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# Negative And Positive Attention Bias In Anhedonia And Anxious Arousal: Can Depression And Anxiety Be Distinguished By Patterns Of Engagement And Disengagement Bias?

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# NEGATIVE AND POSITIVE ATTENTION BIAS IN ANHEDONIA AND ANXIOUS AROUSAL:

# CAN DEPRESSION AND ANXIETY BE DISTINGUISHED BY PATTERNS OF ENGAGEMENT AND DISENGAGEMENT BIAS?

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Abstract

NEGATIVE AND POSITIVE ATTENTION BIAS IN ANHEDONIA AND ANXIOUS AROUSAL: CAN DEPRESSION AND ANXIETY BE DISTINGUISHED BY PATTERNS OF ENGAGEMENT AND DISENGAGEMENT BIAS?

Negative and positive attention bias (AB) is the preferential allocation of attentional resources to negative and positive stimuli in the environment, respectively. AB has been studied in various clinical and non-clinical populations and the process has been linked to symptoms of depression and anxiety. Findings so far suggest that negative AB is a trait-based factor that predisposes individuals to anxiety and depression. Positive AB appears specific to a depressed state, yet findings generally remain mixed. Measures of AB have been recently critiqued for their poor psychometric properties. This study addresses three gaps in the literature to further our understanding of the relationship between AB and psychopathology. The aims of this study were to determine whether 1) the core symptoms of depression (anhedonia) and anxiety (anxious arousal) are related to differential patterns of negative and positive AB, 2) anhedonia and anxious arousal have incremental utility in predicting AB over and above negative affectivity, 3) AB predicts group membership (clinical vs non-clinical). The dot-probe paradigm was administered to 144 participants from various settings. Mixed effects modeling was used to predict the relationship between Type of Trial (negative or positive vs neutral), Congruence (congruent vs incongruent), and Group (anhedonia, anxious arousal, comorbid, control) on response rate or error rate. Results from random effects analysis showed that inter-subject variability was significant. Fixed effects analyses showed that the present study failed to capture positive and negative AB. Between group differences in raw reaction times were observed.

Implications of the findings with regards to methodological differences across studies are discussed.

KEY WORDS: attention bias, dot probe paradigm, cognitive psychology, internet-based study, depression, anhedonia, anxiety, anxious arousal, reaction time, mixed effects modeling

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# CHAPTER I

## Introduction

Individuals with psychological disorders, particularly depression and anxiety, attend to negative information in their environment more quickly, and for a longer duration of time, than individuals without psychological disorders. This phenomenon is observed in everyday life by clinicians and family members of individuals with mood and anxiety disorders, who comment that they are "attracted" to problems in their life, that they focus on problems in the world and "see" the glass half empty. To study this "attraction to the negative" in a scientific manner, researchers have taken it to the lab to further understand this phenomenon.

Cognitive psychology researchers call this phenomenon "attention bias". They hypothesize that compared to non-psychologically disordered individuals, people with depression and anxiety have a *greater* attention bias to negative information. More recently, researchers have also hypothesized that these individuals have a *smaller* bias for positive information, as they engage less in positively reinforcing activities in their daily lives. Studies with non-psychologically disordered individuals have shown a slight positive bias in healthy individuals (Pool et al., 2016) and a bias to avoid negative information (Karparova et al., 2007), a finding consistent with the positive illusion bias that social psychologists have found in non-depressed people.

The study of attention bias (AB) is important as it has a direct impact on emotional wellbeing. Although the link between attention and emotion is complex and bidirectional, research in the last few decades has shown that attention to negative information enhances depressed affect (Nay et al., 2004). Depressed affect in turn biases attention (mood congruent processing), pulling the patient further into a vicious cycle maintained by negative emotion and attention bias to negative information (please refer to *Top-Down or Bottom-Up Processes*

*influence AB* for more details). By understanding the link between attention bias and the development and maintenance of negative emotions, interventions can be created to break this cycle. Depression costs approximately 500,000 lives each year (Bostwick & Pankratz, 2000) and more than $150 billion annually (Chow et al., 2019). Even with mainstream treatments currently available including psychotropic medication and psychotherapy, there remains a need for better understanding of the mechanisms underlying mood and anxiety disorders to create more effective treatments. In the past decade, the NIMH has strongly encouraged the identification of "targets" in research. Targets are environmental, psychological, or biological mechanisms that can be manipulated through treatment with the end goal of ameliorating mental health symptoms (National Institute of Mental Health, 2015). If research shows that attention bias (AB) is a target for mental health symptoms or problem behaviors, then interventions can be created to alter this process with the goal of reducing symptoms and behaviors that maintain the disorder. Such interventions have already been created (please refer to *Attention Bias Modification*).

Attention bias to negative and positive information has been studied for over three decades now. Although findings generally show evidence in support of a relationship between depression and anxiety symptoms and negative and positive AB, findings are not robust for many reasons: 1) previous studies have not separated the core symptoms of depression (anhedonia) and anxiety (anxious arousal) in the assessment of their relationship to AB. Studies have relied either on diagnostic categories (example DSM diagnoses) or symptom measures that tend to have low discriminant power. It therefore remains uncertain whether depression and anxiety are related to different patterns of AB or whether attention bias is more related to general psychopathology. 2) there has been debate regarding the construct validity of the cognitive tasks used to measure AB. For this measure to be useful clinically, the reliability and validity of the methods should be

more strongly established. Different methods have been proposed to enhance the psychometric properties of AB tasks. 3) although there has been some establishment of causality, most findings are correlational in nature. To identify psychological processes as "targets" for treatment, the predictive power of these processes needs to be established.

The present study aims to add to the literature by filling in the gaps described above: 1) Participants were divided into groups based on endorsement of core symptoms of depression and anxiety. This allows the direct measure of the relationship between attention bias and anhedonia and anxious arousal. 2) To bypass the problems that have been cited in the literature relating to the reliability and validity of the AB measure, different statistical analysis has been used (for more details, please refer to *Statistical Analysi*s section). 3) To determine whether AB can be used as a "target" in the treatment of mood and anxiety disorders, it first needs to be established as a mechanism that differentiates those with mental health symptoms from those without. Statistical procedures that predict the likelihood of belonging to the clinical (vs control) group based on patterns of AB will be used.

# CHAPTER II

Review of Attention Bias in Mood and Anxiety Disorders

## The Development of Cognitive Tasks to Capture Attention Bias (AB)

### *The Dot Probe Paradigm*

Different tasks have been used in studies to measure attention bias, with the emotional dot probe paradigm being the most commonly used task. The task initially proposed by MacLeod et al. (1986) involved the presentation of pairs of threatening and neutral words on a computer screen for 500 ms to a group of anxious and healthy participants. The words were replaced by a probe (symbol they needed to respond to) in the location previously occupied by either the

threatening word or the neutral word. The participants were to press a button upon detection of the probe. The manipulation in these tasks involves the location of the target (replacing the valence or neutral stimulus). The hypothesis is that the faster the participants respond to the probe, the more they were paying attention to the word it just replaced. The slower they respond to the probe, the more likely they were avoiding the word that preceded it. To obtain a unified measure of AB for each participant, researchers calculated a bias score. The bias score is a measure of the speed with which attention was directed to the valence stimulus compared to the neutral stimulus. The bias score is calculated as response time (RT) to a probe in the location of a previously presented valence stimulus minus the response time to a probe in the location of a previously neutral stimulus (i.e., congruent – incongruent trials). Participants who identified the probe faster when it replaced the negative stimuli (example a gun) compared to neutral stimuli (example a table), are presumed to have been paying more attention to the negative stimuli. This faster response, measured as a shorter reaction time, represents "negative attention bias".

Early studies on individuals with trait anxiety showed that participants with Generalized Anxiety Disorder had a negative AB to words compared with individuals without the diagnosis (MacLeod et al., 1986). Anxious individuals were therefore faster to respond to the probe that replaced a threatening word compared to the probe that replaced a neutral word. The control group, on the other hand, had faster response rates to probes that replaced neutral words compared to probes that replaced threatening words. These results showed that anxious individuals could have focused more attention on threatening words, making detection of probes in the location of threatening words faster and the shift of attention for the detection of probes in the location opposite to the threatening word slower.

A change in the methodology occurred as Macleod determined that these early studies meshed two cognitive processes (engagement and disengagement) into one AB score. In these studies, engagement (attention toward) was measured as RT to the target that replaced the threatening stimulus whereas disengagement (attention away) was measured as RT to the target that replaced the neutral stimulus. Attention bias score was measured as the difference in RT between the two with a larger score indicating more attention bias to the threatening stimulus (Macleod et al., 1986). To separate the two processes, tasks with a baseline measure (presentation of two neutral stimuli) was created. Congruent and incongruent trials were therefore compared to neutral trials to investigate bias toward (engagement/vigilance) or away (disengagement/avoidance) from the emotional stimulus. This allows a clearer distinction between engagement and disengagement processes. It was suggested that although there is some evidence that both engagement and disengagement are impaired in psychiatric disorders, it appears that they are separable processes and should be measured separately by cognitive assessment tasks (Grafton & MacLeod, 2014; Grafton & MacLeod, 2016; Rudaizky et al., 2014). Other changes included creating a task that specifically manipulates the participants' gaze to ensure that engagement entails moving gaze *toward* the target and disengagement entails averting gaze *away* from threatening stimulus. A shift of attention to a location different from the initial focus of attention (marked by an initial or anchor probe) was needed.

### *The Emotional Cueing Paradigm*

Another paradigm that also attempts to capture participants' AB to threatening information is the emotional cueing paradigm. Unlike the dot probe task, the participants are not presented with two stimuli but rather one "cue" to the right or left of a fixation cross. Following the cue is a target (probe) either in the same location or opposite location of the cue. The

participant is asked to respond to the target (for example making a judgement about the direction of an arrow: pointing upward or downward). A facilitation effect, which is comparable to the notion of engagement in the dot probe task, is measured by how fast the participant responds to a target in the same location as a previously presented threatening cue (RT target same location as threatening cue – RT target same location as neutral cue). Those are considered valid trials. A disengagement bias is thought to occur if participants respond more slowly to targets in the opposite location of a threatening cue compared to a neutral cue (RT target opposite location of threatening cue – RT target opposite location of neutral cue). Those are referred to as invalid trials. Similar to problems with early dot probe studies, these calculations do not take into account baseline response times (by including neutral trials). The inclusion of neutral trials is also important to separate engagement from disengagement of attention to emotional stimuli.

***The Emotional Stroop Task***

Other tasks that also tap into attentional bias are the Emotional Stroop Task, in which threatening and neutral words are presented in different colors and participants are required to ignore the meaning of the word to accurately name the color the word is written in. Compared to the dot-probe task, the Stroop task assesses ability to attend to the task at hand (goal-directed behavior) and over-ride the semantic saliency (inhibition). Another difference between the two tasks is that in the Stroop task, both target and distractor (word and color) are presented simultaneously. Selective attention is therefore required to attend to one of the two features (semantic content versus physical feature) of the stimulus. In the dot probe, both stimuli are presented before the participant is cued to the location of attention allocation. The Stroop task is therefore considered a measure of pure selective attention/selective avoidance to different features. It is unclear in the Stroop task, however, at which point in the attention process

impairment in selective attention occurs. Some studies have shown that it is not in early processes but in later processes that include difficulty disengaging attention (Phaf & Kan, 2007). Related to this idea is that of "freezing" when exposed to threatening stimuli. Clarke et al. (2013) critiques current paradigms of AB as the attention bias index cannot differentiate disengagement bias from behavioral freezing unrelated to attention processes.

### *The Spatial Cueing Task*

Research using the spatial cueing task has found evidence for engagement and disengagement processes in healthy individuals depending on duration of stimulus presentation. In short stimulus presentations (< 300 ms) faster engagement to a stimulus tends to occur, whereas for longer presentations (between 300 and 500 ms) inhibition of return (IOR) occurs, where the participant disengages from the stimulus (responses to invalid cues are faster). Arrows presented prior to the probe signify possible location of probe: most of the time accurately (valid trials) and some of the times inaccurately (invalid trials). Neutral trials include conditions where arrows in both directions are presented <>, not indicating location of attention orientation. Responses to invalid vs neutral trials measure cost of disengaging attention from invalidly cued locations and valid vs neutral trials measure advantage of engaging attention in advance (initial orientation).

### *The Rapid Serial Visual Presentation Task*

The Rapid Serial Visual Presentation (RSVP) paradigm is a measure of attentional blink, which represents the temporary unavailability of attentional resources to process a stimulus, as attention is devoted to the processing of the first stimulus. A train of stimuli is presented and two targets are interspersed by distractor stimuli. If the first stimulus is salient it is assumed to capture participants' attention for longer, allowing the second target to pass unnoticed.

It is hypothesized that the stimuli capture attention if they are considered salient, such that the individual favors it over other stimuli in their environment. The perceptual or semantic saliency of the stimulus enhances its detection. Contrast and color are considered salient compared to monochrome. Valence information (such as images of babies or erotic representations) is considered more salient than neutral information due to their arousal properties. Negative stimuli are generally considered salient compared to neutral or positive stimuli. Certain emotional stimuli, particularly threatening stimuli, are considered more salient than other emotional depictions due to their survival properties. This saliency can either enhance cognitive processing (if the goal is to locate the negative stimulus) or interfere with cognitive processing (if the goal is unrelated to the negative stimulus). In the latter case, inhibition of the negative stimulus is needed for goal directed behavior (Nikolla et al., 2018). Some stimuli might capture the attention based on the individual's state. Saliency is therefore also influenced by motivational relevance, for example pictures of food if one is hungry or craving of drug of choice in substance users (Field et al., 2009). Individual's state can also include acute affect. Stimuli representing sadness are hypothesized to be more salient to depressed individuals compared to non-depressed individuals, enhancing their processing and reducing their inhibition (mood-congruent processing). Attention bias is not always motivation- or affect-specific (Ma et al., 2018). Evidence for this comes from studies with asymptomatic family members of patients with psychological disorders who show a bias in attention. The extent to which attention bias is disorder-specific is also another debate in the field and will be discussed in this literature review (please refer to section on *Top-Down or Bottom-Up Processes*). Meta-analysis of AB to positive information in healthy participants found AB to positive compared to neutral stimuli (small

effect). Both general positive and self-relevant stimuli elicited AB but AB was stronger when stimuli were self-relevant (Pool et al., 2016).

### *Recent Alternative Attention Bias Indices*

Recent psychometric research on the traditional attention bias index (Macleod et al., 1986) has called into question the utility of this score. Reliability measures have been found to be poor and validity measures mixed. Some authors have suggested that one reason for the low reliability is that the calculation of the attention bias index (ABI) involves subtraction of mean values ($RT_{incongruent} - RT_{congruent}$), which results in a score that is less reliable than the individual scores (Rodebaugh et al., 2016). Another suggested reason for the poor reliability of the ABI is that participants' RTs are aggregated into a mean score. This could be problematic if RTs vary across time. To remedy this problem, authors came up with alternate measures of attention bias that took into account the variable nature of AB. Various AB scores were suggested such as Trial Level Bias Score (TLBS; Zvielli et al., 2015) and Attention Bias Variability (ABV; Iacoviello et al., 2014). Capturing attention bias as a dynamic process has shown to be a reliable measure (Molloy & Anderson, 2020; Zvielli et al., 2016) and one that could be clinically useful (Swick & Ashley, 2017). The validity of these measures, however, remains in question, as there is evidence that the TLBS and ABV scores capture measurement error and not attention bias (Kruijt et al., 2016). It has been suggested that measures of attention bias variability in clinical populations actual capture standard deviation of response time (variation in RT) rather than AB (Swick & Ashley 2017) as variability of responses is found more often in clinical populations. For example, Lavoviello et al. (2014) found that attention bias is more variable in anxiety and low to moderately correlated with PTSD symptoms. This issue is still under debate as new methods are being suggested to address these questions (Meyer et al., 2017; Takano et al., 2021).

## Relationship between Attention Bias and Symptomatology: Evidence for AB as a cognitive marker

### *AB as a marker for negative affect: correlations between AB scores and symptomatology*

Results from studies that have correlated attention bias scores with symptom measures as continuous variables have generally shown that larger negative attention bias is related to elevated symptomatology. Hommer et al. (2014) found that AB to angry faces was positively correlated with irritability and depression (but not anxiety) in children with Mood Dysregulation Disorder. Iijima et al. (2018) found that AB to angry faces in undergraduate students was positively correlated with trait anxiety. AB to negative words in undergraduate students was positively correlated with cognitive (but not affective or somatic) symptoms of depression (Baert et al., 2010). A meta-analysis on the Stroop effect showed that severity of mood was related to interference (attention bias) when the stimuli were negative compared to neutral (Epp et al., 2012). Studies that have differentiated between engagement and disengagement processes have shown a positive correlation between engagement bias to negative stimuli and measures of trait anxiety (Rudaizky et al., 2014) and social anxiety (Grafton & MacLeod, 2016) in undergraduate students. Engagement bias to negative stimuli was also correlated with anxiety in at risk children with Autism Spectrum Disorder (Milosavljevic et al., 2017).

Results are less clear for measures of disengagement bias. Difficulty disengaging from threatening stimuli was found to be related to higher trait anxiety in healthy individuals (Koster , E. H. W., Crombez, G., Verschuere, B., & De Houwer, J., 2004; Rudaizky et al., 2014) and intrusive thoughts in individuals with PTSD (Wittekind, 2015). Other studies have shown the opposite correlation, with enhanced disengagement (avoidance of threatening stimuli) being positively correlated with trait anxiety in GAD and healthy participants (Britton et al., 2012).

Avoidance of threatening stimuli was also positively correlated with a measure of avoidance in PTSD participants (Wittekind et al., 2014), rumination in healthy participants (Valenas et al., 2017), and depressed mood in patients with Bipolar disorder (Jongen et al., 2007). In a task where only non-valence stimuli were used, disengagement to neutral targets was found to be positively correlated with negative affect in non-clinical individuals (Compton, 2000). Avoidance of positive stimuli was positively correlated with depressive symptoms in patients with medial temporal lobe epilepsy (Preglej et al., 2017).

Studies that have induced a stress response in their participants have shown that healthy individuals prevent an increase in negative mood by altering their attention to stimuli. Malooly et al. (2013) found that reduced increase in sadness in response to stressor (sad film) was correlated with engagement to positive images in non-clinical student participants. Reduced sad affect was associated with disengagement from negative images even after controlling for cognitive flexibility and neuroticism. Ellenbogen et al. (2002) found that increased negative mood after being exposed to a stressor was correlated with avoidance of negative words in non-clinical student participants. Three studies using the RSVP task (de Jong, Koster, E. H. W., van Wees, R., & Martens, S., 2010; Haddara et al., 2018; Peers & Lawrence, 2009) that correlated emotional interference (distraction) to a measure of anxiety (social anxiety, self-reported anxiety, and STAI) showed no relationship between the attentional capture and symptomatology.

***Attention Bias as a marker for clinical diagnosis (group difference)***

Studies that have looked at group differences in attentional bias can shed light on the relationship between clinical diagnosis and attention bias. Review of these studies will be divided based on the task used as the tasks involve different methodology, might tap into different cognitive processes (attentional engagement versus disengagement), have used different

populations (example healthy controls versus clinical patients), and used stress manipulation (mood induction procedures), which could explain the differences in findings across tasks (example Farach et al., 2014).

**Dot Probe Paradigm.** The dot-probe paradigm was introduced by MacLeod et al. (1986). Since then, different versions of the dot probe paradigm have been used to assess AB in different populations using different stimuli. Findings in mood and anxiety disorders have not been consistent across studies. In high trait anxiety, studies have found evidence for attention bias toward threat (Bradley, B.P., Mogg, K., Falla, S. J., & Hamilton, L. R., 1998; Grafton & Macleod, 2014; Mogg & Bradley, 2010; Rudaizky et al., 2014), away from threat (Grafton & Macleod, 2014; Rudaizky et al., 2014; Salemink et al., 2007), null findings (Cooper & Tomporowski, 2017), and AB depending on stimuli, for example toward mild but not high threat stimuli (Wilson & Macleod, 2003). Similar findings were evident in social anxiety disorder or individuals with high social anxiety, with studies showing increased vigilance toward threat versus neutral faces and objects (Bantin et al., 2016; Macleod 2016), increased disengagement from threat stimuli (Chen et al., 2002) or no group difference (Evanset al., 2016). A meta-analysis looking at AB to positive stimuli showed that depressed and anxious participants (although less so for general anxiety) displayed increased avoidance of positive information (Winer & Salem, 2016). This meta-analysis also showed evidence for enhanced vigilance to negative information in depressed and anxious individuals (with no difference between the two) compared to asymptomatic controls, and greater avoidance of negative information (albeit a smaller effect) in the control participants.

Studies using the dot-probe paradigm varied in stimulus duration, stimulus onset asynchrony (SOA[1]), type of stimuli used (words, pictures), and population studied (Winer & Salem, 2016). One explanation for the discrepant findings could be that individuals with anxiety initially (at shorter SOA or stimulus presentations) orient faster to negative stimuli but then (at larger SOA or stimulus presentations) disengage from threat. It has been suggested that presentations < 200 ms engage the socially anxious' attention while at longer exposures (> 1000 ms) it does not (Mogg et al., 2004). This seems to be the case as well in non-anxious participants. In an experiment with healthy college students, fearful (compared to neutral) faces captured and held attention at SOAs between 84 and 266 ms but not at longer SOAs. Happy versus neutral faces captured attention a little later (168 ms) and held it for another 200 ms, with no attention bias found for longer (672 ms) SOAs (Torrence et al., 2017). In Grafton & Macleod's (2016) study, attention bias toward threat was found for 500 ms presentation but not 1000 ms in high socially anxious participants. Most SOAs are 500 ms and findings are discrepant for this time duration. Steven et al. (2009) found no vigilance for angry faces at 500 ms while Mogg et al. (2004) did. Findings are also discrepant for trait anxiety, with bias away from threat found in 100 ms duration (Grafton & McLeod 2014), bias toward and away from threat in 500 ms (Grafton & McLeod 2014; Rudaizky et al., 2014) and toward and away from threat in 1000 ms (Rudaizky et al., 2014). Although AB might be dependent on stimulus duration or SOA, these factors do not fully explain the discrepant findings.

Stimulus valence might moderate the influence of stimulus duration on the size of AB. For negative stimuli (faces, words, and pictures) stimulus duration appears to have an impact on the size of attentional bias with larger effect sizes in short (< 200 ms) and long (> 500s)

[1] Stimulus onset asynchrony is a measure of time between the onset of one stimulus and the onset of the following stimulus.

durations compared to presentations between 200 and 500 ms (Winer & Salem, 2016). A meta-analysis in SAD showed larger effect sizes for vigilance toward threatening faces in short (70 and 175 ms) and medium (500 ms) durations but small effects in durations > 1000 ms (Bantin et al., 2016). For positive stimuli, presentation times smaller than 200 ms, between 200 & 500 ms, and greater than 500 ms did not appear to make a difference in attentional bias although the effect size was (nonsignificantly) larger for the longer durations. The opposite pattern was observed in another meta-analysis where anxious participants showed vigilance to positive information (although no group difference in effect size was reported) but no vigilance in the longer SOAs. It was suggested that durations > 300 ms allow for saccadic eye movements, preventing researchers from capturing initial attention allocation (Rooijen et al., 2017). Some studies have shown no difference between short durations on attentional bias with both subliminal (< 30 ms) and supraliminal (500 ms) presentations affecting attention when the stimuli are faces due to their evolutionary importance. It is also possible that the populations assessed differ in their emotional regulation abilities, which could have influenced the findings. Especially in conditions with longer SOAs or presentation times, non-clinical participants could have engaged their higher-order cognitive resources to manipulate their attention when presented with negative stimuli. Studies on interpretation bias have shown that participants can re-interpret stimuli to protect against increase in negative mood (Malooly et al., 2013). It remains to be evaluated whether participants engage in re-reappraisal even when not explicitly asked to do so by experimenters.

One possible explanation for the results showing both enhanced disengagement and difficulty disengaging attention in individuals with anxiety, is the conceptualization of anxiety as a unitary construct, which could have masked differential processing across individuals. It has

been suggested that anxious apprehension is different from anxious arousal, with the former characterized by behavioral avoidance and the latter by worry (Sharp et al., 2015). Other factors that can also cause discrepant findings are differences in severity of pathology and whether participants are taking psychotropic medication as medications can influence attention bias. Comparison across studies might therefore make it difficult to draw conclusions due to large variability in methodology across studies.

**Stroop Task.** A meta-analysis of findings from the Stroop task in depression showed that depressed participants displayed significant and large interference on positive, negative, neutral and classic (non-emotional) Stroop stimuli compared to controls. The dysphoric group showed more interference than the control group across positive, negative, and neutral stimuli (small to medium effect size), and the sad mood induction group showed more interference than the control group only on the negative stimuli (small effect size). Within group analyses showed small negative bias effects in the clinical depression group for negative vs neutral and negative vs positive stimuli, with no significant bias found in the dysphoric, sad mood induction, and control groups. These findings indicate that negative affect increases bias to negative stimuli, suggesting a quantitative difference in AB between the groups. There appears to also be a qualitative difference between clinical depression and non-clinical depression, as the former group showed interference across stimuli, indicating general cognitive slowing. There was no difference in interference between depression-specific and general negative words. It is possible that cognitive deficit in general (conflict monitoring) underlies the impairment observed in clinically depressed individuals (Epp et al., 2012).

A meta-analysis of Stroop findings in PTSD showed that individuals exposed to trauma had greater interference for PTSD-relevant stimuli versus neutral stimuli compared to individuals

not exposed to trauma. The stimuli used were PTSD-relevant, general threat, positive, and neutral words. No group difference was found between individuals diagnosed with PTSD and individuals exposed to trauma with no PTSD diagnosis. No significant between group differences were found for general threat vs neutral words, general threat vs positive words, positive vs neutral words or PTSD-relevant vs general threat words. Within-group effects showed interference for both PTSD and trauma control group in the PTSD-relevant vs threat, PTSD-relevant vs neutral and PTSD-relevant vs positive conditions (small effect sizes).

Interference was greater to the negative valence stimuli. Both trauma groups showed interference in the threat vs positive condition but only the PTSD group showed interference in the threat vs neutral condition. No significant interference was found in the no-trauma control group. These results show that for the clinical PTSD group, both specific and general negative stimuli were disruptive. For non PTSD trauma exposure group, only PTSD specific stimuli were disruptive (Cisler et al., 2011). These findings could indicate that individuals with PTSD compared to trauma exposed individuals without PTSD, have generalized attention bias to all negative information. The non-PTSD trauma exposed group, however, are only influenced by the saliency of the PTSD-specific stimuli.

