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Evaluating the attention Training Technique as a Transdiagnostic Intervention for Fear-Based Psychopathological Symptoms: a Randomized Controlled Trial

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ABSTRACT

EVALUATING THE ATTENTION TRAINING TECHNIQUE AS A TRANSDIAGNOSTIC INTERVENTION FOR FEAR-BASED PSYCHOPATHOLOGICAL SYMPTOMS: A RANDOMIZED CONTROLLED TRIAL

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Recent research indicates that fear-related psychological disorders are a distinguished class of psychopathology, all of which share the underlying endophenotype of maladaptive acute fear responding. The relationship between maladaptive fear responding and psychopathology has been found to be moderated by executive functioning capacity—most notably attentional control. However, the current psychopathological nosology does not link fear-based disorders together. As a result, many fear-based disorders are treated separately with different evidence-based psychotherapies. These psychotherapies tend to focus on reducing phenotypic behaviors or self-reported experience of symptoms. Individuals with fear-based disorders may be better served by treatments that focus on the aforementioned endophenotypes such as attentional control. The Attention Training Technique (ATT) is a neurobehavioral treatment that has been shown to improve symptoms of many fear-based disorders in several studies and across a diverse set of clinical and non-clinical samples. The present study sought to examine the mechanisms of ATT in a sample with self-reported fear-based symptoms through a randomized controlled trial of ATT vs. a sham control condition. Results indicated that attentional control did not moderate the relationship between fear and fear-based psychopathology and was unrelated to either construct. However, results did indicate that fear and fear-based psychopathology were related to the

alerting system of attention, rather than the executive attentional control system, and that fear-responding appears to partially mediate change in fear-based psychopathology. Implications for these findings with respect to psychiatric nosology and psychotherapy are discussed.

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EVALUATING THE ATTENTION TRAINING TECHNIQUE AS A TRANSDIAGNOSTIC
INTERVENTION FOR FEAR-BASED PSYCHOPATHOLOGICAL SYMPTOMS:
A RANDOMIZED CONTROLLED TRIAL

BY
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TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
Chapter	
1. INTRODUCTION	1
2. LITERATURE REVIEW	8
Fear	8
Threat Bias	11
Attention Control	15
Neurobiology Linking Acute Fear Response and Attentional Control.....	17
Targeted Treatment.....	20
The Attention Training Technique.....	20
Theoretical Basis of ATT.....	22
Therapeutic Process of Change in ATT.....	29
The Present Study	31
Hypotheses	31
Measures Check Hypothesis.....	32
A Priori Hypotheses.....	33
Exploratory Hypothesis	34
3. METHODS	35
Participants.....	35

Chapter	Page
Sample Size.....	36
Measures	37
Time 0 Fear Symptom Survey	43
Procedures.....	47
4. RESULTS	51
Tests of MLM Assumptions, Normality, and Missing Data.....	51
Testing the Hypotheses	53
Hypothesis 0.....	53
Hypothesis 1.....	54
Hypothesis 2.....	59
Hypothesis 3.....	61
Hypothesis 4.....	62
Hypothesis 5.....	64
Hypothesis 6.....	66
Hypothesis 7.....	69
Hypothesis 8.....	70
5. DISCUSSION	74
Limitations	82
Conclusions.....	85
REFERENCES	87

LIST OF TABLES

Table	Page
1. Categorical Variable Differences Between ATT and Sham ATT Groups (χ^2) – Time 1 ...	52
2. Continuous Variable Differences Between ATT and Sham ATT Groups (ANOVA) – Time 1	53
3. Time 4 Attention, Fear, and Psychological Variables, ATT Group Only	55
4. Time 4 Attention, Fear, and Psychological Variables, Sham ATT Group Only	56
5. Time 7 Attention, Fear, and Psychological Variables, ATT Group Only	57
6. Time 7 Attention, Fear, and Psychological Variables, Sham ATT Condition Only	58
7. Correlations of All Data Points Across Time, Condition, and Participant	73
8. Cognitive Variables Across Time, ATT Condition Only	75
9. Cognitive Variables Across Time, Sham ATT Condition Only	76
10. Time 1 Attention, Fear, and Psychological Variables	83

CHAPTER 1

INTRODUCTION

Recent research indicates that fear-based psychological disorders are a distinguished class of psychopathology (Flores et al., 2018; Gorka et al., 2017; LeDoux & Pine, 2016). Fear-related psychopathology includes panic disorder, specific phobias, social anxiety disorder (SAD), and sometimes posttraumatic stress disorder (PTSD; Hettrema et al. 2005; Kendler et al. 2003), which is grouped within a broad “distress” category in an alternative nosology (Ruggero et al., 2019). Additionally, OCD has been included in fear-based psychopathology in this alternative nosology. All empirically derived nosologies exclude generalized anxiety disorder (GAD) from fear-based disorders, which is generally theorized to be a disorder of “misery” (Gorka et al., 2017) or “distress” (Ruggero et al., 2019) rather than of fear, bolstered by network analytic studies that show symptoms of GAD and MDD are far more connected than symptoms of, for example, specific phobia and MDD (Price et al., 2019). The underlying theory behind Gorka and colleague’s (2017) relatively novel grouping of seemingly distinct psychopathologies is straightforward: all of the included disorders share the underlying causal mechanism, or endophenotype, of maladaptive acute fear responding (Velasco et al., 2019). The extant literature also indicates that individual differences in fear responding are modulated by executive functioning capacity, specifically attentional control, which serves to mitigate the effect of overactive fear networks (Bardeen, 2020). Therefore, fear-based disorders commonly share both fear-based and executive attention-based mechanisms. Empirical evidence supports the grouping

of these disorders together—individuals with these diagnoses have been shown in a variety of studies to display similar tendencies such as impairments in fear load and fear extinction (Jovanovic et al., 2012; Jovanovic & Norrholm, 2011; Milad et al., 2009) as well as impairments in attentional control (O’Neil et al., 2019; Scott et al., 2015), although attentional control is likely a less specific mechanism than fear responding (Hsu et al., 2015). For instance, in a study of anxious individuals, increased anxiety was predictive of increased attentional bias towards threat but not predictive of impaired executive functioning (Salahub & Emrich, 2020).

Despite a growing body of research that began prior to the publication of the Diagnostic and Statistical Manual, 5th edition (DSM-5; American Psychiatric Association [APA], 2013), in the most up-to-date version of the DSM-5-TR, many fear-related disorders are conceptualized as diagnostically distinct from one another based upon the notion that subjective experience of cognitive and behavioral symptoms tend to cluster together to form the basis of a unique psychological disorder. Efforts to empirically validate the grouping of phenotypic clusters of symptoms found in the current psychiatric nosology of fear-related disorders have revealed inconsistent results at best (Bartels et al., 2019; Birkeland & Heir, 2017; McNally, Heeren, & Robinaugh, 2017; Price et al., 2019; Spiller et al., 2017). For instance, in a network analysis from Birkeland and Heir (2017) of PTSD symptoms based on the DSM-IV diagnosis, feeling detached, feeling numb, and difficulty concentrating were found to be most central to the disorder. On the other hand, in a separate network analysis using DSM-IV PTSD symptoms, McNally, Heeren, and Robinaugh (2017) found that nightmares, feeling distant from others, and having a foreshortened future were most central to the disorder. A third network analytic study (Spiller et al., 2017) found that the most central symptoms of DSM-5 PTSD were emotional cue reactivity, physical cue reactivity, increased risk taking, and acute startle response. Notably, all

three of the previously described network analyses were produced in culturally distinct adult samples from different countries, which may explain some of the differences between the networks. Ideally, diagnostic categories would not be significantly influenced by cultural factors, as this would reduce their applicability to only the dominant cultural group.

