INDIVIDUAL DIFFERENCES IN THE HEMISPHERIC ASYMMETRY OF
EMOTIONAL WORDS

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Individual Differences in the Hemispheric Asymmetry of Emotional Words

Emotion has long been neglected as a research topic in the field of neuroscience (Damasio, 2000). Emotion was viewed as too subjective and vague of a subject to study. However, in the past two decades, the study of emotion within neuroscience has blossomed and has been embraced by scientists (Damasio, 2000). Scientists have started to discover the biological underpinnings of the experience of emotion and emotion’s value to humans’ survival and social functioning. Damasio defined emotions as “specific and consistent collections of physiological responses triggered by certain brain systems when the organism represents certain objects or situations (e.g., a change in its own tissues such as that which produces pain, or an external entity such as a person seen or heard; or the representation of a person, or object, or situation, conjured up by memory into a thought process).” Emotions involve a complex interaction between physiological reactions, cognition, and behavior.

As research has delved into the physiology of emotion, emotional perception, experience, and expression have been shown to be lateralized in the brain (Demaree, Everhart, Youngstrom, & Harrison, 2005). Therefore, hemispheric asymmetry occurs when there is more activity in one hemisphere of the brain relative to the other during emotional processing (Zhang, Zhou, & Oei, 2011). Emotion is processed in many areas of the brain and consists of the interaction between many brain regions for specific types of emotion, such as positive and negative emotions. There are three dominant contrasting hypotheses that have been proposed about how emotion is lateralized in the brain: the Right Hemisphere Hypothesis, the Valence Hypothesis, and the Integrative Hypothesis.
The Right Hemisphere Hypothesis

First, the right hemisphere (RH) hypothesis posits that the right hemisphere is dominant for the processing of emotion, both positive and negative, over the left hemisphere (LH; Borod, Koff, & Caron, 1983). Several studies have shown that people are better able to identify emotional expressions when they are presented to the left visual field (LVF), and thus the RH, rather than when they are presented to the right visual field (RVF/ LH; Bourne, 2010). Many studies have shown there is a LVF/RH bias towards processing emotional faces (Ashwin, Wheelwright, & Baron-Cohen, 2005; Christman & Hackworth, 1993; Drebin, Federman, Edington, & Terzian, 1997). LVF/RH dominance when processing emotion has also been shown using functional neuroimaging with facial stimuli (Nakamura et al., 1999). In addition, studies have shown that emotions are expressed more intensely on the left side of the face, which demonstrates the RH dominance in emotional expression (Borod, Haywood, & Koff, 1997; Indersmitten & Gur, 2003).

The Valence Hypothesis

In contrast to the RH hypothesis, the valence hypothesis (Davidson, 1992; Tomarken, Davidson, & Henriques, 1990) states the frontal hemispheric asymmetry for emotional processing differs depending on affective valence, such that the RH is responsible for the processing of negative emotions, while the LH is responsible for the processing of positive emotions. Therefore, inducing negative mood is associated with greater activity in the RH prefrontal region (decreased alpha power measured by EEG) than the LH prefrontal region (Davidson, Ekman, Saron, Senulis, & Frieson, 1990). Moreover, individuals who have greater RH frontal activation patterns tend to have more negative affective reactions than individuals
with greater LH frontal activation patterns (Wheeler, Davidson, & Tomarken, 1993). Individuals who possess a more positive disposition tend to show greater left frontal activation than right frontal activation (Sutton & Davidson, 1997). These studies demonstrate the right and left hemisphere specializations for emotional processing in regards to the valence of the emotion.

**The Integrative Hypothesis**

The third hypothesis for how emotion is lateralized is Heller’s integrative hypothesis (Heller, 1993). The integrative hypothesis states that LH frontal activity is associated with positive emotions, and the RH frontal activity is associated with negative emotions. This presumption directly mirrors that of the valence hypothesis proposed by Davidson (Davidson, 1992; Tomarken, Davidson, & Henriques, 1990). However, the integrative hypothesis further proposes that the RH parietotemporal regions play a crucial role in the experience of the arousal of emotions (Zhang, Zhou, & Oei, 2011). Therefore, the integrative hypothesis emphasizes the role of both valence and arousal when determining the hemispheric asymmetry of emotion. The RH parietotemporal regions play a role in the physiological regulation of arousal, thus the fight or flight response when encountering threatening stimuli (Hecht, 2010). The RH’s hypersensitivity to fear is associated with the stronger relationship between the RH and stress regulatory systems, such as the hypothalamic-pituitary-adrenal (HPA) axis that regulates cortisol secretion (Wittling, 1997). Studies have shown that emotionally aversive film presented to the LVF/RH resulted in increased cortisol secretion, but did not result in increased cortisol secretion when presented to the RVF/LH (Wittling & Pflueger, 1990). Also, stroke patients with RH damage showed reduced responses of the HPA axis and cortisol secretion, which suggests the role of the RH in the stress response (Lueken et al., 2009).
Furthermore, the integrative hypothesis examines the role of arousal in emotion; whereas, the RH and valence hypotheses do not. Overall, the prior studies of the lateralization of emotional processing have produced conflicting results. This could be due, in part, to the fact that emotion has not been examined in a way that equates valence with arousal (Holtgraves & Felton, 2010). Many studies have confounded valence and arousal with only having high arousal negative stimuli, such as angry faces. It is important to equate valence with arousal because studies have shown that there may be different neural pathways for valence and arousal of emotion (Heller, 1993).

**The Use of Verbal Stimuli to Study Emotion**

Moreover, most studies examining the lateralization of emotional processing have focused on the emotional processing of facial stimuli with many studies using the Chimeric Faces Test (CFT). However, relatively little research has been done using verbal stimuli in the processing of emotion (Holtgraves & Felton, 2010). Studies examining the enhanced memory of emotional words presented to the right and left visual field have found support for the RH hypothesis with the RH having the dominant role in emotional processing regardless of valence (Collins & Cooke, 2005; Nagae & Moscovitch, 2002), as well as support for the valence hypothesis with the LH having the dominant role in processing positive emotion words and the RH having the dominant role in processing negative emotion words (Ali & Cimino, 1997). These studies may have had conflicting support for the RH and valence hypotheses because they failed to equate emotional words in terms of arousal (Holtgraves & Felton, 2010). These studies did not address the importance of arousal in the hemispheric asymmetry as proposed by Heller’s integrative hypothesis (Heller, 1993). Therefore, studying emotional verbal stimuli that is
equated in terms of valence and arousal is an important topic to study and could potentially validate the integrative hypothesis of Heller.

