9-2011

Lateralization of Emotion, Reaction Time, and Skin Conductance Responsiveness

Kimberley Erin Rose

LOMA LINDA UNIVERSITY
School of Science and Technology
in conjunction with the
Faculty of Graduate Studies

Lateralization of Emotion, Reaction Time, and Skin Conductance Responsiveness

by

Kimberley Erin Rose

A Dissertation submitted in partial satisfaction of
the requirements for the degree of
Doctor of Philosophy in Clinical Psychology

September 2011

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a dissertation for the degree Doctor of Philosophy.

____, Chairperson
Paul Haerich Professor of Psychology

____
Todd Burley Clinical Professor of Psychology

____
Travis Fogel, Associate Professor, Physical Medicine

____
Jason Owen Associate Professor of Psychology

ACKNOWLEDGEMENTS

I would like to thank my committee members and my chair for their advice and direction. To my family and friends, your love and support has meant so much to me. I want to thank my husband, Benjamin Rose, for his encouragement and loving support during this process. My parents have been wonderful in helping me manage the stress of completing this document. The research accomplishments of both of my sisters, Natalie Jarboe and Jameson Brewer, and my husband Benjamin Rose have been inspirational to me. Thank you to my grandmother, Galeta Brewer, and my aunt and uncle, Patricia and Steve Seebold for being there for me. To my mother and father-in-law, thank you for your encouragement. Finally, I would like to thank God for the many answered prayers every step of the way.

CONTENT

FIGURES

TABLES

ABBREVIATIONS

SCR	Skin Conductance Response
RHH	Right Hemisphere Hypothesis
VH	Valence Hypothesis
RH	Right Hemisphere
LH	Left Hemisphere
EEG	Electroencephalograph
RVF	Right Visual Field
LVF	Left Visual Field
CVA	Cerebrovascular Accident
fMRI	Functional Magnetic Resonance Imaging
BIS	Behavioral Inhibition System
BAS	Behavioral Activation System
IAPS	International Affective Picture System
ANEW	Affective Norms for English Words
EHI	Edinburgh Handedness Inventory
SPSS	Statistical Package for the Social Sciences Version 17.0
ANCOVA	Analysis of Covariance
SAM	Psylab Stand Alone Monitor

ABSTRACT OF THE DISSERTATION

Lateralization of Emotion, Reaction Time, and Skin Conductance Responsiveness

by

Kimberley Erin Rose

Doctor of Philosophy, Graduate Program in Clinical Psychology
Loma Linda University, September 2011
Dr. Paul Haerich, Chairperson

Bilateral presentations of brief (250 ms), unmasked emotional and neutral stimuli were examined in two experiments with primarily female samples. Reaction time and accuracy data were used to measure perception of emotion and skin conductance response (SCR) was used to measure experience of emotion. Both words and pictures were used to account for hemispheric differences in language and visuospatial dominance. Response time was faster to emotional pictures than words. Reaction time and speeded accuracy data did not support right hemisphere hypothesis (RHH) or valence hypothesis (VH) in the expected manner. Data suggested emotion caused greater interference under speeded conditions in the right hemisphere (RH) than in the left hemisphere (LH) for strongly right handed individuals. The RH and LH responded differently to language based than to visuospatial information based on handedness. Under unspeeded conditions accuracy data, indicated the RH was more accurate, which supported RHH as hypothesized. SCR had no significant findings.

CHAPTER ONE

LATERALIZATION OF EMOTION, REACTION TIME, AND SKIN CONDUCTANCE RESPONSIVENESS

Processing Emotion in the Brain

When it comes to understanding how emotion is processed in the brain, several different areas of the brain have been implicated. Perhaps the most common structure to be referenced is the amygdala. The amygdala appears to be involved in learning and emotion. Evidence for amygdalar involvement in emotion was first seen in animal studies (Adolphs & Damasio, 2000). The amygdala likely has a specific role in regard to emotion; it is thought to connect the "perception of stimuli that signal potential threat/danger with behaviors, or with knowledge, related to emotional arousal" (Adolphs & Damasio, 2000, p. 202). The central nucleus of the amygdala has been found to increase motivation to pursue a stimulus when it was previously associated with reward (Mahler & Berridge, 2009). Furthermore, when the activation of the central nucleus of the amygdala was increased in rats they responded as strongly to the conditioned stimulus, which signified a food reward was imminent, as they responded to actual food. Due to this, Mahler and Berridge concluded that increasing the activation of the central nucleus of the amygdala will "translate learning into motivation" for reward seeking situations (Mahler & Berridge, 2009, p.6500). These researchers suggested that the amygdala is involved in stimuli that are particularly approach-worthy. The amygdala also appeared to be involved in learning to avoid conditioned stimuli that have previously been paired with an unconditioned noxious stimulus (Adolphs & Damasio). After a conditioned fear response is learned, however, it is unclear if there is further involvement by the amygdala in processing and expressing emotion (Davidson, 2000).

As the research has progressed it has become clear that emotion is not just a subcortical phenomenon. Cortical areas of the brain are also involved in processing and expressing emotion, however, specific localization is less clear. Perhaps to reduce the complexity of finding a specific cortical area in the brain dominant for processing emotions, recent studies have focused on the laterality of emotion. Laterality refers to hemisphere is dominant for emotion. Which hemisphere is dominant for emotion, however is also not entirely clear. There are two main theories have emerged. The right hemisphere hypothesis (RHH) postulated that the right hemisphere (RH) is dominant for emotions (see Gainotti, 2000). Some researchers have obtained data that support RH dominance for emotional perception (see Borod et al., 1998; Mohr, Rowe, & Crawford, 2008) which is consistent with RHH of emotional processing in the brain. Other researchers have suggested that the wealth of data supporting RH dominance for emotion is due to the prevalence of experiments using negatively based stimuli (i.e. Brokenau & Mauer, 2006). Several researchers have suggested that the RH is indeed dominant for negative emotion, but that the left hemisphere (LH) is dominant for positive emotions, referred to as the valence hypothesis (VH) (Davidson, Ekman, Saron, Senulis, & Friesen, 1990b). There has been some suggestion that the VH is more often revealed when examining individuals without brain compromise and the RHH is better supported by work with brain damaged individuals (Borod, 1992; Montreys & Borod, 1998).

The frontal cortex is also known to be involved in emotional processing (Davidson, 1993). More specifically, the prefrontal cortex it is thought to have, "a crucial role in the anticipation of the future affective consequences of action, as well as in the persistence of emotion following the offset of an elicitor" (Davidson, 2000, pp. 1196). Essentially when you consider doing something your prefrontal cortex warns you about how you are going to feel afterwards. This emotional information is useful in decision making. If the prefrontal cortex is impaired, individuals cannot predict how the consequences of their actions will make them feel (Damasio, 1994). Damasio's experiments with individuals with frontal lobe damage illustrated this concept well. Individuals with frontal lobe damage performed poorly at a gambling task, frequently choosing cards from card decks that were too risky to win the game. Both frontal lobe damaged individuals and the normal controls showed increased skin conductance responses (SCRs) after selecting a card which caused them to lose play money. SCR is a physiological measure of how much an individual is sweating, which is thought to indicate emotional arousal (Dawson, Schell, & Filion, 2000). The increased SCRs in this study suggested that participants felt emotional when they lost money. As the game progressed, however, only normal controls began to show SCRs before selecting a card from a deck that was too risky. This suggested that they experienced emotional arousal prior to making a bad choice. This emotional warning of how they were going to feel if they chose from the wrong deck helped them to modify their behavior and begin choosing from the safer card decks. The individuals with frontal lobe damage did not experience this physiological 'warning' prior to making a poor decision in the gambling task. The individuals with frontal lobe damage had lost the ability to anticipate the likely bad outcome of the choice they were about to make. Damasio's experiments suggest that the damage to the frontal lobes for these patients impaired their ability to make good decisions because they did not receive the adequate physiological feedback required for learning. He concluded that emotion, in the form of physiological experience, was required for learning and decision making.

More specifically, it may be the dorsolateral prefrontal area of the frontal lobes which play an important role in the previously described task. Davidson (2000) suggested that the dorsolateral prefrontal cortex holds onto the semantic significance of a spider when the spider is no longer in view. Davidson referred to this "as a form of affective working memory" (p. 1199). Appropriate functioning of the "affective working memory" is important for learning from emotional events. Due to increasing evidence of prefrontal involvement in emotion, several studies have examined electroencephalograph (EEG) asymmetry in the anterior regions of the brain (see Tomarken, Davidson, & Henriques, 1990; Davidson et al., 1990b; Davidson & Henriques, 1990c). Hemispheric differences in activation in the frontal and temporal regions, but not in the parietal or central regions of the brain were found (Tomarken et al., 1990; Davidson et al.). This suggested anterior involvement in the experience of emotion.

There are also individual differences in how the brain responds to emotion. Some individuals have shown resting LH asymmetry activation versus other individuals who have shown resting asymmetry that is mostly right sided. These differences in resting asymmetry probably reflected individual differences in global affect (Tomarken, Davidson, Wheeler, & Doss, 1992). Individuals with greater resting anterior left asymmetry reported feeling more positive affect and less negative affect generally when compared with individuals with right-sided resting anterior asymmetry (Tomarken et al., 1992).

Other researchers however, have found different results with regards to affect and asymmetry. One study found that 15 clinically depressed patients had more variability in their anterior EEG asymmetry than normal controls (Debener et al., 2000). According to this study, unstable EEG asymmetry was suggestive of depression rather than increased right-sided anterior activation (Debener et al.).

Questions of differences in asymmetry in the brain may be relevant to both treatment and outcome measures. It would be fascinating to learn whether resting asymmetry could be affected by psychotherapy and whether the resulting change in asymmetry was associated with improved psychological well being. In the future measures of asymmetry might be used for diagnostic screening. If an individual was identified as having resting right-sided anterior asymmetry, the therapist could focus on identifying experiences in which the individual experienced positive affect and increase their frequency. Furthermore, the therapist could focus on mindfulness and identify and decrease negative rumination. Resting asymmetry follow up measures could be taken to determine if a shift in asymmetry had occurred as a result of treatment. Systematic studies that measure baseline asymmetry before and after different types of therapeutic treatment could be used to measure treatment outcomes. It would be very exciting to determine which therapeutic treatments were most effective in altering resting brain activation. If these questions can be answered by future research it bears greatly on preventive and clinical care. If resting asymmetry can be manipulated, it is possible that this may be used to increase an individual's resilience. Measures of laterality could then be used as a therapeutic outcome measure.

From a clinical perspective, the study of laterality appears to be a relevant research area for better understanding of how emotion is processed in the brain with regards to psychological areas such as learning and decision making. Furthermore, the study of laterality appears to be relevant with regards to treatment of psychopathology, particularly mood disorders (Debener et al., 2000; Tomarken et al., 1992).

Right Hemisphere Hypothesis

The RHH suggested that the RH is dominant for processing emotional material. Jules Bernard Luys (1881; original manuscript in French) is thought to be the first researcher that suggested that the RH was dominant for emotions based on comparing individuals with left hemiplegia to individuals with right hemiplegia (as cited by Harris, 1999). Luys noticed that individuals with left hemiplegia demonstrated changes characterized by emotional variability compared with those with right hemiplegia. This prompted him to suggest that the RH contained the "emotional sphere" whereas the LH housed the "intellectual sphere". Hughlings Jackson (1874/1915; as cited by Harris, 1999) also contributed with his observation that individuals affected with expressive aphasia were sometimes able to produce swear words when they were emotional. RHH has become popular in the research as will be seen in the following paragraphs.

Much of the supporting data for the RHH comes from research with chimeric faces. In this paradigm individuals pose different emotional expressions and photographs are taken. The emotional faces are then divided down the midline of the face. In the classic example (Levy, Heller, Banich, & Burton, 1983) composite faces were made with half an emotional expression and the half a neutral expression from the same person combined into one face stimulus. The mirror image of the composite face was then used for comparison. Several face stimuli were developed in the same way and participants were asked to judge which of the faces was more emotional. The chimeric composite with the emotional half face, or hemiface, presented to the viewer's left field of vision was usually perceived as expressing more emotion than the mirror image with the emotional hemiface presented to the right visual field (RVF) (Levy et al., 1983). Because input from the left visual field (LVF) is first perceived by the RH these findings suggested that the RH is involved in perception of emotion. This supported the RHH. The RH has also been shown to be particularly good at perceiving negative emotion in chimeric faces tasks even when the faces are masked and the participant does not recollect seeing them (Killgore & Yurgelun-Todd, 2007)

In addition to studies that examined how individuals discerned emotion in the faces of others, the intensity of emotion produced by each hemiface has also been examined. A review of 49 studies evaluated the asymmetry of emotion for both posed and spontaneous facial expression (Borod, Koff, Yecker, Santschi, & Schmidt, 1998b). In general, the left side of the face was found to express more emotion, although occasionally greater right-sided hemiface involvement has been seen for positive emotions. Specifically, 7 out of 47 instances involving positive emotional expression were found to have more right hemiface involvement, however, all of the 35 instances of negative emotional expression were found to have more left hemiface involvement. RH superiority for processing faces is a consideration when interpreting these results.

Words stimuli have also been used for laterality of emotion research. One study compared attachment words (e.g. caring, distant) to nonwords (e.g. tratno, cassing) using female undergraduate participants (Mohr et al., 2008). Supportive, anxious, and avoidant attachment words were selected. These stimuli were chosen to elicit positive emotion and approach tendencies (secure words), negative emotion and approach tendencies (anxious words), and negative emotion and withdrawal tendencies (avoidant words). This was done in an effort to examine both the laterality of emotion and the laterality of approach-withdrawal at the same time. Words and nonwords were presented as pairs and participants were given the lexical decision task of deciding whether either letter string was a real word. Words were recognized more quickly when presented to the RVF than when presented to the LVF. This should be expected given that the LH is dominant for language and would receive information presented to the RVF first resulting in a quick response. Information presented to the LVF may require time for interhemispheric transfer to allow the LH to make a language based judgment of word or nonword. The time for interhemispheric transfer is thought to be about 2-5 ms (Iacoboni & Zaidel, 2000). Mohr and colleagues found that secure words were responded to more quickly than either anxious or avoidant words. Both anxious and avoidant words had similar reaction times. Furthermore there was no visual field difference in reaction times for secure words; however, both negative word categories had faster reaction times when presented to the RVF than to the LVF. These findings were judged to support the RHH because they were considered contrary to the VH. Another possible interpretation is that negative words may cause a behavioral inhibition causing all of the responses to negative words to be slower. No difference between visual fields for reaction times for secure word suggested more lateralized dominance for positively valenced stimuli. Furthermore, this study used 10 anxious attachment words, 10 avoidant attachment words, and 10 secure attachment words. Because there are twice as many negative words being tested this may bias results in favor of the RHH.

Mohr and colleagues (2008) study also examined accuracy for lexical decisions. An overall effect of a greater accuracy for lexical decisions when words were presented to the RVF as compared to the LVF was found. Given left hemisphere superiority for words and the task parameters this effect would be expected. However, with LVF presentations they found significantly better lexical decision accuracy for secure words than for anxious or avoidant words ($p = 0.0001$). This evidence that the RH had superior accuracy for positive stimuli was interpreted as contrary to the VH. For the RVF accuracy for anxious words was similar to secure words, but a marginally reliable effect was seen with secure words being more accurate than avoidant words ($p = 0.06$). Though marginally reliable, the results from the LVF appear to suggest that the RH is dominant for accurately identifying positive words. These accuracy results appeared to support the RHH.

Another study examining accuracy with emotion tasks also found RHH support. A divided visual field emotional Stroop study found that there was a difference in accuracy for color naming for emotional (both positive and negative) versus neutral words presented to the LVF for individuals with high trait anxiety (Richards, French, and Dowd, 1995). This suggested that emotional words interfered with accuracy when presented to the RH for anxious individuals (Richards et. al., 1995). For individuals with low trait anxiety there was a difference only between neutral words and threat words. Richards et al. found that words presented to the RVF, however, showed no difference in accuracy between emotional (both positive and negative) and neutral words. They interpreted their accuracy results as support for the RHH because there was no difference between emotional and neutral words presented to the RVF. These findings would be more convincing if low trait anxious individuals showed a difference between neutral words and all emotional words rather than just to threat words, however, the findings are still more supportive of RHH than VH.

Studies, as well as observations of brain damaged individuals, have also given momentum to the RHH. RH brain injury victims often present with monotone vocal quality, flat or inappropriate affect, are rude, and/or cantankerous to work with and fair worse in their interpersonal interactions. Individuals with RH brain injury often demonstrate an inability to read the social and emotional cues in those around them which likely contributes to these deficits. Borod and colleagues (1998) found that RH stroke patients were more impaired in identifying interpersonal emotional cues. In some cases RH stroke patients also appear indifferent or unemotional regarding their injury. Their left-sided stroke counterparts, however, frequently show more signs of what Goldstein (1952) called a “catastrophic reaction” to their injury. Goldstein described this as the inability to experience joy. While he did not differentiate between LH versus RH injury, the catastrophic reaction is more common in LH injury. Individuals with LH injury are typically more depressed and show intense emotional distress that suggests “catastrophic” is an appropriate descriptor. If it is reasonable to assume that a catastrophic depressive reaction to stroke, hemiplegia, and aphasia is a “normal” reaction to these events, then perhaps a catastrophic reaction represents a properly working emotional center of the brain. This would lend further support to the RHH. However, if the catastrophic depressive reaction is seen as abnormal emotional functioning with impaired ability to experience positive emotions, as Goldstein suggested, than this could be interpreted as support for the VH.

Systematic studies have compared left and right brain damaged individuals to determine whether the RHH or the VH better explained dominance for emotion (Borod et al., 1998). Borod and colleagues examined facial, prosodic, and lexical data. For the emotional perception tasks 8 emotions were used (happiness, interest, pleasant surprise, sadness, fear, anger, disgust, and unpleasant surprise). For the facial stimuli actors and actresses posed each of the 8 emotions. For the prosodic emotional task actors read neutral sentences with emotional inflection of each of the 8 emotions. Emotional words and sentences were presented for the lexical task. The RHH was supported across all three types of data; left and right brain damaged participants did not show different performance as a function of valence. Rather right brain damaged participants were more emotionally impaired with regards to emotional identification than left brain damaged participants in all conditions. This suggested that RH impairment affected both positive and negative emotional perception. This study informed lateralization of perception of emotion, because all tasks required perception of emotion from the participants. Participants' expression or experience of emotion was not tested.

One critique of the above study was the proportions of positive versus negative stimuli used. In order to compare the RHH to the VH reliable measures of positive emotion are required. There were 3 types of positive and 5 types of negative emotions used for each task. Because many trials were used (8 [posers] x 8 [emotions] x 4 [trials] = 256) this magnified the difference to 160 negative stimuli and 96 positive stimuli. Having more measurement points generally creates more stable data points, which are less effected by outliers. In this study, there are more data points for negative than positive stimuli making the measurements for positive stimuli potentially less stable. The inequality in the number of measurements taken for each valence likely resulted in less statistical power to detect significant results for positive stimuli than for negative stimuli. Particularly for testing the VH, it is necessary to have sufficient power for both valence categories. If the VH is correct it still would make sense that the right brain damaged individuals appeared more impaired when all emotional stimuli were averaged, because more of the stimuli involved negative emotion, which according to the VH is processed in the RH.

Another study of brain damaged individuals also found support for the RHH (Borod et al., 2000). The effect of emotion on verbal pragmatics was examined. Sixteen left and 16 right brain damaged patients were compared to 16 normal controls. All brain damaged participants had sustained a cerebral vascular accident (CVA) such as embolism, thrombosis, hemorrhage, general infarct and unspecified CVA. There was roughly equal numbers of each type of CVA in each group. A main effect of group was found with regards to recollecting an emotional event. Right brain damaged individuals we more impaired than left brain damaged individuals. Also, an interaction effect between side of brain damage and valence was in the opposite direction as would be expected by the VH. These findings suggest support for the RHH.