Furthermore, significant sex differences in prevalence rates of several fear-based diagnoses (de Jonge et al., 2016; Steel et al., 2014), along with other data discussed here, call into question the validity of the current diagnostic system which, as previously discussed, relies upon classifying phenotypic behaviors or self-reported experiences of symptoms into symptom clusters. One would expect that, due to these sex differences in diagnostic prevalence, there would also exist an observable difference in the underlying causal mechanisms that lead to the development of these disorders between males and females. In other words, males and females would exhibit differential functioning in their fear acquisition or expression mechanisms, observed either neurologically or through systematic controlled experimental paradigms that would explain the sex differences in diagnostic prevalence rates. However, no such differences have been found in humans. According to an extensive review on the topic, while some studies have found differences in fear extinction between males and females, an equivalent number of studies have not (Velasco et al., 2019). Furthermore, human males and females appear to have similarly functioning fear responding mechanisms, although some differences are observed in animal studies (Velasco et al., 2019).

These inconsistent findings have led researchers to seek out and empirically examine other explanations for sex differences in fear-based disorder prevalence. One alternative explanation, like the explanation offered for the differing findings of the PTSD symptom network analyses, is that cultural and gender differences influence diagnosis to a much greater

degree than biological sex. At least one study has found direct evidence for this (Carter, 2011), and emergent literature on COVID-19-related anxiety and threat perceptions revealed a substantial effect of gender on anxiety (Cohen's $d = .316$; Metin et al., 2022). It is generally not the case that gender is reported as a risk factor for contracting COVID-19. In fact, one meta-analysis indicated that COVID-19 was associated with higher mortality in men, rather than in women. Taken together, cultural factors such as increased responsibility for childcare rather than biological sex differences are perhaps a better explanation for these findings. Therefore, it may be more reliable and valid to orient diagnostic procedures in such a way as to eliminate or reduce the impact of culture. This would be particularly important in clinical settings which serve diverse populations and would benefit from universally applicable diagnostic tools, along with psychotherapies specifically targeting these endophenotype-based diagnoses. One possible, but understudied, way to achieve this would be to develop treatments that focus on endophenotypic factors that are known to contribute to or cause psychopathology (e.g., fear load) rather than purely phenotypic symptoms (e.g., self-reported or clinically assessed “marked fear or anxiety about a specific object or situation... not better explained by the symptoms of another mental disorder, including fear, anxiety, and avoidance of situations associated with panic-like symptoms” which is characterized by “an abrupt surge of intense fear, or intense discomfort that reaches a peak within minutes” and is accompanied by 4 or more physiological symptoms, but not physiological symptoms that would fall under the category of “culture-specific symptoms,” and which occur in specific “feared situations” exclusively, rather than situations more generally... etc., etc. [APA, 2013, pp.197, 202, 208]). This alternative approach could avoid or reduce the cultural factors that may bias diagnoses such as panic disorder significantly towards

women, and may improve treatment response due to more accurate diagnosis and responsive treatment selection.

Likely due to the relative novelty of grouping disorders based on endophenotypes such as fear responding, current psychotherapies meant to treat fear-related disorders focus on ameliorating phenotypic symptoms rather than endophenotypic mechanisms (e.g., Foa et al., 1991; Monson et al., 2006) and, in general, a significant minority of patients tend not to respond to these treatments (e.g., Foa et al., 2005; Foa et al., 2013; Powers et al., 2010; Resick et al., 2002). Additionally, new treatment protocols developed alongside the current categorical diagnostic nosology tend to produce no actual comparative improvements in terms of treatment outcome. For example, Acceptance and Commitment Therapy (ACT) has been examined as an evidence-based psychotherapy (EBP) for the treatment of several psychological disorders (Öst, 2014). Initially, ACT appeared to be superior to standard CBT protocols for the treatment of such psychological disorders (e.g., anxiety and depression; Ruiz, 2012). However, more recently, a greater level of scrutiny has been applied to ACT which produced higher quality studies of the EBP. A meta-analysis of these higher quality studies found no difference in treatment outcomes between high-quality traditional CBT and high-quality ACT studies (Öst, 2014). A similar sequence of events can be observed for behavioral activation therapy for depression (Ekers et al., 2014). In fact, a recent meta-analysis found that most common treatments for depression were largely equivalent to each other, with most patients improving after 8-12 weeks but a sizeable minority remaining symptomatic (Barth et al., 2013).

Treatment efficacy may be enhanced when treatments target endophenotypic mechanisms rather than phenotypic symptoms. Individuals with putatively different diagnoses may share a high degree of overlap in the underlying causal mechanisms that contribute to their qualitatively

different experiences of psychopathology. It is critical to advance new treatments that demonstrate greater success in treating fear related disorders, particularly treatments designed to target endophenotypic mechanisms. Endophenotypic mechanisms are advantageous over standard DSM constructs for several reasons. Chiefly among them is the ability for these mechanisms to much more easily translate into the fields of neurology and biology (Iacono et al., 2014). Furthermore, through a nosology based on endophenotypic mechanisms, more accurate diagnostic tools are theoretically possible (Young, 2014). Additionally, animal models of endophenotypes are more easily applied to human behaviors and psychopathology (Anderzhanova et al., 2017).

In that vein, it is important to note that fear-related psychological disorders share the underlying endophenotypic biomarkers of acute fear response (Baker et al., 2019; Briscione et al., 2014) as well as impairment in executive functions (Ghassemzadeh et al., 2019), specifically attentional control. Attentional control is the use of top-down executive attentional processes to regulate bottom-up emotional responses (Derryberry & Reed, 2002). Fear and attentional control, among many other endophenotypes, have been identified by the Research Domain Criteria (RDoC) project as potential dimensional correlates of psychopathology underlying many currently conceptualized categorical diagnoses (Cuthbert, 2014). Furthermore, these endophenotypes may prove to be underlying mechanisms by which individuals develop and maintain fear-related psychopathology. Both fear load and fear inhibition, as measured by the fear potentiated startle (FPS) paradigm, have been found to be related to PTSD and several anxiety disorders (Briscione et al., 2014; Jovanovic et al., 2014, 2013; Yarrington et al., 2022). Additionally, attentional control and other executive functions have been found to be related to PTSD and anxiety disorders (Bardeen & Daniel, 2017; Block & Liberzon, 2016; Fu et al., 2017;

Glassman et al., 2017; Liang, 2021). This suggests that these disorders share a common etiology or, at the very least, share a common risk factor.

CHAPTER 2

LITERATURE REVIEW

The following literature review provides evidence from clinical, cognitive, and neurocognitive science linking the endophenotypes of fear and attentional control in the context of various psychopathologies. Following this review, the Attention Training Technique (ATT) is explored as a viable neurobehavioral treatment that may target the underlying nexus of fear and attentional impairment as its clinical mechanism of action. The general clinical theory upon which ATT is based, metacognitive theory, is then examined. Based on this examination, it is determined that the theoretical underpinnings of ATT are promising, yet understudied, and warrant additional research. Therefore, a randomized controlled trial of ATT was performed in order to test various assumptions of metacognitive theory as well as to determine whether the mechanism of therapeutic change of ATT is related to fear and/or attentional control. The results of this RCT are presented and discussed.

Fear

Acute fear response has been identified as a key underlying endophenotype of anxiety disorders and PTSD. An important paradigm that has provided a great deal of evidence within the extant fear responding literature is the Fear-Potentiated Startle (FPS) paradigm, a translational psychophysiological method of assessing fear responding. Due to the importance of the paradigm to the fear literature, a brief explanation of FPS follows. The paradigm utilizes

basic classical conditioning principles by pairing a neutral conditioned stimulus (CS+) with an aversive unconditioned stimulus (US) to evoke a fear response, such as startle measured by eye-blink magnitude. Fear-potentiated startle is an experimental paradigm that has provided an understanding of fear neurocircuitry in rodents (Davis, 2006; Moaddab & Dabrowska, 2017; Sink et al., 2013), as well as humans (Grillon, 2008; Norrholm et al., 2015). Recently, the paradigm has been utilized to identify trajectories of extinction learning across species (Galatzer-Levy, 2017), as well as to predict PTSD symptoms in a sample of firefighters with the assistance of machine learning (Li et al., 2022). The FPS paradigm produces several markers of fear responding including fear inhibition (decreased startle during later stages of extinction) and fear load (higher startle during early phases of extinction), both of which have been associated with fear-related psychopathology. Studies that utilize FPS tend to selectively use several biomarkers of fear including skin conductance, heart rate, EEG, and eye-blink magnitude. Some report using several markers while others report using only a single marker. Regardless of methodology, the individual variance in the selected biomarker or biomarkers are referred to as fear inhibition and fear load. This review refers to the combination of fear inhibition and fear load together as “fear responding.”