**Spatial Cueing.** The findings from studies using the cueing paradigm are less consistent than those from other paradigms. Generally, results indicate that healthy participants tend to disengage attention when under stress whereas patients with depression and anxiety symptoms have difficulty disengaging attention during stress. The disengagement of attention in healthy participants appears to occur during the medium length presentation times. Compton (2000) showed that healthy participants who had a larger change in negative affect after sad mood induction (watching sad clip) had greater difficulty disengaging attention in the 100 ms

condition. This correlation was reversed in the 500 ms condition, where a larger change in negative affect was related to more disengaging of attention. Ellenbogen et al.'s (2002) study showed that individuals under negative stress tended to show faster disengagement from negative compared to positive or neutral stimuli (stimulus presentation = 290 ms and SOA = 360 ms). The participants with high dysphoria were slower at disengaging attention from negative, positive, and neutral stimuli when they were under negative stress compared to positive stress or no stress condition. In Wittekind's (2015) study, depressed participants had more difficulty disengaging from negative stimuli (depression and trauma related) compared to anxious and neutral stimuli (SOA = 450 ms). Non-depressed participants more easily disengaged from the emotional compared to the neutral stimuli. Baert et al. (2010), using presentation cues of 1500 ms, showed that depressed university students had greater vigilance to negative vs neutral stimuli compared to less depressed students. Results from these studies could indicate that during the medium (~500 ms) presentation times healthy individuals appear to employ emotional regulation strategies to disengage attention when under stress, whereas individuals with internalizing disorders have difficulty disengaging from negative stimuli.

Findings for the spatial cueing paradigm in Generalized Anxiety Disorder (GAD) is less consistent. Yiend et al.'s (2015) study showed that whether participants engaged or disengaged from stimuli depended on the emotion displayed by the facial stimuli. Two experiments were used in this study. In one experiment, GAD participants showed greater disengagement from angry and happy faces compared to neutral faces (600 ms presentation time). In another experiment using slight modification to the task, both GAD patients and healthy participants showed difficulty disengaging from fearful compared to neutral stimuli (at 700 but not 300 ms). Kinney et al. (2017) showed that men (but not women) with GAD responded faster to negative

words presented for 500 ms compared to neutral words (although post-hoc tests were not carried out). Morales et al. (2017) showed that children who were described as behaviorally inhibited were faster at responding to angry faces (and possibly also neutral faces) compared to non-behaviorally inhibited children (500 ms stimulus presentation).

**Rapid serial visual presentation (RSVP).** Many of the RSVP studies have been carried out on non-clinical populations. Results from healthy populations are equivocal, with some showing that participants tend to disengage slower from the first target (T1) when it is an emotionally valence word or image, reducing participants' accuracy in detecting the second target (T2), and others showing enhancement of attention to T2 when preceded by emotional stimuli. In healthy young and old adults, a RSVP paradigm showed more accurate detection of target T2 when preceded by negative and positive arousing words compared to neutral arousing T1 words. The authors explained this finding as expansion of attention that takes place when exposed to emotional information such that other information is incorporated into attentional awareness (Steinmetz et al., 2010). These results could also be explained by disengagement of attention from emotional arousing information (regardless of valence) in healthy participants, consistent with results from other paradigms (spatial cueing tasks) that show that healthy individuals disengage attention as an emotional regulation strategy. Dhinakaran et al.'s (2014) study supports this explanation by showing that participants high on trait extraversion show more disengagement from salient distracting stimuli whereas participants high on neuroticism show overinvestment of attention to irrelevant salient stimuli. As healthy (non-clinical) participants are more likely to score highly on extraversion compared to neuroticism, the findings are consistent with the hypothesis that healthy participants employ flexibility, or cognitive control to remain on-task. Keil and Ihssen (2004) showed that arousing target stimuli (regardless of valence)

enhanced accuracy of target detection in healthy participants and that positive and negative stimuli low in arousal did not cause such enhancement. This provides evidence for enhanced goal directed behaviors in healthy participants to salient (arousing) stimuli compared to low arousing stimuli (in short SOA). In line with the expansion of attentional resources explanation, de Jong, Koster, Wessel, and Martens (2014) found that performance was enhanced when the target was preceded by emotional faces (happy and angry) as distractors (in short but not long time lag). The authors reported that faces have interpersonal relevance, leading to devotion of extra attentional resources with the goal of gathering more information about the situation.

Other studies, however, showed that valence distractors impaired performance due to difficulty disengaging attention from the emotional stimuli. De Jong, Koster, van Wees, and Martens (2010) showed that angry faces compared to happy or neutral expressions reduced participants' accuracy in identifying subsequent letters. The difference in findings between De Jong et al.'s 2014 and 2010 study could be due to methodological differences including task requirements. In the 2010 study, the authors reported that participants needed to indicate the expression of the face observed (distractor) and identify the letter (target), therefore explicitly asking participants to direct their attention to the distractor face. In the 2014 study it was not reported that participants were asked to indicate the expression of the faces, as the faces were the distractors and not the targets. If this was truly the case, then it is possible that participants ignored the distractor, making target detection easier. Haddara et al.'s (2018) and Schwabe and Wolf (2010) showed in healthy young participants that in short lags aversive stimuli were distracting (lower target detection accuracy). Images were used in Haddara et al.'s and words in Schwabe and Wolf's study. Stress influenced performance differently in the two tasks. When under threat of electric shock, participants in Haddara's study were distracted by negative images

and were less accurate at reporting the orientation of the target image (clockwise or counterclockwise). This was the case even at longer lags (400ms) although participants generally recovered by the long lags (700ms; Haddara et al., 2018). In this study, performance decreased even when distractors were neutral during the stress condition, indicating fewer attentional resources devoted to goal directed behavior. In Schwabe and Wolf's study, where participants were asked to report the emotional target words by writing them, stress enhanced performance (small effect). The differences between the two is that in Schwabe's study, the emotional words were centrally processed as they represented the target stimuli (not distractors). The meaning of the words was task relevant, which indicates that stress could have enhanced direction of attention to the emotionally arousing words, improving performance. In Haddara's study, on the other hand, the emotional stimuli were considered distractors so stress hindered performance as emotional processing was not target relevant. The orientation of the target image is what needed to be processed. Peers and Lawrence (2009) found no difference between neutral and valence stimuli and no difference between the emotional stimuli (fearful and disgust) in distraction. They found, however, that attentional control moderated the relationship between valence of distractors and performance. This was the case only in the short SOAs such that participants with poor emotional control were more distracted by emotional versus neutral distractors.

Studies using a clinical population showed that emotional T2 stimuli are processed at a lower threshold compared to neutral stimuli. Studies with individuals with a spider phobia showed a reduced attentional blink (reduced impediment of inhibitory processes) when T2 images were spiders compared to other images (Reinecke et al., 2008; Trippe et al., 2007). This indicates that high threat stimuli are more easily picked up by the attention network. Participants with Post-Traumatic Stress Disorder have a greater difficulty disengaging from threat stimuli

(Echiverri-Cohen et al., 2016; Schonenberg & Abdelrahman, 2012) although there is also some indication that the difference in processing between threat and neutral stimuli is driven by reduced attention to the neutral stimuli rather than enhanced attention to the combat-related stimuli (Todd et al., 2015). This suggests general impairment in attentional processes (possibly cognitive slowing) rather than enhanced emotional processing. A similar finding was observed in a study with individuals with dysphoria that used only neutral stimuli. The participants with severe dysphoria showed greater attentional blink to the neutral stimuli (Rokke et al., 2002). This could indicate that stimuli, regardless of valence, are processed for longer in working memory, delaying the process of consolidation, and therefore inhibiting the processing of a second stimulus. Using sad and happy facial expressions, Milders et al. (2016) showed that patients with depression did not have a lower threshold for detecting sad faces compared to non-depressed participants but had a higher threshold for detecting happy faces.

Findings from the RSVP paradigms show: 1) healthy participants disengage from emotional information when they are considered distractors (task irrelevant) and show enhanced engagement when emotional information are targets (task relevant). This indicates that healthy individuals are able to use cognitive control strategies to engage in goal directed behaviors and reduce distraction. Stress enhances focus on emotionally salient information, making it distracting when it is not task relevant, but enhancing performance when it is in line with goal directed action. 2) There is little evidence for specificity of valence in control participants. Evidence for emotion specificity is mixed for participants with PTSD and specific phobia. 3) Short SOA conditions show more evidence for distraction. Longer SOAs allow participants to engage extra resources to recover from the distraction and enhance performance. 4) The studies that correlated distraction to measures of anxiety showed no relationship between the two.

### *Evidence from Patients in Remission and Family History of Depression*

AB has been found to be dependent on state and trait factors. Avoidance of positive information in individuals with depression appears to occur during acute states of anhedonia, indicating that AB is at least partially influenced by participants' affective state (example Karparova et al., 2007). Enhanced engagement to negative information, however, appears to be a trait factor as this process has been found in depressed individuals who have recovered from depression and in non-disordered family members of MDD patients. Depressed individuals in remission show normalized AB to positive information but their attention to negative information remains impaired. Using measurement of eye movements, Soltani et al. (2015) showed that remitted and never depressed individuals increased their fixations to happy faces whereas the acutely depressed participants reduced their fixations after a 2-4 second interval. Acutely and remitted depressed participants attended to sad faces similarly throughout an 8 sec period of stimulus presentation whereas never depressed participants tended to disengage from the sad faces after 2-4 seconds. Using a behavioral task, Fritzsche et al. (2010) showed that only currently depressed participants showed evidence of bias away from happy faces whereas biases toward sad stimuli was found in both current and recovered depressed participants compared to the controls who showed bias away from sad stimuli. Isaac et al. (2014) showed that the healthy individuals and remitted depressed, but not the currently depressed participants, had longer glance duration toward the happy faces, indicating that positive bias might be a state factor (although there is evidence for reduced positive bias in remitted depression; Dai & Feng, 2011). The current and remitted depressed groups showed enhanced engagement to emotionally salient features, irrespective of valence, as they maintained fixations for longer to sad, angry, and happy

faces compared to healthy control participants. It is therefore possible that heightened emotional processing in general is a trait factor in depression.

Studies on AB in first degree relatives of individuals with mood disorders support the hypothesis that engagement to negative information can be influenced by trait factors. It has been found that non-symptomatic daughters (but not sons) of a heterogeneous sample of disordered mothers (mood, anxiety, or comorbid mood and anxiety) showed increased AB to threat (Montagner et al., 2016). Non-symptomatic daughters of mothers with MDD showed increased AB to sad stimuli and reduced AB to happy stimuli (Joorman et al., 2007) compared to daughters of non-disordered mothers. The reduced positivity bias in the at-risk girls could be explained by state factors (higher depression scores), or it could be indicative of a trait influence. Relatives of patients with MDD show abnormal activity in the ACC during emotional processing (Watters et al., 2018). Abnormal processing of emotional information, independent of acute affect, could suggest that AB acts as a vulnerability factor, placing individuals at increased risk for developing mood disorders.

### *Attention Bias as a Marker for Treatment Response: Attention Bias Modification, Psychotherapy, and Medication Treatment*

The studies described in this review used group difference statistics to delineate the relationship between AB and psychopathology; these statistical procedures cannot be used as predictive tools. For attention bias to be used as a marker to identify individuals at risk of developing a psychological disorder or for diagnosis of psychological disorders, we need to go beyond simple correlations or regressions to determine whether attentional bias scores adequately differentiate between the two populations of interest (example depressed vs non-depressed). This could either be done using: 1) logistic regression, which is used to determine the

probability or odds that an individual falls in the patient versus control group based on their AB score, 2) receiver operating characteristics (ROC), which can be used to determine the predictive power of the attention bias score, or 3) experimental paradigms that manipulate participants' AB. To my knowledge, there has been one study that used logistic regression analysis to determine the predictive power of AB indices (Barry et al., 2015). There have been, however, a few experimental paradigms that manipulated AB and tracked symptom change to find evidence for a causal link between attention bias to threat or positive stimuli, and mental health symptoms. Evidence from Attention Bias Modification (ABM) and Cognitive Behavior Therapy (CBT) studies can shed light on the influence of AB on psychological symptoms. AB is directly manipulated by training participants to alter their attention allocation away from negative stimuli toward positive or neutral stimuli. The change in symptoms from pre- to post- ABM is then measured.

**Attention Bias Modification (ABM).** Hakamata et al. (2010) conducted a meta-analysis on the effectiveness of ABM task, which used the dot-probe paradigm to alter attention bias in anxiety. Results showed that training with ABM was effective in reducing anxiety symptoms. A large (but non-significant) correlation was found between change in AB and change in anxiety scores. Other studies, however, have shown that a change in attention bias is not accompanied by changes in mood. Reinholdt-Dunne et al. (2015) showed in a study with anxious children that attention bias was not correlated with anxiety scores nor was there a correlation between change in attention control and change in anxiety scores. Using the modified Posner task, Enock et al. (2014) found that ABM task delivered via smart phone in social anxiety showed reduction in attention bias in the active condition throughout the 3-week duration of the treatment and at follow up (week 4). A reduction in social anxiety, worry, and depressive

symptoms was found in both ABM and active control groups with no difference between the two. Similar findings were observed in Yang's study using a dot probe task in adolescents with depression (Yang et al., 2016). The ABM procedure successfully reduced attention bias to negative stimuli in the active condition during the post training and at 7-week follow up. At post-training, depressive symptoms decreased more in the active vs placebo condition although at 7-week follow-up the same decrease was observed in the placebo condition. These findings could indicate that in the short-term, ABM training was effective at reducing mood symptoms but that common mechanisms between the ABM and active control treatments are responsible for the affective changes. Another explanation could be that longer duration of treatment with ABM is needed to cause durable change in AB.

One study with PTSD participants showed that a change in AB mediated the relationship between type of treatment (ABM vs attention control) and change in PTSD symptoms but not depressive symptoms (Kuckertz et al., 2014). Although a reduction in both PTSD and depressive symptoms was observed after treatment, change in AB was not a significant mediator for depressive symptoms. This could indicate that the effect of ABM is affect-specific, in which attention directed away from trauma-related words in PTSD participants resulted in a reduction in PTSD symptoms that did not generalize to other symptoms such as depressed affect. There has been a debate as to whether a change in AB directly influences mood or whether the cognitive process acts as a protective factor in preventing future episodes by reducing responses to stressors (Cristea et al., 2015; Grafton, MacLeod, Rudaizky, Holmes, Salemink, Fox, & Notebaert, 2017). Grafton et al.'s meta-analysis indicated that when successfully implemented, cognitive bias modification reduces vulnerability to mood symptoms. It is difficult, however, to differentiate between the concepts of vulnerability and mood itself as the symptom report

measures used in these studies could tap into both acute affect and trait factors. For example, State and Trait Anxiety Inventory (STAI) and Anxiety Sensitivity Index (ASI) are considered measures of vulnerability but they also tap into anxious mood (Kemper et al., 2012; Naragon-Gainey, 2010; Zvolensky et al., 2018).

One mechanism through which ABM has shown to reduce depressive and anxiety symptoms is through increasing positive bias. Kree and Aue (2019) demonstrated a causal relation between ABM training and optimism bias. Using a computational network approach, Kraft et al. (2019) showed that ABM training resulted in increase in interest, i.e., engagement to positive social situations and a decrease in the strength of the relationship between the symptoms of depression and anxiety. This could suggest that ABM, similar to other treatments, increases flexibility (or entropy), resulting in more potential for positive experiences.

There is evidence that ABM acts as a buffer to stress in non-clinical, at risk, and clinical populations, alleviating symptoms of anxiety and depression. After exposure to stress, participants who received ABM showed a reduced increase in social anxiety in socially anxious individuals (Amir et al., 2008), in state anxiety in a non-clinical student sample (MacLeod & Bridle, 2009), and in depressive symptoms in a high-risk adolescent sample (LeMoult et al., 2016). In LeMoult et al.'s study the change in attention bias in the ABM group was accompanied by reduced increase in heart rate after exposure to stressor, acting as a protective mechanism for stress reduction. A study using ABM in social anxiety showed that larger AB at baseline predicts greater change in symptoms, which could either reflect more room for change or regression to the mean (influence of time; Carlbring et al., 2012). Careful consideration is needed when implementing ABM procedures for clinical use as short term (single session) training might not be adequate to alter attention biases (Everaert et al., 2015).

**Psychotherapy.** Pishyar et al. (2008) showed small to large correlations between change in attention bias after CBT and symptoms of depression and anxiety in patients with social phobia. One study using computerized CBT and cognitive bias modification for interpretation (CBM-I) showed that a change in AB (more positive interpretation) mediated the relationship between treatment group and symptom reduction (Bowler et al., 2012). Another study (Vrijsen et al., 2018) showed that although psychotherapy resulted in both changes in symptoms and a change in AB, AB change did not mediate the relationship between treatment and symptom reduction. It therefore remains unclear whether a reduction in psychological symptoms can at least be partly explained by a change in AB after undergoing psychotherapy or whether AB and mood are both separately influenced by independent processes of therapy. In a study using Trial Level Bias Score (TLBS, instead of the traditional bias score) as a measure of attention bias, a study found no correlation between reduction of attention dysregulation and reduction in anxiety symptoms after CBT, suggesting that CBT influences these two processes independently (Davis et al., 2016). Huppert et al. (2018) and Bockstaele et al. (2019) also aimed at measuring mediation, but their treatments failed to change participants' AB. In Huppert's study, therapy resulted in a change in symptoms, which could either indicate that AB does not underly the symptom change or that the measure failed to capture a true change in AB (poor reliability of the dot probe paradigm). It remains unclear whether CBT alters attention bias toward threat or attention bias away from threat (Davis et al., 2016). Price et al. (2011) and Waters et al. (2012) showed that the mechanism underlying the effectiveness of CBT in symptom amelioration involves reduced vigilance to threat more so than avoidance of threat in social anxiety and GAD. Patients who showed disengagement bias did not respond as well to CBT although the opposite finding was described in Barry et al. (2015). Despite these significant

(albeit mixed) findings, only Barry et al. (2015) used logistic regression analyses to determine whether AB could be used to differentiate two groups of interest. Their study showed that change in disengagement bias did not differentiate those who responded to CBT from those who did not respond to the treatment (neither was change in engagement bias score). These results either indicate that change in attention bias is unlikely to be a significant marker of treatment response or that the measures of attention bias have poor reliability and that they are not adequately capturing AB as a mediator of symptom reduction.

**Medication.** Studies on the effect of medication on attentional bias have shown that psychotropic medications reduce AB to negative stimuli although different medications have different influences on AB to positive stimuli. Most of the studies have been carried out on healthy participants. In healthy adult volunteers, administration of one dose of fluoxetine reduced accuracy and slowed response time when responding to angry faces (Capitão et al., 2015). Murphey's et al. (2006) study showed that administration of tryptophan in healthy female participants resulted in increased recognition of positive facial expressions and decreased recognition of expressions of disgust. Other studies have shown that single administrations of citalopram in healthy students increased positive bias and bias to threat (Browning et al., 2007) possibly indicating enhanced response to arousing stimuli regardless of valence. Stein's et al. (2012) study using dot probe task failed to show a change in RT to positive or negative faces in healthy adult students after a one-week administration of Citalopram and Reboxetine.

Brain imaging and electrophysiological studies are helpful to detect changes that occur independent from mood and behavior changes. Using the event-related potential (ERP) N250[2] as

[2] ERP N250 is a negative waveform that occurs 250 ms after stimulus presentation. It tends to be associated with the emotional processing of faces.

an indicator of AB, Kerestes et al. (2009) showed that administration of Citalopram and Reboxetine in healthy males enhanced AB toward positive stimuli even when no change in mood was evident. Administration of ketamine vs citalopram vs placebo in healthy participants resulted in differential N170[3] modulation in response to different emotional expressions presented consciously and unconsciously (Schmidt et al., 2013) with some drugs primarily blunting the encoding of negative and neutral stimuli and others blunting the encoding of all stimuli including positive faces. A study with escitalopram in MDD patients showed that after 8 weeks of treatment, both negative bias and negative mood (HAM-D) were reduced (Zhou, Cao, Li, & Li, 2015) although it is unclear whether negative bias mediated the change in mood. The underlying mechanisms of mood change may not be changes in attention bias (example practice effects, Heeren et al., 2016; Bockstaele et al., 2019). It is possible that the mechanism of action of SSRIs includes a reduction in negative AB that can be detected before a change in mood is observed. The initial reduction in negative AB increases the opportunity to engage with the environment and increases positive interactions (increased positive AB), which then causes improvement in mood (Harmer & Cowen 2013; Harmer, Mackay, Reid, Cowen, & Goodwin, 2006).

Activation in frontal brain regions has been shown to be predictive of treatment response. Klumpp et al. (2014) showed that increased activation in dorsal anterior cingulate cortex (dACC) and frontal superior medial gyrus during a task requiring attentional control predicted symptom improvement after CBT in patients with Social Anxiety Disorder (SAD). Using the same task, the authors (Klumpp et al., 2013) also identified medial prefrontal and visual brain regions

[3] ERP N170 is a negative waveform that occurs 170 ms after stimulus presentation. It tends to be associated with the structural encoding of faces.

during processing of negative faces as possible BOLD[4] response markers for symptom reduction after CBT in patients with SAD. Difficulty disengaging from (but not engagement to) emotional faces, regardless of valence, was observed in healthy individuals after low frequency stimulation using tDCS[5] to the right DLPFC even with no change in reported mood, implicating this brain region in disengagement from threat, possibly as a coping mechanism (Sanchez, Vanderhasselt, Baeken, & De Raedt, 2016). Results from this study are consistent with findings from behavioral studies that have shown delayed disengagement in depression when stimuli are presented for longer than 1000 ms.

**Attention Bias in Depression and Anxiety: Evidence for Differential Patterns of AB**

Studies on attention bias have shown some evidence for differences in patterns AB between depression and anxiety. It is primarily hypothesized that anxiety is characterized by hypervigilance toward threat (example Bantin et al., 2006) and depression is characterized by devaluation of positive experiences (Devaluation hypothesis). Mogg and Bradley (2005) suggested different mechanisms of AB for MDD and GAD patients. Attention bias to negative material in anxiety is immediate and short-lived, followed by disengagement of attention from negative information (Yiend et al., 2015; Koster et al., 2005; Mogg et al., 2004; Rohner, 2002), whereas in depression hypervigilance is less prominent. Studies differ in the way they conceptualize psychopathology and the way they divide their groups. Studies that have used non-clinical populations tend to use continuous measures of mental health symptoms (self-report

[4] Blood Oxygenation Level Dependent (BOLD) reflect increase in blood oxygenation following neural activity.
[5] Low frequency stimulation using transcranial direct current stimulation (tDCS) is used to modulate activity in certain brain regions. Anodal tDCS (as used in this study) over the right dorsolateral prefrontal cortex (DLPFC) is used to increase activity in his region.

questionnaires) to identify mood and anxiety symptoms. Studies that have used clinical populations often times use categorical diagnoses based on DSM 5 criteria to divide their groups.

### *Lack of Attention Bias in Depression explained by Cognitive Slowing*

It has been proposed that general cognitive slowing in depression mitigates the effect of attentional engagement, reducing participants' responses to all stimuli (Gohier et al., 2009). Reduced attentional engagement in individuals with depression is therefore not specific to negative stimuli. Brain imaging studies have suggested that the presence of anhedonia is related to reduced attentional processing. Using an ERP study, Sass et al. (2014) found that in the anhedonic-depressed group but not in the depressed-anxious group, early visual processing was dampened to all stimuli regardless of valence whereas in the comorbid depressed-anxious group vigilance was detected to unpleasant stimuli. Another EEG study looking at prefrontal hemispheric activity found that a group of previously depressed individuals without anxiety had reduced left prefrontal activity compared to a group of depressed individuals with comorbid anxiety who showed normalization of response. The authors suggested that anxious arousal masks this abnormality in individuals with comorbid anxiety and depressive disorders (Nusslock et al., 2017). Although general cognitive slowing could explain the pattern of AB in depressive disorders, another explanation could be a deficit in executive function, more specifically inhibition, irrespective of emotion processing. There is mixed evidence regarding improvement of inhibition in MDD with treatment, with one meta-analysis showing that deficit in inhibition measured with the Stroop task improved with antidepressant treatment (Wagner et al., 2012) and another systematic review and meta-analysis of RCTs showing no improvement in inhibition (Stroop task and Trail Making Test B) with antidepressant treatment (Rosenblat et al., 2016) although a positive effect was found for psychomotor speed. It is unclear, however, to what

extent mood symptoms changed after treatment and whether a failure of cognitive improvement was accompanied by a failure of improvement in mood symptoms.

### *Later Onset of Attentional Engagement in Depression*

There is some evidence that AB in depression cannot be entirely explained by a general cognitive deficit as other studies have shown that hypervigilance does occur in depressed individuals, but at a later onset than that observed in anxious individuals. It appears that in depressed participants, engagement bias is observed when the stimulus is presented for at least 1000 ms. Using a dot probe task, Lin Ji et al. (2017) found that when the stimuli were presented for 500 ms, high and low depression groups did not differ in AB to negative stimuli but in the 1000 ms condition, the high depression group showed increased vigilance to the negative stimuli. This could indicate that once negative information has entered their stream of consciousness, it becomes more difficult to terminate the processing. Using a spatial cueing procedure with longer presentation times for the stimuli (1500 ms) than is typical, Baert et al. (2010) showed that depressed participants engaged faster to negative vs neutral stimuli compared to less depressed participants. Despite a later onset of attentional engagement in depressed compared to anxious individuals, once the negative stimuli are processed in depressed individuals, it becomes more difficult for disengagement to occur. Using a spatial cueing task, Ellenbogen et al. (2002) found that high dysphoric participants had difficulty disengaging from emotional stimuli while under stress compared to low dysphoric participants who disengaged faster from negative words compared to positive words while under stress. In Wittekind's et al. (2015) study, depressed participants but not participants with PTSD had greater difficulty disengaging attention from negative stimuli. Despite individual studies showing a later onset of attentional engagement in depression, Winer and Salem's (2016) meta-analysis showed no evidence for differential

processes regarding hypervigilance to negative information in depressed and anxious groups. It remains to be investigated whether initial orientation to threat (rather than later onset) occurs in individuals with depression when anxious arousal is not present.

### *Reduced Engagement to Positive Stimuli in Depression*

In relation to positive stimuli, a meta-analysis on findings from the dot-probe task showed that participants with primary symptoms of depression showed more avoidance of positive information than those whose primary symptom was not depression (example generalized anxiety; Winer & Salem, 2016), indicating that reduced positivity bias might be specific to depressed mood. When measuring an ERP component, the Late Positive Potential (LPP), which is suggested to be involved in approach-related behaviors, a blunted LPP to positive stimuli was found in depressed participants and depressed participants with comorbid anxiety but not in those with anxiety alone. These results indicate that the presence of depression relates to reduced approach behaviors to rewarding stimuli regardless of comorbid anxiety (Weinberg et al., 2016). The depressed groups also showed some blunting to threatening stimuli (non-significant), which could suggest general avoidance of valence information. In a study with anxious individuals, high anhedonia was related to reduced awareness of anxiety-related interoceptive cues (heart rate) even when anxious arousal was high (Dunn et al., 2010). These findings could indicate that lack of engagement bias in depressed groups could be explained by blunted information processing when anhedonia is elevated due to avoidance of positive and negative stimuli. The presence of anxiety possibly counteracts avoidance to negative stimuli but not positive stimuli, creating a positivity bias but no negativity bias. Lin Ji et al. (2017) found that participants with high depression scores showed reduced AB toward positive information

only when it is self-referential although enhanced vigilance to negative stimuli was not based on the relevance of the information for the participants.

It is possible that anxious arousal and anhedonia represent different processes related to motivation where high anxious arousal triggers approach related behaviors (vigilance) and high anhedonia triggers avoidance related behaviors (disengagement). It remains unclear at this point how AB processes are affected by comorbid anhedonia and anxious arousal symptoms. It is possible that anxiety represents a general vulnerability that increases the probability of processing negative information, whereas anhedonia represents a state factor that drives the individual away from positive material.