There are some caveats regarding the above study. The sample size of the study was small (16 in each group). In small samples individuals with atypical results are more likely to skew the data so there is a greater possibility of spurious results. No outliers or violations of the normal distribution of scores were discussed. Additionally three of the left brain damaged patients showed no signs of aphasia. There are several possible reasons for this, one of which is reverse cerebral dominance. The LH is typically dominant for language, but in reverse dominant individuals the RH is dominant for language. Reverse dominance is not very common for right handed participants, but it does occur. If there was a reverse dominant participant this might have obscured the results. It is reasonable to suspect that if there was reverse dominance for language there might also be reverse dominance for emotional processing. Another issue is whether the anterior part of the LH was affected. The anterior portion of the brain is thought to be involved in the processing emotions (Tomarken et al., 1990; Davidson et al., 1990b; Tomarken et al., 1992). If the anterior portion of the LH is not damaged then the processing of positive emotions would be less likely to be impaired. This could have confounded the results. In this study 4 of the 16 LH damaged patients had evidence for frontal lobe damage and information about lesion location was unavailable for 5 LH participants. For the RH damaged patients 5 of the 16 participants showed frontal lobe damage as a result of their CVA and data about lesion location was unavailable for 3 participants. It may be useful to replicate the results of this study using only patients who show frontal lobe damage to ensure that the area thought to be related emotion is impaired for each group of participants. Furthermore, individuals with severe aphasia could not be included in the study because verbal communication was necessary for testing procedures. Due to this, it is possible that the individuals in the left brain damaged group were less severely brain damaged than the right brain damaged group. Differences in severity of damage might explain why right brain damaged patients showed more impairment than left brain damaged patients. However, what is compelling about this study is that they found a significant interaction between LH and RH damaged participants and valence. Contrary to the VH the LH patients were found to be more impaired on negative monologues than positive ones and the RH patients were found to be more impaired on positive than negative monologues. These significant findings in the opposite direction as would be expected with the VH were convincing despite the valid critiques above.

Further support for the RHH was seen in a study of emotional expression. The relationship between self-reported emotional experience and facial expression during self generated monologues was examined for brain damaged individuals (Montreys & Borod, 1998). Eight emotional (5 negative, 3 positive) and 8 neutral conditions were tested. This study found that for all the monologues left brain damaged individuals had a higher mean emotional intensity rating (M = 2.12) than right brain damaged individuals (M = 1.83) or those of normal controls (M = 1.79). While it is unclear from the article, these do not appear to be statistically significant differences. If these means are considered relevant it is interesting to note that the normal controls reported the least intensity. Right brain damaged individuals rated themselves as less intense in their emotional monologues than left brain damaged individuals. When comparisons were made across each of the eight emotional monologues the right brain damaged individuals gave themselves lower intensity ratings than left brain damaged individuals for 6 of the 8 monologues. Unfortunately, the emotions of the 6 monologues are not reported. It is possible that 4 or 5 of the 6 are the negative monologues. If this is the case, it would bias their results in favor of the RHH. However, their results did indicate that right brain damaged individuals gave lower emotional intensity ratings for at least 1 positive monologue. Left brain damaged individuals had slightly higher scores for positive than for negative monologues which is contrary to the VH. It was not clear if this difference was statistically significant, however. Right brain damaged and normal controls did not show any difference in their positive versus negative monologues. Furthermore, they found a significant correlation between self rated intensity of emotional monologues and intensity rated by the observer for normal controls but not for either group of brain damaged individuals (left brain damaged r = -0.44, right brain damaged r = 0.08) (Montreys & Borod, 1998). This suggests that both brain damaged groups were likely impaired in their self rating of emotional intensity, expression of the intensity of their emotion, or both.

The results of the above study indicated support for the RHH. However, due to the extremely low sample size (2 left brain damaged, 2 right brain damaged, and 2 normal controls) the results should be replicated given that presence of an atypical patient might significantly affect results.

Valence Hypothesis

The VH suggests that the RH is only dominant for negative emotion and that the LH is dominant for positive emotion. In partial confirmation of their hypotheses Davidson and colleagues (1990b) found that viewing video clips designed to elicit disgust caused more activation of the right frontal region compared to EEG recorded during viewing of happy video clips. Although there was more activation in the in the left frontal region during happy than disgust video clips, this difference was not significant. These findings partially supported the VH suggesting that disgust elicited a stronger right frontal response than happiness did. The findings for the left frontal region suggested a more bilateral response to their happy video clips. They also found increased left activation during the happy condition in the temporal region, which suggested some support for the VH in this brain region.

One possible explanation for their findings in the LH may be the stimuli used. One of the positive film clips used was "of monkeys playing and a gorilla taking a bath in the zoo" (Davidson et al., 1990c, p. 333). The video was designed to be amusing, but the approach-withdrawal response (Schneirla, 1949), may have been more equivocal. Approach tendencies are thought to activate the LH and withdrawal responses are thought to activate the RH (Davidson et al., 1990b; Davidson, 1993). A gorilla, even depicted in a zoo, is likely to cause a withdrawal response creating increased right sided activation. This may have made the hemispheric differences for this happy video clip less distinguishable. Davidson and colleagues acknowledged that there was not likely a strong approach response elicited by these happy video clips.

An experiment by Borkenau and Mauer (2006) pitted the RHH against the VH using a lateralized emotional Stroop task. This study found that pleasant words had the longest color naming times followed by negative and then neutral words. Furthermore, regardless of valence, there was a RVF advantage of 4 ms. Because all of the responses in this study were done with the right hand, Borkenau and Mauer suggested that this visual field advantage could be attributable to the time it takes for interhemispheric transfer, which is thought to be around 2-5 ms (Iacoboni & Zaidel, 2000; Borkenau & Mauer, 2006). Because words presented to the RVF are projected to the LH the information would not have required interhemispheric transfer to result in a right-handed response. However words presented in the LVF would have been presented first to the RH and therefore would have to have been transferred to the LH for a right-handed response (Borkenau & Mauer). Additionally, because lexical stimuli were used the RVF would have had faster times because the LH is dominant for interpreting language based information. This study also found that there was a strong valence by visual field interaction. Negative words presented to the LVF and positive words presented to the RVF had longer latencies, or caused more interference, than negative words to the RVF and positive words to the LVF (Borkenau & Mauer). They took these findings as strong support for the VH. Longer reaction times were interpreted as evidence of greater emotional processing due to the interference the processing of the emotion causes in the Stroop task. Interestingly, this is in contrast to Mohr and colleagues (2008) lexical decision study where faster reaction times for emotional words in one visual field were taken as evidence that the corresponding hemisphere was dominant for that emotion. Because they used a lexical decision task, the argument could also be made that emotion created interference with the lexical decision task for their data. Looked at in this way findings would be more consistent with Borkenau and Mauer's findings, which were interpreted in terms of interference.

VH support was also seen in a study which examined how emotion affected spatial attention (Foster et al., 2008). Participants were given pegs with emotional labels on them (sad, afraid, disgusted, happy, joyful and surprised). Participants were asked to arrange the pegs to represent how the emotions felt and the relationship between emotions. Participants showed a significant bias to place positive pegs (happy, joyful, and surprised) distally in the LVF. Foster and colleagues postulated that the positive pegs would increase left frontal activation (based on the VH) which would cause a decrease in left posterior activation followed by an increase in right posterior activation. They predicted that this increase in right posterior activation would cause participants to place positive pegs in the LVF. Results were consistent with their hypothesis. However, only placement of positive emotions, but not negative emotions was significant. While this study is related specifically to theories about allocation of attention with regards to emotion their results also favor the VH.

Killgore and Yurgelun-Todd (2007) attempted to clarify the apparently opposing results of the VH versus RHH. Functional magnetic resonance imaging (fMRI) was used to examine perception of emotion in chimeric stimuli. In this experiment half neutral, half emotional chimeric faces were used as stimuli. They were presented for 50 ms and immediately masked by a neutral face of the same person. Generally they found that the RH was favored, however, comparisons of happy versus sad chimera in the LVF suggested that the RH was particularly specialized for negative emotion. For positive stimuli presented to the RVF greater activity was seen in the left middle temporal gyrus (this fits with Davidson and colleagues (1990b) findings of greater EEG activation in the left temporal lobe for positive video clips) in accordance with the VH. Concerning the prefrontal activation, however, they found the opposite pattern of results as would be expected by the VH. Killgore and Yurgelun-Todd also note that their findings should be taken with caution as the temporal resolution of fMRI is possibly inadequate for their methodology.

It is interesting that Killgore and Yurgelun-Todd (2007) found opposite results of what would be expected for the VH in the prefrontal area. This finding was similar to a few other reports of valence specific findings in the opposite direction (Montreys & Borod, 1998; Mohr et al., 2008). Additionally, if Borkenau and Mauer's (2006) data was reinterpreted with longer reaction times seen not as interference, but as evidence that the hemisphere was not dominant for emotion (i.e. it required more time to respond), then their study would also be consistent with the fMRI findings of Killgore and Yurgelun-Todd. The point here is that sometimes longer reaction times to emotional stimuli were seen as interference suggesting a particular hemisphere was dominant for processing emotion (Borkenau and Mauer). At other times shorter reaction times to emotional stimuli were seen as proof that the hemisphere was dominant for emotion and thus facilitated a faster response (Montreys & Borod,). At least for the lexical decision and emotional Stroop studies presented above it appeared that their basic data was more consistent either both seen as interference or as facilitation.

Motivational Theories

Some researchers have interpreted emotionally lateralized data to be consistent with motivational theories. For example, many positive stimuli are likely to result in an organism having a propensity to approach a given stimulus whereas the majority of negative stimuli (although again perhaps not all) are likely to produce active withdrawal (e.g. a fleeing response; Davidson, 1993) or potentially a behavioral inhibition response (e.g. a freezing response). These theories were designed to explain the most basic behavioral activities of all organisms. Approach-withdrawal theory asserted that the brain has basic approach and withdrawal mechanisms that explain behavior (Schneirla, 1949). Alternatively a behavioral activation system (also called behavioral approach system) and a behavioral inhibition system have been theorized to explain organism behavior (BIS-BAS theory; Fowles, 1988; Fowles, 1994; Gray, 1987). Other theories combined the previously mentioned theories and postulated 3 systems: a behavioral approach system and a fight/flight system that explained behavioral activation elicited by positive and negative environmental stimuli, respectively, as well as a behavioral inhibition system that operated when it was most advantageous for an organism to freeze or inhibit a behavior in response to environmental stimuli (Gray). Causing some confusion, the behavioral inhibition system has sometimes been interpreted as the ceasing of behavior (see Gray), and sometimes as a behavioral withdrawal response to aversive stimuli (see Fowles, 1988). These motivational theories have also been applied to theories of pathology etiology and have suggested that anxiety, depression, psychopathy and other psychopathology may be caused by disruptions in BIS-BAS or the aversive and appetitive motivations (Fowles).

Davidson (1993) suggested it might be useful to view emotion relevant experiments in terms of the approach-withdrawal theory. Approach behaviors in response to environmental stimuli are thought to be controlled by the left frontal region whereas right frontal region is thought to control withdrawal behavior (Davidson, 1993; Davidson et al., 1990b).

MacNeilage, Rogers, and Vallortigara (2009) have proposed a new theory to explain lateralized behavior; however, their research also informed approach-withdrawal theory. They suggested that the RH was dominant for responding to unexpected stimuli and the LH was dominant for responding in ordinary familiar circumstances. They further emphasized that the LH produced self motivated behaviors and the RH produced environmentally driven behaviors. To support this idea, they reported that frogs, whales, birds and other animals have a right-sided feeding preference. For example, in one of their experiments a frog was presented with a grasshopper replica either moving toward the frog from the left or from the right. If the grasshopper was started in the LVF and moved towards the frog, the frog only began to strike at it as it passed into the RVF. This suggested that feeding behavior was controlled by the LH. They took this as support for their theory that the LH is dominant for every day behavior since feeding was an everyday activity. In a similar experiment MacNeilage and colleagues (2009) had a false snake head approach from either the left or right side of the frog's visual field. The frog was unresponsive to the snake when it approached from the right side, but jumped away when the snake approached from the left side. Again this supported their theory that the RH was dominant for processing novel stimuli in the environment. They made convincing arguments for their conceptualization of hemispheric dominance, which they believed was the basis of laterality before other hemispheric specializations evolved. Their data, however, also supported approach-withdrawal theory. Feeding behavior is an approach behavior and was shown by their data to be LH dominant where as fleeing a predator is a withdrawal behavior which their data showed to be RH dominant. Their data was equally supportive of approach-withdrawal theory. Because their new theory does not add any additional explanatory value to the data, the approach-withdrawal theory appears to be a better supported theory to explain their findings.

Other researchers suggested that a BIS-BAS model fit research findings better than an approach-withdrawal hypothesis. Given the above studies, it may be that the LH is dominant for approach behaviors (e.g. feeding and attack behaviors) whereas the RH is dominant for both withdrawal and inhibition (e.g. fleeing and freezing behaviors). Other studies have found that the LH was dominant for behavioral activation, in any direction (i.e. approach or withdrawal behaviors), and the RH was activated for behavioral inhibition (Wacker, Chavanon, Leue, & Stemmler; 2008). There is good supporting evidence for this postulate seen in stroke/brain damaged individuals. Individuals with left frontal damage to the brain frequently have exhibited the "bump on a log syndrome" (Fogel, personal communication, 2009). This is characterized by the individual failing to show self initiated behavior such as self care activities (e.g. feeding, grooming). Additionally, patients with RH damage, particularly those with frontal damage, frequently have demonstrated impulsivity and inability to inhibit inappropriate behaviors (e.g. inappropriate comments, unsafe behavior with respect to their physical impairments, and impulsivity on neuropsychological testing). In the study by Wacker et al. (2008) individuals who scored higher on withdrawal traits showed greater left than right anterior activation in response to emotional imagery. This indicated that withdrawal behavior was associated with left frontal activation. These results suggested that the left anterior region was dominant for all behavioral activation: approach and withdrawal (Wacker et al.). Furthermore Wacker and colleagues found that if individuals believed that freezing was the best response to the emotional imagery situation, they showed more right anterior activation. If their impulse was to flee the emotional imagery situation, they showed more left sided anterior activation. They interpreted these results as more consistent with the BIS-BAS motivational model of behavior than the approach-withdrawal theory.

Individual Differences in Resting Asymmetries

As a follow up to the VH, Davidson (1993) has proposed that individuals also have what he called affective style. Affective style refers to individual differences in resting anterior asymmetry. This theory postulated that individuals who have resting asymmetry which favors right anterior activation will be more susceptible to withdrawal related emotional experiences whereas problems with failure to initiate will be seen more by individuals who have left anterior activation at baseline (Davidson, 1993). It was Davidson's (2000) contention that these resting asymmetries might predispose individuals to certain psychopathology such as mood or anxiety disorders.

Individuals with relative right anterior activation at baseline may be more prone to depressive symptoms whereas those with left anterior activation at baseline may show resilience to depression (Davidson, 2000). Likewise, depression and resilience may cause changes in resting asymmetries in the brain. These individual differences in resting asymmetry combined with amygdala involvement are thought to produce affective style (Davidson). Affective style is thought to determine an individual's ability to learn from negative emotional experiences. Affective style has been shown to affect how quickly an individual can recover from the experience of the negative emotion once the information is gleaned (Davidson). For example, Larson, Sutton, and Davidson (1998) used affective pictures in an emotion modulated startle paradigm (as cited by Davidson). They found that individuals with greater relative resting left sided prefrontal activation showed diminished startle response after the offset of negative pictures while their startle responses during the negative pictures were comparable to individuals with right sided resting activation. This suggested that they had recovered from the "emotional challenge" more quickly (Larson et al., 1998, as cited by Davidson, pp. 1207). Individual differences in affective style may be adaptive for pack animals, such as humans (Davidson). For example, it may be advantageous for some members of a pack to have resting left anterior activation which might cause them to seek out positive stimuli such as food and other members of the pack with resting right anterior activation which might cause them to be more concerned with and fearful of predators (Davidson).

Based on the affective style theory individuals with resting asymmetry should respond differently to emotionally evocative experimental situations based on whether they are more prone to withdrawal (greater right sided activation) or approach (greater left sided activation) (Davidson, 1993).

To test this hypothesis, participants were exposed to positive and negative film clips (Tomarken, Davidson, & Henriques, 1990). Participants rated the negative film clips on fear, disgust, sadness, and anger and the positive film clips on happiness, amusement and interest. Global negative and global positive scores were summed from these ratings. Individuals who demonstrated right side activation in the frontal region at baseline had a greater reported negative response to unpleasant film clips (Tomarken et al., 1990). They noted, however, that this result should be taken with caution given that some of their measures of negative affect and affective valence were not entirely independent. Resting left activation, however, was not predictive of ratings of positive film clips. Again these results did not clearly distinguish between the VH and RHH; however, they were taken by the authors to favor the VH.

In a follow up study, participants' baseline brain activation was again measured by EEG (Tomarken, Davidson, Wheeler, & Doss, 1992). Participants were selected who scored in the top 25th percentile, indicating extreme anterior LH activation compared to their RH at baseline. The bottom 25th percentile of participants who showed relative RH activation compared to their LH at baseline were used as a comparison group. General affect was then measured using the PANAS-GEN. The PANAS-GEN contains 20 descriptions of emotions (10 negative, 10 positive) which participants used to rate how they generally feel. Participants with marked left anterior activation at baseline had greater self-reported positive affect and less negative affect when compared to individuals with greater right sided anterior activation (Tomarken et al., 1992). These results were supportive of the VH as it operates with regard to affective style differences. It should be noted, however, that using top and bottom quartiles rather than examining the whole range of a continuous variable (as they have done in this study) may have caused more complex linear relationships in the data to be missed. However, generally these findings supported VH, which would be expected with self-reported data and experience of emotion (Borod et al., 1992).

Davidson (2000) also attempted to refocus research in this area. He emphasized that finding locations in the brain that deal with processing emotion was less important than understanding how someone's affective response style was created in the brain. Essentially Davidson (2000) asked: What happened in the brain which created and maintained an affective style for an individual, which in turn may have predisposed them to psychopathology? Understanding this question may prove useful in preventative care for psychopathology.

Perception of Emotion versus Expression of Emotion

One of the factors that may explain the seemingly conflicting evidence for VH versus RHH is the distinction between the perception and the expression of emotion. Some researchers have recognized that with emotion, similar to language, the part of the brain dominant for expression may be distinct from the area of the brain dominant for understanding or perceiving (see Borod, 1992). The RH is thought to be dominant for perception of emotion (Borod). Study tasks that require perception of emotion should be more likely to favor RHH. Expression of emotion is less clearly lateralized; however, there was some evidence to suggest expression/experience of emotion experiments support the VH (Borod). This suggested that physiological measures, which index the experience of emotion, should be more likely to support VH. Studies using self-report measures of emotional experience were also more likely to support the VH (Borod et al., 1998).

EEG analysis during emotional facial expressions in response to video clips found support for the VH (Davidson et al., 1990b). This supported the theory that expression of emotion may be better explained by the VH. A review by Borod (1992) showed that RHH support was most consistent for the perception of emotion whereas the expression of emotion had less consistent results with some support for the VH. Borod and colleagues (1998b) did a study a few years later which evaluated emotional perception and again found evidence in support of the RHH (Borod et al., 1998b).

In summary, it appears that there is strong support that the RH is dominant for the perception of emotion; however, laterality of the expression of emotion is less clear with some support for the VH.

Stimulus Modality as a Confounding Variable in Laterality of Emotion Research

A variety of different types of emotional stimuli have been researched. Verbal stimuli, usually single word presentations (love, hate, happy, sadness, etc.) are commonly used in emotion experiments (see Borkenau & Mauer, 2006; Mohr et al., 2008).