**Individual Differences in Hemispheric Asymmetry**

Another important variable that most studies have not addressed in the hemispheric asymmetry of processing emotional stimuli is the importance of individual differences of the participants (Holtgraves & Felton, 2010). Participants may have prior dispositional differences that could influence their performance in tasks using emotional stimuli. One individual difference in participants could be their level of depression. EEG recordings have shown that negative mood and depression are associated with relatively greater RH frontal activity than LH frontal activity (Henriques & Davidson, 1991; Flor-Henry, Lind, & Koles, 2004). Different neuroimaging studies have shown that unipolar depressed patients have an underactive LH and an overactive RH (Grimm et al., 2008). Grimm et al. (2008) also found that the severity of the depression was correlated positively with RH hyperactivity.

Unilateral brain lesions can also demonstrate the hemispheric asymmetry present in depression, specifically the hypoactive LH. Individuals who suffered LH damage tend to show depressive symptoms (Black, 1975; Gasparrini, Satz, Heilman, & Coolidge, 1978). Similarly, when participants were injected with the sedative drug sodium amytal in the left carotid artery, which made the LH inactive, participants began crying, having pessimistic thoughts, guilt, and worry about the future (Ahern et al., 1999; Silberman & Weingartner, 1986).

When brain lesions cause reduced brain function, different neurochemical imbalances can occur that would contribute to a depressive symptomatology. First, when individuals have a LH stroke, their binding of the neurotransmitter serotonin is inhibited, which then leads to a
depressed mood. On the other hand, RH strokes, often result in a happier mood because they have an increased serotonin receptor binding that is not found in LH strokes (Robinson & Starkstein, 1989).

In addition, the LH is more involved in the biochemical processes that deal with the neurotransmitter dopamine, while the RH is more involved in the biochemical processes that deal with the neurotransmitter norepinephrine (Tucker & Williamson, 1984). With depression’s reduced LH function, depressed individuals could have less dopamine binding that would contribute to a less happy mood and a reduced pursuit of pleasure (anhedonia; Hecht, 2010). With depression’s increased RH function, depressed individuals could have higher levels of norepinephrine binding that would lead to an increased hypersensitivity to fear and a heightened startle response. Increased RH function has also been shown to be linked to other depressive symptomatology like pessimism, guilt, and inward withdrawal because of the RH’s role in negative affect.

Another individual difference that could influence participants’ hemispheric asymmetry of emotion is the participants’ level of anxiety. Anxious participants, like depressed participants, have a certain pattern of cortical activation when they are viewing emotional stimuli. Similarly to depressed individuals, anxious individuals do possess a hyperactive RH (Mathersul, Williams, Hopkinson, & Kemp, 2008). Bourne and Vladeanu (2011) found that individuals with generalized anxiety disorder (GAD) had greater RH prefrontal activation while viewing angry faces than non-anxious participants. They also found greater RH prefrontal activity was associated with the severity of the anxiety. In addition to overactive RH prefrontal regions, anxious individuals also have a greater activity in the RH parietotemporal regions that deal with the stress response (Heller, 1993). The RH parietotemporal regions deal with the hypothalamic-
pituitary-adrenal (HPA) axis that regulates cortisol production in response to stress. This explains why anxious individuals have biases in responding to negative or threatening stimuli, such as angry faces, because anxious individuals have a heightened stress response that non-anxious individuals do not possess.

**Comorbidity of Depression and Anxiety**

Depression and anxiety have a high comorbidity rate, which can hinder the diagnosis and treatment of these disorders (Altamura, Montresor, Salvadori, & Mundo, 2004; Kessler, Nelson, McGonagle, & Liu, 1996). If individuals are given the wrong diagnosis for their depression or anxiety, they may not receive the proper treatment, such as medication and/or therapy. Some of depression and anxiety’s comorbidity can be explained by similar patterns of brain activity. Both depression and anxiety display relatively greater right than left frontal brain activity (Mathersul, Williams, Hopkinson, & Kemp, 2008), which can lead to a negativity bias when interpreting emotional stimuli. Therefore, depressed and anxious individuals both share negative affect (Clark & Watson, 1991). However, depression and anxiety each have different patterns of brain activation and symptomatology that can help distinguish the disorders. Distinguishing the pathology of depression and anxiety is vital to effectively treating individuals with these disorders.

**Distinguishing Depression from Anxiety**

First of all, in the adult population, depression and anxiety may be distinguished in terms of arousal. Anxiety is characterized by hyperarousal (such as the fight or flight response, agitation, muscle tension, and increased heart rate), whereas depression is characterized by hypoarousal (fatigue, apathy, lack of energy; Clark & Watson, 1991). The hyperarousal present
in anxiety is due to the overactivation of the right parietotemporal regions involving the HPA axis (Heller & Nitschke, 1998).

In addition, depression may be characterized as reduced left frontal activation and anxiety as increased right frontal activation (Gray, 1987). This coincides with Gray’s (1987) theory of trait motivation that postulates the brain has two distinct systems of processing that correspond to two traits. A trait approach motivation deals with the behavioral activation system (BAS), which motivates people to seek positive experiences and avoid punishment. In contrast, a trait withdrawal approach deals with the behavioral inhibition system (BIS), which motivates people to be sensitive to punishment and fear stimuli. The BIS inhibits behavior, increases arousal, and directs attention toward aversive stimuli (Harmon-Jones, Gable, & Peterson, 2009). Harmon-Jones, Gable, & Peterson (2009) found that relatively greater left frontal activation is associated with BAS sensitivity, while relatively greater right frontal activation is associated with BIS sensitivity. Therefore, greater BAS activation is associated with positive affect, while greater BIS activation is associated with negative affect (Harmon-Jones, Gable, & Peterson, 2009).

In depressed individuals, there is reduced left frontal activity, so they have less BAS activity and approach motivation than non-depressed individuals (Gray, 1987). This explains depressed individuals’ propensity toward anhedonia and lack of energy because they are not motivated to pursue positive experiences. In anxious individuals, there is increased right frontal activity, so they have more BIS activity and withdrawal motivation than non-anxious individuals (Davidson, 1998). This then explains anxious individuals’ tendency to have heightened arousal and overreact to aversive stimuli.
The distinctions between depression and anxiety are summarized well by the tripartite model of depression and anxiety presented by Clark and Watson (1991). First, Clark and Watson (1991) note that depression and anxiety share the nonspecific factor of negative affectivity because of increased right frontal activation. However, depressed individuals have a harder time expressing positive affectivity than anxious individuals due to their reduced left frontal activation. Second, anxiety is distinguished from depression by its feature of physiological hyperarousal. In sum, depressed individuals possess high negative affectivity and low positive affectivity, and anxious individuals possess high negative affectivity and high physiological arousal. In turn, comorbid depression and anxiety would then be defined by high negative affectivity, low positive affectivity, and physiological hyperarousal.

**Subtypes of Anxiety**

There are two subtypes of anxiety that can further complicate the study of the lateralization of emotional processing. Heller and Nitschke (1998) discuss the two subtypes of anxiety that have distinct frontal and parietotemporal activations. First, there is anxious arousal which is defined by physiological arousal and hyper-reactivity and fits the typical definition of anxiety (Mathersul, Williams, Hopkinson, & Kemp, 2008). An anxiety disorder that would fit this description would be panic disorder where individuals develop recurrent panic attacks. This subtype of anxiety would have increased activation in the RH because of the HPA axis and cortisol secretion involved in physiological arousal and stress response.

