ATTENTION AND EMOTION PROCESSING

AMONG INDIVIDUALS WITH WORRY

By

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Abstract: Worry has been defined as a core feature of Generalized Anxiety Disorder and is characterized by excessive and uncontrollable thoughts regarding future uncertain or potentially threatening events. Models of worry have identified attentional biases as a primary maintaining factor, specifically a tendency for individuals with worry to attend to threat-related or uncertain stimuli more than non-anxious individuals. The Attentional Control Theory suggests that these biases result in reduced performance efficiency (i.e., reaction times), but not performance effectiveness (i.e., accuracy). Additionally, individuals with worry report more negative interpretations of uncertain or ambiguous stimuli, such as surprised faces, as measured by valence and arousal ratings. The current study sought to examine the impact of worry on performance efficiency and subjective ratings of valence and arousal of threatening and surprised facial stimuli using a modified Flankers Task and Self-Mannequin Task. It was hypothesized that individuals high in worry would display increased (longer) reaction times on the Flankers Task when presented with fearful and surprised facial stimuli. Furthermore, we expected that individuals high in worry would rate fearful and surprised facial stimuli as more negative and arousing than individuals with low to no worry. Results did not provide support for differences between groups; however, this study was limited by a number of potential confounds.

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CHAPTER I

INTRODUCTION

Worry has been defined as a key feature of Generalized Anxiety Disorder (GAD) and is characterized by excessive and uncontrollable thought regarding future uncertain or threatening events (American Psychiatric Association, 2013). Individuals with worry display increased physiological symptoms such as sweating, increased heart rate, and muscle tension (Borkovec, Robinson, Pruzinsky & DePree, 1983), as well as attentional biases for threat-related information (Eysenck et al., 2007). Prominent models of anxiety posit that such biases are primary maintaining factors and therefore have been a main focus among anxiety researchers. Although extant literature has demonstrated biases towards threat-related information, little research has examined emotional processing of uncertain or ambiguous stimuli (i.e., ambiguous facial cues) despite the prominent role of intolerance of uncertainty as a risk factor for GAD and anxiety disorders broadly (Freeston et al., 1994; Dugas et al., 1995). Given that intolerance of uncertainty also has been shown to play an important role in the development of anxiety symptoms, the current study utilized emotionally valenced facial stimuli to investigate how individuals with worry may differentially process or interpret ambiguous stimuli (i.e., surprise).

Eysenck and colleagues (2007) suggested that worry has a significant negative impact on attentional control. Specifically, the Attentional Control Theory (ACT) posits that anxiety impairs the goal-driven system (top-down) while increasing the stimulus-driven system (bottom-up). Research regarding this theory has identified inhibition, shifting, and updating as the three mechanisms of attentional control. Inhibition involves deliberately ignoring distractions and responding only when necessary, shifting is the ability to switch between task demands, and updating is the ability to monitor working memory representations (Miyake et al., 2000). Due to these deficits, individuals with anxiety display decreased performance efficiency (increased response times) but maintain performance effectiveness (task accuracy). For example, Dennis and Chen (2009) evaluated this using a Flankers task, a speeded response task which requires participants to respond to a target stimulus while ignoring distractor stimuli. Trials may be congruent (target and distractors the same) or incongruent (target different from distractors). Results of this study show significantly greater reaction times to incongruent compared to congruent trials. This study further demonstrated that individuals with anxiety display significantly greater reaction times overall, but do not show differences in accuracy. According to ACT, efficiency is impaired as a result of attentional biases and reduced attentional control. Specifically, individuals with anxiety display a tendency to attend to threat-related or uncertain information, taking over cognitive resources that results in reduced performance efficiency (Eysenck et al., 2007; Eysenck & Derakshan, 2011). Studies have found that the stimulus-driven system is affected by the automatic processing of threat-related information, in turn decreasing the influence of the goal-directed system (Fox, Russo, & Georgiou, 2005).

Research using a variety of paradigms has found that as threat intensity increases, attention allocation to threat also increases among individuals with anxiety (Wilson & MacLeod, 2003; Koster, et al., 2004). Horstmann, Borgstedt, and Heumann (2006) utilized a modified Flankers task, during which participants were presented with facial stimuli of varying emotional intensity to assess for threat-related biases. Results showed that response times to target flankers with angry distractors were slower than with happy or neutral distractors. Such results demonstrate that even when threatening stimuli are presented outside of an individual's primary focus, attentional biases are still present. Additionally, Bar-Haim and colleagues (2005) found that individuals with anxiety respond slower to angry and fearful facial stimuli compared to healthy controls. Taken together, research suggest that emotion processing may be influenced by both top-down and bottom-up processes.

Parra and colleagues (2017) examined attentional biases during a modified emotional Flankers task. This task made use of threatening and neutral images from the IAPS (Lang et al., 1988) during which a target flanker was surrounded by either congruent or incongruent emotional flankers. Participants were asked to attend and respond to only the target flanker. Results of this study revealed slower reaction times for target threat compared to target neutral conditions, suggesting emotional processing of threat-related information leads to decreased task efficiency. Similarly, Moser and colleagues (2008) used an emotional Flankers task to examine emotional biases in individuals high and low in social anxiety. Participants were presented with angry, disgust, happy, and surprise facial expressions during either congruent or incongruent trials. Results found that accuracy did not vary between groups or by facial type; however, reaction times were slower on trials with threatening (anger and disgust) facial stimuli as compared to positive (happy and surprise) stimuli.

It is important to note that research has been mixed in regard to the valence of surprised faces. For example, Moser and colleagues (2008) classified surprised facial stimuli as positive, whereas Neta, Tong, and Henley (2018) described surprise as ambiguous, evidencing both the positive (e.g., birthday party) and negative (e.g., car accident) aspects of surprised facial expressions. The Intolerance of Uncertainty Model (IU; Freeston, Rheaume, Letarte, Dugas, & Ladouceur, 1994; Dugas, Letarte, Rheaume, Freeston, and Ladouceur, 1995) suggests that individuals with worry perceive uncertain or ambiguous situations as more stressful and upsetting than non-anxious individuals. Furthermore, this can lead to cognitive avoidance and cognitive biases. For example, individuals with a negative interpretation bias, such as those with worry, tend to interpret ambiguous stimuli as more negative than those without this bias (Holmes et al., 2009). Anxiety has been widely associated with a negative interpretation bias to ambiguous sentences (Eysenck et al., 1991; MacLeod and Cohen, 1993), words (Richards and French, 1992) and scenarios (Hirsch and Mathews, 1997). Although negative interpretation biases have been well documented in individuals with anxiety, few studies have utilized ambiguous facial stimuli. Park and colleagues (2016) examined how trait anxiety impacts interpretations of surprised facial expressions. Participants were presented happy, neutral, and surprised facial expressions at different spatial frequencies and asked to rate them each as positive (1) or negative (2). Results demonstrated that individuals high in trait anxiety rated surprised facial expressions as more negative than happy and neutral expressions compared to individuals low in trait anxiety. Based on models of worry, these findings suggest that uncertain or ambiguous stimuli (i.e., surprise) are viewed as more negative compared to neutral face stimuli, which should lead to attentional biases among individuals with worry.

In addition to behavioral measures of attentional biases, it is also important to understand basic perception of emotional expressions. Dennis and Chen (2009) utilized a self-assessment mannequin (SAM; Lang, Bradley, & Cuthbert, 1998) task to assess individual ratings of facial stimuli. Participants were asked to rate arousal and valence of fearful, sad, happy, and neutral facial expressions. Results indicate that sad faces were rated as less arousing than fearful and happy faces, but not neutral faces. Happy faces were rated as more positive than fearful and neutral faces, and sad faces were rated as more negative than fearful and neutral faces. Overall, sad faces were perceived as more negative and less arousing than the other facial stimuli.

Taken together, research provides evidence for increased attention toward threat-related information among those high in anxiety (Parra et al., 2017; Moser et al., 2008; Fenske & Eastwood, 2003). Such results provide support for the attentional control theory, such that individuals with anxiety utilize additional attentional resources to a task, negatively affecting task efficiency. Additionally, previous literature has focused primarily on threatening stimuli, such as anger or disgust, and has not yet evaluated emotional processing of ambiguous stimuli. It remains important to understand situations in which individuals with anxiety may display attentional biases. Further research is needed to examine the extent to which ambiguous stimuli (surprise) impacts attentional control in individuals with anxiety.