Recent evidence implicates basic fear responding as a particularly robust factor that predicts PTSD (see Zuj & Norrholm, 2019 for review). Fear inhibition has also been shown to differ at varying levels of PTSD severity, as individuals with severe PTSD show a relative inability to inhibit startle response when compared to individuals with PTSD in the low severity range and trauma-exposed individuals without PTSD (see Norrholm & Jovanovic, 2018 for review). Norrholm et al. (2011) similarly demonstrated greater fear load, as well as poorer fear inhibition, in trauma-exposed individuals with PTSD compared to those without PTSD. Perhaps

most convincingly, new research has indicated that an intensive inpatient prolonged-exposure therapy for PTSD reduced the within-subjects pre-post fear load of participants who responded to treatment (Maples-Keller et al., 2022). The study also found that low-responders to treatment (those who reported a less than 50% reduction in PTSD symptoms) retained their high fear responding characteristics at the end of treatment. This study indicates that fear responding is directly related to an individual's subjective experience of a psychological disorder.

Studies show that acute fear responding is also important to many anxiety disorders. A recent meta-analysis of the FPS paradigm in individuals with anxiety disorders found that, during the acquisition phase, anxious individuals exhibited greater fear responding to safety cues relative to healthy controls (Duits et al., 2015). This finding suggests that patients with anxiety disorders exhibit an overgeneralization of fear responses and thus show patterns of more acute fear responding behavior (Dymond, et al., 2015; Lissek et al., 2010), which is very similar to individuals with PTSD. Another study found that high trait anxiety was related to an impaired ability to detect environmental safety cues (Haaker et al., 2015), which is also similar to the findings regarding PTSD. Studies using the FPS paradigm in patients with anxiety disorders have also revealed that, during the extinction phase, anxious participants display a stronger response to conditioned stimuli (Duits et al., 2015), despite the aversive stimulus no longer being paired with the conditioned stimulus (i.e., in the extinction phase). This finding is indicative of a deficit in fear inhibition (Duits et al., 2017), a factor that significantly contributes to overall acute fear responding. Furthermore, the link between anxiety and acute fear response does not appear to be improved by cognitive-behavioral methods of treatment (Duits et al., 2016), suggesting that acute fear response is a predictor of the development of an anxiety disorder, rather than a symptom of the disorder.

Threat Bias

Theories of the etiology and maintenance of fear-based disorders, including anxiety disorders and PTSD, tend to include attentional bias towards threat (ABT) as a contributing factor, with varying levels of emphasis (Bardeen, 2020; Weierich, Treat, & Hollingworth, 2008). This construct is distinct from fear responding generally, as ABT describes the attentional processes that theoretically result from and/or produce maladaptive fear responding in individuals with fear-based psychopathology. As such, ABT is an important factor to consider in fear-based psychopathologies as it is the point at which attentional and fear systems connect. Based on large-scale population-wide data, it has been established that people suffering from PTSD or anxiety disorders display attention deficits in addition to fear-based symptoms (Fu et al., 2017; Glassman et al., 2017; Scott et al., 2015). Therefore, a unified theory of fear-based disorders may be well suited to explain the abundance of apparent overlapping components of several anxiety disorders and PTSD. The nexus of many of these components is within the concept of ABT.

Given its importance to a wide swath of the clinical literature, ABT has been studied extensively and in many contexts. However, there are several gaps and points of disagreement in the ABT literature worth noting. For example, ABT is generally considered by some to be an automatic bottom-up attentional process that is learned through classical conditioning processes (Constans, 2005; Yiend, 2010). Therefore, individuals with high levels of anxiety and/or fear are thought to more quickly detect and attend to feared stimuli (Bardeen, 2020), which is highly adaptive in actual dangerous contexts, but maladaptive in safe contexts. However, ABT has also been conceptualized in the literature as simply the tendency for an individual to attend to

threatening stimuli (Cisler & Koster, 2010). This broader definition may be preferred, since it more easily fits with evidence that shows that individuals with high levels of anxiety and/or fear attend to the feared stimuli for longer in addition to recognizing it sooner. The devotion of excessive resources to threat processing over long periods of time is associated with hyperarousal, functional impairment, and other symptoms of anxiety and PTSD (Constans, 2005). Notably, this definition does not indicate whether ABT is a top-down or bottom-up attentional process, which leaves open the possibility for ABT to be the result of deficits in executive planning functions, (inaccurate) expectancy effects, or other such top-down executive processes.

Based on neuroimaging and neuropsychological studies, it appears that ABT is influenced by both bottom-up and top-down executive processes. Specifically, neuroimaging studies have found functional connectivity networks associated with the amygdala that appear to be exclusively dedicated to quickly identifying and processing the presence of threatening stimuli, and that activity in this specific neurocircuitry is associated with individual differences in anxiety levels (Phelps, 2006). Furthermore, a translational neuroscience study examining the dot-probe task in high anxiety vs low anxiety individuals found that the task was associated with greater activity in the amygdala of high anxiety individuals (Frewen et al., 2008). These studies strongly indicate that bottom-up fear detection processes significantly contribute to observable differences in ABT. However, most importantly to the present study, the relationship between threat detection neurocircuitry and the presence of anxiety symptoms was moderated by activation of several areas of the brain associated with attention networks, namely the dACC and the dlPFC (Frewen et al., 2008). In other words, individuals with high levels of functional connectivity between areas of the brain associated with executive attention processes and fear

networks did not show a relationship between amygdala activation and anxiety symptoms. More recently, threat bias studies have merged these two conceptualizations to form a general understanding that non-normative bias to threat in either direction (e.g., both away and towards threat) can be indicative of maladaptive functioning. For example, in a prospective study of threat bias in young children, participants who tended to have either ABT or attentional bias away from threat went on to later develop early signs of SAD when compared with individuals who did not display a significant bias in either direction (Morales et al., 2016). This study is notable due to the prospective study design's ability to produce causal inferences that indicate attention bias variability is a potential causal mechanism of SAD.

The merging of bottom-up and top-down attentional processes as they relate to threat bias, referred to as the “dual process theory” (Bardeen, 2020), is well explained by the attentional control theory of anxiety (Eysenck et al., 2007), described in greater detail below. Attentional control theory suggests that the balance of either of these systems can be disrupted and thereby produce maladaptive patterns of attention and behavior associated with anxiety disorders (Eysenck & Derakshan, 2011). For example, evidence suggests that individuals with PTSD detect all salient danger and threat-related cues more quickly than healthy controls due to a top-down mis-assessment that the probability for danger in any given situation is high, leading to a constant state of alertness and arousal (White et al., 2008). In disorders where fear is less generalized, such as in SAD, attentional control deficits are still observed across feared and non-feared situations (Yuan et al., 2019), but perhaps due to the context-specific nature of the bottom-up fear elements, individuals with SAD are not characterized as having constant hyperarousal, since their impaired attentional control ability only produces functional impairment in social contexts.

Further exacerbating the effects of attentional control deficits on psychopathological symptoms, the experience of experimentally manipulated anxiety and fear can greatly diminish the inhibition and shifting functions of the top-down attentional system (Lavie et al., 2004). Therefore, across all functioning levels of the attentional control system, anxiety may inhibit the system's functioning to some degree. This phenomenon has been shown in one study to partially explain why some individuals go on to develop chronic PTSD after experiencing a trauma and others develop mild symptoms that fade over time (Aupperle et al., 2012). The magnitude of the disruption in the attentional control systems of participants appeared to explain the difference between those who recovered from the trauma and those who did not.