In contrast, the anxious apprehension subtype of anxiety is defined by verbal ruminations and worry, so individuals with this subtype of anxiety may demonstrate increased left frontal activity because of the specialization of the LH for language (Mathersul, Williams, Hopkinson,
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& Kemp, 2008). The anxious apprehension subtype of anxiety most fits the description of
generalized anxiety disorder (GAD), which involves trait worrying. Anxious apprehension
individuals differ from anxious arousal individuals because of their increased left frontal activity,
but both subtypes of anxiety will share increased activation in the right parietotemporal regions
because of their increased level of arousal.

The Role of Personality in Depression and Anxiety

Specific personality traits could be related to the development of depression and anxiety.
Extraversion is a personality trait that has been found to be inversely correlated with depression
and anxiety (Jylhä & Isometsä, 2006). Extraversion may have an inverse correlation with
depression and anxiety because of its high degree of positive emotionality. On the other hand,
neuroticism is a personality trait that has been linked to the development of depressive and
anxious symptomatology (Minnix & Kline, 2004). In Clark and Watson’s (1991) tripartite model
of anxiety and depression, they found that neuroticism is a general factor that is highly associated
with anxiety and depression. People who score high on the trait of neuroticism tend to have more
negative affect and emotional lability than individuals who score low on neuroticism (Minnix &
Kline, 2004). With neuroticism’s tendency for negative affect, researchers have often proposed
that individuals with high neuroticism have higher right frontal activity than individuals with low
neuroticism. However, researchers have found inconsistent results when trying to link
neuroticism to increased right frontal activity.

Minnix and Kline (2004) recorded participants’ EEG at rest and had participants
complete a personality inventory to measure the trait of neuroticism. The researchers found
individuals who scored high on neuroticism had more frontal asymmetry variability, which
meant that the individuals were inconsistently lateralized to one hemisphere frontal region or another. This finding could be due to neuroticism’s high degree of emotional lability. Therefore, individuals who score high on neuroticism may fluctuate more easily in their emotions, and therefore, have inconsistent hemispheric asymmetry patterns. Neurotic individuals have been shown to be more hostile and prone to anger. Anger is an approach based emotion, rather than a withdrawal based emotion like sadness. Therefore, anger is lateralized to the LH (Minnix & Kline, 2004). Neurotic individuals may vacillate between approach based and withdrawal based emotions, which would create the inconsistencies in their hemispheric activation patterns.

The Present Study

The aim of the present study was to examine hemispheric asymmetry in the perception of emotion by measuring the processing of emotional words. The present study applied the framework of the integrative hypothesis proposed by Heller and the findings from Holtgraves and Felton (2010) study to test its hypotheses. The study employed a lexical decision task and a divided field procedure used by Holtgraves and Felton (2010). The words presented in the lexical decision task varied in terms of affective valence, but were equated in terms of arousal and frequency. These words were presented briefly (>200 ms) to the right and left visual field (RVF/LVF) to measure the processing in the contralateral hemisphere.

In the Holtgraves and Felton (2010) study, participants responded more quickly to positive valence words presented to the RVF/LH than the LVF/RH, but participants did not have a significant hemispheric difference in response to negative valence words. Therefore, I expected to observe a Visual Hemifield/Hemisphere (LVF/RH versus RVF/LH) x Valence (positive versus negative) interaction. Participants should have also responded more quickly to negative
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High arousal words presented to the LVF/RH than the RVF/LH because of the role of the RH in processing negative arousing stimuli and eliciting a fear response. Thus, I expected to observe a Visual Hemifield/Hemisphere (LVF/RH versus RVF/LH) x Valence (positive versus negative) x Arousal (low versus high) interaction.

The present study explored the relationship between hemispheric asymmetry of emotion present in subclinical anxiety and depression. Studying subclinical populations is particularly important because of their high rate of prevalence in the general population, and the fact that subthreshold levels of symptomatology have been found to predict later onset of clinical disorders (Mathersul, Williams, Hopkinson, & Kemp, 2008). Subclinical populations can also shed light on clinical disorders without having the potential confounds of medications or other forms of treatment (Mathersul, Williams, Hopkinson, & Kemp, 2008).

Past research has demonstrated that depressed and anxious individuals have some similarities and differences in their hemispheric asymmetry when presented with emotional stimuli. I predicted participants with higher levels of depression or anxiety would both have a negativity bias in the RH, so they would respond to negative words in the LVF faster than lower depressed or anxious participants. I expected to find the negativity bias in the RH because of the RH’s role in processing negative stimuli in depression and anxiety (Mathersul, Williams, Hopkinson, & Kemp, 2008). Therefore, I expected a three-way interaction between Visual Hemifield/Hemisphere (LVF/RH versus RVF/LH) x Valence (positive versus negative) x Depression (low versus high), as well as a three-way interaction between Visual Hemifield/Hemisphere (LVF/RH versus RVF/LH) x Valence (positive versus negative) x Anxiety (low versus high).
In addition, for participants with higher levels of depression, I also expected reduced LH function, so I predicted that they would have a lack of positivity bias in the LH that is present in lower depressed participants. Therefore, I predicted a three-way interaction between Visual Hemifield/Hemisphere (LVF/RH versus RVF/LH) x Valence (positive versus negative) x Depression (low versus high), whereby higher depressed individuals would respond slower to positive stimuli presented in the LH than lower depressed participants.

For participants with higher levels of anxiety, I expected they would have a bias toward responding to high arousal words presented to the RH, so they would respond faster to high arousal words in the RH than lower anxious participants. I expected to observe this because anxious individuals have a heightened fear response to high arousal stimuli because of their overactive RH parietotemporal regions (Heller, 1993). I then predicted a three-way interaction between Visual Hemifield/Hemisphere (LVF/RH versus RVF/LH) x Arousal (low versus high) x Anxiety (low versus high) where higher anxious participants would respond more quickly to high arousal words presented in the RH than lower anxious participants. In addition, I conducted exploratory analyses of the subtype of anxiety, anxious apprehension, on how this subtype performs in the lexical decision task with emotional words.

