	.16	1.00	.06	0.00	.77
ACCUR	r=	.05	.02	.30	0.00	-0.05	.06	1.00
	p=	.77	.90	.11	1.00	.80	.77	0.00

VOC= Vocabulary
BD= Block Design
BDI= Beck Depression Inventory
AIM= Affect Intensity Measure
STAI= State Anxiety Inventory
ACCUR= Accuracy

Table 6

Pearson Correlation Coefficients for Self-Report Questionnaires, WAIS-R Scores, and Accuracy Scores for Study 1.

Elderly Group (N=30)

		VOC	BD	BDI	GDS	AIM	STAI	ACCUR
VOC	r=	1.00	.63	0.00	0.03	-0.30	-0.007	0.08
	p=	0.00	.002	1.00	.88	.12	.97	.68
BD	r=	.63	1.00	0.00	-0.15	0.02	0.13	0.11
	p=	.002	0.00	1.00	.42	.92	.49	.58
GDS	r=	.03	-0.15	0.00	1.00	-0.12	.11	.04
	p=	.88	.42	1.00	0.00	.51	.57	.82
AIM	r=	-0.30	.02	0.00	-0.12	1.00	.31	.13
	p=	.12	.92	1.00	.51	0.00	.09	.49
STAI	r=	-0.007	.13	0.00	.11	.31	1.00	.17
	p=	.80	.50	1.00	.57	.09	0.00	.36
ACCUR	r=	0.08	.11	0.00	.04	.13	.17	1.00
	p=	.69	.58	1.00	.83	.49	.36	0.00

GDS= Geriatric Depression Scale

Table 7

Pearson Correlation Coefficients for Self-Report Questionnaires, WAIS-R Scores, and Intensity Ratings for Study 1.

YOUNGER GROUP

		VOC	BD	BDI	GDS	AIM	STAI	INTENSITY
VOC	r=	1.00	.35	-0.01	0.00	-0.26	- 0.21	-0.13
	p=	0.00	.05	.96	1.00	.16	.24	.50
BD	r=	.36	1.00	-0.20	0.00	.15	-0.11	-0.06
	p=	.05	0.00	.30	1.00	.44	.43	.74
BDI	r=	-0.01	-0.20	1.00	0.00	.24	0.22	.24
	p=	.95	.28	0.00	1.00	.21	.16	.22
AIM	r=	-0.26	.14	.24	0.00	1.00	.35	-.40
	p=	.16	.44	.21	1.00	0.00	.06	.03
STAI	r=	-0.21	-0.11	.22	0.00	.35	1.00	.38
	p=	.24	.43	.16	1.00	.06	0.00	.04
INTENSITY	r=	-0.13	-0.06	.24	0.00	.40	.38	1.00
	p=	.50	.74	.22	1.00	.03	.04	0.00

Table 8

Pearson Correlation Coefficients for Self-Report Questionnaires, WAIS-R Scores, and Intensity Ratings for Study 1.

		ELDERLY GROUP						
		VOC	BD	BDI	GDS	AIM	STAI	INTENSITY
VOC	r=	1.00	.63	0.00	.03	-0.3	-0.007	.053
	p=	0.00	.002	1.00	.90	.12	.98	.79
BD	r=	.63	1.00	0.00	-0.15	.02	.13	.05
	p=	.002	0.00	1.00	.42	.92	.50	.80
GDS	r=	.03	-0.15	0.00	1.00	-0.12	0.11	-0.04
	p=	.88	.42	1.00	0.00	.51	.57	.82
AIM	r=	-0.30	.02	0.00	-0.12	1.00	.31	.32
	p=	.12	.92	1.00	.51	0.00	.09	.09
STAI	r=	-0.007	.131	0.00	0.11	.32	1.00	.22
	p=	.97	.49	1.00	.57	.09	0.00	.25
INTENSITY	r=	0.05	.05	0.00	-0.04	.32	.22	1.00
	p=	.79	.80	1.00	.80	.09	.25	0.00

Table 9

Pearson Correlation Coefficients for Self-Report Questionnaires, WAIS-R Scores, and Mean Reaction Times in msec for Study 2