One concern in emotion research has been whether or not understanding of emotional processing in the brain has been confounded by the type of stimuli used in each experiment. Borkenau and Mauer's (2006) emotional Stroop study used word stimuli and found support for the VH. LH dominance for language may have affected these results. The emotional Stroop task was language based in at least two-ways. First, word stimuli may have confounded results. Stroop studies have suggested that word reading is an automatic, over learned process, which occurs even when it is disadvantageous for the task at hand. This has been particularly evident when individuals have tried to name the color of the ink of a word when the word is an incongruent color name. For example the word 'green' is printed in red ink. Emotional Stroop has shown that emotional words slow down color naming in a similar manner to incongruent color names. Since the LH would automatically read the words in an emotional Stroop task it might be more impaired by the emotional content of words than the RH which is not language dominant. This might have increased the chance of results favoring the VH. Faster color naming latencies for words presented to the RVF may be because the RH required language input from the LH about each word stimulus which slowed down LVF responses. Second, color naming is a particularly language based task. This is frequently seen with aphasic patients. Often even aphasic patients with some preserved expressive abilities will have difficulty naming colors because it is a heavily language based task (Fogel, 2009). The heavily language based nature of color naming would also explain why the LH would respond faster overall to this task. Indeed, Borkenau and Mauer found faster reaction times for all stimuli presented to the RVF. In tasks such as these it should be more clearly elucidated how the type of stimuli affected lateralized results.

Another widely used set of experimental stimuli is the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). These contain various pictures with human and nonhuman content. With picture stimuli, the RH is likely to have an advantage due to its superior ability to integrate visuospatial information (see Springer & Deutch, 1998). Furthermore, because the RH is thought to be dominant for perception of faces and for integration of material (see Springer & Deutsch, 1998) many of these emotional pictures would likely have a RH advantage. This may cause experiments with visuospatial information to be more likely to favor the RHH. For example, studies with chimeric faces typically have shown a RH advantage (Levy et al., 1983; Killgore & Yurgelun-Todd, 2007). However, opposing results have been found with infant chimera causing researchers to suggest that lateralization of emotion may shift from left to right as a function of development (Best & Queen, 1989).

In order to control for differences in each hemisphere's ability to process verbal versus visuospatial stimuli both types of stimuli should be used in a single experiment. In this way, hemispheric specializations unrelated to emotion may be controlled.

Measuring Emotion

Lang (1978) presented a three-pronged approach to measuring the experience of an emotion. The first was overt behavior. In emotion research facial expressions such as smiling, frowning, grimacing, etc. are often used as measures of overt behaviors that suggested an emotional experience. The second was physiological response which was measured through means such as EEG, SCR, heart rate, etc. These measures are likely to signify emotion with relatively good indication of the timing of the emotional occurrence. Activation has been shown in physiological systems such as heart rate, SCR, eye movement, etc. and has been found to be associated with emotional imagery, suggesting that these physiological measures are meaningful indicators of emotion (Lang). Physiological measures are shown to be a good way to verify that “emotional” experimental conditions caused emotion since there may have been individual differences among participants (Lang). Individuals have shown differences in their ability to utilize imagery to create emotional states, which may cause individual differences in overall emotional intensity in response to imagery paradigms (Lang). The third way of measuring emotional response was through self-report after an emotional event had taken place. Self-reports may be less exact if the participant was recalling or reflecting back on a previous experience of emotion. Therefore, some studies attempted to address this issue. They had their viewers introspect in the moment and record their rating immediately afterwards (see Davidson et al., 1990b).

Facial expressions as an indicator of real time emotional experience have also been called into question (Davidson, 1993). Davidson suggested that emotional facial expressions of fear may be masked due to social learning. However, he also cited the infant study of Hiatt, Campos, and Ernde (1979), which showed that even infants were unlikely to show facial expressions indicative of fear. Moreover, expressions of disgust during experiences designed to elicit fear are common (Davidson). Davidson's review questioned the reliability of facial expression when attempting to measure fear. Davidson also suggested negative emotions may be difficult to reliably differentiate, especially at moderate intensity, using facial expression.

Physiological Responsiveness

Often physiological responses are used to assess emotional reactions because they have been shown to be tied to underlying emotions or to general arousal. Physiological measures such as heart rate, skin conductance, electroencephalography, and electromyography (facial movements) have been used to assess response to emotional stimuli. These measures are useful because they are less likely to be biased than self-report measures and thought to be directly linked to underlying biology.

Skin conductance measures are thought to reflect general arousal states (Dawson, Schell, & Filion, 2000). SCRs occur when an individual perspires in response to a stimulus. Because sweat is a salt solution it is able to conduct electricity. The term skin conductance refers to the skins ability to conduct an electrical signal which can be measured by electrodes placed on the skin (Dawson et al., 2000). SCRs are sensitive to even small changes in perspiration. Essentially, the more an individual perspires the larger the SCR magnitude. In normal individuals, SCRs occur for both positive and negative stimuli, with similar magnitude for a given individual (Dawson et. al., 2000). Most skin conductance research has assessed amplitude (Dawson et al.). Amplitude is the height of the wave created when an SCR occurs. SCRs are a useful measure of affective intensity of a presented stimulus (Dawson et al.). Smaller SCR amplitudes indicate a less arousing stimulus; whereas larger SCR amplitudes indicate a more arousing stimulus (see Dawson et al.). SCR is useful in that it gives a rather immediate (within 1-5 seconds of stimulus onset) indicator of emotional experience and then skin conductance activity returns close to baseline after about 10 seconds so multiple trials can be used (Dawson et al.).

A lateralized study using positive, neutral, and negative picture stimuli examined SCR to verbally inaccessible pictorial information (Zaidel, Hugdahl, & Johnsen, 1995). Neutral pictures were presented randomly to either the LVF or RVF on each trial with sufficient length (180 ms) that the participants were able to identify what was presented. For the intrahemispheric experimental group, emotional pictures were presented above the neutral picture and to the same visual field for a duration of 50 ms making them "verbally inaccessible." Participants were unaware that the emotional picture had been shown. For the interhemispheric group the neutral pictures were also shown for a duration of 180 ms and a verbally inaccessible emotional picture was shown for 50 ms in the opposite visual field. The control group was shown neutral pictures presented randomly to the LVF or RVF on each trial with no verbally inaccessible emotional stimuli. Overall, the results showed more interference for negative than for positive verbally inaccessible conditions. Larger SCRs were seen for negative verbally inaccessible pictures presented to the LVF compared with positive inaccessible pictures; however no significant differences were seen with the RVF. A significant 3-way interaction was found which showed that there were larger RH responses on negative emotional trials and larger LH responses for positive trials. However the positive results were only seen in the interhemispheric group. This study showed support for the VH with SCR as a measure of emotional experience. Zaidel, Hugdahl, and Johnsen (1995) concluded that the RH was very sensitive to verbally inaccessible negative pictures and that the LH was sensitive to positive emotional pictures, but only in the interhemispheric group. This study suggests that SCR is a useful measure for testing laterality differences with respect to valence and short presentation time for emotional stimuli.

Current Study

The current study attempted to examine several variables that may have influenced the study of laterality of emotion. After measuring several of these factors, this study aimed to determine for which circumstances the VH was supported and for which circumstances the RHH was supported.

One of the issues with laterality of emotion research has been the type of stimuli used. For example, many studies have used words as stimuli to examine laterality of emotion (Mohr et al., 2008; Borkenau & Mauer, 2006; etc.). However the LH is known to be dominant for language in most individuals (for review see Springer & Deutch, 1998). The RH may have been at a disadvantage in these studies because it had to rely on language input from the LH before emotional processing could take place. Other studies used silent video clips to elicit emotion (Davidson, Ekman, Saron, Senulis, & Friesen, 1990). In these studies the RH may have had some advantage because of its ability to integrate visuospatial information (for review see Springer & Deutch, 1998). In this study both lexical (words) and visuospatial stimuli (pictures) were used to assess for differences based on modality of stimuli.

Another factor was whether the perception or expression of emotion was measured and whether this factor affected which emotion hypothesis was supported. The current experiments attempted to address both perception and expression of emotion. Both experiments used bilateral simultaneous presentation of stimuli. This means that two stimuli were presented at a time, one to the RVF and one to the LVF. This presentation style allows the two stimuli to be presented to opposite hemispheres simultaneously. In this way the LH perceived stimuli presented to the RVF first and the RH perceived stimuli presented to the LVF first. In the first experiment participants were asked to choose which word or picture in the pair of stimuli conveyed or depicted more emotion. This task was speeded and the time to perceive or discern which stimulus was more emotional was measured. These data were expected to determine whether the LH or RH was quicker at perceiving emotion. Furthermore, the time it took each hemisphere to evaluate positive compared to negative emotion was assessed. For example, the response times for positively valenced stimuli presented to the RVF were compared to response times for positively valenced stimuli presented to the LVF. This was to measure which hemisphere was discerning positive stimuli more quickly. Likewise, the negatively valenced stimuli presented to the RVF were compared to negatively valenced stimuli presented to the LVF. This was done to determine which hemisphere was quicker at identifying negative emotion. If it was found that the LH was faster for positive emotion and the RH was faster and more accurate for negative emotion this would support the VH. However, if it was found that the RH was faster and more accurate at perceiving all emotional stimuli this would support the RHH. Because the participants were asked to indicate the more emotional word or picture, the hemisphere which was dominant for processing that particular valence of emotion was expected to show faster reaction times. Slower reaction times in the previously mentioned lexical decision task (Mohr et al., 2008) and emotional Stoop task (Borkenau & Mauer, 2006) were thought to suggest more emotional processing. However, in those studies the task the participants were asked to complete were not emotionally based. The automatic emotional processing was thought to draw away processing resources causing interference, so emotion was expected to slow down the task. The experimental task in the current experiments required information about emotion to complete. Therefore faster reaction times for a particular hemisphere were expected to indicate dominance for that emotion.

In addition to reaction time measurements, proportion of accurate responses for each valence and side of visual field presentation were examined similar to response times. Richards et al. (1995) found RHH support for accuracy results in an emotional Stroop task. Mohr et al. (2008) also generally found RHH support for accuracy results. However, another study with task parameters closer to the current study did not show any lateralized emotional perception effects with respect to accuracy (Raccuglia & Phaf, 1997). In the current study RHH support would have been shown by a greater proportion of accurate responses to the emotional perception task when stimuli were presented in the LVF. Support for the VH would have been shown by a greater proportion of accurate responses to positive stimuli when presented to the LH and a greater proportion of accurate response to negative stimuli presented to the RH. Based on the above research, RHH support for accuracy in perceiving emotions was expected.

The second experiment measured SCR elicited to emotional stimuli using the same bilateral stimulus presentation. This was done to measure the experience of emotion. This allowed comparison of the experience of both positive and negative emotions from each hemisphere. For example, SCRs to positive emotional stimuli which are presented to the RVF were compared to SCRs to positively valenced emotional stimuli presented to the LVF. Likewise, SCRs to negatively valenced stimuli were compared based on side of visual field presentation. RHH support would have been supported by larger SCRs for all emotional stimuli when presented to the LVF. This would have indicated that the RH responded more strongly to the emotional stimuli because it is dominant for emotional experience. VH support would have been supported if SCRs to positive stimuli were stronger for the RVF compared to stronger SCRs to negative stimuli in the LVF. Because SCRs are thought to measure experience of emotion it was expected that the SCRs would show VH support. The second study also evaluated accuracy in perceiving emotion in briefly presented stimuli. The second experiment was expected to show more clear accuracy results, given that the emotional perception judgments were done under unspeeded conditions (Van Damme, Crombez, & Notebaert, 2008). For the first experiment a speed-accuracy trade off, was suspected to possibly affect the accuracy results; however, in the second experiment speed was not a requirement so was expected to be less likely to effect accuracy results. Similar to the first experiment, the accuracy results from the second experiment were expected to favor RHH, which would be supported by greater proportion of accuracy for emotional stimuli presented to the LVF.

The type of stimuli used, verbal versus visuospatial, was expected to affect whether data would favor the VH or the RHH. Because the RH is dominant for visuospatial integration and is thought to be dominant with respect to emotional perception, it was expected that the participants' response time to the picture stimuli would be faster for the RH. It was expected that there would be a main effect of reaction time results for picture stimuli such that faster reaction times with pictures were seen in the LVF as compared to the RVF. It was expected that response time to words would be faster for RVF presentations because the LH is typically dominant for language.

It was hoped that these experimental manipulations would elucidate which conditions produced results supporting the RHH and under which conditions the VH explained the data better. Given the wealth of data supporting both hypotheses it was thought that the conceptual and methodological considerations discussed above would bear on previous research. It was hoped that new research accounting for these variables would help to integrate these theories into a unified theory of emotion.

For all hypotheses the degree of handedness was controlled for as this was expected to filter out some of the variance caused by reverse dominance.

Hypothesis One

It was hypothesized that the RHH would be supported with regards to the reaction time dependent variable. Specifically a main effect of side of visual field presentation, regardless of valence, with the reaction time data was expected. Reaction times for emotional stimuli were expected to be faster overall when presented to the LVF as compared to the RVF. This would indicate that the RH was faster at responding to all types of emotional stimuli, both positive and negative.

Hypothesis Two

It was hypothesized that RHH would be supported for the unspeeded accuracy dependent variable for the SCR experiment. Proportion of accurate responses was expected to be greater for stimuli presented to the LVF compared to the RVF regardless of valence. This would support the RHH, because VH would predict greater accuracy for positive stimuli presented to the RVF and greater accuracy for negative stimuli presented to the LVF. Under the speeded condition of the reaction time experiment it was expected accuracy results would be more variable due to speed-accuracy tradeoffs. However, both sets of accuracy data were expected to favor RHH.

Hypothesis Three

It was expected that there would be an overall LH advantage for task accuracy with word stimuli and an overall RH accuracy advantage with picture stimuli due to differential hemspheric dominance for language and visuospatial processing, respectively. This would be seen by an interaction between stimulus type and side of visual field presentation while controlling for handedness, such that task response to words was more accurate for RVF presentations and task response to pictures was more accurate with LVF presentations. These predictions are based on other areas of hemispheric dominance and so do not support RHH or VH in particular.

Hypothesis Four

It was expected that the SCR data would favor the VH because the SCR amplitude represents an experience of emotion. Specifically, it was expected that there would be greater SCR magnitudes for positive stimuli presented to the LH and greater SCR magnitudes for negative stimuli presented to the RH.

Hypothesis Five

It was expected that reaction times to words would be faster for the LH and reaction times for images would be faster when presented to the RH.

CHAPTER TWO

EXPERIMENT 1

Method

The following methods were the same for both Experiment 1 and Experiment 2, except where indicated below. Participants were only allowed to participate in either Experiment 1 or Experiment 2 since the experiments were run concurrently with the same stimuli.

Participants

Thirty-eight participants were recruited from California State University San Bernardino. All participants were enrolled in at least one psychology course at the university. Incentives were offered in the form of extra credit for class. Only participants who were 18 or older were included. Finally, individuals with uncorrected visual impairment were excluded, because the stimuli were visual. Additionally, participants that were illiterate or did not read English fluently were excluded due to the written nature of some of the stimuli. Participants were not excluded based on handedness, so this variable was controlled statistically.

Power Analysis

A power analysis was run using the G*power 3.1.0 program (Institut für Experimentelle Psychologie, Duesseldorf). The necessary sample size was estimated for a power of 0.80 for an effect size of 0.37 with an estimated correlation among the repeated measures of 0.50. The estimate of the effect size was calculated using findings from Raccuglia and Phaf's (1997) study. They conducted a similar experiment and found a three-way interaction with valence, side of visual field presentation, and presentation time for participant reaction time. Since this study was looking for interactions between valence and side of visual field presentation this was judged to be an appropriate estimate. This analysis provided adequate power to find a medium effect size. The sample size needed was estimated to be 9 participants. The actual number of participants collected was 38, so the a priori power based on the same assumptions above was 0.99.

Materials

Photographs from the IAPS (Lang et al., 2005) were used as stimuli. Photographs were chosen from the 384 available based on normed valence and arousal ratings. Forty positive (e.g. erotic images, cute puppies and kittens, appetizing food), forty negative (e.g. dog baring teeth, gun pointed at participant, mutilated body, violence being depicted, emaciated child), and eighty neutral (e.g. rolling pin, mushroom, table) pictures were selected. Valence and arousal ratings from the IAPS norms indicated that the valence of positive pictures ($M = 7.35$, $SD = 0.39$) and negative pictures ($M = 2.63$, $SD = 0.81$) differed significantly ($p < 0.001$). Positive ($M = 5.44$, $SD = 0.83$) and negative pictures ($M = 5.65$, $SD = 0.90$) were comparable in terms of their arousal ($p = 0.29$, two tailed). The neutral images were selected so that their mean valence rating ($M = 4.90$, $SD = 0.25$) was approximately half way between the mean positive and mean negative valence ratings. The average arousal rating for the neutral images was 3.64 ($SD = 1.12$). For a complete list of images used in this study see Appendix A.

Words with positive (e.g. happy, loved, sweetheart, lucky), negative (e.g. torture, suffocate, abuse, depression) and neutral (e.g. bench, curtains, elbow, item) content were selected from the Affective Norms for English Words (ANEW) (Bradley & Lang, 1999). Forty positive, forty negative, and eighty neutral words were selected. The valence of the set of positive words ($M = 8.31$, $SD = 0.20$) and the negative word set ($M = 1.73$, $SD = 0.18$) differed significantly ($p < 0.001$), but were comparable in terms of their arousal ($M = 5.44$, $SD = 0.83$; $M = 5.56$, $SD = 0.91$; $p = 0.29$). Neutral words were selected such that their average valence ($M = 5.16$, $SD = 0.51$) was approximately half way between the valence mean of the negative and the positive words. The average arousal rating for the neutral words was 3.84 ($SD = 0.52$). For a complete list of words used in this study see Appendix B.

A fixation stimulus (i.e. black plus sign) occurred before each stimulus display centered on the computer screen. Participants were seated approximately 90 cm away from a 17” color monitor. The background for all stimulus displays was light grey.

Half of the stimulus displays were composed of two pictures each. For each of these displays one picture was presented to the RVF and the other to the LVF simultaneously. One picture in each stimulus pair had a strong valence rating (either positive or negative) and the other was neutral. Side of presentation of both the positive and negative pictures was counterbalanced such that 60 stimulus displays contained a positive and a neutral picture (30 with the positive image on the right and 30 on the left) and 60 stimulus displays contained a negative and neutral picture (30 with the negative image on the right and 30 on the left). The horizontal visual angle from the fixation to the inside edge of the picture was 0.6° and the visual angle to the outside edge of each picture was 9.6°. The vertical visual angle for the pictures was 4.2° to the top or bottom of the picture. The number of pixels varied slightly for each image, but the maximum number was 1024 x 768 pixels (Lang et al., 2005).

The second half of the stimulus displays were composed of two words each. The words varied in length from 3 letters to 11 letters with the average length of word being approximately 6.3 letters. Courier new, bold, 18 point font was used for all words. For each of these stimuli one word was presented to the RVF and the other was presented to the LVF simultaneously. Again, similar to the picture presentations, one of the words had a strong valence rating (either positive or negative) and the other had neutral valence rating. The side of presentation of both the positive and the negative words was counterbalanced such that there were 60 stimulus displays with a negative word and a neutral word (30 with the negative word on the right and 30 on the left) and 60 stimulus displays with a positive word and a neutral word (30 with the positive word on the right and 30 on the left). The visual angle from the center of the screen to the inside edge of each word was approximately 1.4° on either side. The horizontal visual angle from the center of the computer screen to the outside edge of the words varied from 2.8° to 6.1°. The vertical visual angle was about 0.5°.

The order of presentation of stimulus displays was randomized using E-prime 2.0 (Psychology Software Tools, Sharpsburg) and both word and picture trials were intermixed randomly throughout the experiment.

The Edinburgh Handedness Inventory (EHI; Oldfield, 1971) was used to assess handedness. The EHI consists of 10 self-report items regarding handedness in different activities. It measured the degree of handedness which has been shown to be associated with side of hemispheric dominance for language (Isaacs, Barr, Nelson, & Devinsky, 2006; Levy & Reid, 1978) which may affect hemispheric specialization for emotion as well.