In the present study, I also examined participants’ personality traits. I measured the Big Five personality traits of openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. I conducted an exploratory analysis of these personality variables with the potential relationships to depression and anxiety, but focused on the personality trait of neuroticism.
In sum, I tested the following hypotheses in the present study:

i. I expected a three-way Visual Hemifield/Hemisphere x Valence x Arousal interaction where participants responded faster to positive words presented in the LH than the RH, regardless of level of arousal. For negative words, the RH bias only would exist for high arousal negative words, not low arousal negative words.

ii. I expected a three-way Visual Hemifield/Hemisphere x Valence x Depression interaction where higher depressed participants responded faster to negative words presented to the RH than do lower depressed participants, and slower to positive words in the LH than lower depressed participants.

iii. I expected a three-way Visual Hemifield/Hemisphere x Valence x Anxiety interaction where higher anxious participants responded faster to negative words presented to the RH than lower anxious participants.

iv. I expected a three-way Visual Hemifield/Hemisphere x Arousal x Anxiety interaction where higher anxious participants responded faster to high arousal words presented in the RH than lower anxious participants, and no difference in responding to high or low arousal words in the LH.

Method

Participants

Participants (N =100, 64 women, 6 left-handed) were introductory psychology students who completed the study for partial course credit through the Psychology subject pool. Seventy-seven participants were Caucasian, ten were African American, seven were biracial/multiracial,
four were Hispanic, one was Puerto Rican, and one reported as other. The mean age of the participants was 19.51 years with a range of 18-32 years.

Measures

**Handedness.** To determine participants’ handedness, participants completed the Edinburgh Handedness Inventory (Oldfield, 1971; See Appendix A). Handedness is an important factor in determining hemispheric dominance.

**Health Survey.** Participants completed a health survey containing information about history of head injury, current medical conditions and medications, and whether or not participants were currently in counseling. This health survey assessed pertinent areas, such as neurological concerns and mental health that could influence participants’ performance on questionnaires and the lexical decision task. The health survey also contained demographic information (See Appendix B).

**Mood.** To determine participants’ mood during the study, participants completed the Positive and Negative Affective Schedule (PANAS; Watson, Clark, & Tellegen, 1988; See Appendix C). The measure consists of two scales, one for positive affect (PA) and one for negative affect (NA). Each of these scales contains 10 items. The PANAS has high internal consistency with Cronbach’s alpha values ranging from .86 to .90 for PA and .84 to .87 for NA (Watson, Clark, & Tellegen, 1988). The PA and NA scales were also found to be largely uncorrelated, which demonstrated the independence of the two scales (Watson, Clark, & Tellegen, 1988).

**Depression.** To measure participants’ level of depression, participants completed the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II contains 21
questions each being answered on a 0 to 3 scale for the level of severity of the participants’ symptoms. The questions assess how the participants have been feeling the past two weeks including the day of the test. Questions on the BDI-II measure areas such as the sense of failure, guilt feelings, irritability, sleep disturbance, and loss of appetite. The BDI-II has an overall score for depression, but also breaks up the score into the affective and physical subtypes of depression. The BDI-II examines the affective components of depression, such as pessimism and guilt, as well as the physical symptoms of depression, such as fatigue and changes in appetite and sleep patterns. The clinical cutoff scores for the BDI-II are the following: 0-13: minimal depression, 14-19: mild depression, 20-28: moderate depression, 29-63: severe depression. The BDI-II is psychometrically sound measure with a high internal consistency (Cronbach’s alpha = .91; Beck, Steer, Ball, & Ranieri, 1996), high one week test-retest reliability ($r = .93$; Beck, Steer, & Brown, 1996), and a high convergent validity ($r = .71$) with another commonly used measure of depression, the Hamilton Psychiatric Rating Scale for Depression (Groth-Marnat, 2009).

**Anxiety.** To measure participant’s level of anxiety, participants completed the Beck Anxiety Inventory (BAI; Beck & Steer, 1993). The BAI consists of 21 questions asking how the participants have been feeling the last week including today. These questions are answered on 0 to 3 scale for the level of severity of the participants’ symptoms. The BAI measures both the somatic and cognitive aspects of anxiety. The somatic subscale of the BAI examines the symptoms of physiological arousal which would be present in the anxious arousal subtype of anxiety. These questions include physical symptoms such as sweating not due to heat, difficulty breathing, heart racing, and hands trembling. The clinical cutoff scores for the BAI are the

To measure whether participants have the symptoms of the anxious apprehension subtype of anxiety, participants completed the Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990; See Appendix D). The PSWQ consists of 16 questions answered on a 5-point scale of not at all typical of me to very typical of me. These questions assess the trait of worrying and ruminating which is present in the anxious apprehension subtype of anxiety. The PSWQ has been shown to demonstrate a high internal consistency and is appropriate for measuring generalized anxiety disorder (GAD) and distinguishing it from other anxiety disorders, such as panic disorder and obsessive-compulsive disorder (Brown, Anthony, & Barlow, 1992).

**Five Factor Model of Personality.** Participants completed a measure of personality that examines the following five factors: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Goldberg, 1992; See Appendix E). This measure contains 100 items that are answered on a 9-point Likert scale, ranging from 1 being extremely inaccurate to 9 being extremely accurate. Each of the five factors consists of 20 items that are descriptive adjectives of personality. The five factors on the scale demonstrate high internal consistency (Goldberg, 1992).

**Stimuli**

The emotion word list for the lexical decision task was selected from the affectively normed words developed by Bradley and Lang (1999; See Appendix F). This word list is identical to the word list used in Holtgraves and Felton (2010). The words have been rated on 9-
point scales in terms of their affective valence (higher scores indicate positive valence) and arousal (higher scores indicate greater arousal). Sixteen negatively valenced words ($M = 2.41$, $SD = 0.69$) and sixteen positively valenced words ($M = 7.69$, $SD = 0.62$) were chosen for inclusion, $F(1,28) = 756.6$, $p < 0.001$. Orthogonal to the valence variable, words were selected that were either high ($M = 6.93$, $SD = 0.62$) or low ($M = 4.12$, $SD = 0.72$) in arousal, $F(1, 28) = 132.03$, $p < .001$. The positive and negative words were equated in terms of arousal (positive words: $M = 5.55$, $SD = 1.67$; negative words: $M = 5.51$, $SD = 1.51$); $F(1, 28) = < 1$, word frequency based on the Kucera and Francis (1967) norms (positive words: $M = 76.62$, $SD = 92.18$; negative words: $M = 49.25$, $SD = 39.96$); $F(1, 28) = 1.18$, $p > .28$, and number of letters (positive words: $M = 5.44$, $SD = 2.10$; negative words: $M = 5.19$, $SD = 1.22$); $F(1, 28) = < 1$.

Also included in the stimulus set were 32 neutral words (e.g., number, add, today, etc.) and 64 non-words (for a total of 128 targets). Valence and arousal ratings did not exist for the neutral words. Non-words were orthographically plausible (e.g., thinx, huft).

**Procedure**

First, participants read a description of the study. Then, participants completed the Edinburgh Handedness Inventory, the health survey, and the PANAS mood questionnaire. Next, the participants completed the depression, anxiety, and personality measures before or after the lexical decision task. The order of completing the rest of the questionnaires and the lexical decision task was counterbalanced to reduce the probability of encountering an order effect where the measures influenced the performance on the lexical decision task or vice versa.