### *Automaticity of Attention Bias in Depression and Anxiety*

Similarities and differences in the automaticity of AB processes between anxiety and depressive disorders have also been delineated. Teachman et al. (2012) reviewed different AB tasks in MDD and anxiety to determine whether processing of emotional stimuli is automatic. The authors found that although anxiety was characterized by unconscious (subliminal priming) and unintentional (non-goal oriented) processing of negative stimuli, there was little evidence that this was also the case in depression, supporting findings that show a later-onset for attentional engagement in depression. Lichtenstein-Vidne et al. (2016) used a task that included distracting information outside the participant's direct focus of attention to determine whether unintentional emotional processing (non-goal directed behavior) occurs. The authors showed unintentional processing in the anxious group, who displayed attention bias toward negative stimuli, whereas no such bias was found in the depressed group. This study also found that whereas the initial hypervigilance to negative information might be less prominent in depression compared to anxiety, participants with depression have more difficulty disengaging from the

processing of negative material once it has started, consistent with findings of rumination in depression (Teachman et al., 2012; Zhang et al., 2017). There was evidence in both disorders, however, for the uncontrollability of emotion processing (Teachman et al., 2012). This indicates that although separate mechanisms of AB exist between anxiety and depressive disorders, these disorders also have mechanisms in common.

### *Different Patterns of Attention Bias between Anxiety and Depression are not Robust*

Despite the separate mechanisms of AB suggested for depression and anxiety, almost all studies investigated attention bias in a specific clinical group by comparing it to a control group. Conclusions regarding the underlying mechanisms of AB are therefore an extension of these findings and rarely represent direct comparisons between the two clinical groups (Rooijen et al., 2017). Even when depressed and anxious groups are included in the same study, AB between these two groups are usually not statistically compared. For example, using a spatial cueing task, Ellenbogen and Schwartzman (2009) showed that depressed participants had difficulty disengaging attention from dysphoric but not threat stimuli compared to controls, in the non-stress condition. In the stress condition, participants with anxiety showed enhanced disengagement from threat but not dysphoric stimuli compared to control participants. The depressed and anxious groups, however, were not directly compared. Interestingly, the authors noted that the high depression scores in the anxious group were partly related to disengagement from threat, which suggests that perhaps negative affectivity in general predicts avoidance (disengagement) of threatening stimuli. Although this is inconsistent with other spatial cueing tasks that have shown depression and anxiety to be characterized by difficulty disengaging attention rather than enhanced avoidance of negative stimuli, it is consistent with other studies that have shown avoidance of threat.

Hommer et al. (2014) found that threat bias in individuals with Severe Mood Dysregulation (SMD) was correlated with symptoms of irritability and depression (but not anxiety). AB to threat did not differ between the SMD groups with and without comorbid depression and anxiety diagnoses. This supports the idea that perhaps AB to threat is a vulnerability factor that predisposes individuals to internalizing disorders regardless of specific symptoms endorsed. Recently, AB tasks have been used with a variety of patient populations including individuals with eating disorders (Seage & Lee, 2017) and alcohol use disorder (McAteer et al., 2018). Results from these studies generally show that attention bias is specific to the participants' primary presenting problem, such as food-related stimuli in patients with eating disorders, although results were inconsistent across stimuli (calorie-related, weight-related etc.; Starzomska, 2017). Another study (Mano et al., 2018) investigated the specificity of AB to academic threat in students with test anxiety. Although there was some evidence for specificity, high test-anxiety participants also showed AB to social threat images. These results indicate that despite some evidence for differential processing, it is important that direct comparisons of AB are carried out between depression and anxiety groups for the above conclusions to be more tenable.

**Top-Down or Bottom-Up Processes influence AB?**

Mood congruent attention bias has also been observed in studies using depressed individuals and participants induced into a sad mood (example Koster et al., 2005). In mood-congruent AB, it is hypothesized that a person is more likely to turn their attention to information consistent with their affect. Acute affect can be described as the participant's "feeling" during the experiment. Affect has been measured as a continuous variable or used to divide participants into groups (example clinical vs non-clinical). Studies have generally shown some support for

the notion that the way participants attend to information is related to how they are feeling in the moment (evidence reviewed above). For example, individuals who are experiencing sad mood display AB exclusively to sad stimuli and those who are experiencing happy mood display AB to stimuli that depict joy. This cognitive process is assumed to be top-down, i.e., based on the individual's goals or motivational needs (example motivation to approach or avoid). Others have argued that it is not the individual's affect, per se, that is influencing AB but more general characteristics of the stimuli they attend to, such as stimulus valence or its capacity to induce arousal. This is referred to as stimulus-driven attention, a bottom-up process, in which stimulus-specific characteristics influence attention. This is in contrast to goal-oriented attention, which is primarily participant-specific (Nikolla et al., 2018). Below is a review of evidence for the former. There are, of course, many more stimulus-specific characteristics (example color, shape, familiarity of the stimulus etc.). We will only review the three stimulus-specific characteristics that are relevant to the topic of AB in mood and anxiety disorders.

### *Evidence for Stimulus-Specific Characteristics that Influence AB*

Attention bias can be influenced by the following stimulus-characteristics: 1) arousing quality of the information; 2) valence of the information; or 3) specific emotion depicted. At the most general level, stimuli can be differentiated based on their nature to arouse an individual (arousal). At a more specific level, stimuli are discerned based on their valence: how positive or negative they are. At the most specific level, stimuli are discerned based on the specific emotion they display, for example anger, sadness, happiness, disgust etc. Evidence for each will be discussed below.

***Arousal.*** Studies with clinical populations and healthy populations, and individuals under stressful conditions, have shown evidence for enhanced attention bias to emotional stimuli

compared to neutral stimuli. Arousal is one characteristic that differentiates emotional from neutral information in our environment. It is therefore suggested that emotional stimuli are preferentially processed due to their arousing nature, which increases their saliency. In Jongen et al.'s (2007) study, depressed patients with bipolar disorder showed disengagement bias from both positive and negative stimuli compared to control participants. Another study used positive and negative mood induction in children and showed that those in the negative mood induction condition had more eye gaze fixations to the sad stimuli. Although the authors did not test it statistically, those in the sad mood induction had even larger fixations to the happy and fearful stimuli (Grossheinrich et al., 2018), possibly indicating that negative mood increases engagement to emotional stimuli in general. Goodwin, H., Yiend, J., & Hirsch, C. R.'s (2017) review with GAD patients found that studies that included positive and negative stimuli in their task found enhanced bias in GAD participants to both threat- and positive-related stimuli vs neutral stimuli when compared to healthy controls.

***Valence.*** If AB is influenced by the valence of the stimuli, then AB is discerned based on how positive and negative stimuli are. Moreover, negative affect is expected to increase AB to negative stimuli (sad, angry, fear, disgust) compared to positive (happy, erotic) or neutral valence regardless of the specific emotion displayed. A review of attention bias in GAD participants showed that the majority of studies found evidence for AB to negative stimuli, with no difference between the types of stimuli (depression or threat related; Goodwin , H., Yiend, J., & Hirsch, C. R., 2017). A study using a non-clinical sample showed that an anxious mood increases AB not only to threat stimuli but also to depression specific (sad) stimuli, which predicted increased daily worry, whereas no AB was found to happy stimuli (Macatee et al., 2017). This shows that AB is differentiated at the level of valence. Results from a meta-analysis

using the Stroop task in clinically depressed participants showed that dysphoric participants and healthy controls induced into a sad mood had a significant negative bias with no difference in AB between depression specific and general negative words (Epp et al., 2012). Compton (2000) showed that after a sad mood induction, increased AB to non-valence stimuli was related to an increase in anxiety and anger (but not depression) and a decrease in different positive emotions (vigour, friendliness, elation). Participants' mood on the different emotions was measured, and after the sad mood induction, participants showed a reduction in positive emotions generally and an increase in general negative emotions (anxiety, depression, anger, fatigue), making it difficult to attribute AB to a specific emotion. The Stroop task was also used with a sample of children with ADHD (Ma et al., 2018). Disengagement bias was found in ADHD compared to control group for negative words vs neutral words but not for appetitive words, considered motivationally relevant for ADHD. These results suggest an influence of valence rather than arousal, as appetitive words are considered salient.

***Emotion.*** The most specific level includes specificity to the emotion displayed, whereby participants show AB to information depicting a specific state and not to others (example threat vs sad stimuli). There is evidence for some stimuli-specificity, for both positive (Pool et al., 2016) and negative stimuli (example Cisler et al., 2011) with motivational (including affective) relevance of the stimulus to the participant increasing AB (i.e., participant's current mood is congruent with the emotion displayed by the stimulus). Disner et al., (2014) found that high risk individuals induced into a sad mood showed longer fixations to sad stimuli and reduced fixations to happy stimuli compared to low risk individuals, with no such bias found for threat or neutral stimuli, supporting emotion-specific AB. Results from Wittekind's (2015) study were more difficult to interpret. In the between group analyses, the depressed group (who also elevated on a

measure of trauma-related symptoms) showed more AB to depressed and trauma related cues, but not the anxiety or neutral cues, compared to the non-depressed group who showed more AB to neutral cues. Within group analyses, however, showed no evidence that AB differed between the different cues in the depression group, which could indicate that the depressed group responded with larger AB to all cues (emotional and neutral) compared to the control group that showed disengagement to the emotional cues. Rohr et al. (2015) showed evidence for emotion-specificity and valence-specificity in healthy individuals even when the stimuli were presented subliminally. Participants were able to differentiate sad from happy stimuli and sad from angry/fear stimuli but were not able to differentiate between anger and fear. Specific information about the emotion can be processed unconsciously resulting in emotion-specific misattribution effects (Rohr et al., 2015), although general valence also played a role.

These findings show some evidence for emotion-specificity in AB, although it is not unequivocal. To establish emotion-specificity of AB, studies have attempted to use stimuli that depict a specific emotion. For example, sad facial expressions or words such as “sad” are used when measuring depressed affect. It is not unlikely, however, that the stimuli can elicit more than one emotion and it therefore cannot be ascertained that a sad facial expression only represents dysphoria. Koster, Crombez, Verschuere, and De Houwer (2004) aimed to use threatening images as stimuli, for example, mutilated faces. These stimuli, however, can evoke fear as well as disgust. Valenas et al. (2017) showed that attentional disengagement to negative exam-related words were predictive of state anxiety. It cannot be ascertained, however, that the exam related words were solely related to threat. It is possible that these words also represent feelings of worthlessness/failure, which are characteristic of depression. Moreover, although the stimuli used were expected to represent a specific emotion (threat), participants were asked to rate the

stimuli on how positive/negative and arousing they were (valence and arousal), making it unclear whether threat was the only negative emotion represented by the stimuli (example Valenas et al., 2017).

### *Evidence for Participant-Specific Characteristics that Influence AB*

When establishing participants' mood during performance of the experimental task, researchers have used self-report measures that detect the dominant symptom characteristic of the diagnostic group under study. If depressed affect is being investigated, for example, then the Beck Depression Inventory is chosen to assess depressed mood. The use of these questionnaires is problematic, however, because the self-report measures used are not emotion specific, i.e., they have poor specificity. The State and Trait Anxiety Inventory (STAI), which is commonly used to assess anxious mood, has shown moderate to large correlations with measures of depression and even includes items related to dysphoria (Balsamo et al., 2013). If results therefore show a correlation between scores on the STAI and AB to anxious stimuli, it cannot be deduced that the anxiety-specific symptoms (anxious arousal, hypervigilance) were related to AB to threatening stimuli.

Other researchers have used the Beck Depression Inventory (BDI) as a measure of depression (example Baert et al., 2010). The BDI has shown no discriminant validity between depression and anxiety. It is therefore difficult to confirm the specificity of the participant's affect using these measures. Many studies have used the STAI-trait to assess for trait anxiety (example Koster, Crombez, Verschuere, and De Houwer, 2004; Rudaizky et al., 2014; Iijima et al., 2018) without controlling for measures of dysphoria. In many of the studies these were the sole measures used with no other symptoms assessed. In studies that did include other measures (example depression scale in an anxious sample), it was often found that participants also

elevated on that measure (example Britton et al., 2012). In Jongen's et al. (2007) study on groups of patients with bipolar disorder, scores on the BDI were correlated with AB as expected, but the patient group also showed elevated scores on the STAI. It therefore cannot be determined whether AB was related to depressed affect, anxious arousal, both, or affect as well as the other cognitive and vegetative symptoms of depression and anxiety. Although Becker and Leinenger (2011) showed that healthy individuals induced into a sad mood displayed negative AB to sad faces and those in the happy mood induction condition displayed positive AB to smiling faces, those who identified more sad faces had higher anxiety levels compared to those who missed it, and those who identified the smiling face had lower anxiety levels compared to those who missed it.

Other problems related to emotion specificity of AB is the high prevalence of comorbid symptoms in patient (and even non-clinical) populations. Studies measuring attention bias in a specific population rarely control for comorbid symptoms or a history of other psychiatric disorders (example Joorman et al., 2007; Karparova et al., 2007). Studies therefore rarely use a homogeneous group of patients who only display the dominant symptom characteristic of their diagnostic group. Even though participants' dominant state is assessed, non-dominant symptoms can influence AB. This problem is not related to low discriminant validity of the measures used, but to the inherent comorbidity of symptoms in various mood states.

Other studies have shown that the relationship between AB and affect is not a simple and linear one nor is it uni-directional. It is more likely that stimulus-specific characteristics interact with participant-specific characteristics to influence AB. Beevers and Carver (2003) showed that AB after but not before mood induction predicted increased dysphoria, indicating that biased attention acts as a vulnerability factor that needs to be activated by stress to influence mood.

MacCabe et al. (2000) showed how mood can also act as a vulnerability factor that influences attentional processes. Results from that study showed that a sad mood induction in recovered depressed patients resulted in reduced positivity bias compared to previously depressed patients not induced into a sad mood and never depressed controls. AB and acute affect are therefore most likely linked via a vicious cycle whereby negative affect increases AB to negative information and away from positive information, which then further increases negative affect, exacerbating the syndrome and increasing risk for relapse. Clasen et al. (2013) showed that attention bias to sad stimuli was correlated with mood reactivity after sad mood induction and the correlation was greater in MDD compared to control participants. Although this could be a statistical anomaly, it could also suggest that trait-based vulnerabilities, independent of acute affect, are at play. A study by Sanchez, Vazquez, Gomez, and Joormann (2014) showed that in healthy individuals, a negative mood induction failed to create AB to sad or angry faces despite increased report of sad mood. The relationship between AB and emotional disturbance is therefore a complex one, with both state and trait factors playing a role.

**Dimensional Models and Cross-Diagnostic Measures**

Findings from studies on AB are not robust regarding the specific contribution of top-down and bottom-up processes to AB. Inconsistent results could be due to methodological flaws (Borsboom, 2006) or lack of sensitive measures used, which makes conclusions regarding specificity unclear. It is also possible, however, that inconsistent findings are not due to the lack of methodological rigor but to the inherent lack of specificity of emotional processing in mood and anxiety disorders. Even though humans are able to differentiate between different emotional stimuli early in the process of attention, it appears that emotional disorders do not show a specificity of AB. For example, elevated symptoms of depression in survivors of childhood

emotional abuse increase interference to threat related words, positive-related words, and specific emotional abuse-related words (Fontenot, Jackson, & Terry, 2015). The findings could therefore indicate that AB is not necessarily mood congruent, but represents a common vulnerability factor to psychological problems by increasing processing of negative information. Despite little evidence from behavioral studies regarding differential patterns of AB between anxiety and depressive disorders, brain imaging studies have presented some differences between the two. Studies that have included both groups have found that anhedonia seems to be related to reduced hypervigilance and increased avoidance of positive information, possibly due to general cognitive slowing whereas anxious arousal appears to be related to greater negative attentional bias.

### *Neurobiological Evidence for Differentiation between Depression and Anxiety Disorders*

Are the positive valence system and negative valence system separable constructs? In the last few years there has been increased support for a dimensional system of psychopathology (Insel et al., 2010). As a response to the limitations of the categorical system for understanding mental health disorders, there has been attempts at defining processes that are unique to specific psychological symptoms (for more details, please refer to the section on *The Research Domain Criteria)*. The positive and negative valence systems have been defined as separate domains due to their distinct brain mappings, different clinical features, and non-identical response to treatments (Medeiros et al., 2020). The positive valence system primarily implicates the fronto-striatal brain regions, which are involved in approach-related behaviors (motivation for seeking reward). The negative valence system implicates the amygdala, insula, and striatum, which are involved in avoidance-related behaviors (response to threat). Core symptoms of unipolar depression, bipolar depression, and anxiety disorders have been linked to specific cortical

activity (Nusslock et al., 2015). Decreased left frontal EEG activity has been linked to decrease in approach motivation, resulting in anhedonia. Abnormally elevated left frontal EEG activity has been linked to excessive increase in approach motivation, resulting in hypomanic or manic symptoms. Interestingly, a similar pattern of reduced relative left frontal EEG activity is observed in anxious arousal compared to anxious apprehension (i.e., neuroticism).

Brain regions implicated in different disorders (example OCD, MDD, anxiety) show large overlap in fMRI studies (Sprooten et al., 2016; Williams et al., 2016). The Anterior Cingulate Cortex (ACC), a region involved in reward processing and prediction and pursuit of long-term goals, has been implicated in a number of disorders such as depression, substance abuse, OCD, and neuropsychiatric diseases like Parkinson's Disease (Holroyd & Umemoto, 2016). The same brain regions (left globus pallidus and putamen) were found to be associated with depressive and social anxiety symptoms in healthy participants (Luo et al., 2017). Interestingly, a different pattern to what is expected was found: the positive correlations were found between depressive symptoms and reactivity to threat and between social anxiety symptoms and reactivity to sad stimuli. These results could suggest that activity in those brain regions represent a vulnerability factor that interacts with environmental cues to influence mood. Another study also found a region of the basal ganglia (caudate nucleus) that showed cortical thinning only in individuals with MDD who displayed anxiety symptoms (Zhao, Liu, Yan, Hua, Chen, Shi, . . . Yao, 2017). Cortical thinning in other brain areas was common to both MDD groups with and without comorbid anxiety symptoms. It is unclear whether cortical thinning in the caudate is the result of increased severity of symptoms (quantitative difference) or specific to the presence of comorbid anxiety symptoms (qualitative difference).

Nusslock and Alloy (2017) suggested that underlying many disorders, is a dysfunction in sensitivity to rewards. Hypersensitivity to reward underlies bipolar disorders and hyposensitivity to reward underlies unipolar depression. An imbalance in reward sensitivity and representation underlies positive and negative symptoms in schizophrenia and both processes could also be mechanisms underlying addictive disorders. An fMRI study with both anxiety and depression showed hypercoupling in a brain network involving the right DLPFC during a Stroop task, consistent with avoidance of threat (Spielberg et al., 2014). Only the depressed group showed hypocoupling in a brain network involving the left DLPFC, consistent with dysfunction in approach motivation (reduced positivity bias). It is therefore possible that anxiety and depression share underlying risk factors (dysfunction in threat circuitry), while other risk factors (dysfunction in reward circuitry) is particular to anhedonia, the hallmark of depression. Dillon et al. (2014) reviewed evidence from studies across modalities (brain imaging, genetics, and behavioral studies) and suggested separable neutral circuitry for anxiety and depression that represent increased response to threat and decreased response to reward, respectively. Although little research is carried out on anxious depression, it appears that individuals experiencing anxious arousal and anhedonia have impairment in brain regions involved in both threat- (amygdala) and reward- (nucleus accumbens) based circuitry. Neurochemical and immunological processes have been found to underly depression and anxiety disorders by influencing fear and reward circuitry (Felger, 2018).

### *Evidence from Self-Report for Differentiation between Depression and Anxiety Disorders*

Findings from psychometric studies have shown that almost all scales have failed to differentiate between depression and anxiety disorders (example Boschen & Oei., 2007) most probably due to overlap of symptoms and heterogeneity of the diagnostic categories. High

comorbidity of symptoms is one of the reason diagnosticians have critiqued the categorical DSM model and are moving toward a dimensional view of mental illness. The debate about whether depression and anxiety are separable constructs is still ongoing. Differentiation between anxiety and depression in factor analytic models have shown support for separable but overlapping constructs. The tripartite model of depression and anxiety offers a succinct view of the relationship between the two disorders, with anxious arousal and anhedonia, representing the anxiety- and depression-specific factors, respectively, and the other symptoms representing common factors (Dunn et al., 2010; Watson., Clark, Weber, Assenheimer, Strauss, & McCormick, 1995). Validity of the tripartite model has been recently questioned (Boschen & Oei., 2006). Buckby et al. (2007) and Boschen & Oei (2007) used the Mood and Anxiety Symptom Questionnaire to determine whether disorder-specific symptoms (anxious arousal in anxiety and anhedonia in depression) accurately predict their respective disorders. The latter found low area under the curve (AUC[6]) for both measures in predicting anxiety and depression. Buckby's findings were a little more optimistic regarding the use of anxious arousal (AUC = .72) and anhedonia (AUC = .82) in predicting MDD although these measures did not accurately detect those with anxiety disorders (AUC = .62). This study also indicated that although theoretically anxious arousal and anhedonia are separable constructs specific to anxiety and depression, respectively, they correlated at .59. Measures of anxiety symptoms appear to be general to different disorders, but measures of depressive symptoms have some specificity to depressive diagnoses (Boschen & Oei., 2007; Buckby et al., 2007) although more recent findings are pointing toward anhedonia as also being cross-diagnostic, for example it has been described as part of schizophrenia (Bedwell, 2014).

[6] The area under the curve is a measure of sensitivity and specificity of a diagnostic test. Higher AUC represents better validity of the test.

Buckby et al. (2007) showed that when general distress was added to the disorder-specific subscales (anxious arousal and anhedonia), the model did not improve. The reverse was not tested, so it cannot be determined whether the specific factors are superfluous if general distress was accounted for firstly. Factor analytic studies using other questionnaires have shown that symptoms common to both disorders explain the majority of the variance in the data. When variance explained by negative affectivity was factored out, factor loadings of GAD and MDD items decreased significantly (Byllesby et al., 2016). The correlation between anxiety and affective depression factors was large and showed the greatest attenuation when general negative affect was controlled for. Negative affectivity, however, does not explain all the shared variance between these two constructs as the correlations between the factors remained significant even after parsing out negative affectivity. Using bifactor models, studies have shown that about 70% of the variance in mood, cognitive, and vegetative symptoms are shared among internalizing disorders. That common factor has been described as "neuroticism" (Gore & Widiger, 2018; Griffith et al., 2010) in the non-clinical personality literature and "demoralization" in the personality disorder literature (Greene, 2011).

Genetic studies support common genetic effects among neuroticism and depressive symptoms, showing that the genetic factors for neuroticism explain phenotypic variance in depressive symptoms and general psychological distress, whereas extraversion does not (Luciano et al., 2012). Negative affectivity, considered a stable trait that predisposes individuals to various internalizing disorders, has shown to explain approximately 50% of the variance in depression and GAD and between 16 and 49% of the variance in other anxiety disorders in both student and patient samples (Mahaffey et al., 2016). This study showed that personality traits such as negative and positive temperament are not fundamentally different from clinical symptoms and

cognitive processes that characterize psychological disorders. This indicates that processes such as rumination and anxiety sensitivity (and possibly attention bias) act as predispositions to emotional disorders.

Generally, findings from factor analytic studies have shown that some symptoms load on a specific depression or anxiety factor, explaining a small portion of the variance in the data. Symptoms such as feelings of worthlessness, guilt, inferiority and suicide tend to load on a specific depression factor and account for approximately 10% of the variance. Some somatic symptoms (heaviness/lightness in body, weakness, numbness or tingling sensations, nausea) load on the specific somatic factor, also explaining about 10% of the variance. No item on the anxiety scales loaded on the specific anxiety factor (Simms et al., 2012), indicating that symptoms of anxiety are fully explained by a common factor. Naragon-Gainey and Watson (2011) also showed that suicide ideation remained uniquely associated with MDD and PTSD after accounting for negative affectivity but not the anxiety disorders (findings with suicidal ideation has been mixed). Another study using bifactor models showed that some anxiety items loaded on a specific GAD factor but none of the depression items loaded on the specific depression factor, with the general factor explaining the largest proportion of variance in depressive and anxiety symptoms. The GAD items in this study, however, all consisted of vegetative/somatic symptoms and did not include affective or cognitive symptoms such as worries, mind racing, afraid something bad will happen (Blanco et al., 2014). This could explain why these GAD symptoms were not exclusive to the general negative affect common factor.

Price and van Stolk-Cooke (2015) tested models of MDD, GAD and PTSD and discovered very high correlations between the depression and GAD factors and moderate to high correlations between the PTSD and depression factors. These three diagnoses share a large

number of symptoms, calling into question their uniqueness. Pietrzak et al. (2015) showed that items on questionnaires assessing symptoms of PTSD, MDD, and GAD loaded on three factors that describe symptoms of loss, threat, and somatic anxiety with low to moderate correlations between the three factors. Loss symptoms consisted of measures of apathy, cognitive and psychic anxiety, vegetative symptoms, arousal and emotional numbing, threat symptoms consisted of avoidance, re-experiencing, and anxious arousal, and somatic anxiety consisted of the Hamilton somatic anxiety items. The authors suggested that this 3-factor transdiagnostic model assesses separate aspects of pathology that are common to the three disorders.

Some studies have supported models that show positive and negative affectivity as orthogonal constructs, or only slightly correlated, with participants scoring high or low on either or both constructs (Paulus et al. 2017; Watson, Clark, & Tellegen, 1988) whereas others have shown negative and positive affectivity to be moderately correlated (r = -.41; Naragon-Gainey & Watson, 2011). Measuring processing of positive and negative information using different methods (self-report and behavioral measures) support the positive affect/approach motivation and negative affect/avoidance as separate dimensions. Factor analytic studies have consistently shown that anxiety and depression have a great amount of shared variance, with the majority being explained by negative affectivity. There is some evidence that positive and negative affectivity manifest differently in depression and anxiety, with variability in affect being more characteristic of anxiety and mean levels of affect more characteristic of depression (Heller, Fox, Davidson, 2018). Despite that, negative and positive affectivity were correlated and mean negative affectivity contributed to the largest variance in predicting depression and anxiety.

***Evidence from Measures on AB for Differentiation between Depression and Anxiety Disorders***

The findings reviewed throughout this literature review of AB suggest that attention bias to negative information is present in both depression and anxiety but it has a slightly later onset in depression. This could be explained by general cognitive slowing in depression but future research needs to target this question specifically. Reduced hypervigilance in depression to negative but not positive stimuli is reversed when comorbid anxious arousal is present indicating that negative AB might be more related to anxious arousal than low mood. Avoidance of positive information appears to be more specific to depression and is present even when anxiety is comorbid, indicating that positive AB might be more related to depressed mood and anhedonia. Studies that have shown normalization of AB to positive stimuli after remission further supports this notion.