Procedure

The study was advertised using the university's research website. All studies being conducted at the university were advertised on the same website. Through the website participants signed up for individual time slots and came into the laboratory to participate in the study. The online research announcement asked for individuals interested in participating in a study that assessed reaction time and physiological response to emotional stimuli. The advertisement indicated that individuals had to have normal or corrected to normal vision and had to be fluent and literate in English.

All individuals who volunteered to participate selected a 45-minute time slot from available appointment times. When participants arrived to the laboratory they were given a consent form to read and sign which described the procedures (Appendix C). Furthermore, the purposes and procedures were explained verbally to ensure understanding and verbal assent was obtained. Participants were informed prior to starting the experiment that should they choose to discontinue at any point to simply inform the researcher.

Demographic information (i.e. age, gender, ethnicity, and handedness) for the participant was collected and entered into E-prime 2.0 (Psychology Software Tools, Sharpsburg) based on the participants' verbal report with any additional comments entered into the log sheet (e.g. if the participant indicated mixed race, the stated racial identifications were noted). This information was used to characterize the sample for the generalizability of the study results and comparison to other similar studies.

Participants were seated in a chair centered in front of a computer screen. Participants were told that both pictures and words of varying emotional content would be presented on the computer screen. They were advised that due to the nature of some of the images they may be tempted to close their eyes or turn away from the screen, but to please refrain from doing so. They were asked to sit quietly and view all of the pictures and words presented. Participants were told that during the experiment a series of black plus signs would be presented in the middle of the screen and the participants should look directly at the black plus sign every time it appeared. They were told the plus sign would be followed by either a pair of words or pair of pictures. For each pair the participant was asked to decide which word or which picture depicts or evokes stronger emotion. It was explained that the stimuli may depict either pleasant or unpleasant emotion and the participant was to choose which stimulus was more emotional. They were told to indicate their selection by pressing a computer key. If the image or word that evoked more emotion was on the left side of the screen then they were to press the "z" key on the left side of the keyboard with the first finger of their left hand. If, however, the more emotional word or picture was presented on the right side of the computer screen they should press the "m" key on their right side of the keyboard with the first finger of their right hand. Participants were told that their responses were being timed and they should make their selection as quickly as possible without making any mistakes. Participants were then encouraged to ask questions and any confusion was then clarified. The experiment instructions were also reiterated on the computer screen at the start of the experiment.

E-prime 2.0 (Psychology Software Technology, Sharpsburg) was used to present the experiment. Participants pressed the space bar to begin a series of 16 practice trials. After the completion of the practice trials a screen appeared indicating that the participant should ask the experimenter if they had any additional questions at that time. The participant then pressed the space bar to begin the test trials. The plus sign (+) appeared before each word or picture pair and lasted for 1250 ms. The pair of stimuli was then presented for 250 ms each to ensure that the participants gaze fixation did not change as eye saccades take 250 ms. This was done to ensure the information presented was first registered only by the intended hemisphere. Stimuli were followed by a blank screen. The participants' response times and accuracy were recorded for each trial. Trials continued regardless of whether the participant responded; trial timing was not contingent on response time. Time between trials was 3500 ms and participants had to make their response before the start of the next trial. Each participant was presented with 240, including 120 picture pairs and 120 word pairs. Participants were given a rest break midway through the experiment. An example of the experimental sequence is shown below (Figure 1).

Reaction times and accuracy of responses was recorded using E-prime 2.0 (Psychology Software Tools, Sharpsburg). Trials in which the participant responded with the wrong key press were scored as incorrect. Following completion of the 240 experiment trials, participants completed the EHI.

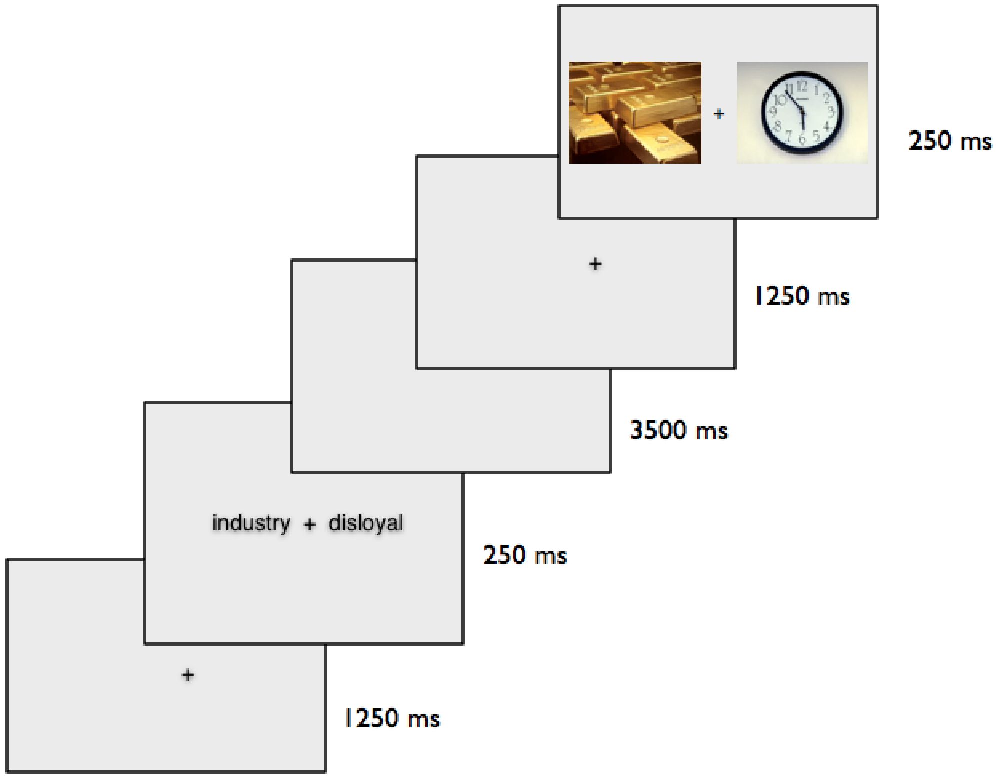


Figure 1. Experimental Sequence: Black plus sign (+) appeared as a fixation stimulus (1250 ms), followed by a pair of words or pictures (250 ms). Participants have 3500 ms to respond during a blank screen before the next fixation stimulus appeared followed by another trial (250 ms).

After completion of the EHI the participants were asked 5 additional questions. They were asked to indicate which side of the screen each of the following categories was presented to more frequently: the positive images, negative images, positive words, negative words, and overall the most emotional stimuli. In actuality, the frequencies were equal. These items were intended to measure the participant's subjective experience of emotion during the experiment.

Design

The design of the experiment was a within-subjects experimental design, since each participant was exposed to all conditions of the experiment. There were three categorical independent variables (valence, side of visual field presentation, stimulus type), two continuous dependent variables (reaction time, accuracy), and one continuous between subjects covariate (handedness).

Data Analysis

The statistical analyses in this study were performed using Statistical Package for the Social Sciences Version 17.0 (SPSS; SPSS Inc., Chicago). Some basic means and frequencies were computed using Microsoft Office Excel 2003 (Excel 2003; Microsoft Corporation, Redmond).

A frequency analysis was performed on gender, ethnicity, age and handedness. This was used to characterize the sample and determine whether the results of this study would generalize to other populations and conditions.

For the reaction time analyses only reaction times from accurate responses were used. Prior to analysis, each participant's reaction times were standardized, or converted to z-scores, based on each participant's mean reaction time and their average deviation from that mean. This was done for two primary purposes. One reason was to control for the variance across participants in terms of average reaction times. Converting to individualized z-scores allowed for comparison across participants and accounted for this individual variability. Secondly, this was done in order to identify reaction times which fell more than 2.5 standard deviations away from the individual's mean reaction time. In this way, extreme scores were trimmed from the data to prevent any one score from disproportionately affecting the mean. Additionally, very long reaction times, in particular, are more likely to be due to momentary distraction or confusion rather than the brain functions involved in processing emotion, which is the primary area of interest for this study. This procedure is similar to, but slightly more conservative than the data preparation in another lateralization study which trimmed their data using 3 standard deviations (Root, Wong, & Kinsbourne, 2006). The data trimming procedure for this study was less conservative than another reaction time study for emotional Stroop (Dresler, Mériau, Heekeren, & van der Meer, 2009). The procedure used in the current study on average eliminated 2.3% (*SD* = 1.0%) of participant responses which on average was about 4.5 responses (*SD* = 2.0) per participant. No participant had more than 4.4% of their responses removed. This percentage of trimmed scores is similar to numbers reported by Root and colleagues (2006).

To analyze the reaction time data a 2 (picture valence: positive or negative) X 2 (stimulus type: word or picture) X 2 (visual field: LVF or RVF) design repeated measures Analysis of Covariance (ANCOVA) with reaction time as the dependent variable and degree of handedness as the covariate was performed.

A second repeated measures ANCOVA was performed on the proportion of accurate responses. The repeated measures ANCOVA was a 2 (picture valence: positive or negative) X 2 (stimulus type: word or picture) X 2 (visual field: LVF or RVF) design with handedness as a covariate.

Results and Discussion

Sample Characterization

Participants for this study were taken from an undergraduate university with a diverse student population in terms of both age and ethnicity. There were 38 participants. Due to technical difficulties, data was lost for one participant, such that demographic information was used, but accuracy and reaction time data was not available. In terms of education, all participants were enrolled in at least one college psychology course. There were a large percentage of females and the sample was mostly Hispanic and Caucasian. The age variable was positively skewed suggesting the majority of the participants were close to 22 years of age with a small number of much older participants. (see Table 1)

Table 1

Demographic Characteristics of Experiment 1 Participants

Demographic Characteristics	Number (%)	Mean (*SD*)
Gender		
Female	32 (84.2%)	
Male	6 (15.8%)	
Age (years)		24.2 (8.3)
Ethnicity		
Hispanic	13 (34.2%)	
Caucasian	13 (34.2%)	
African American	8 (21.1%)	
Asian	2 (5.3%)	
Mixed Race/Other	2 (5.3%)	
Handedness		
Right	32 (84.2%)	
Left	2 (5.3%)	
Ambiguous	4 (10.5%)	

Handedness

The EHI produces scores from -100 (extremely left handed) to 100 (extremely right handed) with scores from -40 to 40 classified as ambiguous handedness. Because the EHI is a roughly continuous scale these scores were entered into the ANCOVA as a continuous covariate rather than using cut scores. Cut scores were used for Table 1 in order to characterize the sample, however. According to the EHI the majority of the sample was right handed. For this sample the range of EHI scores was from -100 to 100. The mean EHI score was 62.97 (SD = 45.04) and reporting extreme right handedness was the most common ($Mode$ = 100; 16.22%).

Accuracy

Overall the participants were accurate on approximately 75% (SD = 16.5%) of trials on average. For each participant the percentage of accurate responses for each trial type was computed in order to compare accuracy across trial type. The mean proportion of accurate responses for each trial type is displayed in Figure 2.

The mean proportion of accurate responses for negative stimuli was 0.77 (SD = 0.20, SE = 0.03) and the mean proportion of accurate responses for positive stimuli was 0.72 (SD = 0.19, SE = 0.03). The difference between these means was non-significant ($F(1, 35) = 2.21$, $p = 0.15$, two-tailed). This suggests that participants were equally accurate in identifying positive and negative stimuli.

The proportion of accurate responses for words was 0.74 (SD = 0.20, SE = 0.03) and for images it was 0.75 (SD = 0.19, SE = 0.03). This difference was not significant

($F(1, 35) = 0.01$, $p = 0.94$; two-tailed), suggesting participants were equally accurate with at identifying emotional content in words as in pictures.

The RH was slightly more accurate with pictures ($M = 0.76$, $SD = 0.18$, $SE = 0.03$) than with words ($M = 0.70$, $SD = 0.19$, $SE = 0.03$) and the LH was slightly more accurate with words ($M = 0.77$, $SD = 0.21$, $SE = 0.03$) than with pictures ($M = 0.75$, SD = 0.0.21, $SE = 0.03$) consistent with hypothesis three, however, these differences were not significant as seen by the insignificant stimulus by visual field interaction while controlling for handedness ($F(1, 35) = 1.27$, $p = 0.14$, one-tailed). Although the expected pattern was found the results were non-significant and thus did not support hypothesis three that the LH would be more accurate with words and the RH would be more accurate with pictures.

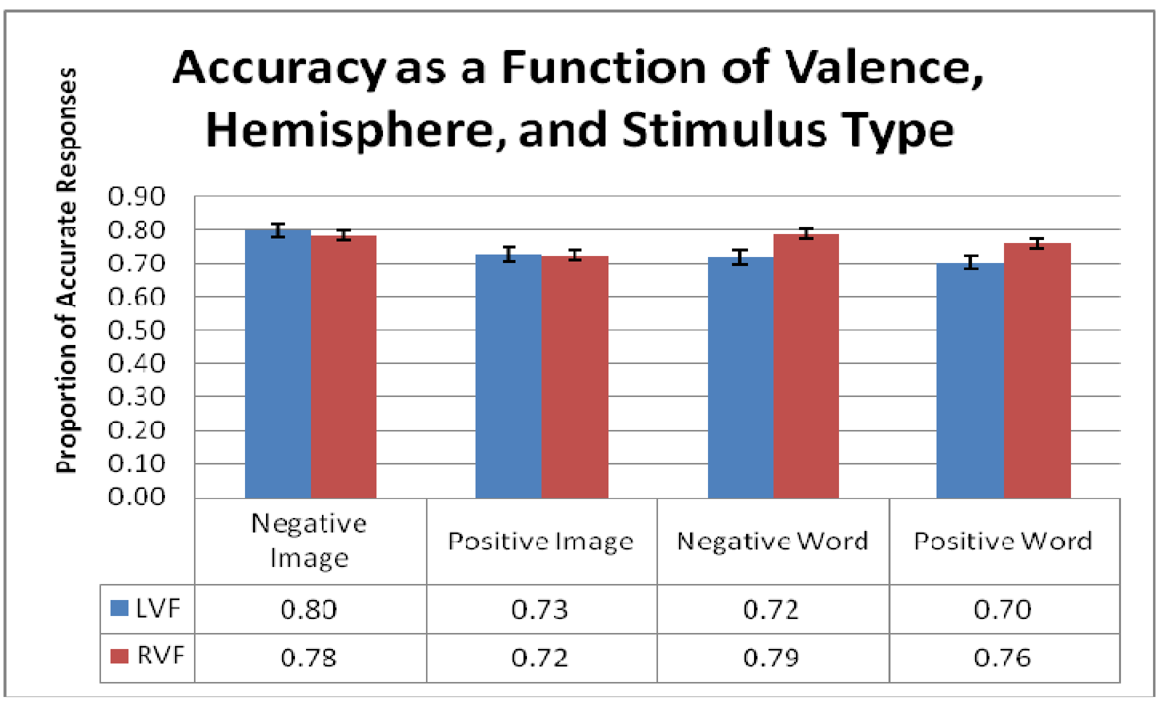


Figure 2. Proportion of accurate responses as a function of valence, hemisphere, and stimulus type. Mean proportion of accurate responses for each trial type is displayed.

The proportion of accurate responses for the LVF was 0.73 (*SD* = 0.19, *SE* = 0.03) and for the RVF it was 0.76 (*SD* = 0.21, *SE* = 0.03). This difference was significant while controlling for handedness ($F(1, 35) = 4.00$, $p = 0.05$, $r = 0.32$, two-tailed). This effect was in the opposite direction of what was expected by hypothesis two. Hypothesis two predicted the proportion of accurate responses for stimuli presented to the LVF would be greater than for the RVF while controlling for handedness. In order to understand the nature of the interaction the participants were dichotomized based on handedness the results were represented graphically. Greater accuracy was observed for presentations to the RVF for strongly right handed participants and similar accuracy for both visual fields for left-handed, ambiguous-handed, and moderately right-handed individuals (see Figure 3). Because the RHH predicts that emotional material is best processed by the RH, an accuracy advantage for LVF stimuli was predicted. These results, especially for right-handers, are in the opposite direction, of what was expected based on the RHH.

In order to obtain another view of the above interaction, the participants were divided into groups based on their self-reported handedness. Viewed in this way the interaction suggested that left-handed individuals showed the opposite pattern of results that right-handed participants showed. Left-handed participants were more accurate in perceiving emotion when stimuli were presented to the RH. Because their results were opposite the right handed participants, this suggested that some, if not all of the left handed participants, were reverse dominant. Additionally, examining the below figure compared to the above figure suggests that some of the moderately right handed individuals were also reverse dominant. If the left-handed participants were reverse

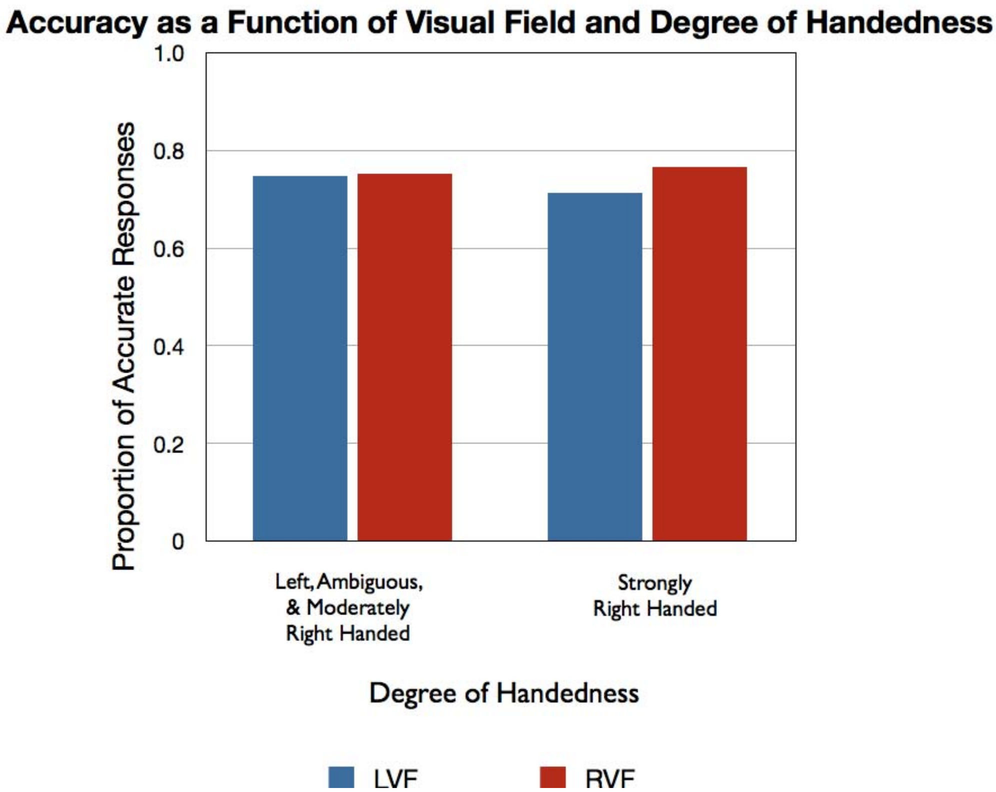


Figure 3. Proportion of accurate responses by visual field after dichotomizing participants into strongly right-handed individuals (EHI > 75) compared to the combined left-handed, ambiguous, and moderately right-handed individuals (EHI ≤ 75). Strongly right handed individuals were more accurate in judging emotional content of stimuli when it was presented to the LH. The second group, left, ambiguous, moderately right handed appeared to have similar accuracy for either side of visual presentation.

dominant then RHH would indicate that LH would be more accurate at perceiving emotional stimuli. These results are opposite what would be expected by RHH. (see Figure 4).

None of the other accuracy interactions were significant.