Participants completed a lexical decision task, which was adopted from Holtgraves and Felton (2010). During the lexical decision task, participants had their heads stabilized in a head
rest, UHCOTech HeadSpot, approximately 57 cm in front of a computer screen. Participants were informed that a string of letters would appear quickly on the screen and their task was to decide if the letter string constitutes a word as quickly and accurately as possible. Participants were not given any information containing the nature of the words. On each trial, a fixation mark of an X was presented in the middle of a computer screen. Participants were instructed to focus their vision on the fixation mark and make judgments based on stimuli presented in the periphery of the computer screen. A tone (500 Hz) sounded for 250 ms and a target string of letters was presented randomly to either the LVF or RVF. Participants used their right hand to press YES to indicate the target string of letters was a word or NO if it was not a word. Target strings were presented for 190 ms. After each trial, feedback on lexical decision accuracy was given for 1500 ms. After the completion of the lexical decision task and the measures, participants were debriefed.

Results

Exclusion from Data Analysis

Participants (n = 13) were excluded from the following data analyses for being left-handed and currently taking anti-anxiety or antidepressant medications. Left-handed individuals may be laterализed differently with their RH being their dominant hemisphere, so they must be excluded. Also, individuals taking anti-anxiety or antidepressant medications may have alterations in brain chemistry that may affect their responses to depression and anxiety measures and their performance on the lexical decision task.
Outlier Exclusion for the Lexical Decision Task

Trials where participants’ reaction times were under 50 ms or over 1500 ms were excluded from data analysis. The percentage of trials excluded was 1.51%. In addition, participants’ reaction times to trials were included for correct responses only. Therefore, 15.01% of trial reaction times were excluded based on incorrect responses.

Analyses of the Measures

I ran bivariate correlations for the mood, depression, anxiety, and personality measures (See Table 1). I found significant positive correlations between scores on the following measures: Negative Affect (NA) on the PANAS, Beck Depression Inventory (BDI-II), Beck Anxiety Inventory (BAI), Penn State Worry Questionnaire (PSWQ), and Neuroticism on the Big Five personality measure. I found a significant negative correlation between the scores on the BDI and Positive Affect (PA) on the PANAS. I also calculated the participants’ mean and standard deviation for the performance on the measures (See Table 2).

Overall Data Analyses for the Lexical Decision Task

The mean accuracy rate for the participants’ lexical decision task performance was 87.07% with a standard deviation of 11.65%. To examine how participants performed overall on the lexical decision task, I ran a 2 (Visual Hemifield: left versus right) x 2 (Valence: positive versus negative) x 2 (Arousal: low versus high) ANOVA with repeated measures on all factors for the reaction time to the emotional words presented in the lexical decision task. For Hypothesis 1, I expected to find a three-way interaction where participants respond more quickly to positive words presented in the LH regardless of arousal and to respond faster to high arousal negative words in the RH. However, there was no significant interaction between Visual
Hemifield x Valence x Arousal, $F < 1$. I did find a significant main effect for Valence, $F(1,86) = 11.19$, $p = .001$, with participants having a faster reaction time to positive words ($M = 478$ ms) than negative words ($M = 504$ ms). There was also a significant main effect for Arousal, $F(1,86) = 25.30$, $p < .001$, with participants having a faster reaction time to high arousal words ($M = 475$ ms) than low arousal words ($M = 507$ ms). There were no other significant main effects or interactions in this analysis.

**Data Analyses for Depression**

To examine depression, I performed a median split on the participants’ Beck Depression Inventory (BDI-II) scores. The median was a score of 8, which falls in the minimal depressive symptoms category according to the Beck Depression Inventory manual (Beck, Steer, & Brown, 1996). The clinical cutoff score for mild depression is 14. After the median split, the lower depression group consisted of 46 participants, and the higher depression group consisted of 39 participants. Two participants were excluded from the depression analyses due to incomplete BDI-II questionnaires.

I ran a 2 (Visual Hemifield: left versus right) x 2 (Valence: positive versus negative) x 2 (Arousal: low versus high) x 2 (Depression: low versus high) ANOVA with repeated measures on the first 3 variables for the RT to emotional words. For Hypothesis 2, I expected a three-way interaction with higher depressed participants responding faster to negative words in the RH and slower to positive words in the LH than lower depressed participants. However, the interaction between Visual Hemifield x Valence x Depression was not significant, $F < 1$. There was a significant Visual Hemifield x Depression interaction, $F(1, 83) = 3.98$, $p = .049$ with lower depressed participants having a faster reaction time to emotional words presented in the RVF/LH
(M = 491 ms) than presented to the LVF/RH (M = 518 ms), but higher depressed participants did not have a faster reaction time to emotional words presented in the RVF/LH (M = 476 ms) than the LVF/RH (M = 469 ms; See Figure 1). Follow-up simple effect tests were run for each visual hemifield separately and indicated that lower depressed participants had a significant difference in reaction time to emotional words presented in each visual hemifield, $F(1, 45) = 4.12, p = .048$. In contrast, higher depressed participants’ reaction time difference to emotional words presented in each visual hemifield was not significant, $F < 1$.

I also found a marginally significant interaction between Valence x Depression, $F(1, 83) = 3.20, p = .077$, with lower depressed participants having a faster reaction time to positive words (M = 486 ms) than negative words (M = 523 ms), but higher depressed participants did not have as large of a reaction time difference for positive words (M = 468) and negative words (M = 477; See Figure 2). Follow-up simple effect tests were run for valence separately and displayed a significant difference in reaction time to different valence words for lower depressed participants, $F(1, 45) = 9.17, p = .003$. However, for higher depressed participants, there was no significant difference in the reaction time to different valence words, $F < 1$.

**Data Analyses for Anxiety**

To examine anxiety, I performed a median split on the participants’ Beck Anxiety Inventory (BAI) scores. The median was a score of 6, which falls in the minimal anxiety symptoms category according to the Beck Anxiety Inventory manual (Beck & Steer, 1993). The clinical cutoff score for mild anxiety is 8. After the median split, the lower anxiety group consisted of 48 participants, and the higher anxiety group consisted of 39 participants.
I ran a 2 (Visual Hemifield: left versus right) x 2 (Valence: positive versus negative) x 2 (Arousal: low versus high) x 2 (Anxiety: low versus high) ANOVA with repeated measures on the first 3 variables for the RT to emotional words. For Hypothesis 3, I expected a three-way interaction where higher anxiety participants respond faster to negative words presented in the LVF/RH than lower anxiety participants. However, the interaction between Visual Hemifield x Valence x Anxiety was not significant, $F < 1$. For Hypothesis 4, I expected a three-way interaction where higher anxiety participants responded faster to high arousal words in the LVF/RH than lower anxiety participants. However, the interaction between Hemifield x Arousal x Anxiety was not significant, $F < 1$. I found a marginally significant interaction between Valence x Anxiety, $F(1, 85) = 3.156, p = .079$, with lower anxiety participants having a faster RT to positive words ($M = 475$ ms) than negative words ($M = 513$), but higher anxiety participants having less of a difference between the RT to positive ($M = 482$ ms) and negative words ($M = 493$ ms; See Figure 3). Follow-up simple effect tests were done for valence separately and demonstrated a significant difference in reaction time to different valence words in lower anxiety participants, $F(1, 47) = 16.18, p < .001$. In contrast, there was no significant difference in reaction time to different valence words in higher anxiety participants, $F < 1$.