Because attentional control theory indicates that fear and attention are connected through the tendency of fear to sometimes overload or override attentional systems, it can be difficult to study the unique effect of either the fear system and the attention system while also examining their interaction. One paradigm that was partially designed to accomplish this is the dot-probe task, a common way to assess attentional bias (e.g., Bardeen & Orcutt, 2011; Iacoviello et al., 2014; Wald et al., 2011). However, a review of the dot-probe literature within the context of PTSD suggests that the scoring procedure of the dot-probe task may cause unacceptable unreliability (Bardeen, 2020). Another method to study the link between fear and attention is to examine the behavioral output of an individual with an overloaded attentional system.

An experimental paradigm designed to accomplish this is the Multi-Source Interference Task (MSIT). This paradigm was originally developed to activate the dACC during fMRI studies (Bush et al., 2003). Particularly relevant to fear-based psychopathology, a recent study found that MSIT performance moderated the relationship between trauma exposure and PTSD symptom severity (Darnell & Valentiner, 2020). The MSIT is well-validated (Deng et al., 2018) and a

frequently cited behavioral proxy for dACC activation. The dACC functions as an integral part of the salience network (Akiki et al., 2017; Seeley et al., 2007), an important attentional network that is involved in threat detection (Pannekoek et al., 2013). As such, the dACC is also important to a fear-responding network which also includes the amygdala and a handful of other areas of the brain (e.g., Klavir, GenuD-Gaba, Paz, 2013; Levar et al., 2017). Because the MSIT was designed to be more difficult than other similar tasks and to maximally tax the dACC, MSIT scores can be operationalized as taxed attention.

Attentional Control

Based on the findings of the threat bias literature, it is clear that attentional control is a key construct to understanding fear-based disorders. Fear and attention are clearly and inextricably linked to one another through the threat processing and detection processes that contribute to threat bias as well as through attentional control theories of anxiety whereby fear overwhelms the attentional systems of the brain. Attentional systems are commonly conceptualized using Posner's tripartite model (Fan et al., 2009; Fan et al., 2002; Posner & Petersen, 1990) wherein the construct of attention is divided into three neurobiologically distinct networks: the alerting network, the orienting network, and the executive control network. The extant literature indicates that the executive control network is most important to PTSD and anxiety (e.g., Leskin & White, 2007) and is most closely analogous to the construct of attentional control that is typically used in clinical psychology literature (e.g., Eysenck et al., 2007). The executive control network allows for "the monitoring and resolution of conflict between expectation, stimulus, and response" (Macleod et al., 2010) and can be measured using a validated behavioral attention task referred to as the Attention Network Task (ANT; Fan et al.,

2002). A single time-point study using the ANT paradigm comparing individuals with anxiety disorders to healthy controls found that anxiety was related to reduced efficiency of the executive control network and poorer ability to disengage attention from invalid cues (Pacheco-Unguetti et al., 2011). No differences were found in the alerting network, a finding that is similar to Leskin and White's (2007) investigation in individuals with PTSD. Another study in a PTSD sample using a Stroop task found that a diagnosis of PTSD was related to lower activations in the dorsal and rostral anterior cingulate cortices and greater activation in the insula (Fani et al., 2019), which are areas of the brain associated with the executive control network and the salience network, respectively. Lower levels of functioning in executive control networks related to attention and over-activity in the salience network corresponded to poorer performance on the Stroop task, and the effect persisted even when the authors controlled for the severity of trauma exposure.

Evidence suggests that these attention networks are an ideal target for intervention over more specific components of attention. For example, a systematic review (Cristea et al., 2015) found that attention bias modification (ABM), a neurobehavioral treatment, is not sufficient to alter anxiety because it does not promote attentional control. Rather, ABM simply alters automatic processes of attention. As previously discussed, the alerting network (a significant piece of the automatic attentional systems) was not found to be altered or affected by the presence of pathological anxiety (Leskin & White, 2007; Pacheco-Unguetti et al., 2011). On the other hand, Cristea et al. (2015) suggest that increasing attentional control is associated with greater generalization and healthy reactions even in novel situations, while altering automatic orienting attentional processes appears insufficient. Similarly, Lazarov et al. (2018) found Attention-Control Training (ACT) yielded greater reductions in PTSD and depressive symptoms

compared with attention-bias modification. Another study found that attentional control moderated the relationship between SAD and the threat avoidant type of attentional threat bias (Taylor et al., 2016) such that those that had low levels of attentional control displayed an attentional bias away from threat, but those who had high levels of attentional control did not display this attentional bias. An identical pattern of findings was subsequently found with individuals with PTSD (Bardeen & Daniel, 2017).

These findings indicate that attentional control is a key underlying mechanism through which other observable symptoms of anxiety and PTSD manifest. The combination of these clinical and cognitive studies strongly implicates attentional control as an important factor underlying fear-related disorders.

Neurobiology Linking Acute Fear Response and Attentional Control

Several clinical models of fear-based disorders such as models of PTSD or anxiety (e.g., Brewin, & Holmes 2003; Ehlers, & Clark, 2000; Eyesenck et al., 2007) propose that these disorders and associated symptoms can be, at least in part, attributed to the maladaptive functioning of two distinct pathways. Individuals with fear-based disorders display a maladaptively strong reaction to stimuli that produce an excessive bottom-up emotional /behavioral response, display a top-down dysregulation of this emotional/behavioral response, or some combination of both pathways. These models have been repeatedly demonstrated in clinical populations and have also been supported by neuroimaging data implicating hyperactivation of the amygdala and dACC (Heilbronner & Hayden, 2016; Milad et al., 2007; Schmid et al., 2015; Sehlmeier et al., 2011) as biomarkers for the bottom-up pathway, and in hypoactivation or reduced functional connectivity between the vmPFC, dlPFC, and these

bottom-up areas of the brain (Akiki et al., 2017; Geng et al., 2018). Specifically, the overactivation of the amygdala and dACC produce exaggerated bottom-up fear responses and hypoactivation of several areas of the cortex associated with top-down attentional control, particularly the vmPFC and dlPFC, results in a failure to downregulate this response (Akiki et al., 2017; Geng et al., 2018).

Fear processes are neurologically related to, and overlapping with, attention networks and have been shown to be impaired in individuals who exhibit attention deficits without a concurrent fear-based disorder (Spencer et al., 2017). In individuals with fear-based psychopathology, bottom-up fear processes are thought to override executive attentional processes and can inhibit other higher order cognitive functions such as working memory (Moran 2016; Polak et al., 2012) or attentional control (Bardeen et al., 2015; Cox & Olatunji, 2017; Eyesenck et al., 2007). The inhibition of these higher order cognitive functions may result in behaviorally similar symptoms across the broad category of fear-based disorders such as avoidance and feared-stimulus overgeneralization (Briscione et al., 2014). These findings alone suggest a strong, transdiagnostic link between psychopathology and the interaction of fear and attentional impairment.

Research shows that maladaptive fear learning (via hyperactive amygdala and dACC) is associated with disrupted bottom-up salience/threat detection system (Seeley et al., 2007). Both animal and human studies have found that the dACC is implicated in context-dependent appraisal and expression of fear (Heilbronner & Hayden, 2016) and behavioral persistence (Kennerly et al., 2006), even in the face of challenges (Parvizi et al., 2013). However, individuals with PTSD, for example, have been found to display weaker vmPFC activation and stronger amygdala and dACC activation during extinction learning processes (Bremner et al., 2005; Milad

et al., 2009), and this pattern of activation is associated behaviorally with poor extinction learning ability. Furthermore, hyperactive salience/threat detection is associated with poor top-down attentional control, typically due to hypoactive cortical regions such as the dorsolateral prefrontal cortex (dlPFC), and vmPFC (Akiki et al., 2017).