### *The Research Domain Criteria (RDoC) Approach*

Despite those differences in AB mechanisms between depression- and anxiety-specific symptoms, AB could represent a more trait-related cognitive bias which predisposes individuals to various psychological disorders and remains present even when symptoms remit. Evidence from genetic (example Zilhao et al., 2016), heritability (example Song et al 2015), brain imaging (Williams et al., 2016), and behavioral studies have shown that depression and anxiety share common underlying risk factors. Identifying those risk factors, irrespective of specific diagnostic group, helps in understanding the psychopathological processes and informing treatment. The NIMH has emphasized the importance of finding markers (or targets) for psychological disorders that can enhance the accuracy of our diagnoses and identify individualized treatments (National Institute of Mental Health, 2015). A good target, as defined by the NIMH Strategic Plan for Research, is one that is strongly related to a symptom or deficit implicated in a psychological or biological pathway that can be altered through interventions. Given the movement of the field

toward an approach to studying psychopathology that involves the investigation of processes rather than discrete symptoms, it would be important to determine if negative and positive AB act as a possible markers for internalizing disorders.

**Aims of the Present Study**

The aims of the present study were to build on the literature on AB in mood and anxiety disorders to provide possible answers to the mixed findings. Measures of AB have been critiqued for their poor reliability and validity (please refer to *Recent Alternative Attention Bias Indices*). One reason provided for the poor reliability of the AB score is the way it is calculated. Difference scores produce measures that are less reliable that raw scores (Edwards, 2001; Rodebaugh et al., 2016). An alternative statistical approach (mixed effects models) to measuring attention bias was chosen in the present study to avoid subtraction of AB scores. Linear mixed effects analyses also have the following advantages: they allow the analysis of all observations without averaging; they allow the analysis of unequal group sample sizes; and they allow the partialing out of participant-specific factors that contribute to "noise" (Baayen & Milin, 2010). Moreover, generalized linear models were used to determine the utility of this measure as a marker of mental illness. By specifically calculating the odds of an individual belonging to the clinical vs non-clinical group based on their AB, the utility of AB as a target for group membership can be determined.

Another aim of this study was to determine the patterns of AB that characterize negative affectivity, anhedonia, and anxious arousal. Negative affectivity, also known as neuroticism, is considered a trait that predisposes individuals to various kinds of internalizing symptoms. Negative affectivity includes cognitive, vegetative, and mood symptoms common to both depression and anxiety. Anhedonia, or the difficulty experiencing interest or pleasure, is

characteristic of depressive disorders. Anxious arousal is characteristic of anxiety disorders. The psychometric literature has considered disorder-specific symptoms (anhedonia, anxious arousal) as those that explain additional variance beyond that explained by symptoms common to different presentations. The RDoC literature has considered specific symptom domains of anhedonia and anxious arousal as those associated with the constructs of Loss and Sustained Threat, respectively. Because patients rarely experience anhedonia or anxious arousal without also struggling with other symptoms, previous studies that have relied on broader symptom measures have not been able to capture the disorder-specific symptoms. By including measures specific to anhedonia and anxious arousal, this study aimed at investigating AB mechanisms that specifically relate to each of the two domains. If no such differentiation in AB patterns was found, then it is likely that AB reflects a mechanism common to both presentations. Previous studies have rarely taken into account comorbidity of symptoms (Gibb et al., 2016). The present study includes comorbid and non-comorbid groups to specifically test the differences in AB between participants high in anhedonia, those high in anxious arousal and those with both symptoms elevated.

It is expected that participants scoring high on anhedonia will show greater avoidance of positive information. Greater disengagement[7] from positive stimuli is therefore anticipated to be specific to anhedonia. These participants are therefore more likely to respond slower and less accurately to positive congruent stimuli (probes replacing positive words) consistent with their tendency to avoid positive information. It is expected that participants scoring highly on anxious arousal will show greater vigilance to negative stimuli and will therefore show a greater engagement bias to negative stimuli. It is anticipated that these participants will respond faster

[7] In this context, avoidance and disengagement are used interchangeably

and more accurately to negative congruent stimuli (probes replacing negative words) consistent with their tendency to orient to negative stimuli. In this study, stimuli will be divided according to valence. Emotion specificity will not be considered, as there is little evidence for attention bias to specific kinds of emotions. Although AB in depression and anxiety has been particularly studied with sad and threat stimuli, respectively, evidence for such specificity is weak. We therefore anticipated that participants scoring highly on anhedonia will display avoidance of positive information regardless of what the stimulus is describing and those with elevated scores on anxious arousal display increased vigilance to negative information regardless of the specific emotion elicited.

# Chapter III

Methodology

## Participants

Participants in this study included a heterogeneous sample of clinical and non-clinical populations (Appendix A). Participants were recruited from the community, university settings, and mental health clinics (Appendix D). A dimensional approach to capturing psychopathology was taken, in line with recent evidence showing poor construct validity of diagnostic categories (example Hartman et al., 2001; Wollburg et al., 2013). Due to the transdiagnostic nature of the study, categorical diagnoses were not be considered. What is primarily of interest is core symptomatology of depression and anxiety and patient categorization (clinical vs non-clinical). Comorbid substance use and other disorders were not criteria for excluding these participants. Based on large genetic studies showing shared genetic factors between disorders including anxiety, ADHD, drug and alcohol use, these comorbid problems were considered part of the picture of psychopathology (Pettersson et al., 2015). One strength of the present study was

therefore greater ecological validity as the participants represent patients whom clinicians come across on a daily basis in their clinical practice. Results from this study, if replicated, could inform treatments that can be used with similar patient populations.

**Group coding**

Participants were divided into four groups based on their endorsement of core symptoms of depression and anxiety. Group 1 included participants scoring high on anhedonia and low on anxious arousal (anhedonia group); Group 2 includesd participants scoring low on anhedonia and high on anxious arousal (anxious arousal group); Group 3 included participants scoring high on anhedonia and high on anxious arousal (comorbid group); Group 4 included participants scoring low on anhedonia and low on anxious arousal (healthy control group).

**Hypotheses**

***Hypothesis 1***

Based on evidence showing engagement bias to negative stimuli to represent a trait-based vulnerability that predisposes individuals to experience a range of symptoms (described above), it was hypothesized that AB to negative information is not symptom-specific, but rather differentiates clinical from non-clinical populations (Groups 1, 2, 3 vs Group 4). There is also supporting evidence showing that anxious arousal is characterized by greater attention bias toward negative compared to neutral information. We therefore predicted that if it is indeed the case that high anxious arousal is related to vigilance[8] to negative stimuli, then it is expected that the groups scoring high on anxious arousal, irrespective of anhedonia scores (Groups 2 & 3), will show engagement bias to negative stimuli. If the comorbid group (Group 3) showed vigilance to

[8] Vigilance and engagement is used interchangeably

negative stimuli then this could either indicate that the presence of both symptoms is necessary for this pattern of AB to occur or that the increased severity (disability) resulting from comorbidity relates to negative engagement bias. Negative attention bias is represented by smaller (faster) response times to negative stimuli in the negative-neutral pair.

***Hypothesis 2***

Anhedonia is characterized by greater attention bias away from positive compared to neutral information. We therefore predicted that if it is indeed the case that high anhedonia is related to disengagement from positive stimuli, then it is expected that the groups showing high anhedonia (Groups 1 & 3), regardless of scores on anxious arousal, will display disengagement bias to positive stimuli. If there was no group differentiation and all clinical groups showed this bias (Groups 1, 3, 4 vs 4) then avoidance of positive information is not specific to anhedonia and could reflect a trait rather than state-based effect. If only the group with comorbid anhedonia and anxious arousal showed this bias (Group 3), then this could indicate one of two phenomena: either the presence of both symptoms simultaneously is required for the avoidance of positive information to be observed, or the increased severity expected from comorbidity is related to disengagement bias. Disengagement from positive information is represented by larger (slower) response times to positive stimuli in the positive-neutral pair.

***Hypothesis 3***

This hypothesis tests whether core symptoms of depression (anhedonia) and anxiety (anxious arousal) have incremental validity over general negative affectivity in predicting attention bias to positive and negative stimuli, respectively. Based on evidence described in this review, we predicted that anhedonia and anxious arousal have incremental utility over negative affectivity in predicting positive and negative attention bias, respectively.

### *Hypothesis 4*

To establish AB as a marker of psychopathology, the measure of AB should significantly predict group membership (clinical vs non-clinical). It is hypothesized that negative and positive AB are significant markers of group membership.

### *Hypothesis 5*

Accuracy of response can also be a measure of attention bias to negative and positive stimuli. Analysis from hypotheses 1 and 2 were repeated with error of responses as the dependent variable.

## Procedures

Ethical approval was obtained from the University of North Dakota. For more details about the procedure, please refer to Appendices B and E.

### *Materials*

**Dot Probe Task.** The task used in this study is the Dot Probe paradigm (please refer to The Dot Probe Paradigm for more details). The script used for the present task is the one published on Inquisit 4 by Katja Borchert for Millisecond Software LLC (Appendix H). The script was edited by the primary investigator and Dr. Ronald Marsh to fit the hypotheses of this study. Two blocks were included, a negative bias and a positive bias block. Each consisted of 120 trials. The negative bias (NB) block consisted of 96 pairs of negative - neutral words and 24 pairs of neutral - neutral words. The positive bias (PB) block consisted of 96 pairs of positive – neutral words and 24 pairs of neutral – neutral words. The neutral pairs were randomly interspersed in each of the blocks. All participants completed the NB and PB conditions. All

participants began with the NB condition. Within each condition, the word pairs were randomly counterbalanced across participants.

The task began with a fixation cross (+) presented at the center of the screen followed by two words, one to the right and one to the left of the (+). After 500 ms, the words disappeared and were replaced by a probe on either side of the (+). The probe can either be an arrow pointing to the right ( → ) or to the left ( ← ). The participants were asked to identify which probe they saw by pressing the → or ← key on their keyboard. The probe remained onscreen until the participant responded. The time it took them to make a button press (response time, RT) and the accuracy of their response (correct or incorrect identification of probe) were recorded. Figure 1 shows an example of a congruent trial and an incongruent trial in the negative bias condition.

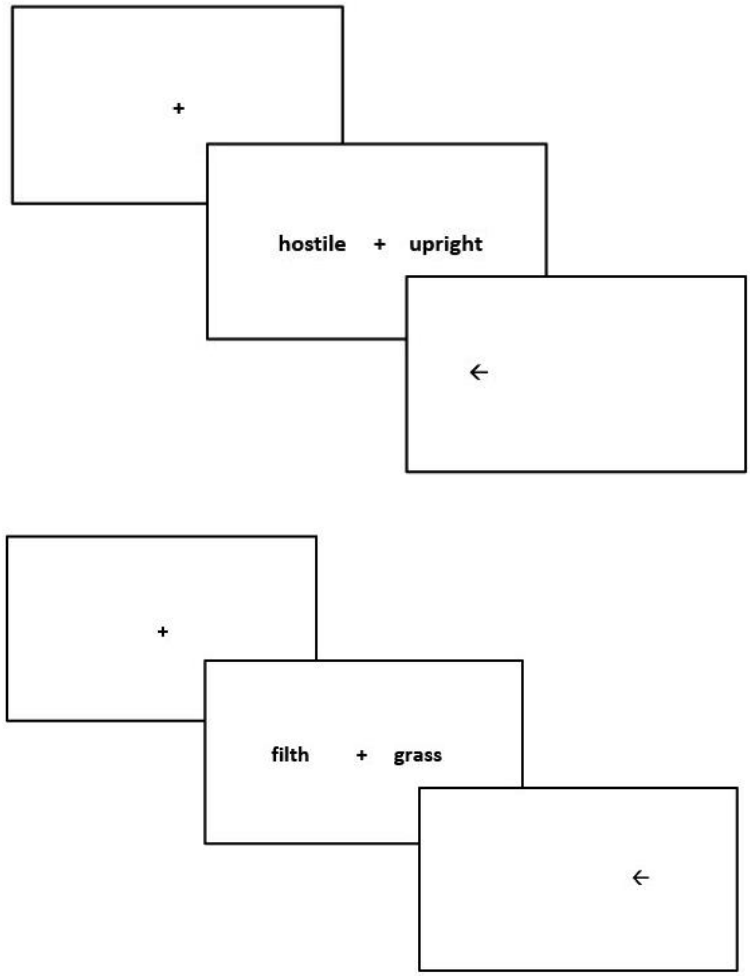
After the instructions, the experiment began with a practice block (20 trials) that included two neutral stimuli (numbers). If the participant made an error (identified the probe incorrectly), a red X appeared on the screen. After the practice run is over, participants began the task (Appendix B).

**Stimulus Words.** The stimuli consisted of 96 negative words, 96 positive words, and 288 neutral words (Appendix C). Each valence word was paired with a neutral word. The negative condition consisted of 96 negative-neutral word pairs; the positive condition consisted of 96 positive-neutral word pairs, and the neutral condition consisted of 24 neutral-neutral pairs. The negative and positive conditions were arranged in blocked design (i.e., negative-neutral word pairs and positive-neutral word pairs were presented continuously as a block). The negative condition preceded the positive condition for all participants. The neutral condition was not presented as a block. Neutral-neutral word pairs were interspersed throughout the negative and

positive conditions. The neutral condition acts as a baseline to which the negative and positive conditions are compared to.

**Figure 1**

*Example of a Trial of the Dot Probe Task in the Present Study*




*Note.* Fixation cross is presented at the center of the screen for 500 ms. The cross is replaced by a pair of words for 500 ms. The probe (left or right arrow) replaces one of the words. The top figure shows an example of a congruent trial (probe replaces valence word). The bottom figure shows an example of an incongruent trial (probe replaces neutral word).

**Self-report Measures.** The three self-report measures included (Appendix G):

***State and Trait Anxiety Inventory – Trait (STAI-T)***. The STAI-T is used as a measure of negative affectivity. High scores represent trait factors (cognitive, affective, somatic, and

vegetative symptoms) that predispose individuals to psychological dysfunction and social and occupational impairment. High scores indicate greater symptomatology. Suggested cutoff scores include 30 – 40 (Fountoulakis et al., 2006; Kruyen 2013; Ortuño-Sierra et al., 2016). Smith (1972) suggested a cutoff of 47 to discriminate feigned anxiety. In the present study, STAI-T was used as a continuous variable and showed excellent reliability ($\omega_t$[9] = .95).

***Snaith Hamilton Pleasure Scale (SHAPS).*** The SHAPS is used as a measure of anhedonia. A total score below 3 is considered in the "normal" range and therefore represents low anhedonia. Scores of 3 or more fall in the "abnormal" range for hedonic tone (Snaith et al., 1995) and will therefore be considered to represent high anhedonia. In the present study, SHAPS showed adequate reliability ($\omega_t$ = .79).

***Depression Anxiety Stress Scale – Anxiety subscale (DASS 21 - Anxiety).*** The anxiety subscale includes 7 items assessing primarily physiological arousal and is therefore used as a measure of anxious arousal in this study. Raw scores are multiplied by 2. Scores below 10 fall in the normal or mild categories and will be considered low anxious arousal. Scores 10 or higher will be considered high anxious arousal. A cutoff of 8 had an AUC of .86 in identifying brain injury patients with an anxiety disorder (Dahm et al., 2013). In the present study, the DASS – Anxiety showed good reliability ($\omega_t$ = .82).

## Data Analysis

### *Statistical Analysis*

The statistical software R was used for data analysis (RStudio Version 1.2.5033). Linear mixed effects analysis was carried out to test the influence of the relationship between attention

[9] Omega total ($\omega_t$) has been proposed as a robust measure of reliability (Trizano-Hermosilla & Alvarado, 2016).

bias (interaction of Congruence and Type of Trial) and symptom groups (Groups 1, 2, 3, 4) on response time (RT) and accuracy (number of errors). Two separate models were created to test for attention bias to threat and attention bias to positive stimuli. Fixed and random effects were included in the linear mixed effects models. The following variables were included as fixed effects: Congruence (congruent vs incongruent), Type of Trial (Negative vs Neutral or Positive vs Neutral), Group (contrasts), Age (in years), and Time (trial number). Congruence, Type of Trial, and Time were modeled as within-participant factors; Group and Age were modeled as between-participant factors. Group, Congruence, and Type of Trial were modeled as interactions based on a-priori hypotheses. The random effects tested were the intercepts (baseline RT and accuracy) and Time as slope. Including random intercepts for each participant helps account for the variation in individual mean reaction times. Time was included as a random effect to control for change in rate of RT across time as a result of fatigue or low motivation that could be idiosyncratic. Time was also included as a fixed effect to account for variation in RT across time. The models started out with maximal fixed and random-effects structures, which were simplified if models did not converge[10]. If models with Time as a random variable did not converge, this variable was removed as a random effect. Independent variables that did not significantly add explanation power to the model were removed one at a time. Best fit was determined by comparing models using Log Likelihood ratios and Akaike Information Criterion (AIC). If the addition of a variable to the model increased the log likelihood (or decreased AIC) considerably, the variable is considered to be a significant addition to the model and therefore retained.

The following contrasts were created to test the effect of Group on RT: for the negative-neutral trials, contrasts were as follows: Contrast 1: Groups 1, 2, 3 vs Group 4 to test the

[10] Linear mixed effects models will fail converge if overfitted (model trying to explain more than is supported by the underlying data)

hypothesis that engagement to negative stimuli is not disorder specific (trait vulnerability); Contrast 2: Groups 2, 3 vs Group 1 to test the hypothesis that engagement is related to presence of high anxious arousal; and Contrast 3: Groups 2 vs 3 to test the hypothesis that elevated anxious arousal alone influences AB. For the positive-neutral trials, contrasts were as follows: Contrast 1: Groups 1, 3 vs Group 2 to determine if the presence of anhedonia predicts disengagement from positive stimuli; Contrast 2: Groups 1, 2, 3 vs Group 4 to determine whether disengagement is not disorder specific; and Contrast 3: Groups 1, 2 vs Group 3 to determine whether severity or comorbidity influences positive AB.

To determine whether disorder-specific symptoms (anhedonia for depression and anxious arousal for anxiety) influence AB over and above disorder non-specific symptoms (negative trait affectivity), the measures were included in linear mixed effects models. For the negative-neutral trials, anxious arousal was added to STAI-T to assess for the effect of the IVs on negative AB. If the 3-way interaction between the disorder-specific symptoms, Type of Trial, and Congruence was a significant predictor of rate of response, then it can be deduced that anxious arousal has incremental utility in predicting negative AB over and above symptoms that cut across disorders. For the positive-neutral trials, anhedonia was added to STAI-T to assess for the effect of the IVs on positive AB. If the 3-way interaction was significant, it can be deduced that anhedonia has incremental utility in predicting positive AB over and above general negative affectivity.

To test whether AB can be a marker for psychopathology, participants were divided into two groups: clinical vs non-clinical based on the following criteria: positive for a mental health diagnosis or seeking psychotherapeutic care and/or medication management at a medical or mental health clinic (Table 3). If participants denied having a mental health diagnosis or seeking mental health care, they were categorized as non-clinical. A generalized linear mixed effects

model was created with Response Time, Type of Trial, and Congruence as independent variables and Group membership (clinical vs non-clinical) as a dependent variable. If the 3-way interaction is significant, this indicates that AB is predictive of group membership. Since the model with random effects did not converge, the random effects were removed, and a logistic regression was run instead.

Another measure of AB is number of errors made (i.e., accuracy of response). To determine whether participants made more errors in response to negative or positive stimuli, generalized linear models were created. Group, Type of Trial, Congruence, Age and Time were modeled as fixed effects with number of Errors made as the DV. A significant 3-way interaction between Group, Type of Trial, and Congruence, indicates the presence of AB. Intercepts and Time were allowed to vary as random effects. If models with random effects did not converge, logistic regression models were created instead. In behavioral studies of AB, participants tend to have high hit rates (very low error rate). Nevertheless, if participants make errors, then the accuracy of their performance will be modelled with number of Errors as the dependent variable.

***Data Cleaning***

One hundred and forty-four participants had complete datasets. Eight datasets were removed because error rate in the dot probe task approximated 50%, which indicates random responding or misunderstanding of the instructions. Error rates in studies of attention bias tend to be very low. Inverse transformation (1/RT) was applied to the reaction time data to normalize it as the data were right-skewed.

A conservative approach for outlier removal was carried out to avoid the elimination of real effects (Lachaud & Renaud, 2011). Molloy and Anderson (2020) showed that the attention bias studies with a more conservative approach to outlier removal (+3 SD from mean) generally

tended to have higher reliability estimates than the more liberal approaches. A two-step process for outlier removal was used according to Baayen and Milin (2010). Reaction time data were screened on a case-by-case basis. Very short reaction times (RT < 250 ms) were removed case-wise. Normality of RT for each participant was visualized through histograms. Those that appeared highly right skewed were further investigated using means and standard deviations. Data points that were more than 3 standard deviations (SD) above the mean were removed casewise (i.e., for each participant separately). No more than 5% of the data was excluded for each participant. After the initial screening, model inspection was used to further remove influential data points.

For the univariate outliers, the datasets from each valence were inspected separately. In the negative-neutral dataset, there were 421 errors out of 13056 (3.2% error rate across all participants). The highest percent of error rates were: 24%; 16%, 14%, 11%. Median error rate was 3.1%. Only 5 RT data points were below 250 ms and were removed. Visual inspection of the histogram of all RTs showed that data points above 2000 ms were likely outliers. Data points that were above 2000 ms AND/OR were more than 3 SD above the mean of each participant were removed. Twenty-four datapoints were removed from the entire threat dataset. No more than 5% of the data was excluded for each participant.

In the positive-neutral dataset, there were 348 errors out of 13056 (2.6% error rate across all participants). Eleven RT datapoints were below 250 ms and were removed. Visual inspection of the data (histograms) showed that data points above 2000 ms were likely outliers. For most of the participants, datapoints were removed if 1) RT above 2000 ms AND/OR 2) they were 3 SD above the mean. Sixty-one datapoints were removed in total. No more than 7% of the data was removed for each participant.

In the neutral-neutral dataset, there were 205 errors out of 6528 responses, indicating an error rate of 3.1%. Only three RT were below 250 ms and were removed. Visual inspection of the data (histograms) showed that data points above 2000 ms were likely outliers. For most of the participants, datapoints were removed if 1) RT above 2000 ms AND/OR 2) they were 3SD above the mean. Only one participant had 11% of their data removed (due to large outliers). For the others, no more than 7% of the data was removed for each participant.

For multivariate outliers, studentized residuals and Cook's Distance were used to determine the presence of multivariate outliers and their influence on the model. The datapoints considered the most influential were removed: for the negative-neutral dataset[11], data points with studentized residuals > |4| were removed. Twenty-seven datapoints were removed in total. Interestingly, most of these influential points were RTs < 300 ms. The points considered most influential by Cook's D tended to correspond to the points that had studentized residuals > |4|. The same was applied for the positive-neutral dataset. Twenty-nine data points had studentized residuals > |4|. Those corresponded to the highest Cook's D values and were removed from the dataset as outliers.

# Chapter IV

## Results

The sample used in the analyses consisted of 136 participants. Please refer to Tables 1, 2, and 3, and Appendix F for demographic information.

[11] The negative-neutral dataset included 96 negative-neutral word pairs and 48 neutral-neutral word pairs. The positive-neutral dataset included 96 positive-neutral word pairs and 48 neutral-neutral word pairs.

**Table 1**

*Recruitment sites*

| | n | % |
|---|---|---|
| Medical or mental health organization | 18 | 13 |
| University setting | 47 | 35 |
| Community | 71 | 52 |
| Total | 136 | 100 |

*Note*. n represents number of participants. % represents percent of total sample

**Table 2**

*Participant Demographics*

| | | |
|---|---|---|
| Mean age (SD) | 27.63 (13.97) | |
| Age range (years) | 18 – 77 | |
| Race | n | % |
| Caucasian | 117 | 86.03 |
| Hispanic | 4 | 2.94 |
| Middle Eastern | 4 | 2.94 |
| African American | 2 | 1.47 |
| Asian | 9 | 6.62 |
| Gender | | |
| Female | 98 | 72.06 |
| Male | 34 | 25.00 |
| Non-Conforming | 4 | 2.94 |
| Highest Educational Level | | |
| High School | 17 | 12.59 |
| Some College | 69 | 51.11 |
| Bachelor's degree | 30 | 22.22 |
| Graduate/Professional School | 19 | 14.07 |

**Table 3**

*Participant Mental Health diagnosis and family history*

| | n | % of total sample |
|---|---|---|
| Previous mental health diagnosis | 32 | 23.53 |
| No previous mental health diagnosis | 104 | 76.47 |

| | | |
|---|---|---|
| Current mental health diagnosis | 60 | 44.12 |
| No current mental health diagnosis | 76 | 55.88 |
| Currently prescribed psychotropic medications | 49 | 36.03 |
| Not currently prescribed psychotropic medications | 87 | 63.97 |
| Currently receiving psychotherapy services | 37 | 27.41 |
| Not currently receiving psychotherapy services | 98 | 72.59 |
| First degree relative with mental health diagnosis | 54 | 39.71 |
| No first degree relative with mental health diagnosis | 82 | 60.29 |
| Second degree relative with mental health diagnosis | 44 | 32.35 |
| No second degree relative with mental health diagnosis | 92 | 67.65 |

Groups were divided based on participant scores on the following symptom measures: SHAPS (anhedonia) and DASS – Anxiety (anxious arousal). Please refer to *Self-Report Measures* for more detail. Group 1 (n = 6) included participants with high anhedonia ($M_{SHAPS}$ = 4, $SD_{SHAPS}$ = 1.5) and low anxious arousal ($M_{DASS}$ = 3.3, $SD_{DASS}$ = 3.3). Group 2 (n = 46) included participants with high anxious arousal ($M_{DASS}$ = 17, $SD_{DASS}$ = 5.8) and low anhedonia ($M_{SHAPS}$ = 0.4, $SD_{SHAPS}$ = 0.6). Group 3 (n = 26) included participants with high anhedonia ($M_{SHAPS}$ = 5.1, $SD_{SHAPS}$ = 2.1) and high anxious arousal ($M_{DASS}$ = 18.4, $SD_{DASS}$ = 5.7). Group 4 (n = 58) included participants with low anhedonia ($M_{SHAPS}$ = 0.3, $SD_{SHAPS}$ = 0.6) and low anxious arousal ($M_{DASS}$ = 4, $SD_{DASS}$ = 2.6). Score differences on the SHAPS between the groups that were high versus low in anhedonia were statistically significant, $W$[12] = 3328, $p < .0001$. Score

[12] Wilcoxon Rank Sum tests were used to compare group differences due to the non-normality of the scores.

differences on the DASS – Anxiety between the groups that were high versus low in anxious arousal were statistically significant, W = 4608, $p < .0001$.

The number of observations in each group were the following: for the negative-neutral dataset, Group 1 (n = 836), Group 2 (n = 6334), group 3 (n = 3618), Group 4 (n = 8085); for the positive-neutral dataset, Group 1 (n = 848), Group 2 (n = 6368), Group 3 (n = 3621), Group 4 (n = 8062). Due to the complex nature of the analyses, classical approaches to power calculations cannot be used (Kumle et al., 2020). Statisticians have used simulation-based power calculations to estimate power in linear mixed models. Brysbaert & Stevens (2018) showed that for within-group analyses of reaction time data in psychology, 1600 observations per condition are needed for adequate power. This allows the detection of differences as small as 15 ms, which is typical in attention bias studies. This study also showed that using inverse RTs is more powerful. Based on this guide, only Group 1 in the present study falls short of the suggested number of observations.