Data Analyses for Anxiety Subtype

To examine the anxiety subtype of anxious apprehension, I performed a median split on the participants’ Penn State Worry Questionnaire (PSWQ) scores. The median was a score of 52, which is over the cutoff score of 45 indicating some worry symptoms. After the median split, the lower worry group consisted of 47 participants, and the higher worry group consisted of 39 participants. One participant was excluded from the worry analyses due to an incomplete questionnaire.
I ran a 2 (Visual Hemifield: left versus right) x 2 (Valence: positive versus negative) x 2 (Arousal: low versus high) x 2 (Worry: low versus high) ANOVA with repeated measures on the first 3 variables for the RT to emotional words. There was a significant main effect for worry with higher worry participants responding faster to words ($M = 451$) than lower worry participants ($M = 525$), $F(1, 84) = 4.68$, $p = .03$. There was a significant Worry x Arousal interaction, $F(1, 84) = 4.33$, $p = .04$, with lower worry participants having a much faster RT to high arousal words ($M = 503$ ms) than low arousal words ($M = 547$ ms), but higher worry participants not having as much of a difference between low arousal ($M = 460$ ms) and high arousal words ($M = 442$ ms; See Figure 4). Follow-up simple effect tests were run for arousal level separately and indicated a significant difference in RT to different arousal words in lower worry participants, $F(1, 46) = 23.72$, $p < .001$, and a significant difference in RT to different arousal words in higher worry participants as well, $F(1, 38) = 4.16$, $p = .048$.

Data Analyses for Personality

To analyze the Big Five personality variables, I performed median splits for each of the variables. I ran a 2 (Visual Hemifield: left versus right) x 2 (Valence: positive versus negative) x 2 (Arousal: low versus high) x 2 (Personality Variable: low versus high) ANOVA with repeated measures on the first 3 variables for the RT to emotional words for each personality variable. I found a marginally significant Visual Hemifield x Neuroticism interaction, $F(1, 85) = 3.72$, $p = .057$, with lower neuroticism participants having a faster RT to words presented in the RVF/LH ($M = 496$ ms) than words presented in the LVF/RH ($M = 521$ ms), but higher neuroticism participants did not have a difference in RT to the LVF/RH ($M = 467$ ms) and RVF/LH ($M = 474$ ms; See Figure 5). Follow-up simple effect tests were run separately for each visual hemifield, and there was a marginally significant difference in RT to the different visual hemifields in lower
neuroticism participants, $F(1, 46) = 3.50, p = .068$. However, there was no significant difference in RT to different visual hemifields in higher neuroticism participants, $F < 1$. There were no significant interactions for the four other personality variables: Openness to Experience, Conscientiousness, Extraversion, and Agreeableness.

**Discussion**

Previous research has shown emotion is lateralized in the brain (Demaree, Everhart, Youngstrom, & Harrison, 2005). Specifically, research has stated there are hemispheric differences in the perception of emotion in depression and anxiety. This study builds upon the prior research by delving into the factors potentially differentiating the pattern of asymmetry found in depression and anxiety, particularly in the perception of emotional words.

First of all, when examining lexical decision task performance overall, participants showed a bias for perceiving positive stimuli, such that they responded faster to positive emotional words than negative emotional words. In a study conducted by Yoon and colleagues (2009), participants demonstrated a positivity bias toward emotional faces during binocular rivalry. Faces were presented at the same time but to each eye separately. Positive, neutral, and negative faces were paired against one another, and participants judged positive faces to predominate over both neutral and negative, which suggests a perceptual bias toward positive stimuli. Another study found participants will spontaneously unscramble scrambled sentences to form positive statements rather than negative statements up to 70-80% of the time (Viviani et al., 2010). Viviani and colleagues also used neuroimaging and found the brain areas involved in effortful attention and executive function had reduced activation during the task, which suggested the positivity bias was not defined by directed control during the task. The researchers proposed the positivity bias while interpreting emotional content may be a regulatory mechanism
people use to avoid negative content that may be detrimental to their physical or psychological well-being.

In addition, participants demonstrated a bias toward responding to higher arousal emotional words overall, such that they had a faster reaction time when responding to high arousal words than low arousal words. Studies have revealed that arousal does affect cognitive processes. In a study by Dresler and colleagues (2009), participants completed an emotional Stroop task where emotional words were presented in color. They found participants had more interference when the emotional words were more arousing, regardless of valence. They also found that when asked to recall the words, participants were more likely to remember the high arousal words than the low arousal words. This study demonstrates how arousal can influence attentional processes, which could in turn influence higher processes of emotional perception and memory.

When analyzing level of depression’s effect on lexical decision performance, I found hemispheric differences in reaction time to emotional words. Individuals with lower levels of depression were significantly faster at responding to words in the RVF/LH than the LVF/RH. However, individuals with higher levels of depression demonstrated no hemispheric difference in reaction time to emotional words. This finding is supported by previous research on depression and hemispheric activation. Neuroimaging studies have revealed that depressed participants have an underactive LH (Grimm et al., 2008), which results in less binding of serotonin and dopamine (Robinson & Starkstein, 1989; Tucker & Williamson, 1984). In people not afflicted by depression, there is a LH specialization for language (Mathersul, Williams, Hopkinson, & Kemp, 2008). This would explain why individuals with lower levels of depression had the LH
advantage in responding faster to emotional words. In contrast, people with depression have reduced LH functioning, so they do not display the LH advantage for language.

Furthermore, when examining depression and lexical decision performance, I found participants with lower levels of depression had a positivity bias and responded faster to positive emotional words than negative emotional words. However, participants with higher levels of depression did not show a difference in reaction time to positive or negative words. This could relate to the hemispheric differences finding stated previously. If people with higher levels of depression have reduced LH functioning, then the neurotransmitters involved with positive emotion, such as serotonin and dopamine, are not binding efficiently. Therefore, in participants lacking the depressive symptoms, the positivity bias is present, but in higher depressed participants, the positivity bias is virtually erased.