The current study aimed to document attentional biases to emotional stimuli using a modified Flankers task and emotional rating task. First, it was hypothesized that individuals with worry would display increased reaction times for fearful and surprised trials compared to happy and neutral while maintaining performance effectiveness. Additionally, it was hypothesized that this relationship would be exacerbated during incongruent trials. Overall, it was expected that fearful and surprised faces would be rating as more arousing and negative than neutral and happy faces, and that this relationship would be moderated by individual level of worry.

CHAPTER II

METHODOLOGY

Participants

Participants were recruited via SONA to participate in an online study for 1 course credit. The initial pool of participants included 223 undergraduate students; however, only 117 participated in experimental portion. Those who did not complete the full online experiment were excluded from analyses. The final online sample consisted of 78 participants. Using the Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, and Borkovec, 1990), participants were grouped into high and low worry groups (extreme groups approach). Low worriers were classified as PSWQ scores falling below 47 and high worriers with scores falling above 62 (Behar et al., 2003). Based on the extreme groups approach, the final sample included *N* = 21 low worry, and *N* = 26 high worry. This sample was primarily female (76.6%) with an average age of 20.89. Participants primarily identified as White (83%), Mixed (6.4%), African-American (4.3%), Asian (2.1%), and Latinx (2.1%).

An a priori power analysis (Cohen, 1988) of a repeated measures ANOVA using effect sizes documented in previous studies ($\eta^2 = 0.086$) suggested a range from 26-186 individuals were needed to achieve adequate power (i.e., $\beta = .80$, $\alpha = .05$). Based on this and similar study designs (*N* = 28; Dennis & Chen, 2007; *N* = 36; Dennis & Chen, 2009), a total sample of 70 was deemed appropriate.

Measures

Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990). The PSWQ is a 16-item self-report measure of worry. Responses are indicated using a 5-point Likert-type scale with responses ranging from 1 (*not at all typical of me*) to 5 (*very typical of me*). Higher total scores on the PSWQ indicate greater levels of worry. This measure demonstrates high internal consistency (α = .95; Meyer et al., 1990), and has good test-retest reliability. The current study demonstrated excellent internal consistency (α = 0.94).

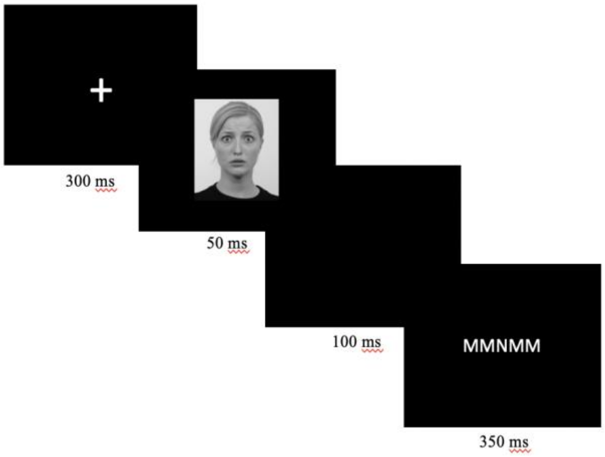
Intolerance of Uncertainty Scale (IUS; Freeston et al., 1994). The IUS is a 27-item self-report measure of reactions to ambiguous situations and uncertainty. Responses are indicated using a 5-point Likert-type scale with responses ranging from 1 (*not at all characteristic of me*) to 5 (*entirely characteristic of me*). Higher total scores on the IUS indicate greater levels of intolerance of uncertainty. This measure demonstrates high internal consistency (α = .95; Freeston et al., 1994). The current study demonstrated excellent internal consistency (α = 0.94).

Attentional Control Scale (ACS; Derryberry & Reed, 2002). The ACS is a 20-item measure of attentional control that captures individual differences in abilities to focus and shift attention. The ACS is rated on a 4-point Likert-type scale ranging from 1 (*almost never*) to 4 (*always*). This questionnaire has demonstrated good internal consistency (α = .88) and has been shown to be a valid measure of attention regulation in samples of individuals who worry (Spada, Georgiou, & Wells, 2010; Judah et al., 2014) and also is predictive of behavioral indicators of attention (Derryberry & Reed, 2002; Judah et al., 2016). The current study demonstrated good internal consistency (α = 0.81).

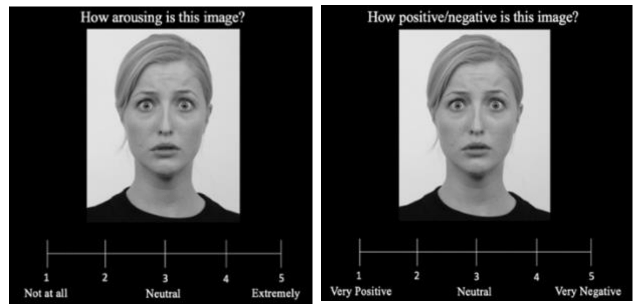
Facial Stimuli. Facial stimuli used in the current study were taken from the Radboud Faces Database (Langner et al., 2010), a set of 39 Caucasian males and females. Happy, neutral, fearful, and surprised faces were used.

Procedures

All procedures were approved by the Institutional Review Board at Oklahoma State University. Participants were provided informed consent before completing demographics forms and self-report measures of trait worry, uncertainty, and attentional control. Upon survey completion, participants were directed to Pavlovia, an online experimental software. Participants were instructed to enter their randomly assigned ID number before beginning the online experiment. Next, they were instructed to complete a modified version of the Flankers task (Figure 1), a speeded response task in which individuals are asked to respond to a target stimulus while ignoring other distractor stimuli. Prior to each Flanker trial, participants were presented with one of four possible facial expressions (neutral, happy, fearful, surprised). Participants responded to the target by pressing either the left or right arrow. Trials may be congruent (MMMMM; NNNNN) or incongruent (MMNMM; NNMNN). The following instructions were given, "For this task you will be asked to respond to stimuli that appear on the screen. A facial stimulus will be presented, followed by a fixation cross, and an array of the letters M and N. Do not pay attention to the face. If the MIDDLE letter is M you will press the left arrow. If the MIDDLE letter is N you will press the right arrow. You will have a chance to practice first. Keep your eyes on the fixation cross. Answer as fast as you can without making mistakes. If you make a mistake, just keep going." Participants completed 20 full feedback practice trials (without facial stimuli) prior to the experimental phase. Participants then completed two blocks of 304 trials with a 30 second break between blocks. A fixation cross was presented for 300 ms, followed by facial stimuli for 50 ms, a 100 ms inter-stimulus-interval, and Flanker stimuli for 350 ms. Participants were allowed up to 450 ms to respond. Upon completion of the modified Flankers task, participants completed a facial rating task (Figure 2) in which they were asked to rate valence and arousal of each facial stimulus. Faces were rated on a scale of 1-5, with 1 indicating low arousal and 5 indicating high arousal, and an additional 1-5 scale to rate valence, with 1 being very positive and 5 being very negative. At the end of the study, participants were debriefed and thanked for their participation.



Figure



Figure

Analytic Strategy

A series of 2 (PSWQ: High, Low) by 4 (Facial Type: Neutral, Happy, Fearful, Surprise) by 2 (Trial: Congruent, Incongruent) repeated measures ANOVAs were used to assess reaction time and error rates with repeated measures on the last two factors. A series of 2 (PSWQ: High, Low) by 4 (Facial Type: Neutral, Happy, Fearful, Surprise) repeated measures ANOVAs were used to examine average arousal and valence ratings with repeated measures on the last factor. Supplemental analyses examined the overall online sample (N = 78) using a repeated measures ANOVA of reaction time, error rate, arousal and valence ratings by 4 (Facial Type: Neutral, Happy, Fearful, Surprise) by 2 (Congruent, Incongruent) with repeated measures on the last two factors.