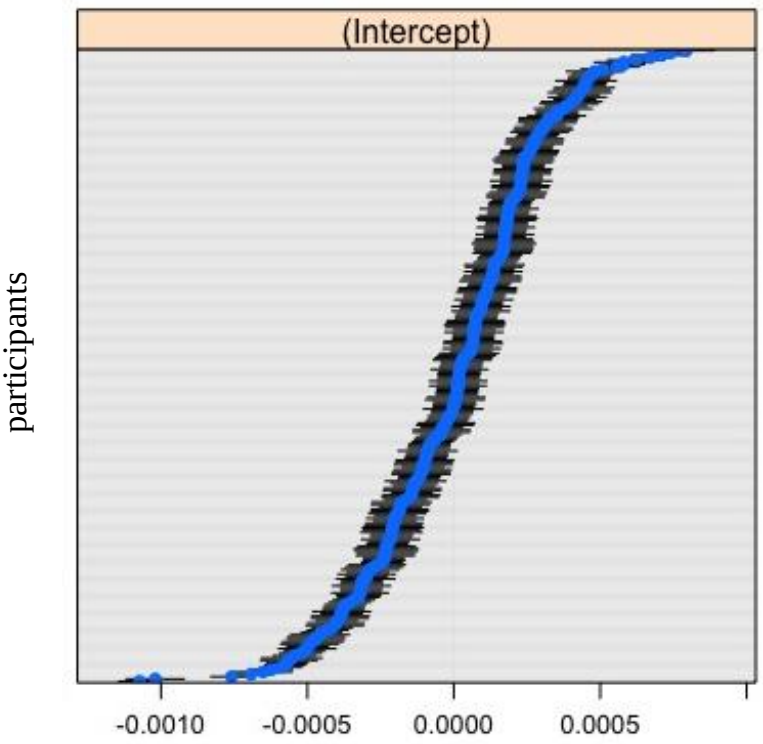
To test hypothesis 1 (AB to negative stimuli is not disorder-specific), a model was created with Group, Type of Trial (negative vs neutral), and Congruence (congruent vs incongruent) as independent variables and rate of response (inverse RT) as the dependent variable. Contrast 1 was included to test the hypothesis that the clinical groups (Groups 1, 2, 3) will differ from the non-clinical group (Group 4) in attention bias to threat. Contrast 2 tests the hypothesis that the clinical group with low anxious arousal (Group 1) will differ from the clinical groups with high anxious arousal (Groups 2, 3) on attention bias to threat. Contrast 3 tests the hypothesis that the anxious group (Group 2) differs from the group with comorbid anxious arousal and anhedonia (Group 3) on attention bias to threat. Age and Time were also included as fixed effects. The

model with Time as a random effect did not converge. It was simplified to include only participants as a random effect.

Random effects revealed significant variability across participants in average RT ($\chi 2(1) = -13522.7$, $p < .0001$, Figure 2). Participant variability explained 43% of the variance in the data ($ICC^{13} = .43$). Results of the fixed effects analysis showed that Time ($b = 7.4 \times 10^{-7}$, $t(18740) = 7.1$, $p < .0001$) and Age ($b = -1.4 \times 10^{-5}$, $t(137) = -7.1$, $p < .0001$) were significant predictors of rate of response. Time was negatively correlated with RT; participants became faster as they completed the task. Age was positively correlated with RT; older participants had longer RTs.

**Figure 2**

*Variability across Participants in mean Rate of Response*




[13] Intraclass Correlation Coefficient (ICC) is the proportion of variance explained by the grouping factor, in this case, participants.

*Note.* Each row represents the difference between a participant's rate of response (inverse RT) and the mean rate of response (indicated by value of 0). This graph shows that participants varied in their rates of response.

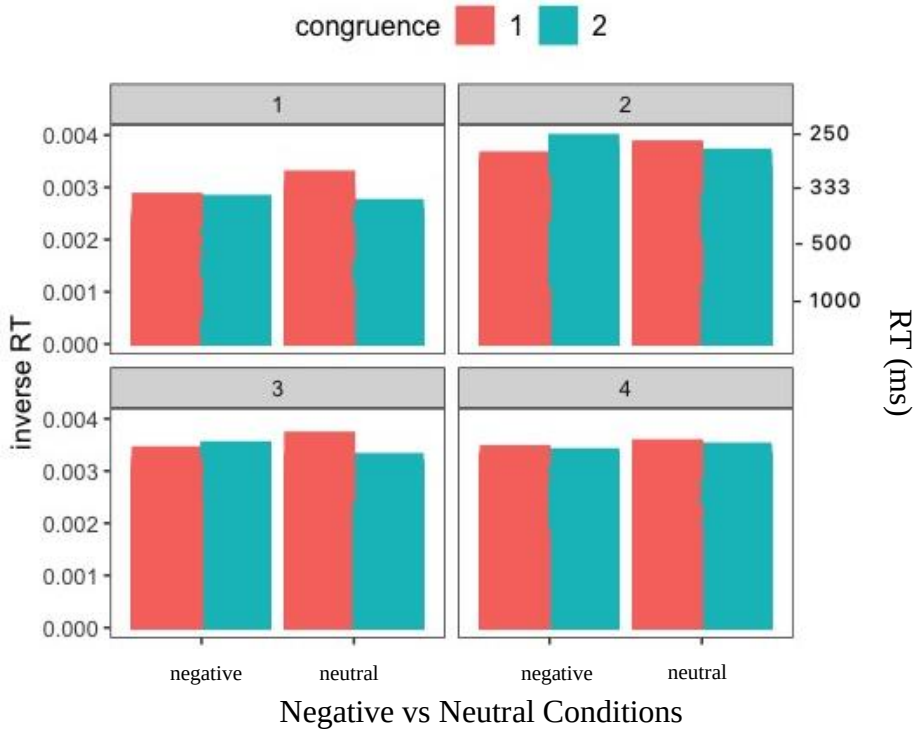
Although a three way interaction between Group, Type of Trial and Congruence was statistically significant ($b$ = -1.3 x $10^{-5}$ , t(18740) = -2.07, $p$ = .038, Figure 3), model comparison using a chi-square likelihood ratio test showed that Congruence was not a significant addition to the model ($\chi^2(8) = 10.87$, $p$ = .2). Type of Trial was also not a significant addition to the model ($\chi^2(4) = 1.36$, $p$ = .8). These variables were therefore dropped from the model. After model simplification, results revealed a significant main effect of Group on rate of response. Group contrast 2 was significant: Groups 2 (anxious) and 3 (comorbid) vs Group 1 (anhedonia), with Group 1 showing larger RTs ($M_{group1}$ = 606, 95% CI[14] = [595-617]) than the two groups with anxiety ($M_{group2}$ = 481, 95% CI = [476-483]; $M_{group3}$ = 463, 95% CI = [461-467]). No other effects were significant ($p > .05$).

To test hypothesis 2 (anhedonia specifically predicts disengagement from positive stimuli), a model was created with Age, Time, Group, Type of Trial, and Congruence as independent variables and rate of response (inverse RT) as the dependent variable. Contrast 1 was included to test the hypothesis that the two clinical groups with high anhedonia (Groups 1, 3) will respond differently to the clinical group with low anhedonia (Group 2) to positive stimuli. Contrast 2 tested the hypothesis that all clinical groups (Groups 1, 2, 3) will respond differently to the positive stimuli compared to the non-clinical group (Group 4). Contrast 3 tested the hypothesis that comorbidity (Group 3 vs Groups 1, 2) influences rate of responding to positive stimuli. The model with Time as a random effect did not converge so the model was simplified to include the intercept as a random effect.

[14] Mean RTs are calculated by back-transforming inverse RTs. Note that the confidence intervals are not symmetric around the means in the back-transformed scale.

**Figure 3**

*Rate of Response for each Group based on Type of Trial (negative vs neutral) and Congruence*




*Note.* Congruence = 1 (pink) represents congruent trials and congruence = 2 (blue) represents incongruent trials. Group 1 (anhedonia), Group 2 (anxious arousal), Group 3 (comorbid), Group 4 (control). For ease of interpretation, back-transformed RTs (ms) are displayed to the right of the graph. This graph shows that Group 1 displays lower rates of response (i.e., slower response rates).

Random effects revealed significant variability across participants in baseline RT ($\chi 2(1) = -12705.1$, $p < .0001$). Participant variability explained 40% of the variance in the data (ICC = .4). Results of the fixed effects analysis showed that Time ($b = 5.1 \times 10^{-7}$, $t(18760) = 4.7$, $p < .0001$) and Age ($b = -1.3 \times 10^{-5}$, $t(136) = -6.9$, $p < .0001$) were significant predictors of rate of response indicating that participants became faster as they completed the task and older participants had longer RTs. Congruence and Type of Trial were non-significant predictors of response rate and were therefore removed from the model. Group was a significant predictor of RT. Group contrast 3 was significant: Groups 1 (anhedonia) and 2 (anxious arousal) versus Group 3 (comorbid), *b* =

$-9.88 \times 10^{-5}$, t(135) = -2.14, $p$ = .03. Group contrast 1 was marginally significant: Groups 1 and 3 vs Group 2, $b = -7.7 \times 10^{-5}$, t(135) = -1.7, $p$ = .08. Means and 95% confidence intervals were as follows: $M_{group1}$ = 588, 95% CI = [578-599]; $M_{group2}$ = 476, 95% CI = [474-481]; $M_{group3}$ = 461, 95% CI = [457-463]; $M_{group4}$ = 508, 95% CI = [505-510]. These results indicate that the anhedonia group showed slower responding compared to the other two clinical groups.

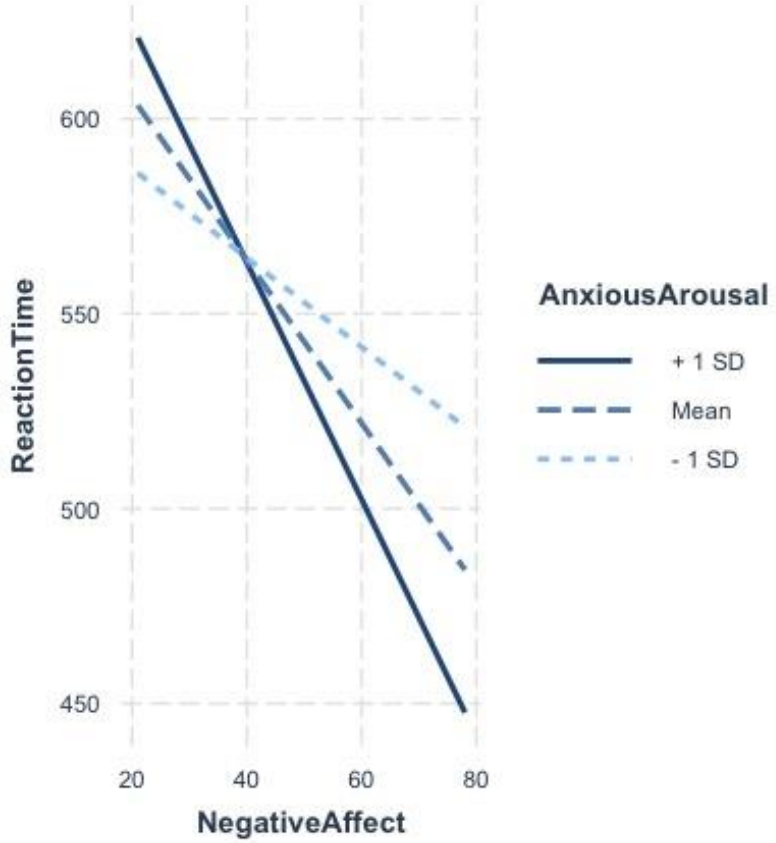
To assess for the incremental utility of anxious arousal in explaining negative AB, (Hypothesis 3), over and above negative trait affectivity, the following were modeled as independent variables: STAI-T total score, DASS – Anxiety total scores, Type of Trial, Congruence, Time, and Age. Inverse RT was set as the dependent variable. Results of the fixed effects analysis from the negative-neutral trials revealed a significant effect of Time ($b = 7.4 \times 10^{-7}$, t(18750) = 7.1, $p < .0001$), and Age ($b = -1.4 \times 10^{-5}$, t(272) = -10.2, $p < .0001$) on response rate, and a marginally significant main effect of DASS – Anxiety score ($b = -2 \times 10^{-5}$, t(272) = -1.91, $p$ = .05). Results also showed a significant DASS – Anxiety by STAI-T score interaction ($b = 4.07 \times 10^{-7}$, t(272) = 2.1, $p$ = .03, Figure 4). These results indicate that anxious arousal had a significant effect on response rate over and above the general negative affectivity. The interaction shows that response times are fast (small RTs) when both DASS – Anxiety scores and STAI-T are high. Model comparisons showed that Congruence ($\chi^2(8) = 12.8$, $p > .05$) and Type of Trial ($\chi^2(4) = 1.7$, $p > .05$) were non-significant additions to the model.

A similar model was built with SHAPS score as the added IV to test for the added effect of anhedonia on negative affect in predicting positive AB (Hypothesis 3). Type of Trial ($\chi^2(4) = 7.6$, $p > .05$), and Congruence ($\chi^2(8) = 4.7$, $p > .05$) were non-significant additions to the model. Results from the fixed effects analysis in the positive-neutral condition showed that SHAPS score was marginally significant ($b = 7.3 \times 10^{-5}$, t(920) = 1.7, $p$ = .09) and SHAPS score by

STAI-T interaction was marginally significant ($b$ = -1.2, t(528) = -1.6, $p$ = .1). These findings show that response times can slow down when SHAPS is elevated and STAI-T is low (Figure 5). When both anhedonia and STAI-T scores are high, response times are faster.

**Figure 4**

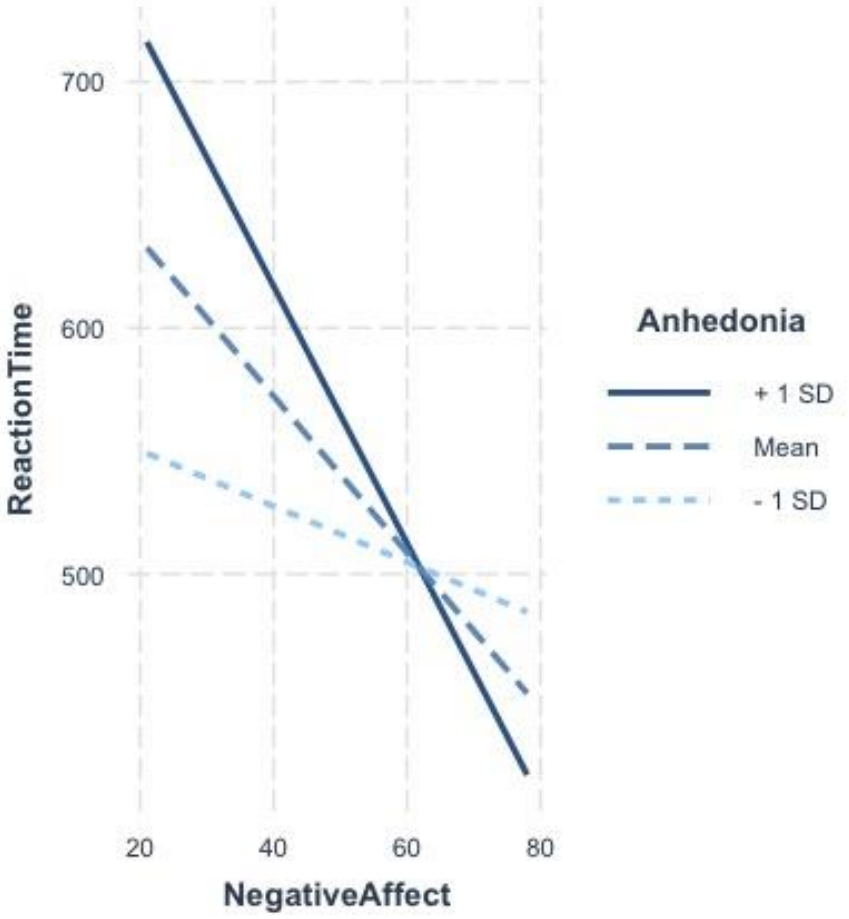
*Incremental Validity of Anxious Arousal over Negative Affectivity in predicting Rate of Response*




*Note.* This graph displays the interaction between the DASS scores (anxious arousal) and STAI-T (negative affectivity) in predicting rate of response. Reaction Time in ms is displayed for ease of interpretation. The graph shows that elevated anxious arousal and elevated negative affect predicts faster RTs.

**Figure 5**

*Incremental Validity of Anhedonia over Negative Affectivity in predicting Rate of Response*




*Note.* This graph displays the interaction between the SHAPS scores (anhedonia) and STAI-T (negative affectivity) in predicting rate of response. Reaction Time in ms is displayed for ease of interpretation. The graph shows that elevated anhedonia alone predicts slower RTs (effect marginally significant).

To test whether negative or positive attention bias are markers for psychopathology (Hypothesis 4), two logistic regression[15] models were built with Response Time[16], Congruence, and Type of Trial as independent variables and Group Membership (clinical vs non-clinical) as

[15] The generalized linear models did not converge. Only fixed effects were therefore considered.

[16] Raw response times (i.e., non-inverted RTs) were used in the logistic regression analyses as the RTs were modeled as independent variables.

the dependent variable. Results of the negative AB model showed Response Time as a significant predictor of group membership, $b$ = -0.0003, SE = 0.0001, $p$ = .01, OR[17] = .9996 [.9994 - .9999]. This indicates that a unit increase in RT (1 ms), decreases the odds of belonging to the clinical group by 0.04 %. Response times in the clinical group (M = 531, SD = 189) were faster than the non-clinical group (M = 547, SD = 209). The interaction between Congruence, Type of Trial, and RT was non-significant ($p$ > .05). No other significant main effect was found. Similar results were found for the positive AB model. Raw Response Time significantly predicted group membership, $b = -3.9 \times 10^{-4}$, SE = $1.2 \times 10^{-4}$, $p$ = .001, OR = .9996 [.9993 - .9998]. Response times for the clinical group (M = 526, SD = 189) were faster than the non-clinical group (M = 544, SD = 223). No other significant effect was found ($p$ > .05).

To test whether accuracy could be used as a measure of AB (Hypothesis 5), Errors were used as the dependent variable in a model containing Age, Time, Group, Type of Trial, and Congruence as IVs. A generalized linear mixed model with participants as random effects was compared with a logistic regression model without a random intercept. Model comparison using log likelihood ratios showed that there was significant variability across participants in average accuracy ($p$ < .0001). This was the case for both negative-neutral and positive-neutral trials.

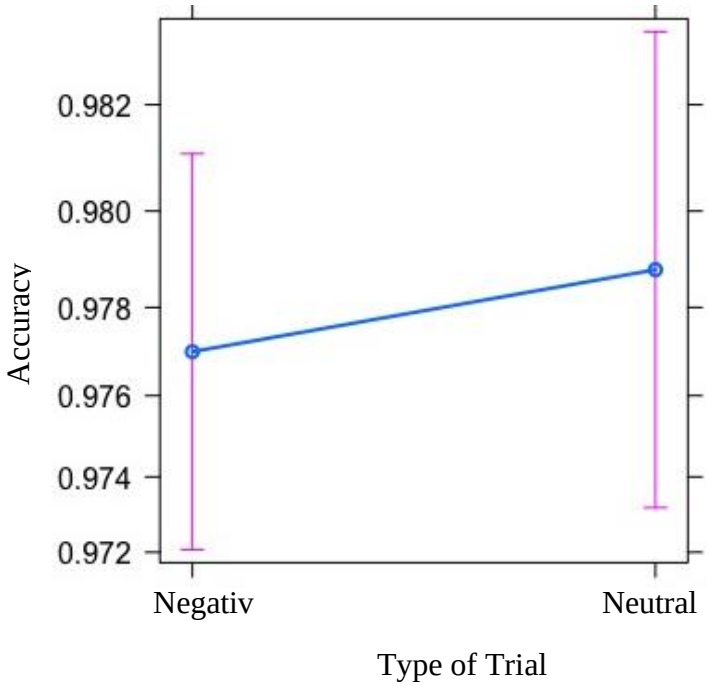
Age was a significant predictor of accuracy in the negative-neutral and positive-neutral trials. The older participants had a higher probability of getting more accurate responses (negative-neutral trials: $b$ = 0.04, SE = 0.006, $p$ < .0001, OR = 1.04 [1.03 – 1.05]; positive-neutral trials: $b$ = 0.04, SE = 0.008, $p$ < .0001, OR = 1.04 [1.02 – 1.05]). This indicates that a unit increase in age (1 year) increases the odds of correct responses by 104%. Time was a significant predictor of accuracy in the negative-neutral trials only ($b$ = 0.01, SE = 0.001, $p$ < .0001, OR =

[17] Odds Ratio (OR) represents the odds of having more accurate responses. Values in brackets represent 95% confidence intervals.

1.01 [1.008 – 1.015]). As time went by, the participants tended to become more accurate in their responses. Type of Trial was a significant predictor of accuracy in the negative-neutral trials (Figure 6). Participants tended to be more accurate in the neutral (98%) than the negative trials (97%, $b = 0.33$, SE = 0.15, $p = .02$, OR = 1.4 [1.04 – 1.86]). Comparing the Log Likelihood ratios showed little improvement to the model by the inclusion of Type of Trial ($p > .05$), indicating that the difference in accuracy between negative and neutral trials might not be meaningful.

**Figure 6**

*Probability of Obtaining Correct Responses based on Type of Trial (negative vs neutral)*




*Note*. This graph displays the probability of correct responses that participants make based on the type of trial (despite the statistically significant difference between negative and neutral trials, Type of Trial was not a meaningful addition to the model).

To better understand why AB was not captured in the present study, two models with and without participant as a random effect were compared. The models were identical except for the random variability being accounted for in one of the models. The model that did not include

random variability replicates studies in the literature that used ANOVA based analysis. The two models were compared for each of the conditions (Negative-Neutral and Positive-Neutral conditions). This analysis allows the determination of whether the null results were due to the statistical procedure chosen for this study (please refer to *Aims of the Present Study* for more details). Results showed that for the negative-neutral condition, when random variability across participants was not included in the model, Type of Trial was statistically significant ($p$ = .001) and the 3-way interaction between Group Contrast 1, Congruence, and Type of Trial was marginally significant ($p$ = .07). Comparing model fit showed that the model without random variability had poorer fit (AIC = -236620.6) compared to the model with participant variability accounted for as a random effect (AIC = -246343.3). In the positive condition, no difference between the two models was found regarding the statistical significance of the predictors. Comparing model fit showed that the model that included random variability across participants had a better fit (AIC = -245564.2) than the model that did not account for this variance (AIC = -236310.3).

# Chapter V

## Summary and Conclusions

The aim of the present study was to assess attention bias to negative and positive stimuli using a computerized cognitive task with individuals with varying severity of depression and anxiety symptoms. The goals of the present study were to add to the literature on attention bias in the following ways: 1) avoid poor psychometric properties of the measure by using different statistical procedures that circumvent the subtraction method. 2) using a dimensional approach to psychopathology to more specifically assess the relationship between core symptoms of

depression and anxiety and attention bias to negative and positive stimuli. 3) directly measuring the utility of this attention process in predicting psychopathology.

We predicted that attention bias to negative stimuli will be observed in all clinical groups as this bias has been suggested to represent a trait-based factor (Hypothesis 1). We also predicted that attention bias to positive stimuli will be observed in the groups with high anhedonia (Hypothesis 2) as avoidance of positive information has been suggested to be specific to individuals experiencing low mood. We predicted that the core symptoms of depression (anhedonia) and anxiety (anxious arousal) have incremental utility over general negative affect in predicting positive and negative attention bias, respectively (Hypothesis 3). We predicted that negative and positive AB will significantly differentiate clinical vs non-clinical sample (Hypothesis 4). The clinical sample consisted of participants who have sought mental health care and have a mental health diagnosis. We also tested the hypothesis that attention bias can be measured through accuracy of responses (error rate, Hypothesis 5). Analyses carried out for hypotheses 1 and 2 were repeated and response time was substituted for accuracy as the dependent variable.

Despite the effort to circumvent methodological limitations of the attention bias measure, results of this study failed to capture attention bias as proposed by the pioneers of the dot-probe paradigm; participants did not respond differently to congruent versus incongruent probes presented on the screen. This indicates that there was no evidence that participants' responses to probes were faster when the probes replaced the target words (valence stimuli). There was also no evidence for a difference in response time between the valence pairs of stimuli and the neutral pairs (Type of Trial); participants did not show a bias in attention to the positive or negative words vs neutral words. There are multiple possible explanation for these findings.

The null findings are unlikely a result of lack of power as the number of observations were adequate to detect a small effect size in Congruence and Type of Trial (Brysbaert & Stevens, 2018). One possible explanation for the null congruency effect is the unique way this variable was modelled in the present analyses. To avoid a difference score method (subtraction of congruent and incongruent trials), Congruency was modeled as an independent variable. Evidence for attention bias would therefore be reflected by a significant 3-way interaction between Congruency (congruent vs incongruent), Type of Trial (negative or positive vs neutral), and Group (1, 2, 3, 4). This is in comparison to most studies that have modelled attention bias as a dependent variable after subtracting response times of congruent trials from incongruent trials. The methodology used to measure attention bias is currently being critiqued as studies have demonstrated poor psychometric properties for the attention bias indexes (example Aday & Carlson, 2019; Bockstaele et al., 2015; Clarke et al., 2013; Staugaard, 2009). It is therefore possible that findings of a congruency effect in studies that have used traditional statistical methods were false positives. The construct validity of the attention bias indexes remains under debate.

Although the lack of a congruency effect is inconsistent with other findings in the literature that have shown a RT difference between congruent and incongruent trials, results of the present study are in line with another study that showed a null finding. Kappenman et al. (2014) used a traditional statistical method and another method (Bayesian analysis) to determine whether the traditional method results in false positives. Results of the study demonstrated that neither method showed a congruency effect using the dot probe task. It is therefore possible that findings of a congruency effect are not always replicable.

A unique characteristic of the present study was the use of mixed effects models in the analyses. Unlike studies using ANOVA-type analyses, mixed effects analyses can be used to partial out the variance attributed to random variation across participants. It is therefore possible that previous studies that have shown evidence for AB have actually been capturing random variability across participants in reaction time. This was specifically tested in the present study by comparing two models with the same predictors, one that accounts for random variability across participants and the other does not. Results showed that when random variability was not accounted for, a significant effect of Type of Trial in the Negative-Neutral analysis was found. Moreover, a marginally significant 3-way interaction between Group, Congruence, and Type of Trial was also found. These effects were not found in the Positive-Neutral condition. This provides direct evidence that a Valence effect is found when random variability across participants is not taken into account, but the effect disappears when inter-subject variance is accounted for. It is therefore possible that significant findings of AB in previous studies that used traditional statistical approaches actually represent idiosyncratic participant factors. One study (Tonta et al., 2019) used generalized linear mixed effects models with subjects as a random factor and found an effect of disengagement bias in their sample. This study, however, used the traditional subtraction method for calculating attention bias and modeled the AB scores as dependent variables. Direct comparison between Tonta et al.'s (2019) study and the present study might therefore not enhance our understanding of the contribution of different methodological factors on AB findings.

To avoid reliance solely on behavioral measures, many studies are including eye tracking and electrophysiological measures in tandem with behavioral measures to better establish the construct being assessed. Some studies are showing that the processes being measured by the

behavioral tasks differ from the ones captured by eye tracking and electrophysiological measures. Waechter et al. (2014) found no correlation between their behavioral measure of AB and eye movements. Thigpen et al. (2018) showed that differences in RT in dot probe paradigms were not associated with attention selection based on electrophysiological measures. Price, Woody, Panny, & Siegle. (2019) showed separable processes that are captured by the dot probe task and eye tracking measures. Other studies have provided some evidence to show that behavioral measures of AB and eye tracking measures at least partly capture similar phenomena (Soleymani et al., 2020; Van Ens et al., 2019).