YOUNGER GROUP

		VOC	BD	BDI2	GDS2	AIM	STAI2	MRT*
VOC	r=	1.00	.17	-0.01	0.00	-0.36	-0.15	.20
	p=	0.00	.37	.60	1.00	.05	.43	.31
BD	r=	.17	1.00	-0.17	0.00	-0.05	-0.11	-0.04
	p=	.37	0.00	.36	1.00	.79	.60	.82
BDI2	r=	0.10	-0.17	1.00	0.00	.18	.44	-0.32
	p=	.60	.36	0.00	1.00	.33	.02	.08
AIM	r=	0.47	-0.05	.18	0.00	1.00	.35	.01
	p=	.05	.79	.33	1.00	0.00	.06	.94
STAI	r=	.15	-0.10	.44	0.00	.35	1.00	-0.02
	p=	.43	.57	.02	1.00	.06	0.00	.91
MRT	r=	.20	-0.04	-0.32	0.00	.01	-0.02	1.00
	p=	.31	.82	.09	1.00	.94	.90	0.00

* MRT= Mean Reaction Time

Table 10

Pearson Correlation Coefficients for Self-Report Questionnaires, WAIS-R Scores, and Mean Reaction Times in msec for Study 2

ELDERLY GROUP

		VOC	BD	BDI2	GDS2	AIM	STAI2	MRT*
VOC	r=	1.00	.64	0.00	-0.03	-0.30	-0.13	.26
	p=	0.00	.002	1.00	.85	.12	.51	.17
BD	r=	.65	1.00	0.00	-0.18	-0.07	0.09	.43
	p=	.002	0.00	1.00	.33	.97	.61	.02
GDS2	r=	-0.03	-0.18	0.00	1.00	-0.11	.08	-0.17
	p=	.85	.33	1.00	0.00	.58	.67	.38
AIM	r=	-0.30	-0.007	0.00	-0.11	1.00	.27	-0.23
	p=	.12	.97	1.00	.58	0.00	.15	.22
STAI2	r=	-0.13	.10	0.00	.08	.27	1.00	-0.02
	p=	.51	.61	1.00	.67	.15	0.00	.93
MRT	r=	.28	.43	0.00	-0.16	-0.23	-0.02	1.00
	p=	.17	.02	1.00	.38	.22	.93	0.00

*MRT=Mean Reaction Time

Table 11

Analysis of Covariance for Mean Accuracy Scores and Vocabulary

Source	df	Sum of Squares	Mean Square	F Value
Model	15	99.54	6.63	1.98
Error	44	184.40	4.19	
Total	59	283.93		.12

Source	Type III Sums of Sqs	df	F	p <
Group	16.83	1	4.02	.05
Vocabulary	31.37	10	.75	.68
Group*Voc	5.23	4	.31	.86

Table 12

Analysis of Covariance for Mean Accuracy Scores and Block Design

Source	df	Sum of Squares	Mean Square	F Value
Model	17	123.80	7.28	1.91
Error	42	160.13	3.81	
Total	59	283.94		.05

		Type III SS	*F* Value	*p*
Group	1	55.05	14.44	.0005
Block Design	8	17.10	.56	.81
Group*BD	8	59.39	1.95	.09

Table 13

Analysis of Covariance for Mean Intensity and State Anxiety

Source	df	Sum of Squares	Mean Square	F Value
Model	33	8.71	.264	1.38
Error	24	4.59	.191	
Total	57	13.31		.21
		Type III SS	*F*	*p*
Group	1	.58	3.01	.10
STAI	22	5.90	1.40	.21
Group*STAI	10	2.74	1.43	.22

Table 14

Analysis of Covariance for Mean Intensity Ratings and AIM

Source	df	Sum of Squares	Mean Square	F Value
Model	52	12.34	.24	1.23
Error	5	.97	.19	
Total	57	13.30		.45
		Type III SS	*F*	*p*
Group	1	.16	.83	.40
AIM	44	10.77	1.27	.44
Group*AIM	7	.82	.61	.74

Table 15

Analysis of Covariance for Mean Reaction Time and Block Design

Source	df	Sum of Squares	Mean Square	F Value
Model	16	2.70	.17	3.43
Error	43	2.11	.05	
Total	59	4.80		.0006
		Type III SS	*F*	*p*
Group	1	1.50	30.51	.0001
Block Design	8	.45	1.16	.34
Group*BD	7	.31	.91	.51

Appendix B

Break-down of Accuracy Errors by Affective Category

Happy Affect Total Errors=15

8 errors=Neutral

3 errors=Sad

2 errors=Angry

2 errors=Fearful

Fearful Affect Total Errors=101

4 errors=Happy

27 errors=Sad

43 errors=Angry

27 errors=Neutral

Sad Affect Total Errors=144

8 errors=Happy

33 errors=Angry

40 errors=Fearful

63 errors=Neutral

Neutral Affect Total Errors=132

35 errors=Happy

53 errors=Sad

34 errors=Angry

10 errors=Fearful

Angry Affect Total Errors=109

10 errors=Happy

21 errors=Sad

53 errors=Fearful

25 errors=Neutral

Appendix C

INFORMED CONSENT TO PARTICIPATE IN RESEARCH

You are being asked to volunteer as a participant in a research study. This form is designed to provide you with information about the study and to answer any of your questions.