CHAPTER III

RESULTS

Reaction Times. Results revealed a significant main effect of Facial type on reaction time (RT), $F(3, 231) = 12.11$, $p < 0.001$, $\eta_p^2 = 0.14$. Examination of pairwise comparisons revealed that happy RT ($M = 0.470$, $SD = 0.05$) were significantly faster than neutral RT ($M = 0.483$, $SD = 0.05$), $p = 0.012$, but slower RT were found for neutral compared to fearful facial stimuli ($M = 0.466$, $SD = 0.05$), $p = 0.029$. Lastly, neutral RT was significantly slower than surprised RT ($M = 0.469$, $SD = 0.05$), $p = 0.006$. There was no significant interaction between worry group and image type on reaction time, $F(3, 129) = 0.99$, $p = 0.39$

Errors. Results revealed a significant main effect of trial between congruent ($M = 38.59$, $SD = 25.39$) and incongruent ($M = 70.03$, $SD = 39.41$) trials, $F(1, 77) = 157.66$, $p < 0.001$, such that reaction times for incongruent trials were greater than congruent trials. Results revealed no significant interaction between worry group and image type on accuracy, $F(3, 129) = 0.67$, $p = 0.56$.

Arousal Ratings. Results revealed a significant main effect of Facial Type on arousal rating, $F(3, 237) = 12.91$, $p < 0.001$, $\eta_p^2 = 0.14$. Examination of pairwise comparisons revealed happy facial stimuli ($M = 2.19$, $SD = 1.26$) were rating as significantly more arousing than both neutral ($M = 1.65$, $SD = 0.85$), $p < 0.001$, and surprise facial stimuli ($M = 1.95$, $SD = 1.17$), $p = 0.047$. Additionally, neutral facial stimuli were rated as significantly less arousing than fearful (*M*

= 1.98, *SD* = 1.25), $p = 0.011$, and surprise, $p = 0.006$. Results revealed no significant interaction between worry group and image type on arousal ratings, $F(3,126) = 0.71$, $p = 0.55$.

Valence Ratings. Results revealed a significant main effect of valence rating, $F(3, 237) = 119.70$, $p < 0.001$, $\eta_p^2 = 0.61$. Examination of pairwise comparisons revealed that happy facial stimuli (*M* = 1.73, *SD* = 0.89) were rated as significantly more positive than all other facial type, neutral (*M* = 3.37, *SD* = 0.65), fearful (*M* = 3.84, *SD* = 0.84), and surprise (*M* = 3.37, *SD* = 0.70), $p < 0.001$. Additionally, fearful stimuli were rated as significantly more negative than neutral and surprise stimuli, $p < 0.001$. Results revealed no significant interaction between worry group and image type on valence ratings, $F(3, 129) = 0.83$, $p = 0.41$.

Exploratory Analyses

Exploratory analyses were conducted in order to further evaluate the relationship among study variables, such as sex and continuous measures of worry, attentional control, and uncertainty. A series of ANCOVA analyses using continuous covariates were used to examine all dependent variables.

Sex. No significant differences in errors, reaction time, valence, or arousal ratings were found between males and females, $p > 0.05$.

Worry. No significant differences in errors, reaction time, valence, or arousal ratings were found when examining worry as a continuous covariate, $p > 0.05$.

Attentional Control. No significant differences in errors, reaction time, valence, or arousal ratings were found when examining attentional control as a continuous variable, $p > 0.05$.

Uncertainty. Results revealed a significant interaction between image type reaction times and continuous levels of intolerance of uncertainty, $F(3, 225) = 5.31$, $p = 0.016$. Examination of parameter estimates revealed no significant effect of uncertainty, $p > 0.05$.

CHAPTER IV

DISCUSSION

The current study aimed to document attentional and emotion processing biases among individuals with worry using both behavioral measures (i.e., reaction times and error rates) and average arousal and valence ratings. Happy facial stimuli were rated as significantly more arousing than both neutral and surprised facial stimuli, and fearful and surprised facial expressions were rated as more arousing than neutral expressions. Additionally, happy facial stimuli were rated as significantly more positive than all other facial expressions, and fearful facial stimuli were rated as more negative than neutral and surprise facial stimuli. Results regarding trial type are in line with previous research such that participants made significantly more errors on incongruent compared to congruent trial types, but no differences in performance effectiveness were found between worry groups. Results indicated that, overall, RTs following neutral stimuli were significantly slower than all other facial stimuli. This was in contrary to stated hypotheses and previous research suggesting slowest reaction times to threat-related or uncertain stimuli.

Original hypotheses predicted that those high in worry would display significantly greater reaction times for fearful and surprise facial stimuli; however, this difference was not found. Primary models of worry suggest differences in performance efficiency between individuals with worry compared to healthy controls (Eysenck et al., 2007; Eysenck & Derakshan, 2011). Studies using a number of attentional control tasks have demonstrated this, such that individuals with worry display significantly greater reaction times compared to non-anxious individuals, and that these differences may be exacerbated by emotional stimuli (Dennis & Chen, 2007; Moser et al., 2008; Dennis & Chen, 2009). Additionally, abundant research has demonstrated emotional processing biases between these two groups, such that individuals with worry display increased attentional biases for threatening or uncertain information (Wilson & MacLeod, 2003; Horstmann, Borgstedt & Heumann, 2006; Parra et al., 2017). Such attentional biases are typically seen in behavioral measures as increased reaction times to threat or uncertain stimuli in individuals with high worry. Research methodologies such as electroencephalography provide additional support for these biases by indicating neural changes to stimuli; however, COVID-19 precautions did not allow use of these measures.

Exploratory analyses were conducted to examine continuous measures of study variables on all dependent variables. Although the current study postulated differences between individuals high and low in worry, previous research has suggested other potential moderators. Intolerance of Uncertainty suggests group differences in processing of and attention to uncertain or ambiguous stimuli (Dugas et al., 1995); however, it is possible that those differences also may be seen based on individual level of uncertainty. In order to examine this relationship, analyses were run using total scores from the Intolerance of Uncertainty Scale (Freeston et al., 1994). Additionally, individual level of attentional control and worry, based on total scores from self-report measures, were examined. No significant differences were found when including continuous variables instead of a cutoff approach, but it is important that future research continues to examine such moderating factors.

Although the current study did not see significant differences in reaction times between the groups, findings may not be representative of the broad literature. Researchers have consistently found performance efficiency differences between individuals high and low in worry, and it is important to note that previous study findings have been found in a controlled laboratory setting. Due to COVID-19 safety protocols, the current study was unable to be conducted in a controlled setting, leading to a number of potential confounds. First, only a small portion of the overall online sample met the cutoff requirements for high and low worry. The small sample size may not be large enough to detect differences seen in previous studies, and may not be representative of a typical worry sample. It also is possible that the nature of an online experiment was not able to control extraneous factors that could have affected the results, such as computer type, browser type, or other outside distractions.

Another possibility for the lack of effects is that the facial stimuli used for this study may not have been strong enough to elicit a typical response seen in worriers, such as attentional biases or cognitive avoidance. However, the current study made use of validated facial stimuli of four facial expressions. Although socially salient cues, such as facial expressions, are often used in the study of social anxiety (Moser, 2008), research also has demonstrated that facial stimuli are adequate to elicit biases in individuals with worry (Dennis & Chen, 2007; Dennis & Chen, 2009). Additionally, participants may not have attended to the stimuli on the screen in an uncontrolled setting.

Finally, it also is important to note that self-report measures may not be an accurate measure of current worry symptoms, and future studies may make use of diagnostic measures in order to ensure the results will generalize to clinical samples. It is important that researchers continue to examine emotional processing of uncertain stimuli among worriers as there is significant amounts of research to support the hypotheses made in the current study.

Taken together, the current study sought to examine emotional processing and attentional biases among individuals with worry using four valenced facial stimuli. Previous research supports the use of facial stimuli within individuals with worry, further evidencing similar biases to surprise stimuli as threat-related stimuli. Although no significant differences were found based on level of worry, it remains important to conduct this study in a controlled laboratory setting with additional measures of attention, such as electroencephalography. Ample research has evidenced attentional biases hypothesized in the current study, and this study should be examined with caution based on limitations and potential confounding factors.