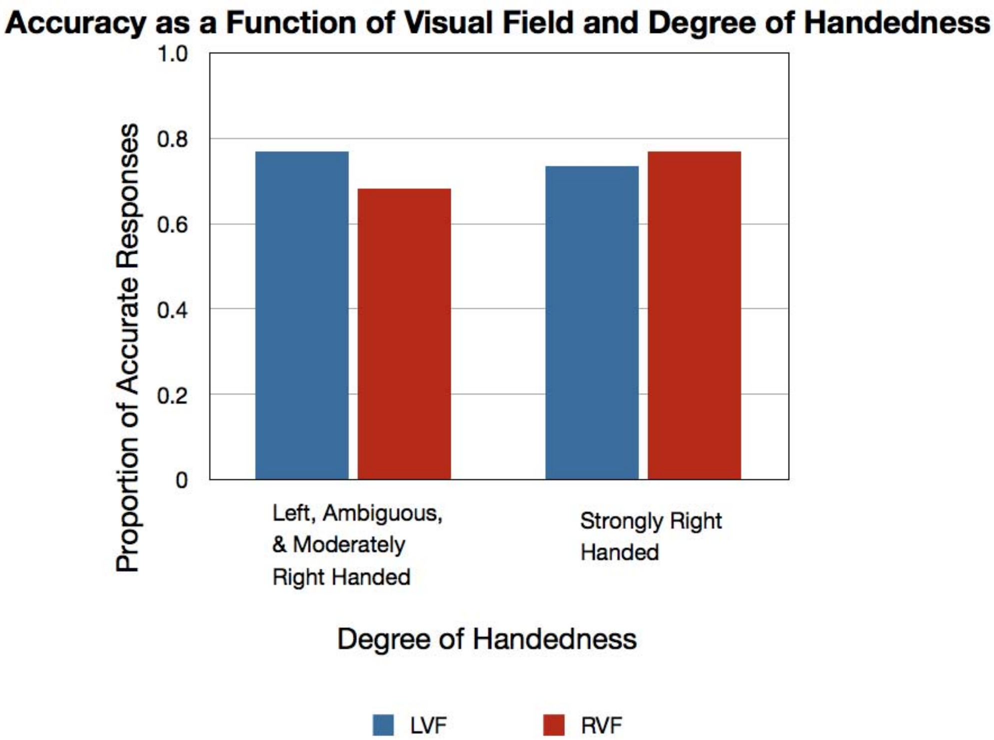


Figure 4. Proportion of accurate responses as a function of visual field and self-reported handedness (3 left handed versus 35 right handed participants). Separating the data in this way suggested that right handed individuals were more accurate in judging emotional content of stimuli when it was presented to the LH. Left handed individuals were more accurate when stimuli were presented to the RH. This suggests the left handed individuals in this study were likely to be reverse dominant. These results are the opposite of what was hypothesized based on the RHH.

Reaction Time

Standardized reaction times for each experimental condition were computed and are presented in Figure 5 below.

The average standardized reaction time to negative stimuli was -0.12 (SD = 0.39, SE = 0.02) and for positive stimuli it was 0.02 (SD = 0.32, SE = 0.02). This main effect of valence was found to be marginally reliable, but did not reach significance (F(1, 35) =

3.46, p = 0.07, two-tailed). While not conclusive, this suggested that participants responded more quickly to negatively valenced stimuli (M = 846.11 ms, SD = 88.20 ms) than to positively valenced stimuli (M = 891.06 ms, SD = 58.39 ms).

Speed of reaction times for the LVF (M = -0.03, SD = 0.37, SE = 0.02) were not significantly different from of the RVF (M = -0.06, SD = 0.35, SE = 0.02; F(1, 35) = 0.01, p = 0.92, two-tailed). When handedness was controlled for the difference was still not significant (F(1, 35) = 0.42, p = 0.52, two-tailed). These findings are contrary to the RHH, which would predict that reaction times to the LVF would be faster when controlling handedness. These findings do not support hypothesis one.

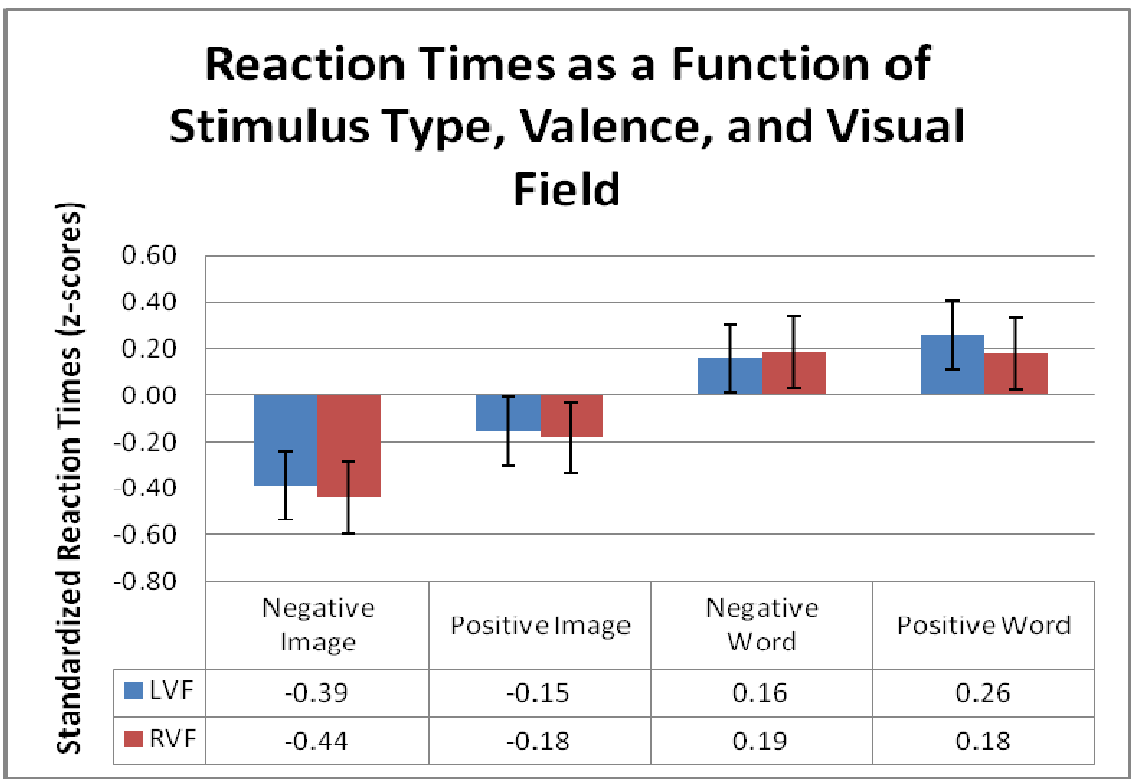


Figure 5. Standardized reaction times (z-scores) as a function of valence, visual field, and stimulus type. Means for each experimental condition are displayed separated by stimulus type, valence, and visual field. As can be seen from the graph, reaction time to images was faster than to words.

The mean standardized reaction time for images ($M = -0.30$, $SD = 0.27$, $SE = 0.02$) was faster than for words ($M = 0.20$, $SD = 0.27$, $SE = 0.03$; $F(1, 35) = 34.20$, $p < .001$, $r = 0.70$, two-tailed). This suggests that reaction times for pictures ($M = 805.58$ ms, $SD = 10.93$ ms) were faster on average than reaction times for words ($M = 931.59$ ms, $SD = 4.34$ ms). This finding was a large effect.

A significant visual field X stimulus X handedness interaction was seen ($F(1, 35) = 4.62$, $p = 0.039$, two tailed), with a medium sized effect ($r = 0.34$). Standardized reaction times for the LVF were faster for images ($M = -0.28$, $SD = 0.27$, $SE = 0.03$) than for words ($M = 0.21$, $SD = 0.29$, $SE = 0.04$). Standardized reaction times for the RVF were also faster for images ($M = -0.31$, $SD = 0.26$, $SE = 0.03$) than for words ($M = 0.19$, $SD = 0.24$, $SE = 0.03$). The RVF had faster responses than the LVF for images and for words. This interaction was significantly affected by degree of handedness. To understand this interaction more clearly the participants were divided in half based on their EHI scores and separate graphs were generated for each group. The two graphs below illustrate the different patterns of results based on degrees of handedness. Figure 6 represents individuals who indicated a strong right hand preference obtaining scores from 76 to 100 on the EHI. When responding to images, strongly right-handed individuals were faster when the image was presented to the RVF than when it was presented to the LVF. Strongly right-handed individuals showed the same pattern of response to words, faster when presented to the RVF than when presented to the left, suggesting that the LH responded more quickly for all types of emotional stimuli. This was contrary to hypothesis five which indicated that the LH would respond more quickly to words and the RH would respond faster to images. Given RH superiority for visuospatial information this finding was unexpected. It appeared that for strongly right-handed individuals the LH was faster at completing the emotional experimental task.

Individuals who indicated either left, moderately right, or ambiguous handedness (based on EHI scores ranging from -100 to 75) showed a different pattern of results. When responding to images these individuals showed similar reaction times when the emotional image was presented to the RVF and to the LVF. This suggested that both the LH and RH were equally fast at deciding whether an image was emotional. However, when responding to words, these individuals had slightly faster response times when

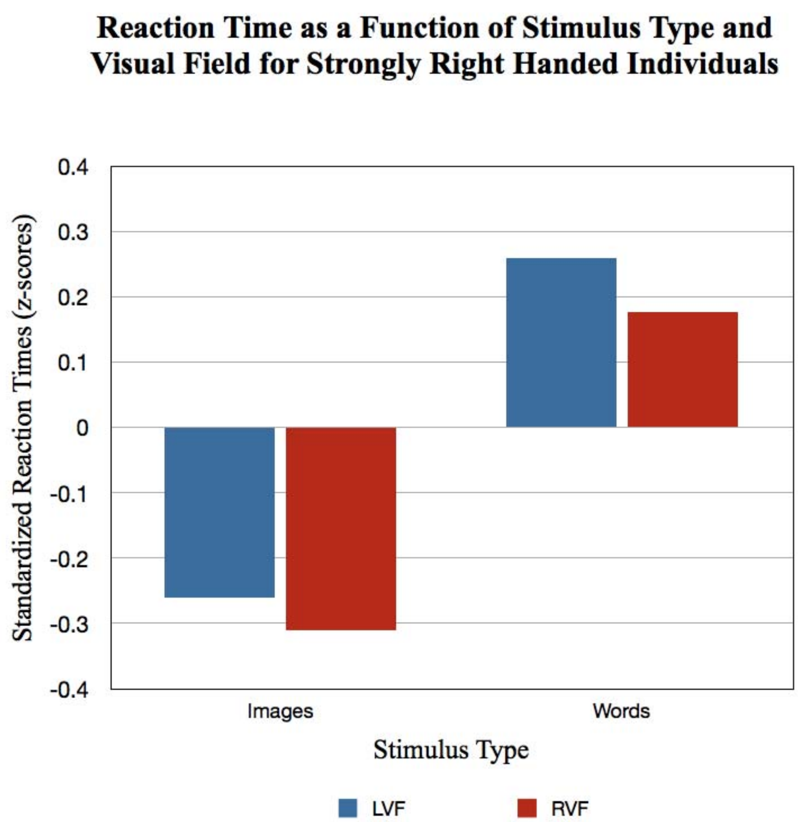


Figure 6. Standardized reaction times for strongly right-handed individuals across visual field and stimulus type. Reaction times were faster for images than words and within each stimulus category reaction times were faster when presented to the RVF.

words were presented to the LVF than to the RVF. These results suggested similar reaction times were seen for images in both hemispheres, with the LH possibly slightly faster for images than the RH, and the RH responded more quickly to words regardless of the valence of the emotional stimulus. (see Figure 7)

Generally, this study found unexpected results with regards to the perception of emotion. Perception of emotion data were expected to favor the RHH. Faster reaction times and better accuarcy for all emotional stimuli was expected. The experimental task required emotional processing to complete so it was expected that RH superiority for perception of emotion would cause faster more accurate responses when stimuli were

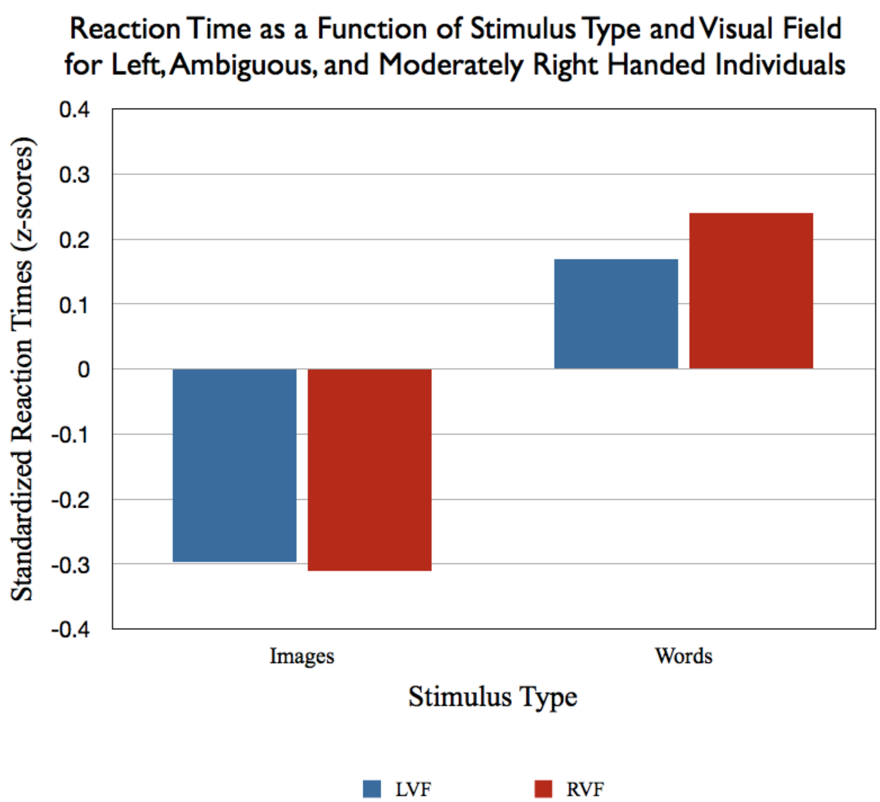


Figure 7. Reaction time pattern for left-handed and moderately right-handed individuals as a function of visual field and stimulus type.

displayed to the LVF. What was found instead, was better accuracy for this speeded task for the LH. Furthermore, for strongly right-handed participants it appeared that the LH was also faster at percieving emotion. Because a LH hypothesis is unlikely given the accumulation of data that has indicated RHH support for perception of emotion, other possible interpretations were considered. Strangly, these data appeared similar to emotional Stroop data. Perhaps the data from Experiment 1 could also be explained by interference. This would suggest that the RH was dominant for emotional perception and it engaged in more processing of the emotion than the LH. The extra processing done by the RH caused it to be more slowed down in completing the experimental task. The automatic processing also interfered with the RH's accuracy at the perception task under speeded conditions. This would be consistent with Algom**,** Chajut, and Lev's (2004) theory that emotion causes a "generalized slow down" for all tasks. It appeared from the current data that because the RH is dominant for emotion it is more "slowed down" by it than the LH, which does not engage in as in depth of processing of the emotion.

CHAPTER THREE

EXPERIMENT 2

Method

Methods were identical to Experiment 1 except where specified below. Participants were only allowed to participate in either Experiment 1 or Experiment 2 since the experiments were run concurrently with the same stimuli.

Participants

There were 34 participants. One participant chose to discontinue the study, so demographic information, but not SCR or accuracy data were obtained.

Power Analysis

Sample size was estimated for a power of 0.80 for an effect size of 0.36 with an estimated correlation among the repeated measures of 0.50. The effect size estimate was calculated from the three-way interaction found for groups X hemisphere X valence for an another SCR study, which showed support for the VH (Zaidel et al., 1995). This study also used short presentation times (50 ms) and was judged to be a comparable study to obtain an effect size for the current study. The above power analysis provided adequate power to find a medium effect size given that there was a large correlation among the repeated measures. The sample size needed was estimated to be 10 participants. Because 34 participants were actually collected the power was estimated to be 0.99.

Materials

For Experiment 2, there were less stimulus displays, 40 with images and 40 with words.

Procedure

Prior to starting the SCR experiment the participants were directed to a sink to wash their hands with warm soap and water because SCR is affected by skin cleanliness, oil, dirt and dead skin (Dawson et al., 2000). Neotrode electrodes (ConMed Corporation, Utica) were then attached to the distal phalanges of the 2nd and 3rd fingers of the participant's non-dominant hand. This site was chosen because of the large number of sweat glands present there and the relative lack of calluses in comparison to the dominant hand (Dawson et al., 2000). The experimental task was explained as in Experiment 1, except participants were not told to give a speeded response to stimuli. They were told there would be a pause after the stimulus pairs were displayed. They were asked to remember whether the left or right stimulus was more emotional while they waited. They were told not to make any movements or give any response until a screen appeared asking for a response. The pause after the stimulus display without movement or response from the participant was necessary to reduce task irrelevant SCRs from occurring. After the pause a screen appeared and stated: press the 'z' key with the index finger of your left hand if the more emotional stimulus appeared on the left side and press the 'm' key if the more emotional stimulus appeared on your right side with your right index finger.

Two changes were made to the sequence of stimulus displays, but all other timing remained the same. After a stimulus pair was presented a blank light grey screen appeared for 7500 ms. Afterwards a screen appeared asking for a response, as mentioned above. This screen remained until a response was given. Participants were given as much time as they needed to respond. Their response initiated the next trial. SCRs were recorded for each presentation. SCR was scored as the largest peak with a response onset occurring between 1-5 seconds after the stimulus onset; earlier and later SCR were disregarded as not stimulus relevant (similar to procedure from Zaidel et al., 1995). A Psylab Stand Alone Monitor (SAM; Contact Precision Instruments, Boston) was used to collect the SCRs with an Isolation Bioamplifier (Contact Precision Instruments, Boston) used to collect SCR. Psylab8 (Contact Precision Instruments, Boston) was used to process the SCR data. A square root transformation was performed in order to normalize the distribution of SCRs (Dawson et al., 2000).

Data Preparation

Square root transformation is a standard method for correcting skew for SCRs and this was done for the current data (Dawson et al., 2000). Examination of the SCR data revealed that a number of participants were non-responders, who produced either no skin conductance amplitudes or produced too few responses to be included in the analysis. For the SCR analysis, participants were included if they obtained a sufficient number and variety of SCR such that responses to at least two experimental conditions could be compared. Twenty-two of the participants produced a sufficient number of SCRs to be included in the analysis. All 33 participants were used for the accuracy analysis.

Statistical Analysis

Two repeated measures ANCOVAs were done. Both had three within subject factors: 2 (picture valence: positive or negative) X 2 (stimulus type: word or picture) X 2 (visual field: LVF or RVF). The covariate was degree of handedness as measured by the EHI for both. SCR magnitude was the dependent measure for one and proportion of accurate responses was the dependent variable for the other.

Results and Discussion

Sample Characterization

Participants for this study were taken from an undergraduate university with a diverse student population in terms of both age and ethnicity. Table 2 shows the characterization of this sample for use in understanding how the results of this study generalized to the population. Additionally, one participant asked to discontinue the experimental portion of the study due to the graphic nature of some of the images. This participant did provide demographic information and the EHI, but did not provide SCR to the computerized portion of the experiment.

Handedness

This sample obtained EHI scores from -50 to 100 with a mean score of 72.59 (*SD* = 30.56) with most participants indicating a strong right hand preference (*Mode* = 100).

Table 2

Demographic Characteristics of Experiment 2 Participants

Sample Characteristics	Number (%)	Mean (*SD*)
Gender		
Female	30 (88.2%)	
Male	4 (11.8%)	
Age (years)		23.6 (7.7)
Ethnicity		
Hispanic	16 (47.1%)	
African American	11 (32.4%)	
Caucasian	4 (11.8%)	
Asian	1 (2.9%)	
Mixed Race	2 (5.9%)	
Handedness		
Right	30 (88.2%)	
Left	1 (3.0%)	
Ambiguous	3 (8.8%)	

Accuracy

For this experiment participants were 80% (*SD* = 8.6%) accurate on average. This suggested slightly better accuracy for Experiment 2. There may have been a speed-accuracy trade off for Experiment 1. For each participant, the percentage of accurate responses for each trial type was computed in order to compare accuracy across trial type. Mean proportions of accurate responses for each experimental cell are presented in Figure 8 below.