Type of Research Study: Emotional Perception as a Function of Aging.

Project Director: Christine McDowell

961-0536

Faculty Advisor: Dr. David Harrison

231-4422

Purpose of the Research: To evaluate your ability in making a decision about facial stimuli. You will tell us, upon presentation of stimuli, whether it was positvely or negatively toned.

Experimental Procedure: You will be asked to fill out several questionnaires. You will then be asked to identify faces which will be presented to you either in booklet form or by a slide presentation. You will record your answers either by an answer sheet or by pressing a button.

If you agree to participate in the study, please read the following statements and sign below.

1. I understand that any data that I provide will be kept strictly confidential.

2. I understand that my participation is strictly voluntary and I may cease particpation at any time by informing the experimenter that I wish to do so.

3. I understand that I will be debriefed about my participation and how the results will be used.

SIGNATURE S.S.#

If, after participating in this experiment, you have any questions regarding the research, you may contact the researchers or the Human Subjects Committee at the phone numbers listed below.

Researchers

Christine McDowell 961-0536 Dr. David Harrison 231-4422

Human Subjects Committee

Dr. Helen Crawford 231-6520 Mr. Charles Waring 231-5284

Self Report Items Used to Measure Lateral Preference

Hand
1. With which hand would you throw a ball to hit target?
2. With which hand do you draw?
3. With which hand do you use an eraser on paper?
4. With which hand do you remove the top card when dealing?

Foot
1. With which foot do you kick a ball?
2. If you wanted to pick up a pebble with your toes, which foot would you use?
3. If you had to step onto a chair, which foot would you place on the chair first?

Eye
1. Which eye would you use to peep through a keyhole?
2. If you had to look into a dark bottle to see how full it was, which eye would you use?
3. Which eye would you use to sight down a rifle?

Ear
1. If you wanted to listen in on a conversation going on behind a closed door, which ear would you place against the door?
2. If you wanted to hear someone's heartbeat, which ear would

Appendix D: Instructions to Subjects and Self-Report Questionnaires

DIRECTIONS: LOOK CAREFULLY AT EACH PHOTOGRAPH AND DECIDE TWO THINGS:
1. WHAT EXPRESSION IS BEING EXPRESSED? The choices are happy, sad, angry, fearful, and neutral.
2. HOW INTENSELY IS THE EXPRESSION BEING EXPRESSED? On a scale of 1 to 5, decide how intense the expression is. A response of 1 would mean that the expression is not being expressed in an intense manner. A response of 5 would mean that you think the expression is being expressed very intensely.

THEN MARK IN THE APPROPRIATE BLANK WHAT THE EXPRESSION IS, AND HOW INTENSELY YOU RATE IT. FOR EXAMPLE, IF YOU CHOOSE THE EXPRESSION IN PHOTOGRAPH #1 AS ANGRY AND YOU THINK IT IS VERY ANGRY, YOU WOULD PUT A 5 IN THE ENTITLED ANGRY NEXT TO PHOTO 1.

	HAPPY	SAD	ANGRY	FEARFUL	NEUTRAL
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					

	HAPPY	SAD	ANGRY	FEARFUL	NEUTRAL
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					
31.					
32.					
33.					
34.					
35.					
36.					
37.					
38.					
39.					
40.					
41.					
42.					
43.					
44.					
45.					
46.					
47.					
48					
49.					
50.					

Geriatric Depression Scale-Short Form

CHOOSE THE BEST ANSWER FOR HOW YOU FELT OVER THE PAST WEEK:

1. Are you basically satisfied with your life?..yes / no
2. Have you dropped many of your activities and interests? yes / no
3. Do you feel that your life is empty? yes / no
4. Do you often get bored? yes / no
5. Are you in good spirits most of the time?...yes / no
6. Are you afraid that something bad is going to happen to you? yes / no
7. Do you feel happy most of the time? yes / no
8. Do you often feel helpless? yes / no
9. Do you prefer to stay home, rather than going out and doing new things? yes / no
10. Do you feel that you have more problems with memory than most?...........yes / no
11. Do you think it is wonderful to be alive? yes / no
12. Do you feel pretty worthless the way you are now? yes / no
13. Do you feel full of energy? yes / no
14. Do you feel that your situation is hopeless? yes / no
15. Do you think that most people are better off than you are?.........................yes / no

AIM QUESTIONNAIRE

DIRECTIONS: The following questions refer to the emotional reactions to typical life events. Please indicate how YOU react to these events by placing a number from the following scale in the blank space preceeding each item. Please base your answers on how YOU react, not on how you think others react or how you think a person should react.