There are other methodological differences such as task design that can have an impact on the findings (Chapman et al., 2019; Price, Beech, Mitchell, & Humphreys, 2012; Staugaard, 2009). In studies that have used internet-based collection of data, including the present study, it is more difficult to control for these influences as the investigator has little knowledge of the circumstances under which the participant is sitting for the task. Attention bias, as measured by the dot probe paradigm, is based on the assumption that participants respond faster to a probe that is in the location of their attention focus. Since two stimuli are presented on the screen, it is assumed that a shift in gaze will occur to a different visuospatial location on the screen. This is different, for example, than the way attention bias is measured in other tasks such as the Stroop task, where only one stimulus is presented on the screen (one word) that has more than one feature (word in blue ink). It is therefore possible that the lack of evidence for a congruency effect in the present study is because participants' attention was focused on the entire screen. If that is the case, then their attention will be divided equally on both stimuli presented, hence losing the congruency effect. It was not possible to assess for this confound as the present study was an internet-based study and participants used their personal devices to complete the task. It

was therefore impossible to control their seating position to ensure that attention will be shifted across different locations of the screen. Studies using eye tracking can better detect visuospatial attention focus. What these studies have found is that eye gaze occurs between 100 and 200 ms after stimulus onset. In behavioral tasks with stimulus presentations of 500 ms, attention focus would have gone back and forth multiple times, possibly resulting in failure to capture initial attention focus.

It has also been suggested that trials are influenced by the preceding trials (Clarke et al., 2013). If a negative-neutral trial preceded a neutral-neutral trial, it is not unlikely that attention to the location of negative stimulus remains even after the stimulus disappears. In fact, studies have shown that trials closer together in time are correlated with each other. Category priming could be another confound (example Kahlaoui et al., 2007). Stimuli-specific characteristics and time variable factors such as fatigue are factors that can influence findings, particularly in experiments where the effect size is small. In the present study, the effect of time was specifically modelled in the analyses to control for such an effect. Results showed that response time does change as the participants complete the task. In the present study, participants became faster as time went by. This is unlikely the result of fatigue or impatience because participants also became more accurate as time went by. This shows that fatigue or lack of motivation did not influence the results, indicating that the length of the present study was an optimal balance between power and feasibility (Brysbaert & Stevens, 2018). There was therefore no evidence for time and accuracy tradeoff in the present study. Older participants were slower than their younger counterparts, which is consistent with studies showing the effect of aging on reaction time (example Woods et al., 2015). It is possible that faster and more accurate responses with time were the result of a practice effect. Recent studies are using more complex methodologies to resolve the issues

discussed above including Bayesian hierarchical models (Krypotos et al., 2015), computational modeling such as drift-diffusion modeling (Price, Brown, & Siegle, 2019), and others (Heitmann et al., 2021).

Although most studies have relied on response time as an indicator of attention bias, response error can also be a useful tool to assess for AB. Results from the present study showed a statistically significant effect of Type of Trial on accuracy, where participants made more errors in the negative-neutral than neutral-neutral trials. The analysis showed that this effect is not robust and therefore might represent a false positive. Replication is needed to determine whether accuracy is influenced by valence in the dot probe paradigm.

Results from analyses testing hypotheses 1 and 2 showed no evidence for a significant difference between the psychopathology (Groups 1, 2, 3) and non-psychopathology (Group 4) groups in rate of response to negative or positive stimuli. Based on these results, there is no global effect of psychopathology on AB where individuals with general (non-specific) mental health symptomatology show a different rate of response to stimuli than healthy controls. Contrary to what was hypothesized, anhedonia was not associated with relatively slower responses to positive stimuli compared to neutral stimuli. Anhedonia was found to correspond with a slower rate of response to all stimuli. One reason for the lack of differentiation of the anhedonia group between valence and neutral stimuli is the failure of the dot probe paradigm to capture the difference in processing. It has been suggested that the lack of effect of valence (example differential response to negative vs neutral stimuli) in these paradigms is due to the task's poor sensitivity to capture the differential processing between the types of stimuli (Sigurjonsdottir et al., 2015). These findings are not surprising in light of new evidence questioning the results of previous dot probe studies. Another reason for the lack of

differentiation of the anhedonia group between valence and neutral stimuli is that anhedonia is related to general slowing of response to all stimuli. The finding that the anhedonia group had slower RTs to all stimuli without differentiation based on valence is in line with studies that have shown general slowed response in individuals with depression rather than a specific AB to certain stimuli (Rokke et al., 2002). It cannot be ruled out that low power could have influenced these findings as the number of observations in the anhedonia group were smaller than suggested for optimal power (Brysbaert & Stevens, 2018).

Results from analyses of testing Hypothesis 3 showed that the slowed response in anhedonia was countered by negative affectivity. Individuals with elevated ratings on both the SHAPS and STAI-T scales had rate of responses similar to individuals with high STAI-T scores only. These findings support results that have shown that comorbid anxiety and depression reverses the slowness observed in depression without comorbid anxiety. This finding also provides evidence for the incremental utility of anhedonia over and above negative affectivity in predicting speed of responding. Results also showed that anxious arousal results in speedier responses in the presence of negative affectivity. It appears that anxious arousal has an additive effect to negative affectivity in predicting behavioral speeding. This shows that anxious arousal has incremental utility over and above negative affectivity in predicting response time. As AB was not successfully captured in this study, it cannot be determined whether anhedonia and anxious arousal have incremental utility over negative affectivity in predicting AB.

Results from Hypothesis 4 showed no evidence for AB as a marker for psychopathology. The process of AB did not differentiate the clinical from the non-clinical group. This could be due to the lack of sensitivity of the task to capture the process of AB. In a meta-analysis of randomized controlled trials of AB in anxiety, Kruijt, Parsons, & Fox (2019) found no evidence

for AB to negative stimuli in participants with anxiety. If AB cannot be captured reliably in participants, then it is unlikely going to be useful to successfully differentiate individuals with and without psychopathology. Before a cognitive measure can be assessed as a marker for psychopathology, its reliability and validity needs to be established. As discussed above, new methodologies are being presented to establish the validity of this task in capturing AB before its clinical use can be studied. In its current state, the dot probe task administered online does not appear to reliably capture AB, rendering its clinical utility uncertain.

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# Appendix A

Recruitment Sites

Participants were recruited in person and via fliers posted in public areas and university campuses. When the COVID-19 pandemic began, in-person recruitment ceased, and other methods were chosen for participant recruitment. These methods included email and social media.

1. University settings: University of North Dakota; North Dakota State University; Concordia University, St. Paul; Winona State University, MN
2. Medical and mental health clinics: Altru Behavioral Health Clinic; Altru Professional Center Family Medicine South; Altru Performance Center; Northern Prairie Community Clinic; Assessment and Therapy Associates; Northeast Human Service Center; NDSU counseling center; National Alliance of Mental Health (NAMI)
3. Community settings: fliers were hung in public locations in Grand Forks (coffee shop, bowling alley, Grand Forks public library); advertisement posted on social media: Facebook, Craiglist; word of mouth

# Appendix B

## Details of the Procedure

Qualtrics XM software Version (2020) was used to disseminate the study. Participants completed the study on their own computer. Upon accessing the link, they were first directed to the consent form which detailed the aims of the study, time to completion, risks and benefits, procedures, and compensation. Upon their consent, they were redirected to the first part of the study, which includes questions about demographics and the questionnaires (Snaith Hamilton Pleasure Scale; Depression Anxiety Stress Scale; State and Trait Anxiety Inventory – Trait). Upon their completion, they were redirected to the Milliseconds webpage to install the Inquisit software 4.0.10 (www.millisecond.com) to run the dot-probe task. After completion of this part, participants were thanked for their participation and asked to exit the page.

Reimbursement for participation initially included a random draw of 5 participants who will win a $50 gift-card. Due to low recruitment rate, reimbursement was changed to include a $10 gift-card for every participant who completes the study. This change was accepted by the IRB. At the end of data collection, the datasets were investigated ensure that the quality of the data has not been compromised. Thirty datasets appeared to have been the output of the same participant. Including these datasets could have compromised a valid interpretation of the results. These datasets were therefore excluded from the analyses.

# Appendix C

## Word Stimuli

The pairs of words were matched on the number of letters and lexical category (the pair was either two nouns, verbs, or adjectives). Attempts were made at equating level of arousal, but due to the nature of valence words, some negative words were more arousing than their neutral counterparts. Stimulus words were chosen from multiple sources and the ANEW database (Bradley & Lang, 1999) was used to determine valence and arousal. For words that were not found in the ANEW, a pilot study was carried out on 21 individuals in the community to determine ratings of valence and arousal. Participants were asked to rate the words twice, on a Likert scale from 1 to 9. For arousal, 1 represented the least arousing and 9 represents the most arousing; for valence, 1 represented the most negative and 9 represented the most positive. If the ratings did not match their word category (example a neutral word was rated 3 on valence), the stimulus was replaced by another word that more clearly represented its category. Words longer than 9 letters were removed, after feedback from participants that long words were not perceived in the short time they were presented. As more words were added, other databases were used. The few words that were replaced after piloting were rated by the primary investigator on valence and arousal.

Databases for word stimuli included:

1. EMOTE database (Grühn, 2016)
2. websites: http://www.easysurf.cc/list9.htm, http://www.thefreedictionary.com/Word-Finder.htm, https://7esl.com/list-of-adjectives/, https://www.talkenglish.com/vocabulary/top-1500-nouns.aspx, https://7esl.com/english-verbs/, https://www.google.com/.

| **Stimulus word 1** | **Frequency (per million words)** | **Stimulus word 2** | **Frequency (per million words)** |
|---|---|---|---|
| Threat words | | Neutral words | |
| "panic" | 20.67516 | "clean" | 99.74738 |
| "distress" | 7.27* | "mushroom" | 1.951133 |
| "cancer" | 22.333333 | "winter" | 26.22* |
| "rape" | 9.071055 | "walk" | 215.862745 |
| "angry" | 61.9664 | "north" | NA |
| "trauma" | 14.6639645 | "doctor" | 234.170152 |
| "helpless" | 11.775257 | "consoled" | 0.25* |
| "spider" | 9.721433 | "border" | 17.18* |
| "hostile" | 8.941176 | "upright" | 3.019608 |
| "surgery" | 32.372549 | "freezer" | 5.16* |
| "victim" | 32.142344 | "utensil" | 0.235294 |
| "wound" | 26.529412 | "storm" | 30.862745 |
| "misery" | 13.657929 | "icebox" | 2.431373 |
| "corpse" | 2.156515 | "detail" | 19.392157 |
| "mutilate" | 0.57* | "consider" | 52.47* |
| "deserted" | 5.41* | "bathroom" | 50.455607 |
| "crisis" | 16.8923 | "faucet" | 1.43* |
| "sick" | 165.431373 | "cold" | 130.156863 |
| "wasp" | 1.431373 | "vest" | 4.36785 |
| "bankrupt" | 3.046505 | "lighting" | 6.33* |
| "hostage" | 10.645654 | "skyline" | 0.67* |
| "slap" | 9.892585 | "crop" | 4.86* |
| "shame" | 41.57* | "tower" | 22.843137 |
| "scum" | 8.557599 | "shoe" | 30.39* |
| "pus" | 1 | "jug" | 3.3453555 |
| "agony" | 4.381491 | "alley" | 13.829081 |
| "horror" | 9.310668 | "branch" | 10.078431 |
| "germs" | 3.135748 | "truck" | 39.159575 |
| "rat" | 20.983234 | "pot" | 22.53* |
| "sad" | 63.372549 | "odd" | 24.039216 |
| "despair" | 5.862745 | "dentist" | 8.660291 |
| "failure" | 20.019608 | "bandage" | 2.862745 |
| "defeated" | 5.568627 | "numerous" | 3.59* |
| "fatigue" | 0.470588 | "cabinet" | 8.489139 |
| "fever" | 19.941176 | "metal" | 19.45098 |

| | | | |
|---|---|---|---|
| "disaster" | 17.27451 | "bookcase" | 1.295343 |
| "injury" | 10.196078 | "dinner" | 202.666667 |
| "hardship" | 1.509804 | "industry" | 11.686275 |
| "infest" | 0.27* | "listen" | NA |
| "addicted" | 4.449952 | "watchful" | 0.39* |
| "filth" | 3.95013 | "grass" | 16.784314 |
| "assault" | 14.5687 | "upgrade" | 2.16* |
| "dump" | 29.50737 | "obey" | 8.94* |
| "ugly" | 35.496923 | "flat" | 26.22* |
| "crash" | 28.647059 | "nudge" | 1.12* |
| "feeble" | 1.686275 | "little" | 1446.392157 |
| "abuse" | 10.254902 | "plant" | 27.607843 |
| "fault" | 104.117647 | "elbow" | 6.137255 |
| "death" | 216.686275 | "month" | 95.176471 |
| "hell" | 470.823529 | "lion" | 15.352941 |
| "weep" | 5.49* | "shop" | 53.55* |
| "irritable” | 2.65823 | "invisible” | 12.35* |
| "pain" | 97.941176 | "news" | 164.686275 |
| "ulcer" | 2.0544975 | "cliff" | 15.1075 |
| "idiot" | 59.184358 | "glass" | 60.705882 |
| "snake" | 21.941685 | "table" | 105.627451 |
| "malaria" | 1.5279485 | "machine" | 54.734406 |
| "hurt" | 246.352941 | "sand" | 20.29* |
| "poison" | 20.401317 | "window" | 86 |
| "worm" | 10.12* | "fork" | 8.21988 |
| "morbid" | 2.588235 | "public” | 71.08* |
| "cemetery" | 6.743388 | "audience" | 25.37* |
| "jail" | 70.627451 | "farm" | 30.039216 |
| "terrible" | 94.019608 | "energetic" | 5.454779 |
| "suicide" | 19.237484 | "context" | 3.196078 |
| "abduction" | 3.63* | "appliance" | 0.8* |
| "destroy" | 47.18* | "reflect" | 4.18* |
| "messy" | 7.162486 | "ready" | 387.8* |
| "accident" | 89.596528 | "category" | 4.06* |
| "anger" | 25.125112 | "shark" | 9.036825 |
| "unease” | 0.1* | "vision” | 25.364725 |
| "prison" | 66.039216 | "number" | 240.94* |
| "anguish" | 2.16* | "country" | 161.84* |
| "bullet" | 27.48701 | "theory" | 28.607843 |
| "burial" | 4.745098 | "series" | 20.16* |

| | | | |
|---|---|---|---|
| "trash" | 22.470588 | "ankle" | 7.872992 |
| "cruel" | 20.504008 | "noisy" | 5.039216 |
| "death" | 216.686275 | "stove" | 7.588235 |
| "depressed" | 13.349855 | "repentant" | 1.069377 |
| "disloyal" | 0.960784 | "rational" | 7.73607 |
| "emaciated" | 0.08* | "shortened" | 0.47* |
| "drown" | 10.59* | "guess" | 453.98* |
| "abortion" | 6.287618 | "volcano" | 3.333333 |
| "killer" | 57.8572395 | "school" | 323.237648 |
| "rejected" | 7.530688 | "possible | 114.04* |
| "murder" | 105.737699 | "secret" | 111.678 |
| "gloomy" | 2.411765 | "stable" | 13.196078 |
| "useless" | 19.941176 | "flowing" | NA |
| "forlorn" | 0.41* | "dynamic" | NA |
| "tormented" | 1.04* | "easygoing" | 0.431373 |
| "lonely" | 34.3281 | "humble" | 9.803922 |
| "unhappy" | 16.529412 | "puzzled" | 1.37* |
| "dull" | 12.078431 | "oval" | NA |
| "dreadful" | 8 | "reliable" | 5.613785 |
| "coffin" | 9.039216 | "napkin" | 3.61* |
| "mistake" | 101.960784 | "quarter" | 26.019608 |

| Positive words | Frequency | Neutral Words | Frequency |
|---|---|---|---|
| "river" | 55.470588 | "boxer" | 3.2907845 |
| "calm" | 89.039216 | "ripe" | 4.18* |
| "sun" | 69.666667 | "pig" | 25.878181 |
| "heaven" | 56.607843 | "avenue" | 10.3029 |
| "flower" | 22.764706 | "banner" | 5.921569 |
| "passion" | 37.482286 | "blender" | 1.67* |
| "beverage" | 2.498819 | "bathroom" | 50.455607 |
| "blossom" | 3.607843 | "baskets" | 1.69* |
| "beach" | 37.927281 | "pencil" | 9.862745 |
| "nature" | 45.156863 | "bench" | 10.645654 |
| "fresh" | 54.51* | "round" | 66.53* |
| "funny" | 218.18* | "black" | 167.941176 |
| "warmth" | 4.45098 | "writer" | 23.529412 |
| "joy" | 28.54902 | "pen" | 24.72549 |
| "ace" | NA | "bus" | 46.998336 |
| "humane" | 4.0652245 | "coarse" | 11.1115205 |
| "paradise" | 13.254902 | "contents" | 4.294118 |

| | | | |
|---|---|---|---|
| "bathtub" | 4.743424 | "context" | 3.196078 |
| "friend" | 419.294118 | "violin" | 4.745098 |
| "kind" | 590.686275 | "dark" | 88.607843 |
| "hug" | 19.333333 | "cut" | 181.592261 |
| "heart" | 302.049032 | "habit" | 14.470588 |
| "bath" | 21.257077 | "dirt" | 22.38668 |
| "tune" | 14.4738 | "door" | 236.429359 |
| "kindness" | 9.019608 | "elevator" | 24.411765 |
| "nectar" | 1.5157595 | "fabric" | 6.093011 |
| "star" | 53.604803 | "fork" | 8.21988 |
| "mother" | 479.921569 | "glacier" | 2.039864 |
| "snuggle" | 1.29* | "explain" | 111.18* |
| "beauty" | 48.235294 | "hammer" | 10.645654 |
| "free" | 185.973752 | "hard" | 307.843137 |
| "wish" | 241.091 | "hide" | 65.38006 |
| "justice" | 45.697581 | "journal" | 8.882353 |
| "cake" | 45.058824 | "rock" | 73.5818 |
| "devoted" | 9.173747 | "average" | 16.647059 |
| "delight" | 5.647059 | "balcony" | 7.31* |
| "girl" | 432.706461 | "tool" | 10.745098 |
| "jewel" | 6.99204 | "alien" | 17.431373 |
| "happy" | 333.196078 | "steep" | 2.45* |
| "cheer" | 18.826719 | "knife" | 32.1778 |
| "luxury" | 6.019608 | "museum" | 13.829081 |
| "daylight" | 9.568627 | "scissors" | 5.476864 |
| "silk" | 9.784314 | "name" | 446.501311 |
| "secure" | 24.333333 | "double" | 62.71* |
| "pleasure" | 80.745098 | "pamphlet" | 1.198064 |
| "comfort" | 24.680117 | "passage" | 7.647059 |
| "dream" | 118.813711 | "pinch" | 6.117647 |
| "baby" | 509.372549 | "time" | 1958.627451 |
| "useful" | 13.117647 | "yellow" | 33.803922 |
| "bunny" | 14.854065 | "board" | 64.156863 |
| "diploma" | 2.6852675 | "cyclone" | 0.470588 |
| "win" | 107.004224 | "egg" | 17.765577 |
| "kitten" | 4.347261 | "engine" | 17.8171 |
| "melody" | 6.607843 | "tissue" | 10.73* |
| "soft" | 32.019608 | "deep" | 76.392157 |
| "elegant" | 6.27451 | "strange" | 86.43* |
| "quiet" | 107.167 | "bland" | 1.7828255 |

| | | | |
|---|---|---|---|
| "chocolate" | 29.392157 | "blasphemy" | 2.294224 |
| "embrace" | 7.57* | "contain" | 6.08* |
| "pillow" | 13.007551 | "butter" | 20.431373 |
| "dove" | 5.568627 | "cane" | 8.333333 |
| "peace" | 69.607843 | "chair" | 49.235294 |
| "sunset" | 10.313725 | "cellar" | 9.372549 |
| "crown" | 13.686275 | "clock" | 27.589701 |
| "wit" | 6.127241 | "cat" | 59.629353 |
| "garden" | 26.54902 | "corner" | 52.529412 |
| "glow" | 5.75* | "vest" | 4.36785 |
| "kiss" | 121.156863 | "push" | 70.55* |
| "fun" | 235.490196 | "hay" | 6.372549 |
| "cozy" | 7.0509835 | "lazy" | 11.1724 |
| "petal" | 0.88* | "ankle" | 7.872992 |
| "silver" | 31.75* | "errand" | 5.339942 |
| "proud" | 83.627451 | "salty" | 2.49* |
| "soothe" | 1.29* | "subdue" | 0.8* |
| "lake" | 36 | "knot" | 5.13456 |
| "humor" | 17.3424 | "swamp" | 8.980392 |
| "respect" | 82.495259 | "thought" | 808.470588 |
| "carefree" | 1.3439635 | "detached" | 1.54902 |
| "honest" | 72.333333 | "clumsy" | 5.392157 |
| "champion" | 10.166428 | "industry" | 11.686275 |
| "fantasy" | 16.235294 | "reptile" | 1.71152 |
| "eat" | 251.88* | "sit" | 311.35* |
| "toy" | 16.843137 | "ink" | 7.490196 |
| "love" | 1114.980392 | "part" | 325.804928 |
| "freedom" | 33.098039 | "trumpet" | 6.4567385 |
| "bird" | 45.45098 | "foot" | 64.921569 |
| "enjoy" | 82.78* | "teach" | 72.84* |
| "nice" | 557.099727 | "tall" | 32.33* |
| "puppy" | 10.440271 | "paper" | 103.352941 |
| "lively" | 4.058824 | "second" | 284.57* |
| "restful" | 0.75* | "floppy" | 1.14* |
| "smile" | 58 | "carry" | 65.901961 |
| "tender" | 8.882353 | "modest" | 5.882353 |
| "health" | 41.521473 | "desert" | 27.98* |
| "loyal" | 15.917135 | "tight" | 50.92* |
| "laugh" | 62.862745 | "stock" | 25.49* |

| Neutral words | Frequency | Neutral words | Frequency |
|---|---|---|---|
| “column” | 10.960784 | “detail” | 19.392157 |
| “cork” | 2.862745 | “lawn” | 12.352941 |
| “chin” | 12.686275 | “rain” | 48.901961 |
| “finger” | 37.00306 | “annual” | 7.2* |
| “history” | 87.76674 | “process” | 27.98* |
| “hairpin” | 0.352941 | “upstairs” | 70.73* |
| “kettle” | 2.803922 | “mobile” | 7.47* |
| “locker” | 16.85587 | “writer” | 23.529412 |
| “material” | 22.137255 | “software” | 8.43* |
| “show” | 488.35* | “lift” | 34.14* |
| “crew” | 47.53* | “land” | 88.12* |
| “nun” | 6.709158 | “rub” | 14.205615 |
| “office” | 203.84202 | “permit” | 12.1* |
| “serious” | 148.352941 | “logical” | 8.181065 |
| “space” | 66.058824 | “phase” | 12.333333 |
| “umbrella” | 7.28476 | “incident” | 17.31* |
| “spice” | 5.29* | “stove” | 7.588235 |
| “taxi” | 10.611423 | “clue” | 17.61* |
| “back” | 2009.16* | “year” | 277.92* |
| “survey” | 4.45* | “street” | 100.499 |
| “nutmeg” | 1.548736 | “market” | 36.235294 |
| “wood” | 27* | “fish” | 62.138 |
| “multiple” | 10.59* | “internal” | 9.84* |
| “city” | 169.098039 | “ball” | 104.96* |
| “piano” | 24.86* | “apple” | 23.67* |
| “bucket” | 10.02* | “orange” | 22.31* |
| “pepper” | 8.803922 | “thirty” | NA |
| “writing” | 55.921569 | “teacher” | 32.861182 |
| “narrow” | 7.019608 | “square” | 31.764706 |
| “meat” | 43.65* | “wool” | 3.16* |
| “outside” | 170.02* | “forward” | 72.333333 |
| “standard” | 18.43* | “ordinary” | 19.078431 |
| “outspoken” | 1.055613 | “surprised” | 63.3129 |
| “docile” | 1.694286 | “ardent” | 8.1314675 |
| “book” | 176.980392 | “bowl” | 17.320581 |
| “cord” | 7.019608 | “mane” | 2.4863475 |
| “corridor” | 5.568627 | “clarinet” | 1.568627 |
| “cow” | 15.67 | “sip” | 5.098039 |
| “acorn” | 0.72549 | “diver” | 2.431373 |

| | | | |
|---|---|---|---|
| “aquarium” | 2.272344 | “boyfriend” | 80.428897 |
| “mitten” | 0.45098 | “muffin” | 7.0365275 |
| “toaster” | 3.2419315 | “gymnast” | 0.588235 |
| “carrot” | 4.547505 | “riddle” | 4.51421 |
| “sage” | 2.498819 | “frog” | 8.489139 |
| “splash” | 4.19538 | “celery” | 1.862745 |
| “idealist” | 0.67* | “discreet” | 4.058824 |
| “realist” | 1.211361 | “lenient” | 1.2472555 |
| “reverent” | 0.215686 | “youngest” | 5 |

Note. Word frequencies were extracted from the following lists in the EMOTE database (Grühn, 2016): “Word frequency in TV & Movie per million”, “Word Frequency in Project Gutenberg per million”, and “Word Frequency in SUBTLEX per million”. If word frequencies differed across databases, the median frequency was considered.
* denotes missing frequencies from the EMOTE database. For those words, the following database was used: online SubtlexUS (Brysbaert & New, 2009).
http://www.lexique.org/shiny/openlexicon/

Appendix D

Study Flier

**Research study in partial fulfilment of the requirements for the doctorate degree in Clinical Psychology at the University of North Dakota**



**PARTICIPANTS NEEDED FOR RESEARCH IN:**

## Attention and Mental Health

We are looking for volunteers 18 years or older to take part in a study assessing

**cognitive function and mental health wellbeing**

As a participant in this study, you would be asked to answer questions about your mental health and to play a computer game. You will be given a web link to access the study on your computer. Your participation is entirely voluntary and would take between 30 & 45 minutes of your time.

By participating in this study, you will help us better understand mental illness and create innovative treatments to help individuals suffering from mental health problems.

In appreciation for your time, you will receive a chance to participate in a draw where 5 participants will win a 50$ gift card.

To take part in this study, go to the following link:
https://und.qualtrics.com/jfe/form/SV_1BOP7Hm4ngHhh2J

To learn more about this study please contact:

**Principal Investigator**: *Helen Sawaya*
helen.sawaya@und.edu

This study is supervised by Dr. Richard Ferraro, PhD

**This study has been reviewed by the University of North Dakota Research Ethics Board.**

Appendix E

Consent Form

Title of Project: Attention Bias in Mood and Anxiety Disorders

Principal Investigator: Helen Sawaya; helen.sawaya@NDUS.edu
Advisor: Dr. Richard Ferraro; f.ferraro@und.edu; 701-777-2414

Version Date: 10/17/19

Purpose of the Study:

We're inviting you to participate in a research study. We want to understand the way in which people pay attention to different things in their environment and how this relates to mental health.