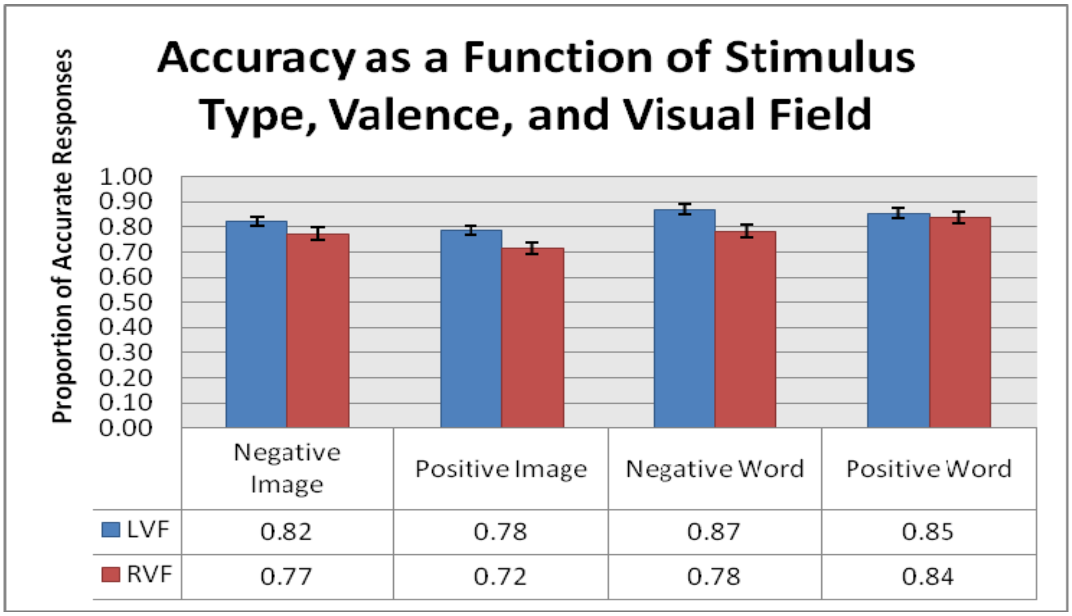


Figure 8. Proportion of accurate responses as a function of stimulus type, valence, and visual field. Means for each experimental condition are displayed.

All main effects were examined. Proportion of accurate responses for the LVF (M = 0.84, SD = 0.17, SE = 0.02) was greater than for the RVF (M = 0.78, SD = 0.17, SE = 0.02). This finding of better accuracy when emotional targets were presented to the RH was significant ($F(1, 31) = 3.75$, $p = 0.03$, $r = 0.33$, one tailed; see Figure 9). This is consistent with hypothesis two. This suggested that for unspeeded conditions the RHH was supported for accuracy in emotional perception. However, this finding was lost after controlling for handedness ($F(1, 31) = 0.88$, $p = 0.18$, one tailed). This suggested that there may have been fewer reverse dominant participants in this experiment as compared with Experiment 1.

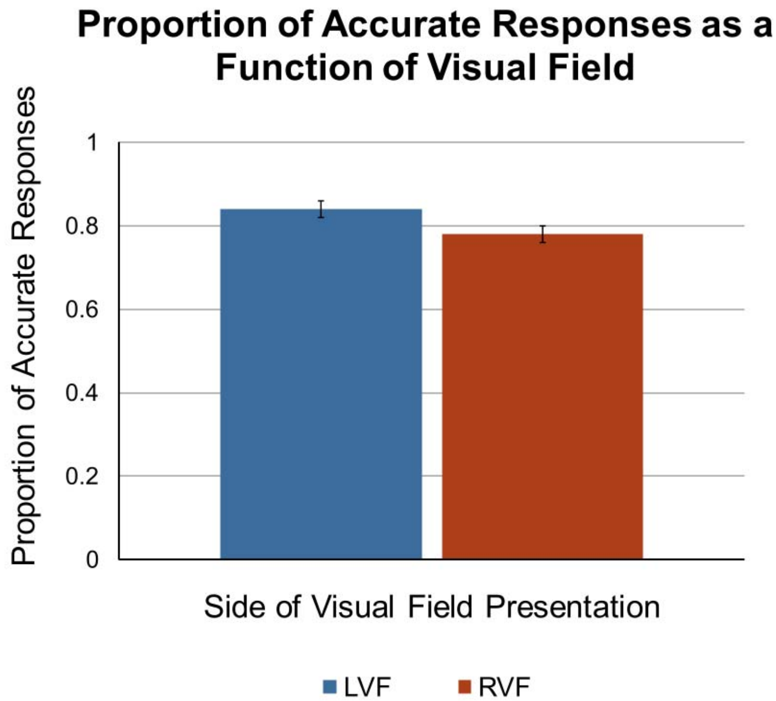


Figure 9. The proportion of accurate responses for Experiment 2 as a function of visual field presentation are shown above. Participants responded more accurately in the unspeeded judgment of emotional content when it was presented to the RH regardless of valence. This suggested RHH support, and supported hypothesis two of the current study.

Participants were more accurate when responding to words (M = 0.84, SD = 0.17, SE = 0.02) than to images (M = 0.77, SD = 0.17, SE = 0.02). This main effect of stimulus type was significant and was a large effect ($F(1, 31) = 10.13$, $p = 0.003$, $r = 0.50$, two tailed; see Figure 10).

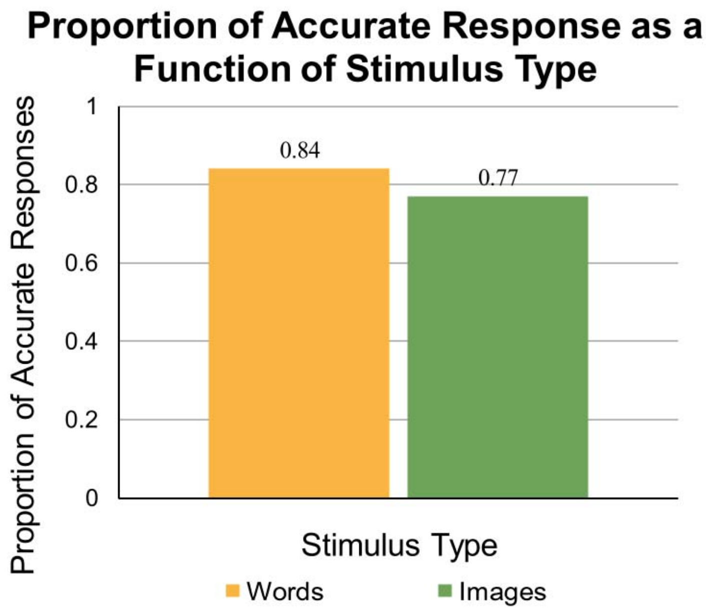


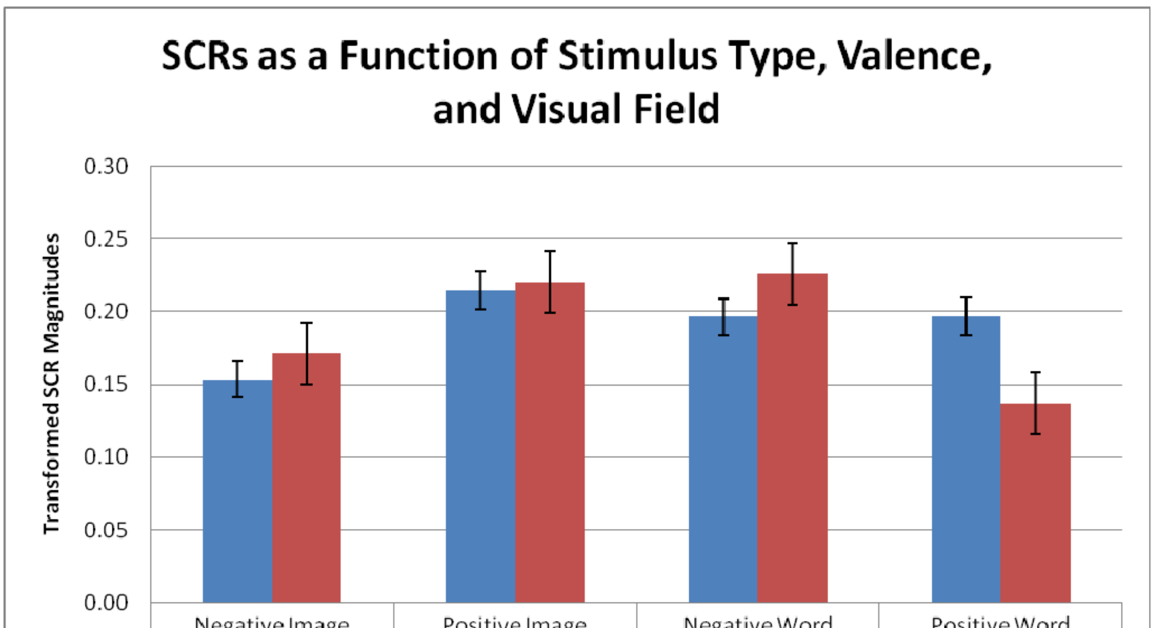
Figure 10. Proportion of accurate responses as a function of stimulus type. Participants were more accurate in responding to words than to images when the task was unspeeded.

The average proportion of accurate responses to positive stimuli was 0.80 (*SD* = 0.15, *SE* = 0.01) and to negative stimuli was 0.81 (*SD* = 0.19, *SE* = 0.03). This difference was insignificant indicating no main effect of valence with ($F(1, 31) = 0.02$, $p = 0.88$, two tailed) or without controlling for handedness ($F(1, 31) = 0.003$; $p = 0.96$; two tailed). Consistent with hypothesis two, there was no interaction between valence and side of visual field presentation for the accuracy data ($F(1, 31) = 0.73$, $p = 0.40$, two tailed).

Proportion of accurate responses for LVF presentations of words was 0.87 (*SD* = 0.17, *SE* = 0.02) and for images was 0.80 (*SD* = 0.16, *SE* = 0.02). Proportion of accurate responses for the RVF for words was 0.81 (*SD* = 0.17, *SE* = 0.02) and for images was 0.74 (*SD* = 0.17, *SE* = 0.02). No significant visual field X stimulus type interaction was found with (F(1, 31) = 0.07; p = 0.79; two tailed) or without (F(1, 31) = 0.05; p = 0.83; two tailed) controlling for degree of handedness. This indicated that accuracy did not depend on which type of stimulus was presented to which hemisphere. These results did not support hypothesis three.

Skin Conductance Response Findings

No significant main effects or interactions were found with respect the SCR variable. Findings did not support hypothesis four. Below is a graph which illustrates the mean transformed SCRs for each experimental condition (Figure 11).



	Negative Image	Positive Image	Negative Word	Positive Word
LVF	0.15	0.21	0.20	0.20
RVF	0.17	0.22	0.23	0.14

Figure 11. Transformed SCRs s as a function of stimulus type, valence, and visual field. Means for each experimental condition are displayed separated by stimulus type, valence, and visual field. There were no significant main effects or interactions.

The average transformed SCR for the LVF was 0.19 (*SD* = 0.24, *SE* = 0.05) and the average for the RVF was 0.19 (*SD* = 0.22, *SE* = 0.04). Average SCR did not differ based on visual field while controlling for handedness ($F(1, 20) = 0.85$, $p = 0.37$, two-tailed). This finding did not support RHH, which would have predicted larger SCR magnitudes for LVF presentations.

For images the average transformed SCR was 0.19 (*SD* = 0.24, *SE* = 0.05) and for words it was 0.19 (*SD* = 0.22, *SE* = 0.04), which indicated there was no difference in magnitude of SCR based on stimulus type ($F(1, 20) = 0.002$, $p = 0.97$, two-tailed). Emotional response to images and words was equivalent. On average both stimulus types evoked the same size of emotional response.

There was also no difference in the magnitude of transformed SCRs for negative (*M* = 0.19, *SD* = 0.23, *SE* = 0.05) or for positive stimuli (*M* = 0.19, *SD* = 0.23, *SE* = 0.05; $F(1, 20) = 1.36$, $p = 0.26$, two-tailed). Both positive and negative stimuli, on average, elicited similar a magnitude of emotional response. Stimuli were chosen such that the normed arousal ratings for positive and negative stimuli were equivalent and this finding experimentally verifies their equivalence for this sample.

To test the VH, the interaction between valence and visual field for SCRs was examined. There was no significant difference in SCR amplitudes to positive versus negative targets when side of visual field presentation was compared while controlling for degree of handedness ($F(1, 31) = 0.06$; $p = 0.81$; two tailed). When the pattern of results was examined it was actually opposite what would be expected by the VH. Though insignificant, the RH responded more strongly to positive (*M* = 0.21, *SD* = 0.26, *SE* = 0.05) than to negative stimuli (*M* = 0.17, *SD* = 0.22, *SE* = 0.05). LH responded more strongly to negative stimuli (M = 0.20, SD = 0.24, SE = 0.05) than to positive stimuli (M = 0.18, SD = 0.20, SE = 0.04).

To examine whether the type of stimuli affected SCR results for valence and visual field the three-way valence X visual field X stimulus interaction was examined which controlled for handedness. No significant interaction of SCR magnitude was found for stimulus type, valence, and side of visual field presentation when handedness was controlled for ($F(1, 35) = 1.50$, $p = 0.23$, two tailed; see Figure 11).

Generally, in terms of the accuracy of emotional perception for unspeeded responses, these data supported that RHH. The RH was more accurate than the LH for identify all types of emotional content. No interaction was found between valence and visual field for accuracy so no support was shown for the VH for perception of emotion. No support was found for the VH for experience of emotion either. There were no significant findings for SCR, including the expected valence by visual field interaction while controlling for handedness. Furthermore, there was no main effect of visual field, so the RHH was not supported for experience of emotion either. The current study could not support the VH or RHH for experience of emotion as no lateralized differences were found for SCR.

CHAPTER FOUR

GENERAL DISCUSSION

Overall, it appeared that for unspeeded conditions the RH is more accurate at emotional perception. For strongly right-handed individuals and speeded conditions it appeared that the RH was slower and less accurate for emotional perception than the LH.

Unexpectedly, speeded accuracy for indicating the location of the more emotional target suggested that right-handed individuals responded more accurately to RVF presentation. Left-handed individuals responded more accurately to LVF presentation. This suggested the LH was more accurate for speeded conditions for emotional perception for individuals who were likely to have normal dominance. Because a "left hemisphere hypothesis" of emotion is untenable considering the literature as a whole, a more plausible explanation of the current data was that interference occurred for this task. This is similar to results found in other speeded tasks such as emotional Stroop tasks (e.g. Borkenau & Mauer, 2006) and some lexical decision tasks (Mohr et al., 2008). This study suggests that findings such as these can be found not only with words, but with images. Other studies have shown Stroop interference with colored face stimuli (Putman et al., 2004).

RHH support was expected for the speeded accuracy data because it was an emotional perception task. It was expected that the dominant hemisphere for emotion would be faster and more accurate at this task. Contrary to hypothesis, it appeared that automatic emotional processing done by the RH did not facilitate the conscious speeded emotional perception task in this study. Participants were asked to respond as quickly as possible and typically made their judgments in just over half a second to just over one second (*M* = 868.58 ms, *SD* = 234.22 ms). It appears that the RH's ability to process emotion accurately may take more time than the speeded task required for a response. The emotional stimuli appeared to slow down RH's ability to make a behavioral response indicating which stimulus was most emotional. Similar effects have been seen in Stroop tasks. In Stroop tasks an automatic process interferes with a conscious task (Stroop, 1935). Traditionally, this has been shown by asking participants to name the color of ink for words with incongruent color names. For example, the word 'red' is printed in green ink. Because the participant automatically reads the word 'red,' this interferes with their ability to respond by saying 'green.' In an emotional Stroop task participants name the color of emotional and non-emotional words. The automatic processing of emotional stimuli is thought to interfere with the experimental task of naming the ink color, or producing a behavioral response to the stimuli. Processing the emotion is thought to be automatic, much like word reading is automatic, and leaves less processing resources for the unrelated experimental task of naming the ink color. This is thought to occur because processing of the emotion and naming ink color are separate, unrelated tasks and therefore interfere with each other. This causes a delayed and less accurate response to emotional stimuli.

The automatic processing of emotion by the RH in the current task was expected to facilitate the experimental task, because the experimental task required processing of the emotional stimulus to complete. The data suggested that under speeded conditions the automatic processing of the emotion done by the RH interfered with accurately choosing the most emotional stimulus. Conversely, the LH was more accurate. Presumably it was able to perform the conscious task unimpeded by any automatic emotional processing. Very unexpectedly, this suggested that under timed conditions the automatic processing of emotion does not facilitate, but rather impedes the conscious processing of the emotion. Perhaps emotion captures attention in the RH to such a degree that less processing resources were left to attend to the experimental task. The data suggested that when rushed, requiring a response within about a second, a person's left hemisphere is more accurate at perceiving emotion.

For Experiment 2 unspeeded accuracy was evaluated for a similar experimental design. Participants were asked to wait 7.5 seconds before responding. Better overall accuracy by about 5% was seen for Experiment 2 (M = 80%; SD = 8.6%) with unspeeded conditions, than for Experiment 1 (M = 75%; SD = 16.52%), which was speeded. Additionally, the unspeeded experiment results showed better accuracy for the RH. Taken with the results of Experiment 1, this suggested that under very tight time constraints, such as just over one second, the RH was more impaired at the task. However, given 7.5+ seconds to respond, the RH was more accurate at the experimental task. This suggested that if a response was required very quickly the LH was more accurate at rudimentary emotional identification than the RH. It appeared from the data that clear RHH support may be better seen when RH has more than 1-2 seconds to accurately perceive emotion. After a few seconds, presumably after the majority of the automatic processing of the emotion was finished, the RH was able to use that information to make more accurate emotional judgments than the LH.

For the reaction time data an interaction was found with visual field, stimulus, and degree of handedness. This indicated a different pattern of response to stimulus type based on visual field for right-handed and left-handed individuals. For strongly right-handed individuals the LH was faster for all emotional stimuli regardless of valence regardless of stimulus type. For left-handed individuals, results were less clear, however which hemisphere was faster appeared to depend upon stimulus type. The results for right-handed participants were again unexpected, as they suggested that the LH was faster at emotional perception. The consistency between these reaction time results and the accuracy results suggested that perhaps interference had occurred and these data actually suggested RHH support.

In Experiment 1 it was emphasized that success on the task was measured in terms of both accuracy and speed. To be most efficient at this task a very quick, rudimentary, identification of an arousal component in stimuli was needed. It may be that both hemispheres possess a rudimentary ability to identify emotionally arousing stimuli regardless of valence type. Because the emotional stimuli in this experiment had intense valence, it is possible that the emotional elements were clear enough for either hemisphere to detect. Thus when an emotional stimulus was presented to the LH it was able to quickly identify the target and initiated a response. However, when an emotional stimulus was presented to the RH it may become involved in further automatic processing of the emotional content of the stimulus which slowed down the response. Given the above explanation the RH would be less accurate and more slowed down by emotional stimuli. Viewed this way the results appear to support the RHH. In summary, emotional stimuli appeared to slow down or impede strongly lateralized right-handed individuals when presented to the RH more than to the LH.

Emotion Causes a Generalized Slow Down

These results are consistent with Algom and colleagues (2004) theory that the emotional Stoop effect is actually not a Stroop effect. They contend that it is a generic slow down caused because any emotional content (Algom et al., 2004). Reading emotional words was found to be slower than reading neutral words under blocked conditions by about the same amount that emotion slowed down performance in emotional Stroop. Based on these results, they concluded that the slow down effect was not specific to Stroop. They cited Öhman, Flykt, and Esteves (2001) to support the idea that emotion captures attention in all situations and resources are directed to processing emotional stimuli first. McKenna and Sharma (2004) concur with the theory that emotional Stroop does not operate based on the same mechanisms as a classic Stroop. Rather than being caused by conflicting processes they suggested that an "emotional intrusion effect" occurs (pg. 382). The theory of Algom and colleagues is consistent with the findings of the current study. The current study suggested that even an emotional discernment task is slowed down by emotional stimuli.