Cross-sectional research designs make it difficult to determine whether the hyperactive bottom-up attentional systems found in individuals with fear-based psychopathology are the consequence or the cause of weaker activation of areas of the brain associated with top-down executive control. Regardless, longitudinal treatment studies suggest that strengthening top-down processes through inhibitory learning does result in more normative activation of bottom-up fear networks and lower fear-based behavioral symptoms (Maples-Keller et al., 2022; Yuan et al., 2016; Zhu et al. 2018). Furthermore, individuals who are able to use cognitive emotion regulation strategies tend to have greater activation in a variety of areas in the PFC and lower activation of the amygdala when experiencing emotion (Ochsner et al., 2002). These same regions of the PFC are associated with increased top-down regulation of amygdala responsivity in fear and safety learning (Giustino & Maren, 2015).

An emerging body of research suggests that these neurobehavioral processes can be directly disrupted in order to assist with the treatment of some fear-based disorders. For example, a recent meta-analysis indicated that transcranial magnetic stimulation (TMS) directly to the dlPFC in patients diagnosed with PTSD may offer short-term symptom improvement (Edinoff et al., 2022). Additionally, a study has shown that TMS of the dlPFC significantly reduces fear responding in the FPS paradigm vs controls (Deng et al., 2021). However, in their review of the literature, Edinoff et al. (2022) note that the sample sizes for TMS studies tend to be small (e.g.,

(Borgomaneri et al., 2020), evidence is mixed, and that the procedure is associated with some physical side-effects including mild pain, headaches and even, in rare cases, seizures.

Targeted Treatment

Taken together, these pieces of neurological evidence indicate that treatment of fear-based disorders should focus on strengthening top-down executive function to regulate an overactive bottom-up fear-system. However, traditional psychotherapy protocols tend to focus on narrowly-defined, behaviorally-expressed symptom reduction and do not directly focus on the overlapping relationship between top-down and bottom-up fear and attention processes described in the neurocognitive literature. This unrefined focus may be the cause of several well-established issues in both the psychotherapy and psychopharmacotherapy literatures: a significant minority of individuals who complete a standalone first-line treatment for a fear-based disorder fails to experience adequate symptom reduction (e.g., Foa et al., 2005; Goncalves & Byrne, 2012; Monson et al., 2006; Powers et al., 2010; Resick et al., 2002; Rush et al., 2006; Schnurr et al., 2007), a significant minority of individuals who attempt a first-line treatment for fear-based disorders drop out of treatment prematurely (Hembree et al., 2003; Opris et al., 2012), and diagnostic heterogeneity leads to some patients completing treatments while still exhibiting significant and negatively impactful residual symptoms such as sleep difficulties and cognitive impairments (Hallion et al., 2018).

The Attention Training Technique

The Attention Training Technique (ATT) is a neurobehavioral therapy that has been shown to be effective in the treatment of anxiety and depressive disorders and may not suffer

from many of the issues with current psychotherapies. ATT involves daily auditory monitoring tasks that are attentionally demanding and are designed to strengthen attentional control (Wells, 2009). A single session of ATT occurs over no more than 15 minutes each day including initial preparation (i.e., 3 minutes to find a quiet, distraction free environment and 12 minutes to participate in the full intervention). A meta-analysis of 10 ATT effectiveness studies found large effect sizes for the reduction of clinical symptoms across mood disorders (Knowles et al., 2016). Specifically, this review found that, within the pooled sample of 10 randomized controlled trials (RCTs), ATT is associated with greater treatment gains than reference groups (which included waitlist controls as well as more active treatment conditions like progressive muscle relaxation) across a majority of outcomes (e.g., anxiety and depression symptoms; adjusted Cohen's d range: 0.40–1.23). Despite increasingly strong evidence indicating that ATT reduces symptoms of emotional disorders, even as a standalone intervention, it remains underutilized and understudied (Fergus & Bardeen, 2016). Given the previous discussion on effect sizes of newly developed psychological treatments, ATT also appears to bring several advantages over traditionally-developed psychotherapies meant to treat a single disorder.

The current literature suggests that ATT has several absolute and relative strengths. Although originally developed for use in depression, preliminary evidence suggests it has broad and nonspecific applicability across many psychological disorders. It is based on a neurobehavioral theory, rather than a cognitive-behavioral theory, which may differentiate it enough to help those who would otherwise not respond to a cognitive behavioral treatment. ATT is also inexpensive to implement and time-effective, so it is unlikely to contribute to increasing common factors that may lead to dropout. In addition, ATT directly addresses cognitive problems that are present in many mental disorders but are not the direct focus of treatment.

Theoretical Basis of ATT

ATT is theoretically grounded in the Self-Regulatory Executive Function (S-REF) model, which posits that psychological dysfunction arises from poor self-regulatory strategies that lead to distress, culminating in mood disorder (Wells, 2009). The S-REF model of psychological function is rooted in metacognitive theory. Metacognitions are internal cognitive factors that “control, monitor, and appraise thinking” (Wells, 2009). Metacognitive theory assumes that maladaptive metacognitive beliefs and cognitive control strategies disrupt adaptive self-regulation strategies leading to the persistence of mental disorder. For example, the proclivity to worry and ruminate, attend to imagined or unlikely threatening possibilities, and cope with unpleasantness with avoidance strategies are all maladaptive metacognitive strategies that perpetuate mental disorder and sustained thoughts about danger.

Several studies have been performed that support many of the assumptions of metacognitive theory. Metacognitive beliefs about memory are associated with trauma symptoms more strongly than features of memory (Bennett & Wells, 2010). Positive outcomes in CBT for obsessive-compulsive disorder and alcohol addiction are associated with metacognitive beliefs (Solem et al., 2009). The range of applications of the metacognitive model has widened in the past decade to include OCD (Hansmeier et al., 2021), eating disorders (Palmieri et al., 2021), borderline personality disorder (D’Abate et al., 2020), and many other psychological disorders.

In the S-REF model, the problematic pattern of metacognitive thinking that arises from poorly regulated attention is referred to as the Cognitive Attentional Syndrome (CAS) and is generally responsible for psychological disturbance in some anxious individuals (Wells, 2007). For example, in support of the S-REF model, individuals with anxiety disorders allocate more

attentional resources towards threatening stimuli than healthy controls (Buckley et al., 2000). Additionally, attention to trauma-related stimuli in the absence of threat activates the CAS (Fergus et al., Orcutt, 2012), a finding which supports the validity of the overall S-REF model of psychopathology. ATT seeks to reduce maladaptive forms of attentional focus, such as inflexibly and repetitively processing threat (Wells, 2013), while simultaneously increasing or strengthening the use of top-down attentional control (Bar-Haim, 2010). Few studies, however, have examined whether ATT functions as theory would suggest.

The S-REF model describes maladaptive executive functioning as inflexible, which leads to recurrent styles of thinking when faced with negative emotions or beliefs (Wells 2009; 2013). The sustained processing of these negative emotions or beliefs, rather than flexibly switching attentional resources to more productive processing, leads to anxiety and distress. This also leads to an observed cognitive deficit related to lower levels of accessible attentional resources (Wells, 2007). Distinctly from the theoretical bases of most cognitive behavioral therapies, ATT seeks to modify negative beliefs about oneself not by questioning their validity, but by encouraging alternative thinking strategies (Wells, 2007). Many other psychological theories focus on inflexible patterns of thoughts (e.g., mindset theory; Dweck, 1999), but metacognitive theory uniquely emphasizes the resulting impact of that inflexibility on cognitive functioning and resources (Wells, 2009).