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APPENDICES

REVIEW OF THE LITERATURE

Generalized Anxiety Disorder

The Diagnostic and Statistical Manual (DSM-5) defines Generalized Anxiety Disorder (GAD) as excessive anxiety and worry about a number of events or activities, occurring more days than not for at least 6 months (American Psychiatric Association, 2013). Sufferers of GAD often report increased sweating, heart rate, muscle tension, and sleep difficulties during worry (Borkovec, Robinson, Pruzinsky & DePree, 1983). Due to these symptoms, cognitive-behavioral models suggest that the perception of physiological symptoms is a maintenance factor of worry (Borkovec, Alcaine, & Behar, 2004; Dugas, Gagnon, Ladouceur, & Freeston, 1998; Mennin, Heimberg, Turk, & Fresco, 2002; Wells, 2004).

GAD frequently results in high personal and societal cost, such as decreased performance in work and school (Hoffman et al. 2008), but often is the most difficult anxiety disorder to treat (Newman, Llera, Erickson, Przeworski, & Castonquay, 2013). Among adults in the United States, GAD has a 12-month prevalence rate of 2.9% and a lifetime prevalence of 5.1% (Kessler et al. 2012). Women are more likely than men to be diagnosed with the disorder with lifetime prevalence rates of 5.3% and 2.8% respectively (Vesga-Lopez et al. 2008).

Previous research has shown that GAD increases the chance of later developing panic disorder, mood disorders, substance use disorders, and posttraumatic stress disorder (Ruscio et al., 2007). When compared to individuals with chronic medical conditions, those with GAD are found to exhibit equal role impairment in their daily lives (Alonso et al., 2011). Furthermore, GAD is highly associated with physical problems, such as increased risk of cardiovascular mortality (Phillips et al., 2009), and increased probability of suicidal ideation and attempts, after controlling for comorbidities (Boden et al., 2007).

Beyond the previously stated implications, individuals with GAD are more likely to experience more intense emotional experiences when compared to those with depression (Aldao et al., 2010). When it comes to managing moods, particularly negative mood states, those with GAD report it being more difficult to recover (Mennin et al. 2005). Additionally, individuals with GAD seem to experience their emotions as more threatening compared to their nonanxious counterparts (Llera & Newman 2010).

Excessive worry is a defining feature of GAD, and can be thought of as a mechanism to manage emotional reactivity and feel a sense of control (Newman, Llera, Erickson, Przeworski, & Castonquay, 2013). Whereas some worry can be normal, those diagnosed with GAD perceive worry to be both distressing and impairing (Ruscio, 2002). Finding this boundary between clinical and non-clinical worriers has been the subject of previous research. Ruscio (2002) sought to examine the factors that differentiate pathological worry (DSM-IV diagnosis of GAD) from normal worry. Results suggested the best differentiating factors were Criterion A (chronic, excessive worry) and E (significant distress or impairment) from DSM-IV. Ruscio et al. (2002) also found that Criterion B, uncontrollability, was useful for distinguishing pathological worry from normal worry, but to a lesser degree. The results are evidence that clinical and non-clinical worriers share similar experiences of worry, but the chronic nature and impairment of that worry is what sets them apart.

Models of Worry in Generalized Anxiety Disorder

<u>Cognitive Avoidance Theory of Worry</u>

The Cognitive Avoidance Theory of Worry (CATW; Borkovec, 1994; Alcaine & Behar, 2004) draws on Mowrer's (1947) fear theory as well as Foa and Kozak's emotional processing model (Foa and Kozak, 1986; Foa, Huppert, & Cahill, 2006). The foundation of this theory is that worry works as a cognitive avoidance strategy in response to believed future threat. Although there are several functions of avoidance in worry, there are two that are most important to this theory. First, worry is used to create ways to prevent the occurrence of bad events, or to prepare an individual in the event that it happens. Second, worry, in general, can reduce somatic responses to threat. Specifically, worry is a thought-based activity in which mental imagery and its associated emotional experiences are inhibited (Behar, Zuellig, & Borkovec, 2005; Borkovec & Inz, 1990). Inhibition of these emotional experiences in turn hinders one's ability to fully process their emotions of fear and results in reduced somatic responses (Foa & Kozak, 1986; Foa et al., 2006; Vrana, Cuthbert, & Lang, 1986). Individuals who inhibit emotional experiences become engaged in a process known as anxious verbal-linguistic internal speech (Borkovec & Inz, 1990; Freeston, Dugas, & Ladouceur, 1996). This process stems from the idea that imagery is more emotionally evocative than verbal-linguistic thought. Therefore individuals with GAD attempt to shift from anxious imagery to verbal thought to lessen experienced negative affect (Lang, 1985; Vrana, Cuthbert, & Lang, 1986).

Within CATW, worry is conceptualized as an ineffective problem solving strategy to remove perceived threat and suppress physiological arousal (Foa & Kozak, 1986). With the exchange of distress imagery with less negative verbal-linguistic activity, worry becomes negatively reinforced. Furthermore, worry continues to be reinforced with positive beliefs; for example, one may believe that worry will help problem-solving abilities (Borkovec, 1994; Borkovec et al., 2004). Additionally, Dugas and colleagues (1998) found that individuals with GAD believe that worry is beneficial, productive, and is a sign of good character.

The model also describes worry as verbal thinking that aims to resolve future problems, and in turn prevent anticipated disasters. Although worry is thought of as verbal-linguistic, imagery is also a key factor (Andor, Gerlach, & Rist, 2008). Previous research has found that imagery leads to greater physiological arousal when compared to verbal thinking (Borkovec et al., 1990; Freeston et al., 1996; Heller, Nitschke, Etienne, & Gregory, 1997). For example, previous studies have found that imagining an anxiety-provoking situation leads to greater cardiovascular arousal than when verbalizing the situation (Borkovec & Hu, 1990; Vrana et al., 1986). Therefore, chronic worriers experience periods of negative imagery, which are lessened by worry.

In addition to negative imagery, Borkovec and colleagues posited that perception of physiological arousal also is important in the maintenance of worry. Andor and colleagues (2008) aimed to examine perception of physiological arousal in individuals with GAD. Thirty-three GAD participants, diagnosed based on DSM-IV criteria for the diagnosis were compared to 34 nonanxious controls. Nonanxious controls in this case were defined as, 'healthy individuals who are not taking mediation.' Skin conductance levels and heart rate were monitored while participants completed a signal detection task in which they were instructed to indicate the presence of physiological arousal following an acoustic signal. Results indicated that GAD individuals are better able to perceive phasic arousal compared to controls. In a second experiment, participants received feedback, which indicated either increased or decreased physiological arousal. Prior to completing the signal detection task, participants were told to worry like normal about their most worrisome topic. Results showed that those with GAD who received feedback about increased arousal maintained their worry. If feedback stated there was decreased arousal, GAD individuals' experienced decreased worry. These findings support the CATW in that worry appears to serve as a strategy to avoid negative somatic reactions. Increased worry may suppress physiological symptoms associated with the anxiety-provoking situation.

<u>Contrast Avoidance Model of Worry</u>

In an extension of the Avoidance Model of Worry, Newman and Llera (2011) developed the Contrast Avoidance Model of Worry. This theory expands on and modifies the relationship between clinical worry and emotion regulation within GAD. Key to this framework is the belief that worry is used as a coping strategy to prepare for the worst possible outcome, rather than experience a shift from a positive state to negative emotions. Newman and Llera (2011) hypothesized that worry is utilized to avoid negative contrasts, but not positive contrasts. For example, an individual high in worry is more likely to judge emotions as more negative when preceded by contrasting emotions when compared to similar, negative emotions. (i.e., happy faces followed by sad faces; Thayer, 1980).

To further understand the implications of worry on varying negative emotions, Llera and Newman (2010a) utilized valenced film clips to elicit a range of emotions. Participants were assigned to one of three conditions: worry, relaxation, and neutral thinking. Following the manipulation, participants viewed four short film clips that included both negative (fear and sad) and positive (calm and happy) emotions. Results indicated that worry, prior to viewing film clips, resulted in less withdrawal and subjective reactivity to fearful clips. With respect to the sad film clips, prior worry led to inhibited subjective reactivity, supporting the CATW.