Stroop tasks typically use negative emotion. Supporting the current study are findings that emotional Stroop effects are seen for both positive and negative stimuli (Richards, French, Johnson, Naparstek, & Williams, 1992). Richards and colleagues (1992) found no differences in the amount of interference caused by positive and negative words in unblocked trials when comparing participants who were high or low on anxiety measures. Another recent study done with normal healthy participants (Dresler et al., 2009) found that positive and negative words matched on arousal both produced longer reaction times when compared to neutral words. They concluded that arousal caused the interference rather than valence. This is consistent with the current study both positive and negative stimuli slowed down responding.

The current study is most consistent with literature suggesting that emotion slows down response time for all tasks. Viewed this was the current results appeared to support RHH for perception of emotion. Because the RH is dominant for perception of emotion it engaged in automatic processing of the emotional stimulus that interfered with the experimental task. This caused the RH to be slower and less accurate in responding to emotional stimuli under speeded conditions because its dominance for processing emotion caused it to be more slowed down by emotional stimuli than the LH. For unspeeded conditions, results showed that given sufficient time the RH was more accurate at perceiving emotion.

Valence Hypothesis and Experience of Emotion

For experience of emotion neither VH nor RHH support was found as there were no significant findings for SCR magnitude. Because SCR is a measure of experience of emotion, VH support was expected. The lack of SCR results is generally consistent with findings of Glascher and Adolphs (2003) with post-surgical epilepsy patients. They did not find differences in SCR based on side of stimulus presentation using IAPS images. Additionally, they found no significant differences between SCR recordings taken from the left hand versus the right hand. Due to this, taking SCR from only the non-dominant hand in the current study was not likely the cause of null results.

The findings of this study are inconsistent with a recent study by Kimura, Yoshinoa, Takahashib, and Nomura (2004) which found greater SCR to negative stimuli when presented to the RH than to the LH with briefly presented (30 ms) masked stimuli. While this study did not include positive pictures and so did not inform the debate between RHH and VH it did show lateralized results with regard to negatively valenced stimuli, which was not seen in the current study.

Additionally, a study by Zaidel and colleagues (1995) measuring SCR with 30 ms presentation of lateralized emotional line drawings found support for the VH, with the RH being particularly sensitive to negative stimuli. Their study showed the visual field by valence interaction that was expected, but not found in the current study.

Effect of Stimulus Type

A main effect of stimulus was significant for the reaction time experiment. It was found that reaction times to images were faster than to words. This effect was not originally hypothesized, as it was not the primary effect of interest. However, given that words are symbolic representations of concepts, and images are graphic representations it is reasonable to conclude that reaction times to images would be faster than to words. Raccuglia and Phaf (1997) conducted series of experiments which involved a lateralized task with words as targets and faces as emotional primes for the first experiment and faces as targets and words as emotional primes for the second experiment. This study provided a good comparison to the current study because it had a condition with similar presentation time. It also involved a similar task in that participants were asked to judge the emotional content of the target stimulus. The current study asked participants to evaluate whether a target had emotional content, whereas Raccuglia and Phaf asked their participants to evaluate whether the target was positive or negative. They were asked to press a different computer key for positive than for negative stimuli making the task slightly more complicated in terms of response. In the first experiment participants were asked to evaluate whether each word was positive or negative. In the second experiment they were asked whether each face was positive or negative. They used two presentation times: 20 ms, 200 ms. For the presentation time closest to the current study (200 ms) the first group of participants on average took 716 ms to respond to word targets and the second group took 593 ms to respond to face targets. Their study showed a difference in word targets versus picture targets of 123 ms. The current study showed a comparable difference of 126 ms between word and picture targets. These results generally supported what was found in the current study. Faster response to images than words would not necessarily affect lateralized emotion experiments, however. Because a main effect of visual field, or the interaction between valence and visual field, is what is examined to differentiate RHH from VH a main effect of stimulus type probably would not obscure results.

The interaction found for visual field X stimulus X handedness for reaction times may be affecting lateralized emotion research. Strongly right-handed individuals responded faster when stimuli were presented to the LH for both words and images, whereas left, ambiguous, and moderately right-handed individuals appeared to have similar speed with both hemispheres to images and are slightly faster with words presented to the RH. Results for the strongly right-handed individuals appeared to support the RHH if they are viewed in terms generalized slowdown for emotion (Algom el al, 2004). Overall, it appeared that stimulus type may affect laterality of emotion experiments more for less strongly lateralized, or reverse dominant individuals (i.e. left, ambiguous, moderately right handed individuals showed less clear results). This suggested that measuring degree of handedness in lateralized research may be important.

It is not clear why participants in Experiment 2 were more accurate with words than with images, since this effect was not seen in Experiment 1. Perhaps it was easier to remember words than images during the delay. Time between emotional stimulus presentation and response may be an important variable in this area of research. These results require replication in order to determine if they are reliable.

Motivational Theories

A BIS-BAS (Fowles, 1988; Fowles, 1994; Gray, 1987) explanation would suggest that the LH controls all response initiation, either approach or withdrawal. This would suggest that for speeded conditions LH might have responded more quickly to all emotional targets because a behavioral response was required. This was seen for strongly right-handed individuals in Experiment 1. Given the pattern of results the BIS-BAS theory appeared to be supported by data of strongly right-handed individuals in this experiment. However, BIS-BAS theory would not explain accuracy results for emotional perception under speeded conditions being better for the LH.

Root and colleagues (2006) suggested that approach-withdrawal elements may affect laterality experiments. They stated that in many laterality experiments the RH's specialization for processing facial expressions has been confounded with the RH's dominance for a withdrawal response when the emotion presented was negative. They contended that this combination produced a strong RH advantage, thus giving RHH support (Root et. al., 2006). They expected that positive facial expressions would produce less support for RHH and possibly VH support depending on the task (Root et al.). Their theoretical viewpoint with regards to how time pressure would affect results was consistent with the data found in the current study. They stated:

> If the LH is recruited at the stage of response preparation and action, then LH dominance would be more likely. This would be particularly the case if the subject were actively responding under time pressure rather than merely passively viewing the displays and responding at leisure, if responding at all. For positive stimuli that elicit approach, the LH bias for response would counteract the right hemisphere bias for recognition in determining the overall asymmetry, leading to an attenuated RH effect or even a reverse bias in favor of the LH. (Root et al., 2006, pp. 474).

Given the tight time constraints in the current study the above theorizing appeared to be particularly relevant to the results found in this study for strongly right-handed participants. Furthermore, Root and colleagues (2006) suggested the LH's tendency to produce an approach response under time restrictions had the ability to essentially override the RH's bias for processing faces to a sufficient degree to produce a LH bias. Given that the image stimuli in this task were primarily non-face stimuli this tendency for the LH to trump the RH would be expected to be even more pronounced. While only half of the stimuli in this experiment were positively valenced, the left hemisphere bias was seen with all valence types in strongly right-handed individuals. This may have been sufficient to bias results in favor of the left hemisphere. Furthermore, even for negative stimuli, if the LH is dominant for behavioral initiation, as suggested by BIS-BAS, the LH would be recruited in order to initiate the key press.

Response Times for Negative versus Positive Stimuli

A marginally reliable main effect for valence suggested that participants had a tendency to respond more quickly to negative stimuli than to positive stimuli. The current study measured this difference at 44.95 ms which is consistent with Borkenau and Mauer's (2006) findings with emotional Stroop. They found longer reaction times for positive words (643 ms) as compared to negative words (637 ms) by about 6 ms. This finding is inconsistent, however, with a lateralized lexical decision task done by Mohr and colleagues (2008) which found that participants responded faster to positive attachment words than to anxious or avoidant attachment words. The current study's findings are also in contrast to an emotional Stroop task with images (Kunde & Mauer, 2008) which found slower response time to negative pictures (695 ms) than to positive pictures (676 ms) by about 19 ms. Their study involved priming with valenced pictures, making it less comparable to the current study. Differences in reaction times to positive versus negative stimuli appear to differ across different task demands. Given that it is a marginally reliable effect replication is necessary to determine whether these results are replicable for the task demands of the current study. From a survival standpoint it could be argued that reaction time to negative stimuli in the environment is more critical than reaction time to positive stimuli in the environment. However, going back to BIS-BAS theory (Fowles, 1988; Fowles, 1994; Gray, 1987) response to negative stimuli may be affected by whether the participant responded with fight, flight, or freeze (Wacker et al., 2008). If a stimulus elicited a freeze response then the participants might be delayed in responding with a key press, whereas if it elicited a fight response they might produce very rapid response.

Reverse Dominance

Degree of handedness appeared to be an important variable for identifying reverse dominance, particularly in right-handed individuals. In Experiment 1, for example, it appeared that some moderately right-handed individuals were reverse dominant. Certain results in this study were only significant if degree of handedness was controlled. Relying only on self-reported handedness may be insufficient for lateralized studies. For Experiment 2, there was less variability in degree of handedness; handedness was a less relevant factor with less variability. One participant reported left handedness and there was a more restricted range on the EHI than for Experiment 1. It is likely that there were more reverse dominant participants in Experiment 1 than in Experiment 2 accounting for this difference in findings.

Gender Differences in Laterality

Given the large proportion of females in the sample it is possible that gender was relevant to the results. A study by Graves, Landis, and Goodglass (1981) found that females showed more varied performance compared to males in a laterality task with emotional and non emotional words. Women were more accurate in deciding if an emotional word was a real English word when it was presented to the RVF as compared to the LVF (Graves, Landis, & Goodglass, 1981). Women were also found to have a LH advantage for emotional words; the LH was more accurate identifying emotional words compared to non-emotional words (Graves et al., 1981). Women's performance showed greater variability than men's performance. If women show greater variability in their lateralized performance, this may explain why the current study did not achieve all of the expected results; increased variability makes it less likely for lateralized results to be found.

The current study results of emotional interference in the RH for strongly right-handed participants for reaction times were consistent with another study done with only females (Van Strien & Valstar, 2004). This study found RH interference for all emotional words, but a larger effect for negatively valenced words (Van Strien, & Valstar, 2004).

Men on the other hand showed a RH advantage for emotional words (Graves, Landis, & Goodglass, 1981). This suggested that men may possess a greater ability to interpret abstract, emotional words with the RH than women (Graves, Landis, & Goodglass). Unfortunately, these results cannot differentiate between VH and RHH as 10 of the 12 words were negative and of the remaining 2 words one was equivocal as to the valence .

Limitations and Future Research Considerations

Motor Dexterity

The findings for strongly right-handed individuals may have been affected by strong right hand dominance for key pressing rather than specifically to the affect of emotion on the LH versus RH. Because they were very strongly right handed, they may have a greater difference in their motor response with right versus left-handed responses. Stimuli presented to the RVF always required a right-handed response for this task, so greater speed might have been due to being faster with the right hand. The left, ambiguous, and moderately right-handed individuals may have had better bilateral motor control. However, a motor control theory of the results, would not explain why individuals were more accurate in perceiving emotion in stimuli with the LH for speeded conditions. Given that the generalized slow down for emotion hypothesis fit both the accuracy and reaction time data better, especially for strongly right handed individuals, this theory has more explanatory value.

Novelty versus Learning

For future research some considerations should be made. The task used in this experiment was rather complex. Individuals were required to choose the more emotional target. Due to this, individuals were simultaneously searching for positive and negative stimuli. The advantage of this was that participants were responding to unexpected stimuli. For future research it may be useful to block the trails based on valence. For example, participants could be given four blocks of trials (2 negative, 2 positive). A simpler task might reduce the cognitive load of the participant during each block. Furthermore, it might cause the task to be more focused on identification of valence rather than arousal. Furthermore, induction of emotion across trials may make the emotional experience for the stimuli additive across the trials, which might produce clearer results. Alternatively, the trials could also be blocked based on stimulus type to reduce complexity.

The advantage of the current design is that every stimulus presentation is novel along the dimensions of valence, stimulus, and visual field. This design was thought to be more relevant to responding to real life, daily stimuli, encountered in the environment. However, a more basic, less complex, blocked design may be useful in clearly answering the hypotheses proposed in this study. Essentially, less complexity would likely reduce variance based on confusion in task parameters.

Elicitation of Emotional Response

This study utilized a very short presentation time, 250 ms. The length of presentation time was selected in order to prevent eye saccades, which ensured that the stimuli presented to the LVF were interpreted first by the RH and the stimuli presented to the RVF were presented first to the LH. A longer presentation would have allowed time for eye movement, which would have allowed both hemispheres to obtain direct access to each stimulus. Longer presentation might have elicited greater emotional response, thus producing greater SCRs, but it was likely to confound laterality results and so was not done.

Although short, the presentation time should have been sufficient to produce reliable SCRs. Previous studies with even shorter presentation time (30 ms) with masking showed lateralized effects with SCR (Kimura et al., 2004; Zaidel et al., 1995). Additionally, Zaidel and colleagues measured SCR for 30 ms lateralized presentation of emotional line drawings. They found support for the VH, with the RH being particularly sensitive to negative stimuli. These studies suggested that the presentation time was not likely to be the cause of null findings in the current study. Both of these studies used masking to ensure that emotional stimuli were only registered subliminally. This suggested that masking may have improved results in the current study.

Valence Value

It may be that negative stimuli are more universally negative, whereas some positive stimuli may be less universally experienced as positive. For example, although erotic pictures are generally rated as positive by both men and women (Lang et al., 2005) there may be more individual variance ratings of these stimuli. For example, individuals with negative sexual experiences may rate these images as less positive or even rate them as negative. For future studies individual ratings of each image and word after the experiment was performed may allow for further analysis of difference in variance between stimuli intended to elicit positive emotion and stimuli intended to elicit negative emotion. The current study used norms rather than gathering individualized ratings from participants. This would have been time consuming in the current study given the very large number of stimuli used. The importance of unambiguous emotional stimuli for laterality of emotion experiments was emphasized by Mohr and colleagues (2008). Because individual ratings were not done the current study cannot evaluate them, making this a study limitation.

For this study reaction times were only gleaned for emotional targets. It might be beneficial for similar future studies to include some analogous measure of neutral targets for comparison. Given the task parameters, however, it may be difficult to design task instructions that would achieve reaction time measures of neutral pictures that would be appropriately comparable to the emotional target reaction times. Perhaps having blocks of trials similar to the current experiment intermixed with trials in which the participant is instructed to respond to the more neutral target would accomplish this goal. The inability to compare emotional and neutral items is a limitation, but did not prevent meaningful findings for the current study.

Furthermore, it may have been useful to examine degrees of valence, rather than selecting highly negative, and highly positive stimuli. If the valence intensity of stimuli were varied it might show that even for timed conditions the RH was more accurate at more difficult emotional discernments. The stimuli in this experiment were strongly valenced, which may be why the LH was able to make an arousal determination quickly and accurately. If it had been more difficult to discern emotion in the stimuli the LH may have been less able to complete the experimental task. For example, using items where emotional detection is easier and comparing them to items for which emotional perception is more difficult.

Degree of Handedness

For future studies on lateralization the incorporation of measures of degrees of handedness may be useful for large samples. It is common for researchers to exclude left handed participants. Understandably it is difficult to include handedness as a variable of interest in small sample sizes because group sizes are frequently unequal given the small percentage of left-handed individuals in the population. Measuring handedness along a continuum helps to resolve this issue and may capture nuances that are relevant to lateralization research.

The number of individuals reporting left or ambiguous-handedness in the study was small relative to the right-handed participants. Recruitment of left-handed participants would be useful in more fully understanding differences in emotional asymmetry in these participants.

Affective Tendencies

It may be useful for future studies with this paradigm to obtain measures of generalized affect. This would allow researchers to control for individual differences in affective state which may affect the results of laterality studies (Davidson, 2000; Tomarken et al., 1992). However, an emotional Stroop laterality study (Borkenau and Mauer, 2006) did not show personality differences to significantly affect laterality results in a study with a reasonably large number of participants ($N = 125$).

Habituation

Given the large number of skin conductance non-responders in Experiment 2 habituation may have been a factor. A large number of practice trials, 16, were administered. This was done to ensure that participants understood the task. However, it may be that participants habituated to the emotional stimuli during the practice trials. On review, some participants showed responding during practice trials and decreased responding as the experiment continued. Other participants produced responses to the first trial of the experiment, after completion of practice trails, and did not produce further SCRs in response to stimuli. This initial response may have been an orienting response. Introduction of startle into this experimental task might slow the rate of habituation. However, the majority of the participants produced sufficient SCR for analysis.

Fatigue

Results of the study may have been affected by fatigue. The participants were asked to attend to a computer presentation of paired stimuli for approximately 23-25 minutes. Participants may have had difficulty sustaining attention or fatigued. To counteract the effects of fatigue a break was given in the middle of trials in which the participants were allowed to relax and resume the experiment when they were ready. Additionally, in order to reduce the possible effect of fatigue or lapses in attention response times that were 2.5 standard deviations away from the participant's mean reaction time were trimmed from the data prior to analysis. This was done to eliminate very long responses that suggest the participant was not sufficiently attending to the experimental task, perhaps due to distraction or fatigue. These long reaction times are likely due to factors unrelated to the experimental questions of laterality. Additionally, fatigue or distraction may have caused participants to impulsively respond before having time to process stimuli resulting in response times that were too short to suggest the stimuli in that trial were processed. The elimination of the shortest responses for each individual helped to eliminate those outlying responses from obscuring patterns in the data. These procedures likely helped to eliminate fatigue as a significant contaminant.

REFERENCES

Algom, D., Chajut, E., & Lev, S. (2004). A rational look at the emotional Stroop phenomenon: a generic slowdown, not a Stroop effect. *Journal of Experimental Psychology, 133*(3), 323-338.

Best, C.T., & Queen, H.F. (1989). Baby, it's in your smile: right hemiface bias in infant emotional expressions. *Developmental Psychology, 25*(2), 264-276.

Borkenau, P., & Mauer, N. (2006). Processing of pleasant, unpleasant, and neutral words in a lateralized emotional Stroop task. *Cognition and Emotion, 20*(6), 866-877.

Borod, J.C. (1992). Interhemispheric and intrahemispheric control of emotion: a focus on unilateral brain damage. *Journal of Consulting and Clinical Psychology, 60*(3), 339-348.

Borod, J.C., Cicero, B.A., Obler, L.K., Welkowitz, J., Erhan, H. M., Santschi, C., Grunwald, I.S., Agosti, R.M., Whalen, J.R. (1998). Right hemisphere emotional perception: evidence across multiple channels. *Neuropsychology, 12*(3), 446-458.

Borod, J.C., Koff, E., Yecker, S., Santschi, C., & Schmidt, J.M. (1998b). Facial asymmetry during emotional expression: gender, valence, and measurement technique. *Neuropsychologia, 36*(11), 1209-1215.

Borod, J.C., Rorie, K.D., Pick L.H., Bloom, R.L., Andelman, F., Campbell, A.L., Obler, L.K., Tweedy, J.R., Welkowitz, J., & Sliwinski, M. (2000). Verbal pragmatics following unilateral stroke: emotional content and valence. *Neuropsychology, 14*(1), 112-124.

Bradley, M.M., & Lang, P.J. (1999). Affective norms for English words (ANEW). Gainesville, FL. The NIMH Center for the Study of Emotion and Attention, University of Florida.

Damasio, A.R. (1994). Descartes' Error: Emotion, Reason, and the Human Brain. New York: G.P. Putnam's Sons.

Davidson, R.J. (1993). Parsing affective space: perspectives from neuropsychology and psychophysiology. *Neuropsychology, 7*(4), 464-475.

Davidson, R.J. (2000). Affective style, psychopathology, and resilience: brain mechanisms and plasticity. *American Psychologist, 55*(11), 1196-1214.