Procedures to be followed:

The study will take approximately 30 to 45 minutes to complete. There will be two parts to the study. In the first part, you will be asked general questions about yourself (demographic information) and you will be asked to fill out three short questionnaires (41questions in total). The questions are in regard to your thoughts and feelings. Before you exit the first part, you will be given a code as your specific user ID. Copy or write down this code, as you will need to enter it or paste it before you begin the second part of the study. In the second part, you will be asked to play a game on your computer. Please follow the directions listed. The game includes responding with a button press on your keyboard to prompts presented on the screen. You will also see words on the screen. If you haven't yet downloaded the Inquisit Lab software, you will be directed to a page where you will be asked to download and install an executable file (Inquisit4.0) at no cost to run the task on (includes a Windows and Mac download).There is no risk to your computer. After you have completed the study you will be prompted to delete the program.

Risks:

There are no risks in participating in this research beyond those experienced in everyday life. Some of the questions are personal and might cause discomfort. If you would like to talk to someone about your feelings regarding this study, you are encouraged to contact The University of North Dakota's Counseling Center at 701-777-2127, which provides counseling services to UND students at no charge. If you are not a UND student, you can contact the Northern Prairie Community Clinic at 701-777-3745.Alternatively, you can contact the crisis line at 1-800-273-8255or Northeast Human Service Center at 701-775-0525. For students at Winona State University, resources include SAMHSA (800-622-HELP/4357) and WSU Health and Wellness Services - Mental Health Services (507-457-5330) and counselingservices@winona.edu.

Benefits:

You might learn more about yourself by participating in this study. You might have a better understanding of your struggles with negative emotions and your ability to pay attention to different kinds of information. This research will increase our understanding of how mental health symptoms and attention focus interact. This information has been used to create novel treatments for people suffering from depression and anxiety.

Duration:

It will take between 30 and 45 minutes to complete the study.

Statement of Confidentiality:

You will not be asked any information that would identify who the responses belong to. Therefore, your responses are recorded anonymously. If this research is published, no information that would identify you will be included since your name is in no way linked to your responses.

All survey responses that we receive will be treated confidentially. However, given that the surveys can be completed from any computer (e.g., personal, work, school), we are unable to guarantee the security of the computer on which you choose to enter your responses. As a participant in our study, we want you to be aware that certain "key logging" software programs exist that can be used to track or capture data that you enter and/or websites that you visit.

Right to Ask Questions:

The researchers conducting this study are Helen Sawaya, MS and Richard Ferraro, PhD. If you have questions, concerns, or complaints about the research please contact Helen Sawaya at helen.sawaya@NDUS.edu

If you have questions regarding your rights as a research participant, you may contact The University of North Dakota Institutional Review Board at (701) 777-4279 or UND.irb@UND.edu. You may contact the UND IRB with problems, complaints, or concerns about the research. Please contact the UND IRB if you cannot reach research staff, or you wish to talk with someone who is an informed individual who is independent of the research team. Alternatively, you can contact the IRB office at Altru Health System at (701) 780-6161 or mreese@altru.org .

General information about being a research participant can be found on the Institutional Review Board website “Information for Research Participants” http://und.edu/research/resources/human-participants/research-participants.html

Compensation:

You will be given the chance to enter a draw to win a 50$ gift card. Five participants will randomly be chosen as the winners. The first 30 participants from outpatient mental health groups and community groups will win an additional $10 gift card. Participants are asked to email the primary investigator to obtain the additional gift card.

Voluntary Participation:

You do not have to participate in this research. You can stop your participation at anytime. You may refuse to participate or choose to discontinue participation at any time.

You do not have to answer any questions you do not want to answer.

Criteria for Inclusion in the Study:

You must be 18 years of age or older to participate in this research study.

You must not be under the influence of alcohol or drugs (other than your usual prescription medication).

You must not be experiencing a psychotic episode.

You must not have a motor or psychomotor impairment that interferes with your ability to effectively work a computer keyboard.

You must not be too tired to the point that you cannot focus on a 45-minute study.

Completion of the questionnaires and the computer game implies that you have read the information in this form and consent to participate in the research.

Please keep this form for your records or future reference.

# Appendix F

## Demographic Information and Inquiry about Psychopathology

Q2 How old are you?
Q3 What is your nationality?
Q4 How would you identify your race?
Q5 What is your gender?
Q6 What is your highest level of education?
o middle school (1)
o high school (2)
o diploma or some college (3)
o bachelor degree (4)
o graduate or professional degree (5)
Q7 How did you find out about this study?
o Advertisement at the Northern Prairie Community Clinic (1)
o Advertisement on UND campus or through UND email (2)
o Advertisement in the community (3)
o other (4) _____
Q8 Are you currently diagnosed with a psychological disorder/mental health problem? If yes, please specify.
o no (1)
o yes (2) _____
o unsure (3) _____
Q9 Have you been previously, but not currently, diagnosed with a psychological disorder/mental health problem? If yes, please specify.
o no (1)
o yes (2) _____
o unsure (3) _____

Q10 Are you taking any psychotropic medication (medication for mental health problems)? If yes, and you know the name of the medication, please specify.
o no (1)
o yes (2) _____
Q11 Are you currently engaged in psychotherapy/counseling services for mental health?
o no (5)
o yes (6)
Q12 Do you have a first degree relative (parent, sibling) diagnosed with a psychological disorder/mental health problem? If yes, please specify.
o no (1)
o yes (2) _____
o unsure (3) _____
Q13 Do you have a second degree relative (cousin, uncle, grandparent) diagnosed with a psychological disorder/mental health problem? If yes, please specify.
o no (1)
o yes (2) _____
o unsure (3) _____

# Appendix G

## Self-Report Questionnaires

Depression Anxiety Stress Scale (DASS) – Anxiety subscale

Please read each statement and click on the answer that you believe has applied to you in the past 6 months. There are no right or wrong answers. Do not spend too much time on any one statement.

Q1.1 I have been aware of dryness in my mouth
- o Does not apply to me at all (0)
- o Applies to me to some degree, some of the time (1)
- o Applies to me a considerable degree or a good part of the time (2)
- o Applies to me very much or most of the time (3)

Q1.2 I have been experiencing breathing difficulty (example excessively rapid breathing, breathlessness in the absence of physical exertion)
- o Does not apply to me at all (0)
- o Applies to me to some degree, some of the time (1)
- o Applies to me a considerable degree or a good part of the time (2)
- o Applies to me very much or most of the time (3)

Q1.3 I have been experiencing trembling (example in the hands)
- o Does not apply to me at all (0)
- o Applies to me to some degree, some of the time (1)
- o Applies to me a considerable degree or a good part of the time (2)
- o Applies to me very much or most of the time (3)

Q1.4 I have been worried about situations in which I might panic and make a fool of myself
- o Does not apply to me at all (0)
- o Applies to me to some degree, some of the time (1)
- o Applies to me a considerable degree or a good part of the time (2)
- o Applies to me very much or most of the time (3)

Q1.5 I have been feeling close to panic

- o Does not apply to me at all (0)
- o Applies to me to some degree, some of the time (1)
- o Applies to me a considerable degree or a good part of the time (2)
- o Applies to me very much or most of the time (3)

Q1.6 I have been aware of the action of my heart in the absence of physical exertion (example sense of heart rate increase, heart missing a beat)
- o Does not apply to me at all (0)
- o Applies to me to some degree, some of the time (1)
- o Applies to me a considerable degree or a good part of the time (2)
- o Applies to me very much or most of the time (3)

Q1.7 I have been feeling scared without any good reason
- o Does not apply to me at all (0)
- o Applies to me to some degree, some of the time (1)
- o Applies to me a considerable degree or a good part of the time (2)
- o Applies to me very much or most of the time (3)

Snaith-Hamilton Pleasure Scale (SHAPS)
This questionnaire measures your ability to experience pleasure (generally in the past 6 months). On a scale of 0 to 3, indicate how much you agree or disagree with each statement.
Q2.1 I would enjoy my favorite television or radio program
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.2 I would enjoy being with my family or close friends
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.3 I would find pleasure in my hobbies or pastimes
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.4 I would be able to enjoy my favorite meal
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.5 I would enjoy a warm bath or refreshing shower
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.6 I would find pleasure in the scent of flowers or the smell or a fresh sea breeze or freshly baked bread
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.7 I would enjoy seeing other people's smiling faces
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.8 I would enjoy looking smart when I have made an effort with my appearance
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)
Q2.9 I would enjoy reading a book, magazine, or newspaper
o strongly agree (1)

o agree (2)
o disagree (3)
o strongly disagree (4)

Q2.10 I would enjoy a cup of tea or coffee or my favorite drink
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)

Q2.11 I would find pleasure in small things, example, bright sunny day, a telephone call from a friend
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)

Q2.12 I would be able to enjoy a beautiful landscape or view
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)

Q2.13 I would get pleasure from helping others
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)

Q2.14 I would feel pleasure when I receive praise from other people
o strongly agree (1)
o agree (2)
o disagree (3)
o strongly disagree (4)

State and Trait Anxiety Inventory – Trait (STAI-T)

A number of statements which people use to describe themselves are given below. Read each statement and then click on the answer that you believe best describes how you have generally felt in the past 6 months. There are no right or wrong answers. Do not spend too much time on any one statement.

Q3.1 I feel pleasant
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.2 I feel nervous and restless
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.3 I feel satisfied with myself
o almost never (1)

o sometimes (2)
o often (3)
o almost always (4)

Q3.4 I wish I could be as happy as others seem to be
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.5 I feel like a failure
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.6 I feel rested
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.7 I am “calm, cool, and collected”
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.8 I feel that difficulties are piling up so that I cannot overcome them
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.9 I worry too much over something that really doesn’t matter
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.10 I am happy
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.11 I have disturbing thoughts
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.12 I lack self-confidence
o almost never (1)
o sometimes (2)

o often (3)
o almost always (4)

Q3.13 I feel secure
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.14 I make decisions easily
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.15 I feel inadequate
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.16 I am content
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.17 Some unimportant thought runs through my mind and bothers me
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.18 I take disappointments so keenly that I can’t put them out of my mind
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.19 I am a steady person
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

Q3.20 I get in a state of tension or turmoil as I think over my recent concerns and interests
o almost never (1)
o sometimes (2)
o often (3)
o almost always (4)

# Appendix H

## Script for Dot Probe Task

```
SCRIPT INFO

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Date: 11-28-2012
last updated: 06-05-2015 by K.Borchert for Millisecond Software LLC

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BACKGROUND INFO


        *Purpose*
This script implements a similar dotprobe procedure as used in:

MacLeod, C. , Soong, L.Y., Rutherford, E., & Campbell, L.W. (2007). Internet-
delivered assessment and manipulation
of anxiety-linked attentional bias: Validation of a free-access attentional
probe software package.
Behavior Research Methods, 39, 533-538.

(the free-access attentional probe software package as well as the stimuli
used is available under:
http://www.psy.uwa.edu.au/labs/cogemo/AttProbe1.html)



          *Task*
After presentation of a fixation cross in the center of the screen,
participants are presented with
2 words from two categories (here: threat and neutral words). The position of
the words is randomly
chosen to be either above or below the location of the fixation cross. After
a short duration,
the two words disappear and a probe stimulus (here: < or >) appears in the
location of one of the
words. Participants are asked to press one key if the probe is < and another
if the probe is >.


DATA FILE INFORMATION:
The default data stored in the data files are:

(1) Raw data file: 'DotProbe_rawdata.iqdat' (a separate script for each
participant)

date, time, participant:       date and time script was run with the current
participant
/probetaskselection:   determines which type of dotprobe task to run

        1 = probe always in threat position
```

2 = probe always in neutral position

3 = probe randomly in threat or neutral position (half the time in threat position) (default)
blockcode, blocknum: the name and number of the current block
trialcode, trialnum: the name and number of the currently recorded trial

(Note: not all trials that are run might record data)
/congruence: 1 = probe and target (threat) congruent; 2 = probe and target (threat) incongruent
/targetlocation:1 = target is displayed top (and comp is presented bottom); 2 = target is presented bottom (comp is presented top)
/probeposition: 1 = probe is displayed on top; 2 = probe is displayed on bottom
/probetype:determines the type of the probe presented (1 vs. 2)

/threat_y-probe_y: the y-coordinate (in %) of the threat/neutral/probe
/neutralword-threatword:contain the current stimuli
text.probe.currenitem: current probe item response:
the participant's response (scancode of response button): 18 vs. 23
correct: accuracy of response (1 = correct; 0 = error)
latency: the response latency in ms (measured from onset of probe until response)

(2) Summary data file: 'DotProbe_summary.iqdat' (Inquisit Lab: one data file for all participants)

script.startdate: date script was run
script.starttime: time script was started
script.participantid: participant id number
script.groupid: group id number
script.elapsedtime: time it took to run script (in ms)
/completed: 0 = script was not completed (prematurely aborted); 1 = script was completed (all conditions run)
/probeselectiontask: determines which type of dotprobe task to run

1 = probe always in threat position

2 = probe always in neutral position

3 = probe randomly in threat or neutral position (half the time in threat position) (default)
/fixationduration/targetduration: the duration of the fixation crosses in ms (default: 500ms)/the targets (default: 500ms)
/TP_ISI: the interstimulus interval between offset of target and onset of probe in ms (default: 0)

/probe_posttrialpause: the interstimulus interval between offset of probe and begin of next trial in ms (default: 0)
/probe1-probe2: the symbols used for probe1 and probe 2 (default: >,<)
/randomprobe_x: 1 = the x-coordinate of the probe is randomly determined within the space that the target previously occupied (see MacLeod et al, 2007); default 2 = the probe is always presented at values.target_x (right above fixation)

/propcorrect: overall proportion correct of all test trials
/meanRT: overall mean latency in ms of correct responses of all test trials

/propcorrect_congruent: proportion correct of all congruent test trials (congruent = target/threat and probe position congruent)
/propcorrect_incongruent: proportion correct of all incongruent test trials (congruent = target/threat and probe position incongruent)

/meanRT_congruent: mean latency in ms of correct congruent test trials
/meanRT_incongruent: mean latency in ms of correct incongruent test trials

/TBI: threat bias index calculated by subtracting the mean latency of responses to probes in threat positions (congruent)

from mean latency of responses to probes in neutral positions (incongruent)

Note: MacLeod et al (2007) use the medians instead of the means

EXPERIMENTAL SET-UP
2 target positions (up, down) x 2 target-probe congruence (congruent, incongruent) x 2 probe symbols, tested within participants

- 1 Block of 20 practice trials with digits; not original; practice trials give errorfeedback
- 1 Block of 96 trials
  - it can be set (see section Editable Values) whether
    a) all the trials are threat-probe congruent
    b) all the trials are threat-probe incongruent
    c) 1/2 trials are congruent; 1/2 trials are incongruent (default)