In order to further test their theory of cognitive avoidance, Newman and Llera (2011) replicated their 2010 study, this time including a questionnaire to assess how worry helped individuals cope with their emotions. Results demonstrated that GAD individuals were more likely to indicate worry helped with coping, whereas non-GAD participants reported worry made them feel less able to cope during emotional film clips. These findings assist in understanding why GAD individuals do not avoid or process negative emotions. This suggests that individuals with GAD prefer to experience negative emotion associated with worry in order to avoid experiencing negative emotional contrast. In other words, worry helps individuals prepare for the worst possible outcome and deal with the associated emotions, in turn reducing the chances of experiencing negative emotional contrast if the event should occur.

To test both the cognitive avoidance and contrast avoidance models of worry, Steinfurth and colleagues (2017) manipulated worry and neutral thinking using topics personal to individuals. Participants were asked to write descriptions of three topics of worry and three neutral events that they think about. The following day, participants were placed in an fMRI scanner and were prompted to imagine their worry or neutral topics as presented to them. Results indicated that the worry condition produced significantly more unpleasant feelings when compared to the neutral condition, suggesting that the presented words were enough to activate emotional networks. These activated networks include the cingulate, frontal, and temporal cortical areas of the brain. Worry has been shown to activate these areas, providing support for heightened negative emotions in the worry condition. In a second experiment (Steinfurth, Alius, Wendt, & Hamm 2017), heart rate, skin conductance, and startle response were measured while the worry and neutral thinking manipulation remained the same. Results demonstrated that worry was associated with heightened physiological response, indicating a negative emotional state. Furthermore, these physiological increases suggest maintained negative emotions providing support for the contrast avoidance model. Negative emotions experienced by these individuals may be brought on by a variety of situations, including threatening or uncertain situations. Avoidance strategies may be a result of anxious individuals' inability to cope effectively with situations characterized by uncertainty.

Intolerance of Uncertainty Model

The Intolerance of Uncertainty Model (IUM; Dugas, Letarte, Rheaume, Freeston, & Ladouceur, 1995; Freeston, Rheaume, Letarte, Dugas, & Ladouceur, 1994) suggests that uncertain situations are thought of as more "stressful and upsetting" to individuals with GAD, which lead to worry (Dugas & Koerner, 2005, p. 62). In these situations, individuals with GAD feel that worrying will help cope or prevent stressful situations in the future (Borkovec & Roemer, 1995; Davey, Tallis, & Capuzzo, 1996; Tallis, Davey, & Capuzzo 1994).

Within this model, the difference between anxious and non-anxious individuals can be drawn from four factors: intolerance of uncertainty (IU), cognitive avoidance (Borkovec, 1994; Borkovec et al., 2004), positive beliefs regarding worry, and negative problem orientation (Dugas, Marchand, & Ladouceur, 2005). Across these four factors, individuals with GAD score significantly higher than controls (Buhr & Dugas, 2002). It is important to understand the implications of each factor in the development and maintenance of GAD.

In relation to negative problem orientation, those with GAD feel their problem solving is inadequate, perceive problems as threats, become frustrated while problem solving, and think the worst about their efforts to solve a problem (Koerner & Dugas, 2006). Research support has been found for the importance of NPO within worry. To examine the relationship between NPO and worry, Fergus and colleagues (2015) used self-report questionnaires completed by 123 adults with primary diagnoses of anxiety or mood disorders. Questionnaires included items assessing beliefs about NPO, the tendency to engage in worry, depressive symptoms, and reactions to social situations (Robichaud & Dugas, 2005a; Meyer, Miller, Metzger, & Borkovec, 1990; Radloff, 1977; Mattick & Clarke, 1998). Among the variables examined, NPO displayed the largest relation with worry, indicating it is particularly important to worry.

Individuals with GAD may exhibit positive beliefs about worry, or beliefs that worry: increases motivation, aids problem solving, prevents negative or stressful outcomes, and expresses a positive personality trait (Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994). Positive beliefs may lead to reinforcement of worry, either positively or negatively. For example, an individual may believe worry is a motivator, and if able to complete a worrisome task, the individual is more likely to worry again, positively reinforcing worry. On the other hand, an individual may believe that worry helps prevent negative events. If the worrisome event does not occur, the individual will be more likely to worry to prevent other future negative events, leading to negative reinforcement. In their 2013 longitudinal study, Iijima and Tanno examined the effects of positive beliefs on experienced worry. One hundred ninety four undergraduate students completed self-report questionnaires assessing worry, beliefs about worry, and stressful life events at two time points, four weeks apart. Results suggested a significant prospective relationship between stressful life events and worry, which was moderated by positive beliefs such that greater levels of positive beliefs increased the experience of worry and stressful life events. On the other hand, individuals who experience lower levels of positive beliefs do not experience as great of an increase in worry caused by stressful life events. Findings support the idea that higher levels of positive beliefs promote the use of worry such that the more an individual believes their worry will help them, the more the individual will worry.

Previous studies have examined these four factors and the role they play in GAD. Findings suggest that of all four factors, IU is the factor most unique to this anxiety disorder (Dugas et al., 2005; Ladouceur et al., 1999). In addition, IU and negative problem orientation are best at predicting symptom severity among clinical worriers (Dugas et al., 2007). Ladouceur, Dugas, and colleagues (2000) utilized a gambling task in which participants played a computerized roulette game. Each individual began with a $20 allowance and was instructed to bet on 15 consecutive trials, each trial requiring a set $2 bet. Participants had a one in three chance of winning. To create a situation resembling betting with stakes, experimenters informed participants that $100 would be donated to charity, but only if after 15 trials the participant's sum of money was greater than or equal to the original $20. Levels of intolerance were manipulated by telling participants that previously individuals had a greater chance of winning than they do currently (increase IU) or that their chance of winning was high (decrease IU). Results indicated that individuals in the increase IU group demonstrated being more intolerant of their chances to win compared to individuals in the decrease IU group. Additionally, increased IU was associated with greater levels of worry compared to decreased IU.

Borkovec and Roemer (1995) used self-report measures to assess motivations for individuals' worries. Results provided support for the IUM in that anxious individuals used worry as motivation to complete activities, prepare for possible feared events, and to develop strategies to avoid or prevent such events. Reasons such as problem solving, distraction, and superstition were rated lower than the previously stated explanations. GAD subjects reported that worry made the feared event seem less likely to happen in comparison to the control group. An interesting finding to emerge is that anxious individuals reported using worry as a distraction from "even more emotional things." This finding suggests that chronic worry potentially serves as an avoidance strategy. Dugas and colleagues (1998) further supported these results. In their study of

24 GAD and 20 control participants, the researchers sought to identify differentiating factors between clinical worriers and a non-clinical group. Using self-report measures, participants were asked to report their reasons for worrying. Results indicated that clinical worriers use worry as a strategy to remove, or avoid, threatening mental images. These findings align with previous findings in regard to the function of worry.

In recent years, researchers at the University of Wisconsin-Milwaukee aimed to compare anxiogenic effects of two types of uncertainty, temporal and occurrence. Temporal uncertainty refers to one's inability to predict when an aversive event will occur, whereas occurrence uncertainty refers to one's inability to predict if an aversive event will occur. Bennett and colleagues (2018) conducted an occurrence uncertainty versus temporal unpredictability task in which fifty-one undergraduates viewed a loading bar indicating the potential to receive shock. Four possible outcomes were included in the image, 1) They will be shocked when the bar is full, 2) They will be shocked at any time while the bar is filling, 3) They might be shocked when the bar is full, and 4) They will not be shocked at any time. The loading bar was used to create an anticipation period for each level of certainty. Startle responses and subjective ratings of their emotions were collected.

A critical finding showed that when comparing the two types of uncertainty, temporal uncertainty was better at eliciting startle responses due to anxiety. However, subjective reports indicate that individuals found both temporal and occurrence uncertainty as equally anxiety provoking, with both being more anxiety provoking than threat in general. Results support the notion that uncertainty associated with the inability to predict when an aversive event will occur may be a powerful generator of physiological anxiety.