When studying anxiety’s effect on lexical decision performance, I found a Valence x Anxiety interaction, which mimicked the valence finding for depression. Lower anxiety participants had a positivity bias with faster reaction time to positive words than negative words. However, higher anxiety participants did not display a difference. This could in part be explained by the neurological basis of anxiety. Anxiety is defined by an overactive RH, which is more focused upon negative stimuli (Mathersul, Williams, Hopkinson, & Kemp, 2008). Therefore, there is less LH activation with neurotransmitter binding of positive emotions. Similarly to depression, anxiety could then have the same underlying neurological basis, lower LH function and higher RH function, which could lead to the decreased bias for positive stimuli. Also, in the present study, the measures for depression and anxiety were highly correlated, Pearson’s $r = .69$. Thus, the measures could be largely measuring the same construct, such as general distress. This could potentially explain the similar valence findings for both depression and anxiety.
When examining anxious apprehension or worry’s effect on lexical decision performance, I did not find the hemispheric differences found in prior research. I found a Worry x Arousal interaction where both low and high worry participants were faster at responding to high arousal words, but high worry participants had less of a difference. This finding is contrary to what would be expected as the relationship between a subtype of anxiety and arousal. The expected result would be that individuals with more anxious symptoms would have faster reaction times to high arousal words than low arousal words. Also, I found a significant main effect for Worry where high worry participants responded faster to words overall than low worry participants. Mathersul and colleagues (2008) proposed individuals with this anxiety subtype have a specialization for language with a more active LH due to their frequent worries and ruminations. While there were no hemispheric differences found in this study, there is some indication that individuals with more worry symptoms may have a specialization for language with their faster reaction time to words overall. In sum of these findings, anxious apprehension may indeed be measuring some other construct that is independent of the anxiety symptoms measured by the BAI.

When examining the Big Five personality traits and lexical decision performance, I found a marginally significant interaction between neuroticism and visual hemifield. Individuals scoring lower on neuroticism had the LH advantage of responding faster to emotional words; however, individuals scoring higher on neuroticism did not have hemispheric differences. This result matches the finding of hemispheric differences with the level of depression. Neuroticism has been associated with the development of depression (Minnix & Kline, 2004). Minnix and Kline (2004) also state neuroticism is related to anxiety. However, there was not a significant relationship between valence and neuroticism as was found between anxiety and depression.
This demonstrates that the relationship between neuroticism and anxiety and depression may need to be studied further to determine similarities and differences between the trait and the disorders.

Although this study produced interesting, significant findings for individual differences in perception of emotional words, the four hypotheses proposed for this study were not significant. One possible reason is because of the small number of participants in the sample. Once participants were excluded based on handedness and medication usage and split into groups based on individual differences, there was then a much smaller number of participants. With having a smaller number of participants in each group, there could have been less statistical power, which could have contributed to non-significant findings for the three-way interactions hypothesized.

Another issue with this study was the lack of variability in the level of depression and anxiety in the participant population. For example, when performing the median split for depression, the median did not fall upon the cutoff for clinical depression, so individuals included in the high depressed group did not meet the cutoff criterion for depression. Therefore, individuals who fell within the minimal depressive symptoms category were being compared, which could have reduced the strength of the findings. Similarly, there was also not enough variability to separately compare comorbid depression and anxiety to depression and anxiety alone because of the small number of participants in the groups. Without being able to make this comparison, it was harder to parse out the differences between depression and anxiety because many of the participants still had a comorbidity of depressive and anxious symptoms. In addition, most prior research has examined individuals diagnosed with depression and anxiety when exploring hemispheric asymmetry of emotion. Since this study was not examining
diagnosed individuals primarily, the significant interactions found in prior research may not have been as easily found in a subclinical population.

For future study of the hemispheric asymmetry of emotion in regards to individual differences, it would be important to take into account the limitations of the present study. First, it would be important to obtain a large number of participants, specifically a large number of participants in each group comparing individual differences. Secondly, to examine comorbidity of depression and anxiety versus depression and anxiety alone, there would have to be enough variability in the sample and enough participants for each group. Lastly, to discover the hemispheric asymmetry patterns of emotional words in depression and anxiety, there may be more distinct patterns in individuals who are diagnosed with clinical levels of depression and anxiety.

Conclusions

This study delved into the hemispheric asymmetry of the perception of emotional words in individuals with depression and anxiety. When examining depression, there were hemispheric differences and emotional valence differences, which may reflect the underlying neurological basis of reduced LH function in depression. Similarly to depression, anxiety did share the emotional valence differences, with the positivity bias present in individuals with less anxious symptoms being absent in individuals with more anxious symptoms. When studying the anxiety subtype of anxious apprehension, there was an interaction with arousal, with individuals with less worry symptoms having a bias toward high arousal words, while individuals with more worry symptoms did not have as much of a bias toward high arousal words. There was also a main effect which indicated individuals with more worry symptoms responded faster to words overall than individuals with less worry symptoms. When exploring personality variables,
individuals scoring lower on neuroticism had the LH advantage for emotional words, while individuals scoring higher on neuroticism had no hemispheric differences. Overall, this study has demonstrated how individual differences can influence the perception of emotional words, which could provide an important key to discovering the neurological basis of emotion perception in individuals with depression and anxiety.
References


HEMISPHERIC ASYMMETRY OF EMOTIONAL WORDS


HEMISPHERIC ASYMMETRY OF EMOTIONAL WORDS


Appendix A: Edinburgh Handedness Inventory

Please indicate your preferences in the use of hands in the following activities by putting a check in the appropriate column. Where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, put 2 checks. If in any case you are really indifferent, put a check in both columns.

Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses.

Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Writing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Drawing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Throwing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Scissors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Toothbrush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Knife (without fork)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Spoon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Broom (upper hand)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Striking Match (match)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Opening box (lid)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL (count checks in both columns)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B: Health Survey

1. What is your age?
2. What is your gender?
3. What is your ethnicity?
4. Since birth have you ever had any medical problems?
   If yes, please explain.
5. Since birth have you ever been hospitalized?
   If yes, please explain.
6. Have you ever hit your head and experienced a concussion?
   If yes, please explain.
7. Do you use tobacco (smoke and/or chew)?
   If yes, please explain.
8. Do you drink caffeinated beverages?
   If yes, indicate how many beverages you drink a day.
9. Are you on any prescribed medications?
   If so, please specify.
10. Have you ever had any psychological diagnoses (e.g., depression, anxiety, ADHD)?
    If yes, please describe your diagnosis briefly.
11. Are you currently seeking counseling?
    If yes, specify the length of your treatment.
The PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following scale to record your answers.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>very slightly or not at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>a little</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>moderately</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>quite a bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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_____ interested
_____ distressed
_____ excited
_____ upset
_____ strong
_____ guilty
_____ scared
_____ hostile
_____ enthusiastic
_____ proud

_____ irritable
_____ alert
_____ ashamed
_____ inspired
_____ nervous
_____ determined
_____ attentive
_____ jittery
_____ active
_____ afraid
Appendix D: Penn State Worry Questionnaire

Patient Name: ___________________________ Date: ________________

The Penn State Worry Questionnaire (PSWQ)