Davidson, R.J., Ekman, P., Saron, C.D., Senulis, J.A., & Friesen, W.V. (1990b). Approach-withdrawal and cerebral asymmetry: emotional expression and brain physiology I. Journal of Personality and Social Psychology, 58(2), 330-341.

Davidson, R.J., & Henriques, J.B. (1990c). Resting frontal brain asymmetry predicts affective responses to films. *Journal of Personality and Social Psychology, 59(4),* 791-801.

Dawson, M.E. Schell, A.M., & Filion, D.L. (2000). The electrodermal system. In J.T. Cacioppo, L.G. Tassinary, & G.G. Berntson (Eds.), *Handbook of Psychophysiology,* 2nd Ed (pp. 200-223). Cambridge: Cambridge University Press.

Debener, S., Beauducel, A., Nessler, D., Brocke, B., Heilemann, H., & Kayser, J. (2000). Is resting anterior EEG alpha asymmetry a trait marker for depression? *Neuropsychobiology, 41,* 31-37.

Dresler, T., Mériau, K., Heekeren, H. R., & van der Meer, E. (2009). Emotional Stroop task: effect of word arousal and subject anxiety on emotional interference. *Psychological Research, 73,* 364–371.

Foster, P.S., Drago, V., Webster, D.G., Harrision, D.W., Crucian, G.P., & Heilman, K.M. (2008). Emotional influences on spatial attention. *Neuropsychology, 22*(1), 127-135.

Fowles, D.C. (1994). A motivation theory of psychopathology. In W.D. Spaulding (Ed), *Integrative Views of Motivation, Cognition, and Emotion: Volume 41 of the Nebraska Symposium,* (pp. 181-238). Lincoln and London: University of Nebraska Press.

Fowles, D.C. (1988). Psychophysiology and psychopathology: a motivational approach. *Psychophysiology, 25*(4), 373-391.

Gainotti, G. (2000). Neuropsychological theories of emotion. In J.C. Borod (Ed.). *The Neuropsychology of Emotion* (pp. 214-236). Oxford, UK: Oxford University Press.

Glascher, J., & Adolphs, R. (2003). Processing of the arousal of subliminal and supraliminal emotional stimuli by the human amygdala. *The Journal of Neuroscience, 23*(32), 10274-10282.

Goldstein, K. (1952). The effect of brain damage on the personality. *Psychiatry, 15,* 245-260.

Gray, J.A. (1987). The neuropsychology of emotion and personality. In S.M. Stahl, S.D. Iversen, & E.C. Goodman (Eds), *Cognitive Neurochemistry,*(pp. 171-190). Oxford, New York, & Tokyo: Oxford University Press.

Graves, R., Landis, T., & Goodglass, H. (1981). Laterality and sex differences for visual recognition of emotional and non-emotional words. *Neuropsychologia, 19*, 95-102.

Harris, L.J. (1999). Early theory and research on hemispheric specialization. *Schizophrenia Bulletin 25*(11), 11-39.

Iacoboni, M., & Zaidel, E. (2000). Crossed-uncrossed difference in simple reaction times to lateralized flashed: between- and within-subjects variability. *Neuropsychologia, 38,*535-541.

Isaacs, K.L., Barr, W.B., Nelson, P.K., & Devinsky, O. (2006). Degree of handedness and cerebral dominance. *Neurology, 66,* 1855-1858.

Killgore, W.D.S., & Yurgelun-Todd, D.A. (2007). The right-hemisphere and valence hypotheses: could they both be right (and sometimes left)? *Social Cognitive and Affective Neuroscience, 2,* 240-250. doi:10.1093/scan/nsm020

Kimura, Y., Yoshino, A., Takahashi, Y., & Nomura, S. (2004). Interhemispheric difference in emotional response without awareness. *Physiology & Behavior, 82,* 727-731,

Kunde, W., & Mauer, N. (2008). Sequential modulations of valence processing in the emotional Stroop task. *Experimental Psychology 55(*3), 151–156.

Lake, D.A., & Bryden, M.P. (1976). Handedness and sex differences in hemispheric asymmetry. *Brain and Language, 3*, 266-282.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2005). International affective picture system (IAPS): Affective ratings of pictures and instruction manual. Technical Report A-8. University of Florida, Gainesville, FL.

Lang, P.J. (1978). Presidential address: A bio-informational theory of emotional imagery. Psychophysiology, 16(6), 495-512.

Levy, J., & Reid, M. (1978). Variations in cerebral organization as a function of handedness, hand posture in writing, and sex. *Journal of Experimental Psychology: General, 107*(2), 119-144.

MacNeilage, P.F., Rogers, L.J., & Vallortigara, G. (2009). Origins of the left and right brain. *Scientific American, 301,* 60-67.

Mahler, S.V., & Berridge, K.C. (2009). Which cue to “want?” Central amygdala opiod activation enhances and focuses incentive salience on a prepotent reward cue. *The Journal of Neuroscience, 29*(20), 6500-6513.

McKenna, F. P., & Sharma, D. (2004). Reversing the emotional Stroop effect reveals that it is not what it seems: the role of fast and slow components. Journal of Experimental Psychology: Learning, Memory, and Cognition, 30(2), 382-392.

Mohr, C., Rowe, A.C., & Crawford, M.T. (2008). Hemispheric differences in the processing of attachment words. *Journal of Clinical and Experimental Neuropsychology, 30*(4), 471-480.

Montreys, C.R., & Borod, J.C. (1998). A preliminary evaluation of emotional experience and expression following unilateral brain damage. *International Journal of Neuroscience, 96,* 269-283.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130,* 466–478.

Oldfield, R.C. (1971). The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia, 9,* 97-113.

Putman, P., Hermans, E., & van Honk, J. (2004). Emotional Stroop performance for masked angry faces: it's BAS, not BIS. *Emotion, 4*(3), 305–311.

Raccuglia, R. A., & Phaf, R. H. (1997). Asymmetric affective evaluation of words and faces. *British Journal of Psychology, 88*, 93-116.

Richards, A., French, C. C., & Dowd, R. (1995). Hemisphere asymmetry and the processing of emotional words in anxiety. *Neuropsychologia, 33*(7), 835-841.

Root, J.C., Wong, P.S., & Kinsbourne, M. (2006). Left Hemisphere specialization for response to positive emotional expressions: a divided output methodology. *Emotion, 6*(3), 473-478.

Schneirla, T.C. (1959). An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal. In M.R. Jones (Ed.). *Nebraska Symposium on Motivation* (pp. 1-42). Lincoln, NE: University of Nebraska Press.

Springer, S.P., & Deutch, G. (1998). Left Brain-Right Brain, 5th Ed. New York: W.H. Freeman and Company.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662.

Tomarken, A.J., Davidson, R.J., & Henriques, J.B. (1990). Resting frontal brain asymmetry predicts affective response to films. *Journal of Personality and Social Psychology, 59*(4), 791-801.

Tomarken, A.J., Davidson, R.J., Wheeler, R.E., & Doss, R.C. (1992). Individual differences in anterior brain asymmetry and fundamental dimensions of emotion. *Journal of Personality and Social Psychology, 62*(4), 676-687.

Van Damme, S., Crombez, G., & Notebaert, L. (2008). Attentional bias to threat: a perceptual accuracy approach. *Emotion, 8*(6), 820-827.

Van Strien, J.W., & Valstar, L.H. (2004). The lateralized emotional Stroop task: left visual field interference in women. *Emotion, 4*(4), 403-409.

Wacker, J., Chavanon, M.L., Leue, A., & Stemmler, G. (2008). Is running away right? The behavioral activation-behavioral inhibition model of anterior asymmetry. *Emotion, 8*(2), 232-249.

Zaidel, D.W., Hugdahl, K., & Johnsen, B.H. (1995). Physiological responses to verbally inaccessible pictorial information in the left and RHs. *Neuropsychology, 9*(1), 52-57.

APPENDIX A

SELECTED IMAGES FROM THE INTERNATIONAL AFFECTIVE PICTURE SYSTEM

Negative Images	Positive Images	Neutral Images	Neutral Images Continued
1026	2058	1121	5740
1040	2070	1303	6900
1050	2080	1616	7002
1052	2154	1935	7004
1090	2208	1945	7006
1274	2209	2038	7009
1275	2216	2102	7010
1280	2299	2104	7020
1300	2900.2	2190	7025
1301	4290	2200	7030
1525	4520	2210	7031
2095	4599	2214	7035
2100	4601	2215	7036
2120	4676	2220	7037
2276	4680	2372	7038
2278	4690	2383	7040
2375.1	4694	2385	7053
2455	4695	2410	7055
2683	4700	2440	7090
2703	5260	2441	7130
2710	5270	2446	7150
2750	5470	2487	7160
2799	5480	2493	7170
2800	5594	2512	7180
2811	5600	2514	7182
2900	5611	2516	7184
3005.1	5621	2570	7186
3015	5631	2595	7187
3016	5833	2635	7207
3030	7270	2780	7211
3051	8470	2830	7217
3053	8496	2880	7224
3060	8499	2890	7233
3160	8500	4000	7491
3170	8501	5120	7560
3180	8502	5130	7705
3261	8503	5510	8160
3266	8510	5532	8475
9000	8531	5534	9070
9001	8540	5535	9411

APPENDIX B

SELECTED WORDS FROM THE AFFECTIVE NORMS FOR ENGLISH WORDS

Positive Words	Negative Words	Neutral Words	Neutral Words Continued
7	1	49	699
31	37	57	701
67	60	66	710
69	100	78	736
77	107	83	737
105	108	84	742
151	121	129	752
172	125	130	757
175	127	148	776
190	156	208	781
192	178	227	784
200	195	229	785
218	222	283	799
220	228	303	813
240	236	307	825
241	244	309	828
248	260	356	829
251	285	380	830
264	289	412	832
266	292	426	841
278	295	434	850
286	321	439	855
291	322	550	864
304	340	560	868
317	344	561	874
332	349	564	901
334	397	565	927
343	418	568	928
364	419	569	929
417	425	578	936
424	430	638	974
431	432	641	991
449	445	642	995
452	447	651	1,001
468	461	655	1,008
469	588	675	1,015
475	591	685	1,020
503	607	688	1,024
759	614	695	1,026
826	879	698	1,029

APPENDIX C

INFORMED CONSENT DOCUMENT

CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO
5500 University Parkway, San Bernardino, CA 92407-2397

COLLEGE OF SOCIAL AND
BEHAVIORAL SCIENCES
Department of Psychology
(909) 880-5570
fax: (909) 880-7003

Informed Consent Document
For
Effect of Emotion Lateralization on Reaction Time and Physiology
Principal Investigator: Paul Haerich
Co-Investigator: Kim Rose

Purpose

You are invited to participate in this research study to help us better understand the effect of different types of visual stimuli on human physiological reflexes, human cognition, and human emotion. This research study will investigate the way people respond to pictures and words by measuring physiology and reaction time. The pictures and words you will be viewing have been chosen to cover a variety of things individuals might encounter in their life. Your responses on the questionnaires will be used to describe the participants as a group in terms of basic demographic variables such as age, gender, handedness, and ethnicity.

Procedure

During this study, you will view a series of picture pairs and word pairs. The pictures depict various subjects including (listed alphabetically): animals, guns, household objects, human nudes, nature scenes, mutilations, plants, rocks, snakes, spiders, sports scenes, etc. The word pairs include a variety of emotional and neutral words.

This research study involves collecting information regarding autonomic nervous system activity. The will be done with two sensors that may be taped to two of the fingers of your non-dominant hand. Alternatively, the sensors may be taped to the bottom of your foot. In either case, these sensors will be used to measure small changes in the amount of sweat being produced – an indicator of small changes in the activity level of the sympathetic division of the autonomic nervous system. You may also have a small pulse meter clipped to your middle finger to measure your heart rate. The configuration of sensors will be described in more detail by the experimenter.

During the study a fixation cross (+) will appear at the center of the computer screen. Please focus on this cross when it appears and continue to focus on it during the trial.

The appearance of the cross will be followed by either a pair of words or a pair of pictures; these words or pictures will be presented briefly. Your task is to decide as quickly as possible which word or picture is more emotional. You should choose the picture or word that evokes, depicts, or describes the stronger emotion. The emotions depicted may be positive or negative, just chose the more emotional one. In some cases, you should make this decision mentally; this requires no response from you, just your mental decision. In other cases you are to indicate your decision by pressing the "z" key on the keyboard with your left index finger if the most emotional word or picture was on the left or pressing the "m" key with your right index finger if the most emotionally evocative word or picture was displayed on the right side of the computer screen. Please make your choice as quickly as possible without making errors. Each subsequent trial will begin with the appearance of another fixation cross (+) after a few seconds. The experimenter will explain more about the response requirements for your participation.

In the second portion of the study, you will be asked to complete a questionnaire. There will be questions about demographic information as well as some questions about handedness.

It will take approximately 45 minutes to complete your participation in this study.

Risks

The pictures and words used in this study are intended to evoke a range of responses and may be perceived by some as disturbing. You may feel uncomfortable while viewing some of the pictures.

None of the stimuli or procedures used in this research study poses a risk beyond that which may be expected in everyday life. Therefore, the committees at both CSU San Bernardino (Department of Psychology Institutional Review Board Sub-Committee) and Loma Linda University (Institutional Review Board) that review human studies have determined that participating in this study exposes you to minimal risk. The official stamp appearing on this form indicates this approval.

Benefits and Reimbursement

You should not expect to receive any direct benefit from your participation in this research study other than the educational experience of participating in a scientific psychological research project.

We anticipate that the results of this study will help advance our understanding of how people respond to emotional stimuli and situations. We hope that this information will eventually be useful in improving psychotherapy techniques

Compensation

Although not a benefit from the research study itself, you may receive extra credit for a course. If you are a student at CSUSB, you may receive extra credit points for your class, at your instructor's discretion. You will receive 4 credits via the SONA system after you finish the study.

Confidentiality

All of the information gathered during your participation in this research study is confidential and will be handled anonymously. That means that your name will not be attached to or stored with any of your responses or physiological data. The responses of individual participants will not be disclosed to anyone. The information you provide will be grouped with that of other participants. Any publications or presentations resulting from this study will refer only to the grouped results.

Third Party Contact & Questions

If at any time you have any other questions regarding your participation in this study, you should feel free to contact Paul Haerich, PhD at the Department of Psychology, Loma Linda University. (Phone: 909-558-4770).

If you wish to contact an impartial third party not associated with this study regarding any complaint about the study, you may contact the Office of Patient Relations, Loma Linda University Medical Center, Loma Linda, CA 92354 (phone: 909-558-4647), for information and assistance.

Participant's Rights

Participation in this study is voluntary. If, after signing this consent form, you decide to discontinue the session at any time, for any reason, you are free to do so. You will receive participation credit whether you complete the session or not. If you have any questions regarding this study, we will be happy to answer them.

Consent Statement

By writing my study ID number in the space below I acknowledge that I have been informed of, and that I have understand, the nature and purpose of this study, and I freely consent to participate. I have read the contents of the consent form and have been given the opportunity to ask questions concerning the study. I have been offered a copy of this form. I acknowledge that I am at least 18 years of age. I hereby give my voluntary consent to participate in this study. Signing this consent form does not waive my rights nor does it release the investigators or institution(s) from their responsibilities. I may call Paul Haerich, Ph.D. at (909) 558-4770 if I have additional questions or concerns.

Participant's Study ID:________________

Date: ___________

CALIFORNIA STATE UNIVERSITY, SAN BERNARDINO
PSYCHOLOGY INSTITUTIONAL REVIEW BOARD SUB-COMMITTEE
APPROVED 11 / 09 / 09 VOID AFTER 11 / 09 / 10
IRB# H-09FA-07 CHAIR

APPENDIX D

REPEATED MEASURES ANCOVA TABLES FOR

EXPERIMENT 1

Reaction Time Experiment 1: Repeated Measures Analysis of Covariance for Reaction Times

Condition	*F*	*p*	Partial η^2
Valence	3.461	0.071	0.090
Valence x Handedness	0.934	0.340	0.026
Valence x Visual Field	0.145	0.706	0.004
Valence x Visual Field x Handedness	0.937	0.340	0.026
Valence x Stimulus	2.054	0.161	0.055
Valence x Stimulus x Handedness	0.577	0.453	0.016
Valence x Visual Field x Stimulus	1.023	0.319	0.028
Valence x Visual Field x Stimulus x Handedness	0.152	0.699	0.004
Visual Field	0.011	0.916	0.000
Visual Field x Handedness	0.423	0.520	0.012
Visual Field x Stimulus	3.504	0.070	0.091
Visual Field x Stimulus x Handedness	4.616	**0.039***	0.117
Stimulus	34.203	**0.000***	0.494
Stimulus x Handedness	1.387	0.247	0.038

*Significant
All p values are listed as two-tailed values for consistency. One tailed values are reported in the text for analyses that had directional hypotheses.

Reaction Time Experiment 1: Repeated Measures Analysis of Covariance for Task Accuracy

Condition	*F*	*p*	Partial η^2
Valence	2.206	0.146	0.059
Valence x Handedness	0.006	0.939	0.000
Valence x Visual Field	1.694	0.202	0.046
Valence x Visual Field x Handedness	2.485	0.124	0.066
Valence x Stimulus	1.154	0.290	0.032
Valence x Stimulus x Handedness	0.080	0.779	0.002
Valence x Visual Field x Stimulus	0.610	0.440	0.017
Valence x Visual Field x Stimulus x Handedness	1.662	0.206	0.045
Visual Field	0.527	0.473	0.015
Visual Field x Handedness	4.00	**0.053***	0.103
Visual Field x Stimulus	0.407	0.528	0.011
Visual Field x Stimulus x Handedness	1.266	0.268	0.035
Stimulus	0.006	0.937	0.000
Stimulus x Handedness	0.580	0.451	0.016

*Significant
All p values are listed as two-tailed values for consistency. One tailed values are reported in the text for analyses that had directional hypotheses.

APPENDIX E

REPEATED MEASURES ANCOVA TABLES FOR

EXPERIMENT 2

SCR Experiment 2: Repeated Measures Analysis of Covariance for SCR

Condition	*F*	*p*	Partial η^2
Valence	1.36	0.258	0.064
Valence x Handedness	1.31	0.266	0.061
Valence x Visual Field	0.035	0.853	0.002
Valence x Visual Field x Handedness	0.057	0.814	0.003
Valence x Stimulus	1.199	0.287	0.057
Valence x Stimulus x Handedness	0.136	0.716	0.007
Valence x Visual Field x Stimulus	0.666	0.424	0.32
Valence x Visual Field x Stimulus x Handedness	1.504	0.234	0.70
Visual Field	0.850	0.368	0.041
Visual Field x Handedness	0.850	0.367	0.041
Visual Field x Stimulus	0.370	0.550	0.018
Visual Field x Stimulus x Handedness	0.156	0.697	0.008
Stimulus	0.002	0.965	0.000
Stimulus x Handedness	0.004	0.951	0.000

*Significant
All p values are listed as two-tailed values for consistency. One tailed values are reported in the text for analyses that had directional hypotheses.

SCR Experiment 2: Repeated Measures Analysis of Covariance for Task Accuracy

Condition	*F*	*p*	Partial η^2
Valence	0.022	0.884	0.001
Valence x Handedness	0.003	0.958	0.000
Valence x Visual Field	1.322	0.259	0.041
Valence x Visual Field x Handedness	0.725	0.401	0.023
Valence x Stimulus	0.001	0.971	0.000
Valence x Stimulus x Handedness	0.631	0.433	0.020
Valence x Visual Field x Stimulus	0.121	0.730	0.004
Valence x Visual Field x Stimulus x Handedness	0.034	0.856	0.001
Visual Field	3.754	**0.062***	0.108
Visual Field x Handedness	0.876	0.356	0.027
Visual Field x Stimulus	0.070	0.793	0.002
Visual Field x Stimulus x Handedness	0.045	0.833	0.001
Stimulus	10.127	**0.003***	0.246
Stimulus x Handedness	3.892	0.057	0.112

*Significant
All p values are listed as two-tailed values for consistency. One tailed values are reported in the text for analyses that had directional hypotheses.