NEVER	ALMOST NEVER	OCCASIONALLY	USUALLY	ALMOST ALWAYS	ALWAYS
1	2	3	4	5	6

1.___ When I accomplish something difficult I feel delighted or elated.

2.___ When I feel happy it is a strong type of exuberance.

3.___ I enjoy being with other people very much.

4.___ I feel pretty bad when I lie.

5.___ When I solve a small personal problem, I feel euphoric.

6.___ My emotions tend to be more intense than those of other people.

7.___ My happy moods are so strong that I feel like I'm "in heaven".

8.___ I get overly enthusiastic.

9.___ If I complete a task I thought was impossible, I am ecstatic.

10.___ My heart races at the thought of some exciting event.

11.___ Sad movies deeply touch me.

12.___ When I am happy it's a feeling of being untroubled and content rather than zestful and aroused.

13.___ When I talk in front of a group for the first time my voice gets shaky and my heart races.

14.___ When something good happens, I am usually much more jubilant than others.

15.___ My friends may say I'm emotional.

16.___ The memories I like most are those of times when I felt content and peaceful rather than zestful and enthusiastic.

17.___ The sight of someone who is hurt badly affects me strongly.

18.___ When I am feeling well it's easy for me to go from being in a good mood to being really joyful.

19.___ "Calm and cool" could easily describe me.

20.___ When I'm happy I feel like I'm bursting with joy.

21.___ Seeing a picture of some violent car accident in the newspaper makes me feel sick to my stomach.

22.___ When I'm happy I feel very energetic.

23.___ When I receive an award I become overjoyed.

24.___ When I succeed at something, my reaction is calm contentment.

25.___ When I do something wrong I have strong feelings of shame and guilt.

26.___ I can remain calm even on the most trying days.

27.___ When things are going good, I feel "on top of the world".

28.___ When I get angry it's easy for me to still be rational and not overreact.

29.___ When I know I have done something very well, I feel relaxed and content rather than excited and elated.

30.___ When I feel anxiety it is normally very strong.

31.___ My negative moods are mild in intensity.

32.___ When I am excited over something I want to share my feelings with everyone.

33.___ When I feel happiness, it is a quiet type of contentment.

34.___ My friends would probably say I's a tense of "high -strung" person.

35.___ When I'm happy I bubble over with energy.

36.___ When I feel guilty, this emotion is quite strong.

37.___ I would characterize my happy moods as closer to contentment than to joy.

38.___ When someone compliments me, I get so happy I could " burst".

Curriculum Vitae

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<u>Date of Birth</u>	December 6, 1950

<u>Educational Background</u>

Doctoral Candidate in Clinical Psychology Virginia Polytechnic Institute and State University Blacksburg, Va.	1988-present
Master of Science, Virginia Tech, Blacksburg, Va.	1986-1988
Bachelor of Arts in Psychology University of North Carolina-Asheville	1984-1986
Bachelor of Arts in Communications University of South Florida, Tampa, Florida	1969-1973

<u>Academic Awards</u>
Who's Who in American Colleges and Universities, 1986.
Psi Chi

<u>Clinical Training</u>
Post-Doctoral Fellowship in Clinical Neuropsychology Present
University of Virginia Health Sciences Center
Dept. Of Behavioral Medicine and Psychiatry
Charlottesville, Va. 22901
Supervisor: Jeffrey T. Barth, Ph.D., and Bernice Marcopulos, Ph.D.

Pre-doctoral Internship 1990-1991
University of Virginia Health Sciences Center
Dept. of Psychiatry and Behavioral Medicine, Charlottesville, Va.

Major rotations in the Pain Management Center and Neuropsychology, minor rotations in Rehabilitation Medicine and Child and Family Clinic.

Supervisors: Joseph R. Dane, Ph.D. and Stephen N. Macciocchi, Ph.D.
Bernice Marcoupolis, Ph.D. and Patrick Fowler, Ph.D.

Neuropsychological Assessment Practicum Team Aug.1989-May 1990
Psychological Services Center, Virginia Tech, Blacksburg, Va.

Co-leader of graduate level practicum team which specialized in assessing and treating neuropsychological disorders related to head injury, stroke, learning disability, and headaches.

Approximate number of hours: 250.
Supervisor: David W. Harrison, Ph.D.

Behavioral Medicine Psychology Technician May, 1989-June 1990
Veteran's Administration Medical Center, Salem, Va.