To better understand neural responding to negative and neutral images, as well as how IOU may affect this relationship, MacNamara (2017) analyzed EEG data during an imagery task. Participants completed the Intolerance of Uncertainty Scale (Carleton, Norton, & Asmundson, 2007) to measure self-reported levels of uncertainty. Stimuli consisted of 28 negative and 28 neutral imagery scenes, worded so the participants imagine themselves in the scene. Each participant was asked to focus on the middle of a computer screen while listening to an audio description of the scene, and to imagine themselves in each situation as vividly as possible. Following the presentation of the scene, ratings of scene arousal and valence were collected based on a 9-point scale. EEG data were recorded throughout the experiment. The LPP was analyzed based off its utility in measuring larger neural responses to negative versus neutral stimuli. This ERP is found to begin approximately 300 ms following stimulus presentation. Results are the first of its kind, in finding the LPP can be elicited by negative imagery without salient visual cues. Additionally, individuals high in IU displayed reduced LPP amplitudes for aversive scenes, potentially indicating avoidance of negative imagery. Lastly, ratings of valence and arousal following scene presentation did not differ between levels of IU, suggesting that the LPP provided a more sensitive measure of response to negative imagery.

Previous research has found that unpredictability of threat leads to greater neural and behavioral responses (Herry et al., 2007; Jackson et al. 2015a). To further research the impact of predictability versus unpredictability, Nelson and colleagues (2016) utilized neural measures during a monetary gambling task. EEG data were recorded while participants completed a doors gambling task, during which either predictable or unpredictable tones were played. Participants were informed they could either win $0.50 or lose $0.25 on any given trial. The task presented individuals with two identical doors of which they were to choose the door that hid the reward. After the door selection, participants received either a green up arrow indicating a gain or a red down arrow indicating a loss. Self-report measures of IOU, depression, and worry were collected at the conclusion of the experiment. Results indicate a decreased ERP response to monetary gains when compared to losses, and this relationship was strengthened within the unpredictable versus predictable contexts. Self-reported anxiety measures suggested that individuals found the unpredictable context as more anxiety provoking when compared to predictable contexts.

Research has suggested that attention, as measured by ERPs, may be enhanced by uncertainty, especially among those with anxiety (Dieterich, Endrass, & Kathmann, 2016; Koenig, Uengoer, & Lachnit, 2017; Nelson, Hajcak, & Shankman, 2015). When uncertain situations appear, attention may be directed to the environment in an attempt at solving the uncertainty (Pearce & Hall, 1980; Peters, McEwen, & Friston, 2017). During this time, anxious individuals also may experience anticipatory emotional responses (Barlow, 2004; Grillon, 2008), which can be measured using peripheral psychophysiology. Although uncertainty has frequently been measured by emotional responses, recent research has begun to examine this idea on a broader dimension.

Traditionally, uncertainty and certainty have been compared dichotomously. In order to examine varying levels of uncertainty on attention and anticipatory emotions, Tanovic and colleagues (2018) utilized a card game task in which participants were to choose a higher card than the computer. Each trial consisted of 10, face-down cards presented on the screen. Participants selected one card and the value was revealed immediately. After selecting their card, participants viewed a countdown while waiting to view the computers card choice, creating the first anticipation period. If the participants' card value was lower than the computer, there was a 50% chance of receiving an electric shock, creating the second anticipation period. There was never a chance to tie with the computer. Levels of uncertainty during the first anticipation period varied based on the participant's card value. For example, a card value of 10 indicated a sure chance of winning, whereas a 5 indicated a 50% chance of losing and a value of 1 was indiviative of a 100% chance of losing. This means that in all, there were 10 levels of uncertainty. To create a condition that signals certain shock, one card was always marked with a lightning bolt. If drawn, the participant was aware a shock would definitely be delivered. Additionally, a card with a lightning bolt with a red line through it was included, signifying no shock no matter what the card values indicated. When either special card was drawn, the computer drew a blank card. This created a certain threat condition during the second anticipation period. During this anticipation period, three levels of uncertainty were possible: either a 0%, 50%, or 100% chance of being shocked if the certain shock card was drawn. This anticipation period allowed individual responses to uncertain versus certain threat and safety to be examined. EEG data were recorded for the duration of the experiment.

Analyses were conducted on the P2 (a neural measure of attention; elicited approx. 200 ms after the presentation of a visual stimulus) and SPN (a neural measure of anticipation that is enhanced by negative emotion) in the first anticipation period, and only the SPN during the second anticipation period. Results indicated attention sensitivity to small variations in threat uncertainty. EEG analyses revealed variation in the P2 as a function of uncertainty, such that larger P2 amplitudes were found on trials signifying greater certainty. The smaller P2 amplitude for greater uncertainty is in contrast with previous literature. Previous studies examining the P2 have found a hypervigilance to uncertainty in clinically anxious individuals (Dieterich et al., 2016; Grupe & Nitchke, 2013; Lin et al., 2015). Discrepant findings could be due to classification of uncertainty. In previous studies, uncertainty has been manipulated in a binary manner (certainty versus uncertainty) whereas the current study examined uncertainty based on a continuum. The SPN did not follow specific uncertainty levels; however, SPN amplitudes were largest for uncertain threat as compared to certain threat and safety. This means that anticipatory neural preparation, although not sensitive to small variations of uncertainty, are influenced by whether threatening stimuli are certain or uncertain broadly. Results were the first to indicate that the SPN evoked immediately prior to an outcome is intensified by uncertain threat, in line with previous research (Catena et al., 2012; Foti & Hajcak, 2012; Seidel et al., 2015).

Additional findings suggest the IOU is associated with attention differences based on uncertainty levels, with greater attention allocated to certain over uncertain stimuli. Importantly, this study does not provide evidence for one specific uncertainty level at which anxious individuals respond excessively. Rather, anxious individuals discriminate more finely between uncertainty levels compared to low anxious individuals.

Taken together, research has supported the importance of intolerance of uncertainty in differentiating individuals with GAD from their healthy counterparts. Differences have been found both at behavioral and neural levels, but more research is needed to examine how uncertainty effects task performance. Although this model states that anxious individuals experience uncertain or ambiguous situations as stressful and upsetting, more recent research has begun to differentiate between uncertainty and ambiguity.

Intolerance of Ambiguity

Although frequently thought of as the same construct, there may be important distinctions between uncertainty and ambiguity. Within anxiety, uncertainty is often described as the being unsure of what will occur in the future. On the other hand, ambiguity refers to the possibility for an individual to interpret stimuli in more than one way (Grenier, Barrett, & Ladouceur, 2005). Krohne (1989, 1993) argued that ambiguity refers to stimulus properties, such that stimuli are novel, complex and/or insoluble. It also was argued that uncertainty is the emotional state provoked by ambiguous stimuli. With this framework intolerance of ambiguity (IA) has been referred to as a stable component focused in the present, or the here and now, whereas IU is referred to as the unpredictable component, oriented toward the future.

Intolerance of ambiguity, first postulated by Frenkel-Brunswik (1948, 1949), refers to the tendency for individuals to interpret situations that have multiple meanings as threatening or uncomfortable. Interpretation biases to perceive ambiguity as negative are a common defining characteristic for anxiety disorders (Mathews, 2011). Reactions to ambiguity have been divided into three manifestations: cognitive, emotional, and behavioral reactions. Cognitive reactions include measures that indicate individual's black or white perception of ambiguous situations. Emotional reactions refer to feelings of uneasiness or discomfort in response to ambiguous situations. Lastly, behavioral reactions are those that signal the individual rejects or avoids the ambiguous stimuli.

To examine ambiguity interpretation biases, Mathews, Richards and Eysenck (1989) recruited clinically anxious versus control individuals to participate in a homophone differentiation task. For the task, 14 homophones were selected, each having both a threatening and neutral meaning. Additionally, 14 unambiguous threat words as well as 28 neutral words were included. Participants were asked to listen to a series of words and were instructed to write the words as they are said. Clinically anxious individuals were more likely to write the threatening interpretation of ambiguous words than their non-anxious counterparts, supporting intolerance of ambiguity, or the tendency for anxious individuals to access threatening meanings more quickly.