ATT also aligns well with attentional control theory (Eysenck et al., 2007), which posits that high levels of anxiety impair attentional switching and inhibition by overloading the cognitive resources required to properly utilize top-down attentional control processes. Attentional control theory states that anxiety increases the allocation of attention to a threat-related stimulus and decreases attention to the current task, unless that task is dealing with the

threatening stimuli. There are other scenarios wherein an anxious individual feels more abstractly threatened in the absence of a directly threatening stimulus. In this case, attentional control theory states that the anxious individual will engage in excessive threat scanning and will divide attentional resources to many areas of the environment, reducing the ability to focus on a single task. ATT seeks to reduce maladaptive forms of attentional focus, such as inflexibly and repetitively processing threat (Wells, 2013), while simultaneously increasing or strengthening the use of top-down attentional control ability (Bar-Haim, 2010).

Attentional control theory is considered to be a “dual-processing” theory in which both bottom-up and top-down processes are relevant (Bardeen, 2020). It is also considered to be an “information processing” model that describes the ways in which particular stimuli can cause differing responses in individuals based on their unique processing attributes (Bardeen & Daniel, 2018). In these models, it is suggested that the ability to deploy attentional resources for the purposes of altering an experience of an emotion (e.g., exerting attentional control) is a key contributing factor to psychological well-being (Gross, 1998). Information processing models of emotion regulation have been studied at length in the literature. Findings suggest that attentional “deployment” (a construct heavily overlapping with attentional control), is one of five emotional regulatory processes (Gross, 2015), which could therefore make it a strong candidate for intervention (Gross & Thompson, 2007).

The S-REF model and attentional control theory are well-suited to explain previous findings that individuals with anxiety disorders allocate more attentional resources towards threatening stimuli than healthy controls (Buckley et al., 2000). Furthermore, the S-REF model is supported by findings that worry is attentionally demanding and is a key feature in many psychological disorders (Hazlett-Stephens, 1997; Mellings & Alden, 2000). In people with

PTSD, several studies using the Stroop task found that processing disruptions were common during attention to trauma-related words (Daggleish et al., 2003; Foa et al., 1991). Similar findings from dot probe tasks have also been reported (Elsesser, Sartory, & Tackenberg, 2004, 2005; Fani, Bradley, Ressler, & Tone, 2011). Attention to trauma-related stimuli in the absence of threat activates the CAS (Fergus et al., 2012), a finding which supports the validity of the overall S-REF model of psychopathology. ATT seeks to directly address these maladaptive disruptions in normal attention processes.

The S-REF model of psychopathology is based firmly in clinical models but is paralleled and supported by behavioral neuroscience studies (Fan et al., 2005; Fan et al., 2002; Posner & Petersen, 1990; Posner & Rothbart, 2007). These studies indicate that the human attentional system is made up of three separate networks that encompass alerting, orienting, and executive control (Fan et al., 2009; Fan et al., 2002). In this model – commonly referred to as the Posner model – the alerting network is responsible for initiating and maintaining vigilance and alertness, the orienting network allows attention to move through space based on relevant sensory input, and the executive control network is responsible for monitoring the attentional system overall and to resolve any conflicts that arise between expectations, stimuli, and responses (Macleod et al., 2010). One review of this theory found evidence that the executive functioning system is impaired in individuals with borderline personality disorder, schizophrenia, and PTSD, but not the alerting or orienting networks, which seem to be impaired by physical injury often associated with trauma, such as concussions, but not the actual PTSD disorder itself (Macleod et al., 2010). This finding is important to the field of clinical psychology, since studies seeking to measure variables of attention in clinical populations must use a measure of attention that is capable of distinguishing between attentional systems that clearly perform differently based on clinical

presentations. These results also suggest that broad measures of executive attention that combine all three attentional systems into one are not sufficient for clinical outcomes studies, as it may obscure important information.

In other categories of psychological interventions, researchers have successfully applied the Posner model of attention to clinical outcomes data. For example, in order to establish the underlying mechanisms of change in mindfulness-based interventions (MBIs), researchers have examined the effects of MBIs on the three distinct attention networks (e.g. Jha et al., 2007; Kwak et al., 2020; Malinowski, 2013; Tang et al., 2007; Tang et al., 2015; van den Hurk et al., 2010). Specifically, Tang et al. (2007) found that a short-term mindfulness meditation training administered in 20-minute sessions over a period of 5 days significantly increased the efficiency of the executive control network in resolving conflicts between expectations and visual stimuli in a behavioral task meant to assess the three attention networks referred to as the Attention Network Task (ANT; Fan et al., 2002). Importantly, only the executive control network was significantly affected by the mindfulness intervention. The alerting and orienting networks were unaffected, again highlighting the importance of distinguishing between these separate networks. The study also found that the mindfulness intervention group reported lower anxiety, depression, anger, and fatigue compared to the control group. Similarly, Kwak et al. (2020) found that an intensive, 4-day mindfulness meditation retreat significantly improved performance as measured by the ANT executive control network. Again, no difference was found within the alerting or orienting networks. Another study compared mindfulness practice with active relaxation controls (i.e., progressive muscle relaxation) and found that both groups showed significant improvements in their ATT executive control scores relative to a non-active control of listening to podcasts (Vieth & von Stockhausen, 2022). This suggests that the effect of mindfulness

meditation on attention and other cognitive processes may not be as specific as psychological theories would otherwise suggest.

Based on these separate pieces of data, researchers were able to show that one of the (perhaps nonspecific) mechanisms of change in MBIs is improvement in the functioning of the executive control network. Reviews of MBI studies have found that, along with body awareness, emotion regulation, and change in perspective on the self, attention regulation is a clear mechanism of therapeutic change (Holzel et al., 2011). Furthermore, a cross-sectional study using a Stroop task found that meditators exhibited less Stroop interference than non-meditators (Moore & Malinowski, 2009). Another study found that a mindfulness meditation intervention improved sustained attention within-subjects on the continuous performance task (CPT; Rosvold, Mirsky Sarason, Bransome, & Beck, 1956), a measure frequently used in assessing broad attentional impairment.

Unlike MBIs, researchers have yet to perform similar mechanisms of change studies using ATT. Little is known about the mechanisms of therapeutic change in metacognitive therapies as they relate to attention and other executive functions. This is in spite of inclusion in many metacognitive therapies of a neurobehavioral intervention component meant to directly address attentional concerns (ATT; Wells, 2009). To date, only one recent study has evaluated the direct effect of ATT on networks of attention (Barth et al., 2019). While this study included several measures of attention, the ANT was not included, although it is able to specifically distinguish between relevant components of the human attentional system. Furthermore, this study did not measure any relevant psychological symptoms of common disorders such as symptoms of depression or anxiety, and therefore is an insufficient investigation into actual mechanisms of therapeutic change, given that no therapeutic change was measured.

Preliminary evidence indicates that ATT modifies activity in the executive attention network that plays an important role in downregulating bottom-up responses to threat. One study demonstrated that ATT increases activity in that executive attention network (Knowles & Wells, 2018), specifically. Another study found that ATT improved selective attentional focusing (Barth et al., 2019) as measured by a behavioral laboratory task. Another study examining attentional control as it relates to ATT found that it had the greatest effect on those who self-reported greater attentional control (Heitland et al., 2020) using the Attentional Control Scale (ACS; Derryberry and Reed, 2002). One other study found that ATT was associated with reduced errors in a Stroop task (McEvoy et al., 2017). To date, no other studies have explored changes in attentional processes among participants undergoing ATT.

From a neurological perspective, ATT enhances activity in brain regions implicated in executive control over attention. For example, a brief trial of ATT was associated with increased activation within the dlPFC during a cognitive task as well as a reduction in amygdala activation in response to negative emotional material after treatment (Siegle et al., 2007). Another fMRI study found that ATT increased activation of the right dlPFC, along with other cortical regions (Rosenbaum et al., 2018). A third fMRI study found a single session of ATT produced alterations in the fronto-parietal attention network along with several other selected regions of the brain (Kowalski et al., 2020). Finally, a single time-point EEG study of ATT indicated that ATT increases the prevalence of resting-state alpha and beta oscillations associated with the fronto-parietal executive attention network (Knowles & Wells, 2018). These are the only imaging studies to date that have examined the neurocorrelates of ATT practice, likely due to the costly nature of fMRI studies. However, despite their limited number, these imaging studies tentatively indicate that ATT promotes symptom improvement by enhancing the functioning of

executive control networks, which serve to downregulate hyperactive threat detection networks related to both fear and attention. Arguably, the ATT literature would be better served through the execution of a handful of high-quality clinical-outcomes studies that examine its mechanisms of change and therapeutic effectiveness as a more practical means of preliminary study.