Responsibilities included working on medical-surgical units of the hospital as a consultation/liason psychologist, designing and implementing therapeutic assessments and interventions for a variety of patients including oncology, geriatric, general medicine, and providing ongoing psychotherapy. Job responsibilities also included providing smoking cessation classes for veterans and employees.

Supervisor: Kathryn C. Finnell, Ph.D.
Approximate number of hours: 700

Testing Assistant Sept. 1989-April 1990

Responsibilities include administering and scoring a variety of projective and objective tests, including the MMPI, Rorschach, TAT.

Supervisor: Pryor Baird, M.D.

Adolescent Group Leader/Children of Divorce Group 1989-1990
Blacksburg Middle School, Blacksburg, Va.

Duties include creating and implementing group therapy for adolescents with divorced parents.

Supervisor: Thomas H. Ollendick, Ph.D and Dorothy Domermuth, Guidance Counselor.

Veteran's Administration Hospital 1988-1989
Mental Hygiene Clinic and Behavioral Medicine Clinic
Salem, Va.

Responsibilities included administering full-battery projective and objective assessments and treatment implementation for inpatients and outpatients and extensive group therapy experience.

Approximate Number of Hours: 700.
Supervisor: Jerry Gilmore, Ph.D.

Psychological Services Center 1987-1988
Virgina Tech, Blacksburg, Va.

Responsibilities included the assessment and treatment of a variety of psychological disorders, including depression, anxiety, headaches, relationship and marital problems, and school phobia.

Approximate Number of Hours: 250
Supervisors: Richard M. Eisler, Ph.D., and Debra Neff, Ph.D.

Instructor Training Oct. 1989
QuitSmart Smoking Cessation Program
Durham, N. C.

Virgina Hypnosis Association Nov. 1990
54 hour certification course on using hypnosis with psychological and medical patients.
Charlottesville, Va.

Society for Clinical and Experiemntal Hypnosis Oct. 1988
3 day seminar on therapeutic applications of hypnosis.

Research Grants

1989 Awarded a grant by the Virginia Tech Women's Research Institute to study differences between young and elderly females in right hemisphere perception of emotion.

1985 Awarded a grant to study the use of computers in psychological research in a five-week intensive course at tbe University of North Carolina-Chapel Hill.

1985 Awarded grant money at the University of North Carolina-Asheville to study effects of exercise on self-esteem.

Research Experience

1989-1990 Dissertation Research: Right Hemisphere Decline as a Function of Aging. Advisor: David W. Harrison, Ph.D.

1988 Thesis Research: The Relationship of Coping and Choice to Verbal Memory and Behavioral Reactivity. Advisor: Dr. Richard Winett.
Exam Stress and Coping Responses. Advisor: Dr. J. J. Franchina.

1987 Driving Behaviors Modeled on Prime-Time Television: A Three-Year Assessment. Advisor: E. Scott Geller, Ph.D.
Motivating Children to use Safety Belts. Advisor: E. Scott Geller, Ph.D.

1986 Effects of Aerobic conditioning on Self-Esteem. Advisor: Lisa Friedenberg, Ph.D.

Professional Paper Presentations

Lash, S.L., McDowell-Rand, C., & Franchina, J.J. (1988). Stress and coping with a college examination: the relationship of coping and blood pressure. Paper presented at the Southeastern Psychological Association annual meeting, Washington, D.C.

McDowell-Rand, C.L., Streff, F.E., Tockas, J.A., & Stuart, J. L. (1987). Driving behaviors modeled on prime-time television: A three-year assessment. Paper presented at the Association of Applied Behavioral Analysis annual meeting, Nashville, Tn.

Lehman, G., Grogan, D., & McDowell-Rand, C.L. (1987). Motivating children to use safety belts: Are extrinsic rewards necessary? Poster presented at the Association for Applied Behavioral Analysis annual meeting, Nashville, Tn. *Awarded Best Poster at Meeting award.

Rand, C.M. & Friedenberg, L. (1986). The effects of aerobic conditioning on self-esteem. Poster presented at the Southeastern Psychological Association annual meeting, Orlando, Fl.

Publications

Rand, C. & Friedenberg, L. (1988). The effects of aerobic conditioning on self-esteem. The UNCA Journal of Undergraduate Research, 1, 21-27.

Teaching Experience

Teaching Assistant, Virginia Tech

Introduction to Psychology	Motivation
Psychology of Learning	Abnormal Psychology
Personality	

Professional Interests

Neuropsychology	Aging
Behavioral Medicine	Marriage and Family Therapy

Professional Memberships

Association for the Advancement of Behavior Therapy
American Psychological Association, Division of Clinical Psychology, student affiliate
Virginia Hypnosis Society

References

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David W. Harrison, Ph.D.
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