More recently, Koerner and Dugas (2008) investigated how individuals with varying levels of IU would respond to positive, negative, and ambiguous situations. Participants were asked to read 55 vignettes consisting of 11 content areas such as friendships, romantic relationships, and personal health. Each content area was presented with one positive, one negative, and three ambiguous scenarios. At the conclusion of each vignette, participants rated their level of concern on a scale of 1 (no concern) to 5 (extremely concerned). Following the vignette tasks, participants completed self-report questionnaires assessing worry, anxiety, and depression. Results demonstrated that individuals high on IU rated ambiguous situations as more concerning than those low on IU. Ratings of concern for ambiguous situations were significantly higher than those for both the positive and negative situations. Although there are clear behavioral differences between those high and low in IU, it is important to understand the potential underlying vulnerability factors between these two groups.

The diathesis-stress model (Mineka & Zinbarg, 2006) suggests that anxiety disorders will occur in individuals who exhibit ingrained vulnerability when experiencing a frightening situation. This means that vulnerable individuals whom experience a real-life conditioning event develop maladaptive fear responses, leading to the development of anxiety disorders. Traditional paradigms utilized to study this concept consist of a neutral stimulus, or conditioned stimulus (CS+), which becomes repeatedly paired with an aversive stimulus, or unconditioned stimulus (US), such as a shock or loud noise. The pairing of a neutral and aversive stimuli results in conditioned fear responses to the once neutral CS+. Another neutral stimulus (CS-) is never paired with the US, indicating safety. Responses to the CS+ and CS- can then be compared to determine discriminatory fear learning. Procedures such as this represent strong opposites, such that the CS+ signals danger and the CS- signals safety. Due to the lack of ambiguity, anxious and non-anxious individuals can be expected to respond similarly (Lissek et al., 2006). Therefore, traditional fear-conditioning tasks do not address differences in interpreting ambiguous information.

Selective fear-conditioning paradigms have been used to address these concerns. Within the selective fear-conditioning paradigm, stimuli compete for control of fear responses, in turn creating a sense of ambiguity. Two procedures, protection from overshadowing and blocking, represent ambiguous versus safety respectively. Within protection from overshadowing, two phases are involved in fear conditioning. The first phase, elemental conditioning, consists of one CS (C) presented without a following US. Compound conditioning, phase two, C is presented with another CS (D) to make CD which is then followed by the US. Because C presented alone is not followed by the US, D is likely dangerous, indicating higher threat. Since D is not observed in isolation, threat status remains ambiguous and must be inferred. Arnaudova and colleagues (2013) sought to examine how trait anxiety would affect selective fear conditioning with greater use of ambiguous situations. Sixty-eight participants were recruited to complete a conditioning paradigm. Six, three-dimensional colored objects served as conditioned stimuli (CS) and unconditioned stimulus (US) was a 95 dB scream. Participants were instructed to use the objects presented to predict the occurrence of the scream by using an expectancy rating scale. Results indicated that high trait anxious individuals displayed deficits in discriminatory learning than low trait anxious individuals, especially when faced with ambiguity. Additionally, high trait anxiety was associated with a greater tendency to overgeneralize in fearful situations as well as mild negativity biases.

Further examining the implications of overgeneralization and ambiguity of fear with GAD, Lissek and colleagues (2014) employed a generalization fear-conditioning paradigm. Within this paradigm, 10 rings of gradual increasing sized were used as conditioned and generalized stimuli. The largest ring served as the danger cue (CS+) whereas the smallest ring served as the safety cue (CS-). The eight between rings served as generalization stimuli (GS) representing the continuum between the CS+ and CS-. An electric shock served as the unconditioned stimulus (US). During the conditioning phase, participants were asked to rate perceived level of risk from 1 (no risk) to 3 (high risk). Results indicated that individuals with GAD were more likely than healthy controls to transfer fear interpretation, or generalize to stimuli that closely resembled the CS+ as indicated by both behavioral ratings and psychophysiological measures.

Haro and colleagues (2017) sought to examine ambiguous word processing, with an emphasis on EEG correlates. Stimuli consisted of 76 ambiguous words and 76 clearly valenced words. Participants completed a lexical decision task in which they were required to decide if the stimulus was a word or nonword. Following their response, feedback was presented indicating a correct or incorrect response. EEG data were recorded throughout the experiment. Greater accuracy, faster response times, and larger N400 amplitudes (negative potential indicative of semantic processing, found 300-600 ms following stimulus presentation) were found for ambiguous words compared to the clearly valenced words. Results suggest greater semantic activation for ambiguous words over unambiguous words in word recognition.

Overall, results of these studies suggest anxious individuals display a tendency to apply negative interpretations of ambiguous stimuli. When confronted with ambiguity, individuals are forced to make decisions with uncertain outcomes. In daily life, individuals are constantly faced with sensory information, and at times need to make a choice. Individuals high in worry display a tendency to interpret this information as threatening, indicating possible attentional differences between high and low worriers. Due to these tendencies, it is important to examine theory behind these differences.

<u>Attentional Control Theory</u>

The previous models of GAD discuss the emotional and physiological aspects of the disorder, but other models take a cognitive approach. Eysenck and colleagues (2007) proposed a theory that focuses on how anxiety affects cognitive performance, Attentional Control Theory (ACT). Specifically, this theory is primarily concerned with functions of the central executive: shifting, updating, and inhibition. Within this framework, control refers to attention that is goal-driven (top-down) or stimulus-driven (bottom-up). Specifically, ACT posits that anxiety impairs the goal-driven system while the influence of processing on the stimulus-driven system is increased. ACT was developed as an extension of the Processing Efficiency Theory (PET) put forth by Eysenck and Calvo (1992). Key to PET is the distinction between performance effectiveness and processing efficiency. Effectiveness is the quality of the performance, whereas efficiency is the effort spent on performing a task. Researchers measure effectiveness by assessing an individual's accuracy in responding on a certain task. Efficiency is measured by differences in individual reaction times or by using neural measures, which assess the amount of attentional resources used to complete a task.

Central to ACT are the differences in performance effectiveness and processing efficiency. An assumption of the theory is that how anxiety impacts attentional processes is fundamental in understanding how anxiety affects performance. According to ACT, efficiency is impaired as a result of anxiety and reduced attentional control (AC). Although this model suggests that individuals with anxiety exhibit slower reaction times, they are able to maintain effective performance (Darke, 1988; Markham & Darke, 1991; Derakshan & Eysenck, 1998; Calvo & Carreiras, 1993; Ikeda, Iwanaga, & Seiwa, 1996; Richards, French, Keogh, & Carter, 2000).

Support for the ACT is based off research focusing on attentional processes involved in anxiety. Within anxiety, individuals have a tendency to attend to threatening stimuli, taking over cognitive resources leading to reduced performance (Eysenck et al., 2007; Eysenck & Derakshan, 2011). Researchers presume that when an individual's goal is threatened, anxiety increases (Power & Dalgleish, 1997). This subsequently requires attention to the source of the threat and the individual must decide how to respond.

Along with the assumption of anxiety's impairment of AC is the view that there are two systems of attention (Corbetta & Shulman, 2002; Posner & Petersen, 1990). As stated previously, researchers distinguish between a goal-directed and stimulus driven attentional system. The goal-directed system, put forth by Posner and Petersen (1990), is influenced by knowledge, expectation, and current goals. In contrast, Corbetta and Shulman (2002) state the stimulus-driven system is used when an individual detects salient, behaviorally relevant stimuli. Although thought of as two distinct systems, the two are commonly found to interact with one another, such that individuals reflect on both goals and recent stimuli. ACT would suggest that these two systems are disrupted by anxiety, in that anxiety increases stimulus-driven attention and decreases goal-directed attention. For example, researchers have found that the stimulus-driven system is affected by anxiety by the automatic processing of threatening stimuli, which in turn decreases the influence of a goal-directed system (Fox, Russo, & Georgiou, 2005).

Although high worry may be associated with low performance efficiency levels, previous studies have found highly anxious individuals do not significantly differ in performance effectiveness compared to low anxious individuals (Blankstein, Flett, Boase, & Toner, 1990; Blankstein, Toner, & Flett, 1989; Calvo, Alamo, & Ramos, 1990; Calvo & Ramos, 1989). This finding, in line with ACT, suggests that worry impacts efficiency more than performance effectiveness. This pattern is found to hold true in tasks involving verbal reasoning (Darke, 1988b), spatial reasoning (Markham & Darke, 1991), and verbal working memory (Ikeda, Iwanaga, & Seiwa, 1996).