Therapeutic Process of Change in ATT

ATT involves daily auditory monitoring tasks that are attentionally demanding and are designed to strengthen attentional control (Wells, 2009). The first session of ATT is typically conducted in-person and involves psychoeducation on the theoretical basis for ATT, including how unnecessary sustained processing of threat stimuli is unhelpful (Fergus & Bardeen, 2016). An audio recording is played and the client is instructed to attend to particular auditory stimuli within the recording. A single session of ATT takes about 12 minutes. Subsequent sessions of ATT beyond the first in person session can be performed at home, and a handful of studies have demonstrated the effectiveness of home-based ATT (Callinan et al., 2015; Fergus et al., 2014; Siegle et al., 2007; Siegle et al., 2014). Clients spend approximately 5 minutes on a selective attention task wherein they attend to specific sounds in the recording and exclude other sounds (Fergus & Bardeen, 2016). The next set of instructions tell clients to perform an approximately 5-minute attention switching task in which they rapidly switch their attention from one sound to another. The final 2 minutes are spent on a divided attention task in which clients attempt to pay attention to multiple sounds at once. Positive outcomes for ATT are increased external focus of attention (S-REF theory indicates that excessive internal foci of attention are related to worry and rumination) and increased attentional control. The construct is of particular interest to research

related to mood disorders, PTSD, and other forms of emotion dysregulation that fall within the scope of the S-REF and attentional control theories.

Despite its strong theoretical basis, proven clinical utility, and ease of administration, ATT remains understudied, particularly in terms of its therapeutic mechanisms of change as well as its long-term feasibility. As previously described, only one study has evaluated the direct effect of ATT on networks of attention (Barth et al., 2019), indicating a significant need for additional research. Furthermore, most studies of ATT do not study its effects over a substantial period of time, with most studies being limited to two or three doses of ATT over one to three days (Fergus & Bardeen, 2016; Knowles et al., 2016). While these very short studies have found significant differences between their ATT and control groups, the brevity of these experimental paradigms cast down on their replicability and broader applicability. Furthermore, studies that have examined the ATT intervention longitudinally focus almost exclusively on clinical outcomes and neglected to identify any intermediary variables that would explain the relationship between experimental group and psychopathological symptom improvement.

Additionally, there is a potential measurement issue in several studies of ATT that use a self-report measure of attention to assess the intervention, the Attentional Control Scale (ACS; Derryberry & Reed, 2002). Many studies examining ATT have used the ACS (e.g., Heitland et al., 2018) which may not be a valid measure of attentional control (Quigley et al., 2017; Williams et al., 2017). Therefore, additional studies that utilize alternative measurement techniques to the ACS are necessary to determine the true effect of the ATT intervention on the construct of attentional control.

The Present Study

The limitations of the extant literature reviewed above indicate that there is a need for further research into broadly applicable, neurobehavioral psychotherapies that are aimed at transdiagnostic psychological factors. Current psychotherapies, while sufficient for many, are not effective for all, indicating the need for adjunctive therapies or new alternative approaches. ATT is a promising neurobehavioral treatment that may address several of the shortcomings of the current first-line treatments for fear-based disorders. Determining the mechanisms of therapeutic change is a fundamental and vital part of studying psychotherapies to ensure they are as effective and broadly applicable as possible. However, researchers have yet to undertake this important scientific work regarding the mechanisms behind ATT. The present study sought to fill this gap in the literature by prospectively examining the two proposed mechanisms by which ATT functions: fear responding and attentional control. Furthermore, the present study examined the ATT intervention over a much longer period of time than has been reported in the literature to date to the author's knowledge—a period of 7 days. Finally, the present study employed innovative measurement techniques, including Ecological Momentary Assessment (EMA) of attentional focus, that is likely to more closely assess a relevant attention variable of interest to ATT.

Hypotheses

Hypotheses are presented following a brief overview of the study design. The study employed an RCT EMA design. Participants first completed a screening and demographics questionnaire (Time 0) to determine their eligibility for the study (participants must have

exhibited at least subthreshold symptoms of fear-based disorders). Random assignment to experimental condition occurred after the screening and consent process for the full study. Participants in the experimental condition listened to a 12-minute ATT recording once per day for 7 days from their smartphone. Participants in the control condition listened to a sham ATT exercise for 12 minutes daily for 7 days from their smartphone. After listening to their respective recordings, participants received extensive evaluations at Time 1, Time 4, and Time 7, and received a very brief questionnaire at all other timepoints utilizing an EMA approach. Time 1, Time 4, and Time 7 all asked participants to complete two cognitive tasks, the MSIT and the ANT, followed by brief self-report measures of fear and attention and any relevant symptom questionnaires. In all other timepoints, participants were administered the Focus of Attention Scale (FAS; Fergus et al., 2014), a single-item measure assessing attentional focus.

Measures Check Hypothesis

Hypothesis 0: It was predicted that scores on the ANT would be significantly positively associated with self-reported focus of attention as measured by the FAS (0.1), taxed attention would be associated with increased self-reported levels of fear (0.2), and initial ratings of Time 1 symptoms (anxiety, posttraumatic stress symptoms (PTSS), etc.) would be associated with symptom levels at Time 7 (0.3). It was also predicted that Time 0 cognitive confidence as measured by the MCQ-30 would be associated with reduced levels of self-reported fear and self-reported external focus of attention (0.4).

A Priori Hypotheses

The following was predicted *a priori*.

Hypothesis 1: ATT will reduce the presence and severity of fear-based psychopathological symptoms relative to controls (1.1).

Hypothesis 2: ATT will improve attentional control as measured by the ANT executive score relative to controls (2.1). ATT will shift self-reported foci of attention from internal to external, relative to controls, as measured by the FAS (2.2).

Hypothesis 3: ATT will improve taxed attention as measured by the MSIT relative to controls (3.1). ATT will reduce self-reported levels of fear relative to controls (3.2).

Hypothesis 4: Attentional control and taxed attention will vary together over time in both the ATT and control groups (4.1).

Hypothesis 5: Attentional control as measured by the ANT executive score will mediate the relationship between experimental condition and taxed attention over time (5.1). Attentional control as measured by the ANT executive score will mediate the relationship between experimental condition and symptom improvement over time (5.2).

Hypothesis 6: Taxed attention as measured by the MSIT will mediate the relationship between experimental condition and symptom improvement over time (6.1). Reduced self-reported fear as measured by the NIH Toolbox for Assessment of Neurological and Behavioral Function - Fear Affect (NIHTB-FA) Short Form will mediate the relationship between experimental condition and symptom improvement over time (6.2). The relationships described in 6.1 and 6.2 would be moderated by gains in attentional control, such that individuals with high gains in attentional control over time will experience greater taxed attention improvements and

symptom improvements, while individuals with low gains in attentional control over time will experience fewer threat bias reductions and symptom improvements (6.3).

Hypothesis 7: Lower scores on the ANT executive control measure will attenuate the effect of ATT on psychological symptom improvement (7.1). In other words, ATT will be more effective for individuals with worse (higher) baseline ANT executive control scores because they have more room to improve.

Exploratory Hypothesis

The following hypothesis examined the relationship between sex and change in symptoms over time. Depending on the result, earlier analyses will be changed *post-hoc*.

Hypothesis 8: Sex will not significantly impact the relationship between experimental condition and fear, attention, or psychopathological symptoms over time.