Instructions: Rate each of the following statements on a scale of 1 ("not at all typical of me") to 5 ("very typical of me"). Please do not leave any items blank.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all typical of me</th>
<th>Very typical of me</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If I do not have enough time to do everything, I do not worry about it.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>2. My worries overwhelm me.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>3. I do not tend to worry about things.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>4. Many situations make me worry.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>5. I know I should not worry about things, but I just cannot help it.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>6. When I am under pressure I worry a lot.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>7. I am always worrying about something.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>8. I find it easy to dismiss worrisome thoughts.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>9. As soon as I finish one task, I start to worry about everything else I have to do.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>10. I never worry about anything.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>11. When there is nothing more I can do about a concern, I do not worry about it any more.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>12. I have been a worrier all my life.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>13. I notice that I have been worrying about things.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>14. Once I start worrying, I cannot stop.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>15. I worry all the time.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
<tr>
<td>16. I worry about projects until they are all done.</td>
<td>1  2  3  4  5</td>
<td></td>
</tr>
</tbody>
</table>
Appendix E: Goldberg (1992) Personality Inventory

Instructions

Please rate yourself on the following traits. Do this by putting a number indicating how accurately that trait describes you, using the following scale:

9 = extremely accurate  
8 = very accurate  
7 = quite accurate  
6 = slightly accurate  
5 = neither accurate nor inaccurate  
4 = slightly inaccurate  
3 = quite inaccurate  
2 = very inaccurate  
1 = extremely inaccurate

<table>
<thead>
<tr>
<th>Trait</th>
<th>Number</th>
<th>Trait</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td></td>
<td>Negligent</td>
<td></td>
</tr>
<tr>
<td>Agreeable</td>
<td></td>
<td>Nervous</td>
<td></td>
</tr>
<tr>
<td>Anxious</td>
<td></td>
<td>Organized</td>
<td></td>
</tr>
<tr>
<td>Artistic</td>
<td></td>
<td>Philosophical</td>
<td></td>
</tr>
<tr>
<td>Assertive</td>
<td></td>
<td>Pleasant</td>
<td></td>
</tr>
<tr>
<td>Bashful</td>
<td></td>
<td>Practical</td>
<td></td>
</tr>
<tr>
<td>Bold</td>
<td></td>
<td>Prompt</td>
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<tr>
<td>Bright</td>
<td></td>
<td>Quiet</td>
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<tr>
<td>Careful</td>
<td></td>
<td>Relaxed</td>
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<tr>
<td>Careless</td>
<td></td>
<td>Reserved</td>
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<tr>
<td>Cold</td>
<td></td>
<td>Rude</td>
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</tr>
<tr>
<td>Complex</td>
<td></td>
<td>Self-pitying</td>
<td></td>
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<tr>
<td>Conscientious</td>
<td></td>
<td>Selfish</td>
<td></td>
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<tr>
<td>Considerate</td>
<td></td>
<td>Shallow</td>
<td></td>
</tr>
<tr>
<td>Cooperative</td>
<td></td>
<td>Shy</td>
<td></td>
</tr>
<tr>
<td>Creative</td>
<td></td>
<td>Simple</td>
<td></td>
</tr>
<tr>
<td>Daring</td>
<td></td>
<td>Sloppy</td>
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<tr>
<td>Deep</td>
<td></td>
<td>Steady</td>
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</tr>
<tr>
<td>Demanding</td>
<td></td>
<td>Sympathetic</td>
<td></td>
</tr>
<tr>
<td>Disorganized</td>
<td></td>
<td>Systematic</td>
<td></td>
</tr>
<tr>
<td>Distrustful</td>
<td></td>
<td>Talkative</td>
<td></td>
</tr>
<tr>
<td>Efficient</td>
<td></td>
<td>Temperamental</td>
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<tr>
<td>Emotional</td>
<td></td>
<td>Verbal</td>
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<tr>
<td>Energetic</td>
<td></td>
<td>Thorough</td>
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<tr>
<td>Envious</td>
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<td>Timid</td>
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<tr>
<td></td>
<td></td>
<td>Touchy</td>
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<tr>
<td></td>
<td></td>
<td>Warm</td>
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<tr>
<td></td>
<td></td>
<td>Vigorous</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Withdrawn</td>
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</tbody>
</table>
Appendix F: Emotional Words

<table>
<thead>
<tr>
<th>Negative Valence</th>
<th>Positive Valence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Arousal</strong></td>
<td><strong>Low Arousal</strong></td>
</tr>
<tr>
<td>Danger</td>
<td>Dreary</td>
</tr>
<tr>
<td>Fear</td>
<td>Failure</td>
</tr>
<tr>
<td>Hate</td>
<td>Gloom</td>
</tr>
<tr>
<td>Hell</td>
<td>Lonely</td>
</tr>
<tr>
<td>Pain</td>
<td>Misery</td>
</tr>
<tr>
<td>Panic</td>
<td>Pity</td>
</tr>
<tr>
<td>Scream</td>
<td>Sad</td>
</tr>
<tr>
<td>Stress</td>
<td>Unhappy</td>
</tr>
</tbody>
</table>
Table 1.

Correlation matrix for measures

<table>
<thead>
<tr>
<th>Measures</th>
<th>BDI</th>
<th>BAI</th>
<th>PSWQ</th>
<th>Neuroticism</th>
<th>PA</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI</td>
<td>1.00</td>
<td>0.69*</td>
<td>0.63*</td>
<td>0.43**</td>
<td>-0.22</td>
<td>0.43*</td>
</tr>
<tr>
<td>BAI</td>
<td>1.00</td>
<td>0.64**</td>
<td>0.49**</td>
<td>0.01</td>
<td>0.32*</td>
<td></td>
</tr>
<tr>
<td>PSWQ</td>
<td>1.00</td>
<td>0.52**</td>
<td>-0.05</td>
<td>0.33**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuroticism</td>
<td>1.00</td>
<td>-0.07</td>
<td>0.23*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA</td>
<td>1.00</td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01
Table 2.

*Means and standard deviations for measures*

<table>
<thead>
<tr>
<th>Measures</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI</td>
<td>9.86</td>
<td>7.04</td>
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<tr>
<td>BAI</td>
<td>9.41</td>
<td>7.86</td>
</tr>
<tr>
<td>PSWQ</td>
<td>50.90</td>
<td>14.83</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>4.93</td>
<td>1.01</td>
</tr>
<tr>
<td>PA</td>
<td>29.79</td>
<td>6.67</td>
</tr>
<tr>
<td>NA</td>
<td>14.08</td>
<td>3.66</td>
</tr>
</tbody>
</table>
Figure 1. Hemispheric differences in reaction time in low and high depressed participants.
Figure 2. Reaction time to different valence words in low and high depressed participants.
Figure 3. Reaction time to different valence words in low and high anxiety participants.
Figure 4. Reaction time to different arousal words in low and high worry participants.
Figure 5. Hemispheric differences in reaction time in low and high neuroticism participants.