Additional support for these differences can be found using self-report and psychophysiological measures. Dornic (1977) asked participants to estimate the amount of effort used following task completion. Cardiovascular measures have been found to reflect task engagement and motivation, making them a useful tool to examine effort (Schwerdtfeger & Kohlmann, 2004). Psychophysiological measures of cardiovascular activity have indicated that high-anxious individuals display considerably more cardiovascular reactivity during the pre and post-task phases than low-anxious individuals (Calvo & Cano, 1997); however, no differences were found during task performance (Calvo, Szabo, & Capafons, 1996; Di Bartolo, Brown, & Barlow, 1997; Schonpflug, 1992). High and low anxious individuals displayed comparable performance, but those high in anxiety reported significantly more effort was used than those low in anxiety. This finding indicates differences in the ability to control attentional resources. It is critical to understand the way in which individuals attend to and move their attention to and from stimuli.

Miyake and colleagues (2000) identified the three control functions of the central executive (inhibition, shifting, and updating). Inhibition is the ability to deliberately inhibit responses, requiring AC to differentiate relevant and irrelevant information. The ability to shift between tasks, known as shifting, requires one to change AC based on the demands of a particular task. Lastly, updating refers to the ability to monitor working memory representations.

Furthering the implications of inhibition, Friedman and Miyake (2004) found that the inhibition function is used when an individual resists distractors, as well as prepotent responses. These findings suggest inhibition involves preserving task goals when encountering task-irrelevant information. This stance implies general function of inhibition involving executive control; however, other approaches identify several types of inhibition. For example, Nigg (2000) identifies four types of inhibition: interference control (as a result of resource competition), cognitive inhibition (suppressing irrelevant information), behavioral inhibition (suppressing prepotent responses), and oculomotor inhibition (suppressing reflexive movement). Friedman and

Miyake have argued that interference control, behavioral inhibition, and oculomotor inhibition have the same underlying function. Within both frameworks, evidence suggests that AC is used to prevent or inhibit resources from being directed to irrelevant information and stimuli.

Friedman and Miyake (2004) used confirmatory factor analyses to assess three of the functions proposed by Nigg (2000). Included in the analysis were Prepotent Response Inhibition (the combination of behavioral inhibition and oculomotor inhibition), Resistance to Distractor Interference (interference control), and Resistance to Proactive Interference (PI; cognitive inhibition). Prepotent Response Inhibition was tested using the Antisaccade task (Hallett, 1978), Stop-signal task (Logan, 1994), and the Stroop task (Stroop, 1935). Resistance to Distractor Interference was assessed using the Eriksen flanker task (Eriksen & Eriksen, 1974), Word naming (Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994), and Shape matching (DeSchepper & Treisman, 1996). Lastly, Resistance to PI was measured using the Brown-Peterson variance (Kane & Engle, 2000), AB-AC-AD (Rosen & Engle, 1998), and Cued recall (Tolan & Tehan, 1999). Results of the CFA found Resistance to PI to be unrelated to Prepotent Response Inhibition and Resistance to Distractor Interference; however, Prepotent Response Inhibition and Resistance to Distractor Interference were highly correlated, $r = 0.67$. Findings suggest that although there may be conceptual differences between inhibition types as proposed by Nigg (2000), the strong correlation suggests the constructs are highly related, providing support for inhibition as a general function.

Shifting supports ACT in that individuals must adaptively move or shift their attention to different stimuli to ensure attention is focused on task-relevant stimuli (Friedman & Miyake, 2004). For example, a task involving the presentation of two-digit numbers, which are either to be added or subtracted, involves shifting attention to the relevant math symbol. ACT holds that anxious individuals can overcome difficulties with shifting and inhibition by increasing attention and resources. Wilson, Vine, and Wood (2009) utilized eye tracking during a basketball shooting task to examine how anxiety impacts the shifting function. Participants in the control condition were simply told to do their best during the free-throw task, whereas the high-threat condition stated that their performance and success rates would be compared to others. Results suggest that among high anxious participants, the shifting function was impaired during the high threat condition. Derakshan, Smyth, and Eysenck (2009) provide additional support for the effect of anxiety on the ability to shift attention. This study utilized a task-switching paradigm in which participants completed mathematical equations. In some conditions, the mathematical task remained the same, whereas in others the task required participants to change, or switch between task type. Results show that among high anxious individuals only, performance was significantly slower in a task-switching condition compared to non-switching conditions. Therefore, these findings further support the ACT by demonstrating that anxiety negative impairs the shifting functions.

In addition to control functions of attention, it is important to understand attentional biases among anxious and non-anxious individuals. Wilson and MacLeod (2003) examined attention allocation to threatening stimuli between high and low trait anxious individuals. Facial morphing was used to create a continuum of threat intensity, whereas attention was measured using an attentional probe task. Participants were asked to view faces varying in emotional intensity, which was followed by a probe task requiring individuals to differentiate the direction of a line on the screen (left or right). The line appeared in the same spot as the facial expression. Results indicated that as threat intensity increased from low levels, participants displayed a tendency to avoid attention to mildly threatening stimuli, but when a critical threat level was reached, attentional vigilance to threat was shown. Furthermore, high trait anxious individuals displayed greater reaction time to discriminate probes when the probe appeared in the location of the mildly threatening faces compared to low trait anxious, suggesting high trait anxiety may be associated with disproportionate attentional vigilance for the mild threat stimuli. Attention to intermediate levels of threat in high anxious individuals supports the hypothesis that anxious individuals shift attention to threatening stimuli, as posited by the ACT.

The third function, updating (Miyake et al. 2000), involves both monitoring and updating. For instance, updating can be observed in a task requiring participants to view members of a category, and to keep track of the most recent member of each category. ACT posits that anxiety does not affect updating to the same extent as inhibition or shifting (Eysenck et al., 2007). In understanding the functions involved in ACT, it is clear that anxious individuals display specific attentional biases.

To further examine attentional biases present in GAD, Bar-Haim and colleagues (2005) used a modified attention shifting paradigm in which faces were used in place of words. In this case, it was hypothesized that fearful facial expressions are a more natural sign of potential threat versus threat-related words, which may be more arbitrary. Additionally, a variety of facial expressions (angry, fearful, sad, happy, and neutral) were included to examine if anxious individuals attend to threatening stimuli in particular, or negativity in general. Participants were required to focus their attention on the facial stimuli presented in the center of the screen and then identify a target shape (square or diamond) located in one of four corners. Individuals were instructed to not move their gaze from the center of the screen. EEG data were recorded throughout the study. Behavioral data indicated that high-anxious individuals responded more slowly to targets for all facial stimuli when compared to low-anxious individuals. Contrary to the behavioral data, ERP data suggested that trait-anxiety levels might modulate processing of threatening stimuli. More specifically, high-anxious individuals displayed larger P2 amplitudes for angry faces compared to low anxious individuals. In other words, greater attentional resources are allocated for threat-related stimuli in high versus low-anxious individuals.

Studies have documented that individuals with anxiety exhibit heightened threat sensitivity, which has been shown to have a negative impact on executive attention (Jazbec et al., 2005; Mathews and Mackintosh, 1998; Wood et al., 2001). Emotional facial stimuli have frequently been used within ERP studies due to their affective salience and social significance (Eimer & Holmes, 2002; Pizzagalli et al., 1999; Sato et al., 2001). Dennis and Chen (2007) modified the Attention Network Task (ANT; Fan et al., 2002) to examine neural responses to varying task-irrelevant emotional stimuli. During the modified ANT task, participants were presented with emotional faces at the beginning of each trial. Following this presentation, a target arrow appeared either above or below the center fixation cross. To the left and right of the fixation cross were four flanker stimuli. Participants were required to indicate which way the center arrow was pointing. During task administration, EEG data were recorded. Findings suggested that enhanced N2 responses to fearful faces were associated with reduced attention performance. In other words, increased N2 amplitude reflected inhibited attention to fearful faces. This relationship was stronger in those with heightened threat sensitivity, a key component of GAD.

Taken together, research provides evidence for increased attention toward threatening stimuli among anxious individuals. This supports the attentional control theory, such that these individuals utilize additional attentional resources, negatively affecting efficiency. However, further research is needed to examine the extent to which uncertainty impacts attentional control in high anxious individuals.

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