- Default trialsequence: fixation (500ms)->targets(500ms)->TP_ISI(0ms)->Probe (until response) -> ISI (1000ms)
- stimuli pairs are randomly determined for each trial
- target positions/target-probe congruence/probe symbol randomly determined
- Probe can be right above the fixation cross or it is randomly placed in one of the previously occupied letter positions (default)
(can be set under section Editable Values)

```
STIMULI
This script uses the stimuli generously provided by MacLeod et al (2007) on
their website (see above)
They can be edited under section Editable Stimuli
Probes can edited under section Editable Parameters.

INSTRUCTIONS
The instructions provided in this script are not originals. The instructions
can be easily edited under section Editable instructions

EDITABLE CODE:
check below for (relatively) easily editable parameters, stimuli,
instructions etc.
Keep in mind that you can use this script as a template and therefore always
"mess" with the entire code to further customize your experiment.

The parameters you can change are:

/probetaskselection:                                        1 = probe always
in threat position (all probe-threat congruent)

       2 = probe always in neutral position (all probe-threat incongruent)

       3 = probe randomly in threat or neutral position (half the time in
threat position) (default)
/fixationduration/targetduration:                    the duration of the
fixation crosses (default: 500ms)/the targets (default: 500ms)
/fixation_posttrialpause :                                  the
posttrialpauses for the fixation crosses/the targets/the probe
/TP_ISI:
       the interstimulus interval between offset of target and onset of probe
in ms (default: 0)
/probe_posttrialpause:                                      the
interstimulus interval between offset of probe and begin of next trial in ms
(default: 0)
/probe1-probe2:                                                     the
symbols used for probe1 (E) and probe 2 (I)
/responsekey_probe1-
responsekey_probe2:                                                 the
keyboard scancodes associated with probe1 (default: 18, "E") and probe2
(default: 23, "I")

       as well as their respective labels
/letterheight:                                                      the
height of the letter in % of screen height (default: 5%)

       !!!NOTE: this script uses mono-spaced Lucinda Console as the default
font;

       we suggest to not change the fontstyle as the calculation of the width
of a single letter

       is based on this particular fontstyle.
/target_left_y-target_right_y:                       the y-coordinate in % of
the top/bottom target (default: 25%, 75%)
```

```
/target_x:
        the x-coordinate of the target (default: center at 50%)
/randomprobe_x:                                                    1 = the
x-coordinate of the probe is randomly determined within the space that the

                target previously occupied (see MacLeod et al, 2007); default

        2 = the probe is always presented at values.target_x (location of
target)



*********************************************************************************
*********************************
*********************************************************************************
*********************************
        EDITABLE PARAMETERS: change editable parameters here
*********************************************************************************
*********************************
*********************************************************************************
*********************************

<values>
/probetaskselection = 3
/fixationduration = 500
/targetduration = 500
/TP_ISI = 0
/probe_posttrialpause = 1000
/probe1 = "<-"
/probe2 = "->"
/responsekey_probe1 = 203
/responsekey_probe2 = 205
/responsekey_probe1_label = "<-"
/responsekey_probe2_label = "->"
/letterheight = 4%
/target_left_x = 40%
/target_right_x = 60%
/target_y = 50%
/randomprobe_x = 2
</values>

*********************************************************************************
*********************************
*********************************************************************************
*********************************
        EDITABLE STIMULI: change editable stimuli here
*********************************************************************************
*********************************
*********************************************************************************
*********************************

<item threatwords>
/1 = "panic"
/2 = "distress"
/3 = "cancer"
/4 = "rape"
/5 = "angry"
```

```
/6 = "trauma"
/7 = "helpless"
/8 = "spider"
/9 = "hostile"
/10 = "surgery"
/11 = "victim"
/12 = "wound"
/13 = "misery"
/14 = "corpse"
/15 = "mutilate"
/16 = "deserted"
/17 = "crisis"
/18 = "sick"
/19 = "wasp"
/20 = "bankrupt"
/21 = "hostage"
/22 = "slap"
/23 = "shame"
/24 = "scum"
/25 = "pus"
/26 = "agony"
/27 = "horror"
/28 = "germs"
/29 = "rat"
/30 = "sad"
/31 = "despair"
/32 = "failure"
/33 = "defeated"
/34 = "fatigue"
/35 = "fever"
/36 = "disaster"
/37 = "injury"
/38 = "hardship"
/39 = "infest"
/40 = "addicted"
/41 = "filth"
/42 = "assault"
/43 = "dump"
/44 = "ugly"
/45 = "crash"
/46 = "feeble"
/47 = "abuse"
/48 = "fault"
/49 = "death"
/50 = "hell"
/51 = "weep"
/52 = "irritable"
/53 = "pain"
/54 = "ulcer"
/55 = "idiot"
/56 = "snake"
/57 = "malaria"
/58 = "hurt"
/59 = "poison"
/60 = "worm"
/61 = "morbid"
/62 = "cemetery"
```

```
/63 = "jail"
/64 = "terrible"
/65 = "suicide"
/66 = "abduction"
/67 = "destroy"
/68 = "messy"
/69 = "accident"
/70 = "anger"
/71 = "unease"
/72 = "prison"
/73 = "anguish"
/74 = "bullet"
/75 = "burial"
/76 = "trash"
/77 = "cruel"
/78 = "death"
/79 = "depressed"
/80 = "disloyal"
/81 = "emaciated"
/82 = "drown"
/83 = "abortion"
/84 = "killer"
/85 = "rejected"
/86 = "murder"
/87 = "gloomy"
/88 = "useless"
/89 = "forlorn"
/90 = "tormented"
/91 = "lonely"
/92 = "unhappy"
/93 = "dull"
/94 = "dreadful"
/95 = "coffin"
/96 = "mistake"
/97= "column"
/98= "cork"
/99= "chin"
/100= "finger"
/101= "history"
/102= "hairpin"
/103= "kettle"
/104= "locker"
/105= "material"
/106= "show"
/107= "crew"
/108= "nun"
/109= "office"
/110= "serious"
/111= "space"
/112= "umbrella"
/113= "outspoken"
/114= "docile"
/115= "book"
/116= "cord"
/117= "corridor"
/118= "cow"
/119= "acorn"
```

```
/120= "aquarium"
</item>

<item neutralwords>
/1 = "clean"
/2 = "mushroom"
/3 = "winter"
/4 = "walk"
/5 = "north"
/6 = "doctor"
/7 = "consoled"
/8 = "border"
/9 = "upright"
/10 = "freezer"
/11 = "utensil"
/12 = "storm"
/13 = "icebox"
/14 = "detail"
/15 = "consider"
/16 = "bathroom"
/17 = "faucet"
/18 = "cold"
/19 = "vest"
/20 = "lighting"
/21 = "skyline"
/22 = "crop"
/23 = "tower"
/24 = "shoe"
/25 = "jug"
/26 = "alley"
/27 = "branch"
/28 = "truck"
/29 = "pot"
/30 = "odd"
/31 = "dentist"
/32 = "bandage"
/33 = "numerous"
/34 = "cabinet"
/35 = "metal"
/36 = "bookcase"
/37 = "dinner"
/38 = "industry"
/39 = "listen"
/40 = "watchful"
/41 = "grass"
/42 = "upgrade"
/43 = "obey"
/44 = "flat"
/45 = "nudge"
/46 = "little"
/47 = "plant"
/48 = "elbow"
/49 = "month"
/50 = "lion"
/51 = "shop"
/52 = "invisible"
/53 = "news"
```

```
/54 = "cliff"
/55 = "glass"
/56 = "table"
/57 = "machine"
/58 = "sand"
/59 = "window"
/60 = "fork"
/61 = "public"
/62 = "audience"
/63 = "farm"
/64 = "energetic"
/65 = "context"
/66 = "appliance"
/67 = "reflect"
/68 = "ready"
/69 = "category"
/70 = "shark"
/71 = "vision"
/72 = "number"
/73 = "country"
/74 = "theory"
/75 = "series"
/76 = "ankle"
/77 = "noisy"
/78 = "stove"
/79 = "repentant"
/80 = "rational"
/81 = "shortened"
/82 = "guess"
/83 = "volcano"
/84 = "school"
/85 = "possible"
/86 = "secret"
/87 = "stable"
/88 = "flowing"
/89 = "dynamic"
/90 = "easygoing"
/91 = "humble"
/92 = "puzzled"
/93 = "oval"
/94 = "reliable"
/95 = "napkin"
/96 = "quarter"
/97= "detail"
/98= "lawn"
/99= "rain"
/100= "annual"
/101= "process"
/102= "upstairs"
/103= "mobile"
/104= "writer"
/105= "software"
/106= "lift"
/107= "land"
/108= "rub"
/109= "permit"
/110= "logical"
```

```
/111= "phase"
/112= "incident"
/113= "surprised"
/114= "ardent"
/115= "bowl"
/116= "mane"
/117= "clarinet"
/118= "sip"
/119= "diver"
/120= "boyfriend"
</item>

<item positivewords>
/1 = "river"
/2 = "calm"
/3 = "sun"
/4 = "heaven"
/5 = "flower"
/6 = "passion"
/7 = "beverage"
/8 = "blossom"
/9 = "beach"
/10 = "nature"
/11 = "fresh"
/12 = "funny"
/13 = "warmth"
/14 = "joy"
/15 = "ace"
/16 = "humane"
/17 = "paradise"
/18 = "bathtub"
/19 = "friend"
/20 = "kind"
/21 = "hug"
/22 = "heart"
/23 = "bath"
/24 = "tune"
/25 = "kindness"
/26 = "nectar"
/27 = "star"
/28 = "mother"
/29 = "snuggle"
/30 = "beauty"
/31 = "free"
/32 = "wish"
/33 = "justice"
/34 = "cake"
/35 = "devoted"
/36 = "delight"
/37 = "girl"
/38 = "jewel"
/39 = "happy"
/40 = "cheer"
/41 = "luxury"
/42 = "daylight"
/43 = "silk"
/44 = "secure"
```

```
/45 = "pleasure"
/46 = "comfort"
/47 = "dream"
/48 = "baby"
/49 = "useful"
/50 = "bunny"
/51 = "diploma"
/52 = "win"
/53 = "kitten"
/54 = "melody"
/55 = "soft"
/56 = "elegant"
/57 = "quiet"
/58 = "chocolate"
/59 = "embrace"
/60 = "pillow"
/61 = "dove"
/62 = "peace"
/63 = "sunset"
/64 = "crown"
/65 = "wit"
/66 = "garden"
/67 = "glow"
/68 = "kiss"
/69 = "fun"
/70 = "cozy"
/71 = "petal"
/72 = "silver"
/73 = "proud"
/74 = "soothe"
/75 = "lake"
/76 = "humor"
/77 = "respect"
/78 = "carefree"
/79 = "honest"
/80 = "champion"
/81 = "fantasy"
/82 = "eat"
/83 = "toy"
/84 = "love"
/85 = "freedom"
/86 = "bird"
/87 = "enjoy"
/88 = "nice"
/89 = "puppy"
/90 = "lively"
/91 = "restful"
/92 = "smile"
/93 = "tender"
/94 = "health"
/95 = "loyal"
/96 = "laugh"
/97= "spice"
/98= "taxi"
/99= "back"
/100= "survey"
/101= "nutmeg"
```

```
/102= "wood"
/103= "multiple"
/104= "city"
/105= "piano"
/106= "bucket"
/107= "pepper"
/108= "writing"
/109= "narrow"
/110= "meat"
/111= "outside"
/112= "standard"
/113= "mitten"
/114= "toaster"
/115= "carrot"
/116= "sage"
/117= "splash"
/118= "idealist"
/119= "realist"
/120= "reverent"
</item>

<item neutral2words>
/1 = "boxer"
/2 = "ripe"
/3 = "pig"
/4 = "avenue"
/5 = "banner"
/6 = "blender"
/7 = "bathroom"
/8 = "baskets"
/9 = "pencil"
/10 = "bench"
/11 = "round"
/12 = "black"
/13 = "writer"
/14 = "pen"
/15 = "bus"
/16 = "coarse"
/17 = "contents"
/18 = "context"
/19 = "violin"
/20 = "dark"
/21 = "cut"
/22 = "habit"
/23 = "dirt"
/24 = "door"
/25 = "elevator"
/26 = "fabric"
/27 = "fork"
/28 = "glacier"
/29 = "explain"
/30 = "hammer"
/31 = "hard"
/32 = "hide"
/33 = "journal"
/34 = "rock"
/35 = "average"
```

```
/36 = "balcony"
/37 = "tool"
/38 = "alien"
/39 = "steep"
/40 = "knife"
/41 = "museum"
/42 = "scissors"
/43 = "name"
/44 = "double"
/45 = "pamphlet"
/46 = "passage"
/47 = "pinch"
/48 = "time"
/49 = "yellow"
/50 = "board"
/51 = "cyclone"
/52 = "egg"
/53 = "engine"
/54 = "tissue"
/55 = "deep"
/56 = "strange"
/57 = "bland"
/58 = "blasphemy"
/59 = "contain"
/60 = "butter"
/61 = "cane"
/62 = "chair"
/63 = "cellar"
/64 = "clock"
/65 = "cat"
/66 = "corner"
/67 = "vest"
/68 = "push"
/69 = "hay"
/70 = "lazy"
/71 = "ankle"
/72 = "errand"
/73 = "salty"
/74 = "subdue"
/75 = "knot"
/76 = "swamp"
/77 = "thought"
/78 = "detached"
/79 = "clumsy"
/80 = "industry"
/81 = "reptile"
/82 = "sit"
/83 = "ink"
/84 = "part"
/85 = "trumpet"
/86 = "foot"
/87 = "teach"
/88 = "tall"
/89 = "paper"
/90 = "second"
/91 = "floppy"
/92 = "carry"
```

```
/93 = "modest"
/94 = "desert"
/95 = "tight"
/96 = "stock"
/97= "stove"
/98= "clue"
/99= "year"
/100= "street"
/101= "market"
/102= "fish"
/103= "internal"
/104= "ball"
/105= "apple"
/106= "orange"
/107= "thirty"
/108= "teacher"
/109= "square"
/110= "wool"
/111= "forward"
/112= "ordinary"
/113= "muffin"
/114= "gymnast"
/115= "riddle"
/116= "frog"
/117= "celery"
/118= "discreet"
/119= "lenient"
/120= "youngest"
</item>

**************************************************************************
********************************
**************************************************************************
********************************
        EDITABLE INSTRUCTIONS: change instructions here
**************************************************************************
********************************
**************************************************************************
********************************
<instruct>
/windowsize = (80%, 80%)
/ fontstyle = ("Arial", 3.00%, false, false, false, false, 5, 1)
/ txcolor = (black)
/ finishlabel = "Press <Spacebar> to continue"
/nextkey = (57)
/nextlabel = "Press <Spacebar> to continue"
/prevkey = (28)
/prevlabel = "Press <Enter> to go back"
</instruct>

<page instructions>
Kindly complete this task alone in a quiet area. It will take approximately
15 minutes to complete.
^^Place two fingers of your dominant hand (whichever position is most
comfortable for you) on the left arrow key and right arrow key of your
keyboard (located on the bottom right of your keyboard).
```

```
^^Two words will briefly appear to the right and left of the fixation cross
(+). The words are followed by either an <%values.probe1%> or an
<%values.probe2%>.
^^*When you see an <%values.probe1%>, press the left arrow key.
^*When you see an <%values.probe2%> press the right arrow key.
^^^This is a timed sorting task. GO AS FAST AS YOU CAN while making as few
mistakes as possible.

^^^To familiarize yourself with the task, please continue on to some practice
trials. If you make a mistake during practice, a red X will appear
in the middle of the screen.
</page>

<page practice>
Practice is over.

^^Remember:
^^*When you see an <%values.probe1%>, press the left arrow key.
^*When you see an <%values.probe2%> press the right arrow key.

^^^^Be as fast and accurate as you can be.

^^^^When you are ready, continue on to the actual task. There is not going to
be any more feedback.
</page>

<page thankyou>
Thank you for your participation!
</page>

************************************************************************
********************************
************************************************************************
********************************
        EDITABLE LISTS: change editable lists here

************************************************************************
********************************
************************************************************************
********************************

<list itemnumbers>
/ poolsize = 120
/ replace = false
</list>

<list targetlocation>
/ items = (
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
```

```
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2)
/ replace = false
</list>

<list congruence>
/ items = (
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2)
/ selectionmode = list.targetlocation.currentindex
</list>

<list probetype>
/ items = (
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
1, 1, 1, 1, 1,
2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
2, 2, 2, 2, 2)
/ selectionmode = list.targetlocation.currentindex
</list>


**********************************************************************
********************************
                                                          !!!REMAINING
CODE: Customize after careful consideration only!!!
**********************************************************************
********************************

**********************************************************************
**********************************
**********************************************************************
**********************************
        DEFAULTS
```

```
************************************************************************************
************************************
************************************************************************************
************************************
requires Inquisit 4.0.8.0 or higher

<defaults>
/minimumversion = "4.0.8.0"
/ fontstyle = ("Lucida Console", values.letterheight, false, false, false,
false, 5, 1)
/ txcolor = (0, 0, 0)
/ txcolor = (0, 0, 0)
/screencolor = white
/canvasaspectratio = (4,3)
</defaults>

************************************************************************************
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************************************************************************************
************************************
        VALUES: automatically updated
************************************************************************************
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************************************************************************************
************************************

/completed:
                0 = script was not completed; 1 = script was completed (all
conditions run)

/itemnumber:
        stores the itemnumber of the current threat-neutral pairing
/congruence:
        1 = probe and target (threat) congruent; 2 = probe and target (threat)
incongruent
/probeposition:
        determines whether the probe is presented in the threat or neutral
position
/targetlocation:
        1 = target is displayed top (and comp is presented bottom); 2 = target
is presented bottom (comp is presented top)

                        1 = threat position; 0 = neutral position
/probetype:
                determines the type of the probe presented

/threat_y-probe_y:
        the y-coordinate (in %) of the threat/neutral/probe
/neutralword-threatword:
        contain the current stimuli


<values>
/completed = 0

/itemnumber = 0
/congruence = 0
```

```
/targetlocation = 0
/probeposition = 0
/probetype = 0

/threat_x = 0
/neutral_x = 0
/positive_x = 0
/neutral2_x = 0
/probe_y = 0
/probe_x = 0

/threatword = "NA"
/neutralword = "NA"
/positiveword = "NA"
/neutral2word = "NA"
</values>


/trialcount:
        counts all trials
/count_congruent:
        counts the number of times probe is in the threat/neutral position
/count_incongruent:
/sum_correct:
        counts the correct responses
/sum_correct_congruent:
        counts the correct responses to probes in the threat position/probes
in the neutral position
/sum_correct_incongruent:
/sumrt_correct:
        sums the latencies of all correct responses
/sumrt_congruent:
        adds up the latencies in ms for CORRECT responses when the probe is in
the threat position (congruent)
/sumrt_incongruent:
        adds up the latencies in ms for CORRECT responses when the probe is in
the neutral position (incongruent)
/meanrt_congruent:
        contains the mean latency in ms for CORRECT responses when the probe
is in the threat position (congruent)
/meanrt_incongruent:
        contains the mean latency in ms for CORRECT responses when the probe
is in the neutral position (incongruent)
/letterwidth:
        the width of one letter in % of screen width

                        !!! NOTE: this percentage depends on the fonttype and
height used

                        the ratio used in this script (0.45) is calculated
based on monospaced LUCINDA CONSOLE

                        (monospaced = all letters take up the same width)
/wordwidth_threatword:
        contains the width of the current threat word
/wordwidth_neutralword:
        contains the width of the current neutral word
```

```
/wordwidth:
               contains the smaller of the two widths
/index:
               helper variable to calculate the x-coordinate of the probe

<values>
/trialcount = 0
/count_congruent = 0
/count_incongruent = 0
/sum_correct = 0
/sum_correct_congruent = 0
/sum_correct_incongruent = 0
/sumrt_correct = 0
/sumrt_congruent = 0
/sumrt_incongruent = 0
/meanrt_congruent = 0
/meanrt_incongruent = 0
/letterwidth = 0.45 * values.letterheight
/wordwidth_threatword = 0
/wordwidth_neutralword = 0
/wordwidth_positiveword = 0
/wordwidth_neutral2word = 0
/wordwidth = 0
/index = 0
</values>

************************************************************************************
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************************************************************************************
************************************
        EXPRESSIONS
************************************************************************************
************************************
************************************************************************************
************************************
/propcorrect:                          overall proportion correct of all test
trials
/meanRT:                                       overall mean latency in ms of
correct responses of all test trials

/propcorrect_congruent:                proportion correct of all congruent
test trials (congruent = target/threat and probe position congruent)
/propcorrect_incongruent:      proportion correct of all incongruent test
trials (congruent = target/threat and probe position incongruent)

/meanRT_congruent:                     mean latency in ms of correct congruent
test trials
/meanRT_incongruent:           mean latency in ms of correct incongruent test
trials

/TBI:                                          threat bias index calculated by
subtracting the mean latency of responses to probes in threat positions
(congruent)
                                                        from mean latency of
responses to probes in neutral positions (incongruent)

<expressions>
```

```
/propcorrect = values.sum_correct/values.trialcount
/meanRT = values.sumrt_correct/values.sum_correct

/propcorrect_congruent = values.sum_correct_congruent/values.count_congruent
/propcorrect_incongruent =
values.sum_correct_incongruent/values.count_incongruent

/meanRT_congruent = values.sumRT_congruent/values.sum_correct_congruent
/meanRT_incongruent = values.sumRT_incongruent/values.sum_correct_incongruent

/TBI = expressions.meanRT_incongruent - expressions.meanRT_congruent
</expressions>

*********************************************************************************
************************************
*********************************************************************************
************************************
        DATA
*********************************************************************************
************************************
*********************************************************************************
************************************

********************
raw data

Ron Marsh - removed from rawdata dump
/columns = [date, time, participant, values.probetaskselection, blockcode,
trialcode, trialnum,
values.randomprobe_x,
values.congruence, values.targetlocation, values.probeposition,
values.probetype,
values.neutral_y, values.threat_x, values.positive_y, values.neutral2_y,
values.probe_y, values.probe_x,
values.threatword, values.neutralword, values.positiveword,
values.neutral2word, text.probe.currentitem,
response, correct, latency]
********************


<data>
/file = "DotProbe_rawdata.iqdat"
/separatefiles = true
/columns = [date, time, participant, values.probetaskselection, blockcode,
trialcode, trialnum,
values.randomprobe_x, values.congruence, values.targetlocation,
values.probeposition, values.probetype,
values.threatword, values.neutralword, values.positiveword,
values.neutral2word, text.probe.currentitem,
response, correct, latency]
</data>

********************
summary data
********************

<summarydata >
```

```
/file = "DotProbe_summary.iqdat"
/columns = [script.startdate, script.starttime, script.participantid,
script.groupid, script.elapsedtime, values.completed,
values.probetaskselection, values.fixationduration, values.targetduration,
values.TP_ISI, values.probe_posttrialpause,
values.probe1, values.probe2, values.randomprobe_x,
expressions.propcorrect, expressions.meanRT,
expressions.propcorrect_congruent, expressions.propcorrect_incongruent,
expressions.meanRT_congruent, expressions.meanRT_incongruent,
expressions.TBI]
</summarydata>

************************************************************************
**********************************
************************************************************************
**********************************
        STIMULI
************************************************************************
**********************************
************************************************************************
**********************************

<text threatword>
/items = threatwords
/select = values.itemnumber
/hposition = values.threat_x
/vposition = values.target_y
/ erase = false
</text>

<text neutralword>
/items = neutralwords
/select = values.itemnumber
/hposition = values.neutral_x
/vposition = values.target_y
/ erase = false
</text>

<text positiveword>
/items = positivewords
/select = values.itemnumber
/hposition = values.positive_x
/vposition = values.target_y
/ erase = false
</text>

<text neutral2word>
/items = neutral2words
/select = values.itemnumber
/hposition = values.neutral2_x
/vposition = values.target_y
/ erase = false
</text>

****************************
other stimuli
****************************
```

```
<text fixation>
/items = ("+")
/ erase = false
</text>

<text probe>
/items = ("<%values.probe1%>", "<%values.probe2%>")
/select = values.probetype
/hposition = values.probe_x
/vposition = values.probe_y
/color = black
</text>

<shape eraser>
/shape = rectangle
/size = (100%, 100%)
/color = white
/position = (50%, 50%)
/erase = false
</shape>

<text feedback>
/items = ("X")
/txcolor = red
/position = (50%, 50%)
/ fontstyle = ("Arial", 10%, true, false, false, false, 5, 1)
</text>

************************************************************************
************************************
************************************************************************
************************************
        LISTS
************************************************************************
************************************
************************************************************************
************************************

*************NOTE: The following lists operate regardless of number of trials

NOTE: list.oddnumbers is used to calculate the random position of the probe
for even
numbered targets
*values.index is randomly determined and depends on the length of the word
<list oddnumbers>
/items = (1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21)
/selectionmode = values.index
</list>

Note: list.evennumbers is used to calculate the random position of the probe
for odd
numbered targets
<list evennumbers>
/items = (0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20)
/selectionmode = values.index
</list>
```

```
Note: list.multiplicator is used to decide whether the probe should appear
on the left or right side of the monitor
(1 = right side, -1 = left side)
<list multiplicator>
/items = (1, -1)
/replace = true
</list>

************************************************************************
************************************
************************************************************************
************************************
        EXPERIMENTAL TRIALS
************************************************************************
************************************
************************************************************************
************************************

<trial threat>
/ ontrialbegin = [values.trialcount += 1]
/ ontrialbegin = [values.targetlocation = list.targetlocation.nextvalue]
/ ontrialbegin = [if (values.probetaskselection == 1) values.congruence = 1
                                        else if (values.probetaskselection ==
2) values.congruence = 2
                                        else values.congruence =
list.congruence.nextvalue]
/ ontrialbegin = [values.probetype = list.probetype.nextvalue]

/ ontrialbegin = [if (values.targetlocation == 1) {values.threat_x =
values.target_left_x; values.neutral_x = values.target_right_x}
                                                  else {values.threat_x =
values.target_right_x; values.neutral_x = values.target_left_x}]
/ ontrialbegin = [if (values.congruence == 1) {values.probe_x =
values.threat_x; values.probeposition = values.targetlocation}
                                        else {values.probe_x =
values.neutral_x}]
/ ontrialbegin = [if (values.targetlocation == 1 && values.congruence == 2)
values.probeposition = 2]
/ ontrialbegin = [if (values.targetlocation == 2 && values.congruence == 2)
values.probeposition = 1]

/ ontrialbegin = [values.itemnumber = list.itemnumbers.nextindex]
/ ontrialbegin = [values.threatword =
item.threatwords.item(values.itemnumber)]
/ ontrialbegin = [values.neutralword =
item.neutralwords.item(values.itemnumber)]
/ ontrialbegin = [values.wordwidth_threatword = length(values.threatword)]
/ ontrialbegin = [values.wordwidth_neutralword = length(values.neutralword)]
/ ontrialbegin = [if (values.congruence == 1) values.wordwidth =
values.wordwidth_threatword else values.wordwidth =
values.wordwidth_neutralword]
/ ontrialbegin = [if (values.randomprobe_x != 1) {values.probe_y =
values.target_y}]
/ ontrialbegin = [if (values.randomprobe_x == 1 &&
mod(values.wordwidth,2)==0)
                                {values.index =
ceil(rand(0,0.5*values.wordwidth));
```

```
                                values.probe_y = values.target_y +
list.multiplicator.nextvalue * list.oddnumbers.nextvalue *
(values.letterwidth/2)}]
/ ontrialbegin = [if (values.randomprobe_x == 1 && mod(values.wordwidth,2) !=
0)
                                {values.index = ceil(rand(0,
0.5*(values.wordwidth +1 )));
                                values.probe_y = values.target_y +
list.multiplicator.nextvalue * list.evennumbers.nextvalue *
(values.letterwidth/2)}]

/ ontrialbegin = [trial.threat.insertstimulustime(text.threatword,
values.fixationduration)]
/ ontrialbegin = [trial.threat.insertstimulustime(text.neutralword,
values.fixationduration)]
/ ontrialbegin = [trial.threat.insertstimulustime(shape.eraser,
(values.fixationduration+values.targetduration))]
/ ontrialbegin = [trial.threat.insertstimulustime(text.fixation,
(values.fixationduration+values.targetduration))]
/ ontrialbegin =
[trial.threat.insertstimulustime(text.probe,(values.fixationduration+values.t
argetduration+values.tp_isi))]
/ ontrialend = [trial.threat.resetstimulusframes()]
/ stimulustimes = [0 = fixation]
/ beginresponsetime =
values.fixationduration+values.targetduration+values.tp_isi
/ responseinterrupt = immediate

/ monkeyresponse = (18, 23)
/ isvalidresponse = [trial.threat.response == values.responsekey_probe1 ||
trial.threat.response == values.responsekey_probe2]
/ iscorrectresponse = [(values.probetype == 1 && trial.threat.response ==
values.responsekey_probe1) ||
                                (values.probetype == 2 &&
trial.threat.response == values.responsekey_probe2)]

/ ontrialend = [if (values.congruence == 1) values.count_congruent += 1 else
values.count_incongruent += 1]
/ ontrialend = [if (trial.threat.correct && values.congruence == 1)
{values.sum_correct_congruent += 1; values.sumrt_congruent +=
trial.threat.latency}]
/ ontrialend = [if (trial.threat.correct && values.congruence == 2)
{values.sum_correct_incongruent += 1; values.sumrt_incongruent +=
trial.threat.latency}]

/ posttrialpause = values.probe_posttrialpause
</trial>

<trial positive>
/ ontrialbegin = [values.trialcount += 1]
/ ontrialbegin = [values.targetlocation = list.targetlocation.nextvalue]
/ ontrialbegin = [if (values.probetaskselection == 1) values.congruence = 1
                                else if (values.probetaskselection ==
2) values.congruence = 2
                                else values.congruence =
list.congruence.nextvalue]
/ ontrialbegin = [values.probetype = list.probetype.nextvalue]
```

```
/ ontrialbegin = [if (values.targetlocation == 1) {values.positive_x =
values.target_left_x; values.neutral2_x = values.target_right_x}
                                                  else {values.positive_x =
values.target_right_x; values.neutral2_x = values.target_left_x}]
/ ontrialbegin = [if (values.congruence == 1) {values.probe_x =
values.positive_x; values.probeposition = values.targetlocation}
                                        else {values.probe_x =
values.neutral2_x}]
/ ontrialbegin = [if (values.targetlocation == 1 && values.congruence == 2)
values.probeposition = 2]
/ ontrialbegin = [if (values.targetlocation == 2 && values.congruence == 2)
values.probeposition = 1]

/ ontrialbegin = [values.itemnumber = list.itemnumbers.nextindex]
/ ontrialbegin = [values.positiveword =
item.positivewords.item(values.itemnumber)]
/ ontrialbegin = [values.neutral2word =
item.neutral2words.item(values.itemnumber)]
/ ontrialbegin = [values.wordwidth_positiveword =
length(values.positiveword)]
/ ontrialbegin = [values.wordwidth_neutral2word =
length(values.neutral2word)]
/ ontrialbegin = [if (values.congruence == 1) values.wordwidth =
values.wordwidth_positiveword else values.wordwidth =
values.wordwidth_neutral2word]
/ ontrialbegin = [if (values.randomprobe_x != 1) {values.probe_y =
values.target_y}]
/ ontrialbegin = [if (values.randomprobe_x == 1 &&
mod(values.wordwidth,2)==0)
                                {values.index =
ceil(rand(0,0.5*values.wordwidth));
                                values.probe_y = values.target_y +
list.multiplicator.nextvalue * list.oddnumbers.nextvalue *
(values.letterwidth/2)}]
/ ontrialbegin = [if (values.randomprobe_x == 1 && mod(values.wordwidth,2) !=
0)
                                {values.index = ceil(rand(0,
0.5*(values.wordwidth +1 )));
                                values.probe_y = values.target_y +
list.multiplicator.nextvalue * list.evennumbers.nextvalue *
(values.letterwidth/2)}]

/ ontrialbegin = [trial.positive.insertstimulustime(text.positiveword,
values.fixationduration)]
/ ontrialbegin = [trial.positive.insertstimulustime(text.neutral2word,
values.fixationduration)]
/ ontrialbegin = [trial.positive.insertstimulustime(shape.eraser,
(values.fixationduration+values.targetduration))]
/ ontrialbegin = [trial.positive.insertstimulustime(text.fixation,
(values.fixationduration+values.targetduration))]
/ ontrialbegin =
[trial.positive.insertstimulustime(text.probe,(values.fixationduration+values
.targetduration+values.tp_isi))]
/ ontrialend = [trial.positive.resetstimulusframes()]
/ stimulustimes = [0 = fixation]
```

```
/ beginresponsetime =
values.fixationduration+values.targetduration+values.tp_isi
/ responseinterrupt = immediate

/ monkeyresponse = (18, 23)
/ isvalidresponse = [trial.positive.response == values.responsekey_probe1 ||
trial.positive.response == values.responsekey_probe2]
/ iscorrectresponse = [(values.probetype == 1 && trial.positive.response ==
values.responsekey_probe1) ||
                                        (values.probetype == 2 &&
trial.positive.response == values.responsekey_probe2)]

/ ontrialend = [if (values.congruence == 1) values.count_congruent += 1 else
values.count_incongruent += 1]
/ ontrialend = [if (trial.positive.correct && values.congruence == 1)
{values.sum_correct_congruent += 1; values.sumrt_congruent +=
trial.positive.latency}]
/ ontrialend = [if (trial.positive.correct && values.congruence == 2)
{values.sum_correct_incongruent += 1; values.sumrt_incongruent +=
trial.positive.latency}]

/ posttrialpause = values.probe_posttrialpause
</trial>


**************************************************************************
**********************************
**************************************************************************
**********************************
        PRACTICE
**************************************************************************
**********************************
**************************************************************************
**********************************
NOTE: this practice session is not original to MacLeod et al (2007)

*****************************
Practice Stimuli
*****************************

<item practicewords_1>
/1 = "one"
/2 = "two"
/3 = "three"
/4 = "four"
/5 = "five"
/6 = "six"
/7 = "seven"
/8 = "eight"
/9 = "nine"
/10 = "ten"
</item>

<item practicewords_2>
/1 = "two"
/2 = "ten"
/3 = "seven"
```

```
/4 = "nine"
/5 = "four"
/6 = "one"
/7 = "eight"
/8 = "three"
/9 = "five"
/10 = "six"
</item>

<text practiceword_1>
/items = practicewords_1
/select = values.itemnumber
/hposition = values.threat_x
/vposition = values.target_y
</text>

<text practiceword_2>
/items = practicewords_2
/select = values.itemnumber
/hposition = values.neutral_x
/vposition = values.target_y
</text>

*****************************
Practice Lists
*****************************

<list practiceitemnumbers>
/poolsize = 10
/replace = false
</list>


<list practicetargetposition>
/items = (1, 1, 1, 1, 1, 2, 2, 2, 2, 2)
/replace = false
</list>

<list practicecongruence>
/items = (1, 1, 1, 1, 1, 2, 2, 2, 2, 2)
/replace = false
</list>

<list practiceprobetype>
/items = (1, 1, 1, 1, 1, 2, 2, 2, 2, 2)
/replace = false
</list>
*****************************
Practice Trials
*****************************

<trial practice>
/ ontrialbegin = [values.targetlocation =
list.practicetargetposition.nextvalue]
/ ontrialbegin = [if (values.probetaskselection == 1) values.congruence = 1
                                        else if (values.probetaskselection ==
2) values.congruence = 2
```

```
                                        else values.congruence =
list.practicecongruence.nextvalue]
/ ontrialbegin = [values.probetype = list.practiceprobetype.nextvalue]

/ ontrialbegin = [if (values.targetlocation == 1) {values.threat_x =
values.target_left_x; values.neutral_x = values.target_right_x}
                                                  else {values.threat_x =
values.target_right_x; values.neutral_x = values.target_left_x}]
/ ontrialbegin = [if (values.congruence == 1) {values.probe_x =
values.threat_x; values.probeposition = values.targetlocation}
                                        else {values.probe_x =
values.neutral_x}]
/ ontrialbegin = [if (values.targetlocation == 1 && values.congruence == 2)
values.probeposition = 2]
/ ontrialbegin = [if (values.targetlocation == 2 && values.congruence == 2)
values.probeposition = 1]

/ ontrialbegin = [values.itemnumber = list.practiceitemnumbers.nextindex]
/ ontrialbegin = [values.threatword =
item.practicewords_1.item(values.itemnumber)]
/ ontrialbegin = [values.neutralword =
item.practicewords_2.item(values.itemnumber)]
/ ontrialbegin = [values.wordwidth_threatword = length(values.threatword)]
/ ontrialbegin = [values.wordwidth_neutralword = length(values.neutralword)]
/ ontrialbegin = [if (values.congruence == 1) values.wordwidth =
values.wordwidth_threatword else values.wordwidth =
values.wordwidth_neutralword]
/ ontrialbegin = [if (values.randomprobe_x != 1) {values.probe_y =
values.target_y}]
/ ontrialbegin = [if (values.randomprobe_x == 1 &&
mod(values.wordwidth,2)==0)
                                {values.index =
ceil(rand(0,0.5*values.wordwidth));
                                values.probe_y = values.target_y +
list.multiplicator.nextvalue * list.oddnumbers.nextvalue *
(values.letterwidth/2)}]
/ ontrialbegin = [if (values.randomprobe_x == 1 && mod(values.wordwidth,2) !=
0)
                                {values.index = ceil(rand(0,
0.5*(values.wordwidth +1 )));
                                values.probe_y = values.target_y +
list.multiplicator.nextvalue * list.evennumbers.nextvalue *
(values.letterwidth/2)}]

/ ontrialbegin = [trial.practice.insertstimulustime(text.practiceword_1,
values.fixationduration)]
/ ontrialbegin = [trial.practice.insertstimulustime(text.practiceword_2,
values.fixationduration)]
/ ontrialbegin = [trial.practice.insertstimulustime(shape.eraser,
(values.fixationduration+values.targetduration))]
/ ontrialbegin = [trial.practice.insertstimulustime(text.fixation,
(values.fixationduration+values.targetduration))]
/ ontrialbegin =
[trial.practice.insertstimulustime(text.probe,(values.fixationduration+values
.targetduration+values.tp_isi))]
/ ontrialend = [trial.practice.reseteventstimulusframes()]
/ stimulustimes = [0 = fixation]
```

```
/ beginresponsetime =
values.fixationduration+values.targetduration+values.tp_isi
/ responseinterrupt = immediate

/ monkeyresponse = (18, 23)
/ isvalidresponse = [trial.practice.response == values.responsekey_probe1 ||
trial.practice.response == values.responsekey_probe2]
/ iscorrectresponse = [(values.probetype == 1 && trial.practice.response ==
values.responsekey_probe1) ||
                                        (values.probetype == 2 &&
trial.practice.response == values.responsekey_probe2)]
/errormessage = (feedback, 1000)
/ posttrialpause = values.probe_posttrialpause
</trial>

*****************************
Practice Block
*****************************

<block practice>
/postinstructions = (practice)
/trials = [1-10 = practice]
</block>

*************************************************************************
*************************************
*************************************************************************
*************************************
        EXPERIMENTAL BLOCKS
*************************************************************************
*************************************
*************************************************************************
*************************************

<block DotProbeTask>
/trials = [1-120 = threat]
</block>

<block Pos_DotProbeTask>
/trials = [1-120 = positive]
</block>

*************************************************************************
*************************************
*************************************************************************
*************************************
        EXPERIMENT
*************************************************************************
*************************************
*************************************************************************
*************************************

<expt >
/preinstructions = (instructions)
/postinstructions = (thankyou)
/blocks = [1 = practice; 2 = DotProbeTask; 3 = Pos_DotProbeTask]
/onexptend = [values.completed = 1]
```

```
</expt>

******************************************************************************
************************************
End of File
******************************************************************************
************************************
```