CHAPTER 3

METHODS

Participants

Participants were 68 Northern Illinois University (NIU) undergraduate students. Participants ($M_{\text{age}} = 19.47$; 22.1% Male; 52.9% White) received course credit (and at times up to \$110) as compensation for their participation. Credit and money were granted based on participants' overall levels of participation throughout the course of the study (i.e., participants received partial compensation based on the number of timepoints completed), and monetary compensation was provided to participants who were participating in a larger, grant-funded study. Participant data were available in real time in order to assess whether a participant completed any given day's assigned activity. The 34 participants in the ATT condition completed 91% of their daily tasks and spent 13.8 minutes ($SD = \pm 1.3$) in the app on each day, while participants in the sham control condition completed 83% of their daily tasks and spent 12.5 minutes ($SD = \pm 1.1$) in the app each day (the sham control was slightly shorter than the ATT).

Inclusion criteria were students with an Android or Apple smartphone with internet access at home who previously reported elevated levels of trait fear or symptoms of a fear-based psychopathology (using the previously discussed cutoff score), assessed using self-report questionnaires as part of the Time 0 screening survey. People who were actively undergoing treatment for a mental health condition or people with uncorrectable auditory or visual

processing deficits were not invited to participate in the study. The intervention and cognitive tests would not have been able to be completed by hearing or visually impaired individuals. All participants had acceptable ANT accuracy ($\geq 93\%$) indicating reasonable effort in the in-person portions of the study. All participants spent an appropriate amount of time in the app at each time point as instructed, and all participants completed at least two of the three in-person sessions. No participants were excluded from the analyses due to attrition.

Sample Size

Multilevel models were needed to analyze the results of this study because grouped data violate the assumption of independence of all observations that is required for standard multivariate models (Maas & Hox, 2005). However, the estimation of required sample sizes for multilevel models (MLM) is difficult due to the complexity of the models (i.e., whether they utilize cross-level interactions or simple fixed effects; Scherbaum, 2009). The present study utilized a repeated measures design over the course of 7 days with two groups – an ATT experimental condition and a sham ATT control condition. Level 2 of the data was the between subjects grouping variable (ATT vs control), while level 1 was the within-subjects repeated measures nested within level 2. Essentially, level 1 variables were all time-varying (e.g., attentional control) while level 2 variables were all fixed (e.g., demographic variables) and did not change over time. The average cluster sizes for the highest levels of analyses were the limiting factor for MLM analyses (Snijders, 2005). Sample sizes of less than 30 at the highest cluster level are associated with smaller standard errors for fixed effects (Maas & Hox, 2005), which reduces the ability of the analysis to find smaller effect sizes. It was estimated that a sample size of 60 would allow the study to avoid inappropriately small standard errors for fixed

effects while also allowing for the analysis of cross-level interactions (based on the guidance of Scherbaum, 2009). The sample appeared to be adequately powered to examine most of the multi-level models. However, the most complex model was a moderated mediation and would likely have required quadruple the sample size achieved (Scherbaum, 2009). Mixed growth models like the aforementioned moderated mediation can fail to converge due to inadequate sample sizes but also due to characteristics of the actual observed variables (McNeish & Harring, 2021), such as the variables having restricted range or having a very wide range.

In their systematic review of ATT in clinical and non-clinical samples, Knowles et al. (2016) found that six out of the 10 studies included in the review reported large effect sizes (range: $d = 0.949$ to 1.776), three reported medium effect sizes (range: $d = 0.551$ to 0.647), and one reported a small effect size ($d = .315$). Using an R package built to assess sample size requirements for longitudinal MLM designs last accessed in 2020, *powerlmm*, a sample size of 60 is 81% powered to find an effect size of $d = .75$, indicating adequate power to find a medium-to-large effect. This package is no longer supported by R and is no longer available in the package repository. Therefore, the above information cannot be updated for an N of 68.

Measures

Attention Network Task (ANT). The ANT is a behavioral reaction time (RT) measure of attentional alerting, orienting, and executive control (Fan et al., 2002). The test is a combination of the commonly used flanker task (see Eriksen & Eriksen, 1974) and a simple cued reaction time task (see Posner, 1980). The ANT provides measures of both RT and error rates (ER; referred to as “accuracy score” in analyses), but ER results are rarely reported (Macleod et al., 2010). For the present study, ER was used as a measure of effortful responding. Individuals with

a 20% ER or higher were excluded from the final analyses based on preliminary pilot data that showed a mean ER of 4.1% in this population.

There are several test conditions of interest in the ANT that produce scores that are indications of efficiency in the three separate attention networks. In all conditions, participants indicate the direction of an arrow presented slightly offset from a central fixation point that is flanked by two additional arrows on both its right and its left. The first condition is the congruent condition in which the flanking arrows are pointing in the same direction as the central arrow. The second condition is the incongruent condition in which the flanking arrows are pointing in the opposite direction. The third condition is a neutral condition in which no lines flank the central arrow. These three conditions are further modified by cues. Three types of cues precede the stimulus arrow (center cue, double cue, and spatially informative cue), all of which are temporally informative (i.e., each cue always indicates to the respondent that an arrow or set of arrows was displayed on the screen in exactly 600ms). Alternatively, no cue may precede the presentation of stimulus arrow, which is referred to as a temporally uninformative condition. The center and double cues prompt the participant to expect that the stimulus arrow will appear soon with 100% accuracy (meaning that the participant is never falsely prompted of an impending stimulus arrow). The spatially informative cue indicates to the participant which portion of the screen the arrows was presented in.

Three scores are computed from the raw data – the alerting network score, the orienting network score, and the executive control network score (also referred to as the conflict resolution score and the executive attention score; Petersen & Posner, 2012). Macleod et al. (2010) summarize the scoring procedures in their review of the psychometric properties of the test. To calculate the alerting network score, for the alerting network score, RT in the temporally

informative double cue condition is subtracted from RT in the temporally uninformative no cue condition (averaging across all flanker conditions). For the orienting network score, RT in the spatially informative cue condition is subtracted from RT in the spatially uninformative central cue condition (averaging across all flanker conditions). Finally, the executive control network score is calculated by subtracting RT in the congruent flanker condition from RT in the incongruent flanker condition (averaging across all cue conditions).

The ANT is the only behavioral measure of attention that separates the three parts of the full attention network that are theoretically vital to distinguish in clinical outcomes research (Macleod et al., 2010). Macleod and colleagues performed a review of the measure and its psychometric properties across several studies. The discriminant validity of the ANT is established by findings from neuroimaging studies that indicate that the three attention network scores derived from the ANT are each associated with different neuroactivity and anatomical structures in the brain (Coull et al., 2001; Fan et al., 2005). While convergent validity has not been specifically examined, the measure's components are a commonly cited flanker task (Eriksen & Eriksen, 1974) and a cued RT task (Posner, 1980) that are currently accepted measures of attentional control.

As for reliability, Macleod and colleagues (2010) report that the test has low-to-moderate test-retest reliability. Specifically, the alerting network score has a test-retest reliability ranging from .36 to .52, the orienting score has a test-retest reliability ranging from .41 to .61, and the executive control score has a test-retest reliability ranging from .77 to .81. The observed changes in scores within persons were not due to experimental manipulation. Unfortunately, the interval between the test and retest were not reported in the paper. As a result, one can assume that the executive control measure is the only sufficiently reliable index from the ANT. In the present

study, test-retest reliability is important, specifically for the executive control score. None of the *a priori* hypotheses make any predictions about changes in orienting or alerting scores over time. The measure is, however, theoretically expected to change based on a variety of factors including intervention (Tang et al., 2007). Importantly, there are only small practice effects for the ANT (Ishigami & Klein, 2011) of about 5% after a first and second repetition, meaning that it can be administered to participants repeatedly and still obtain valid results. Therefore, the ANT executive control measure is ideal for the present study due to its relative stability between administrations, its demonstrated responsiveness to interventions, and its small practice effects. The ANT was presented to participants at Time 1, Time 4, and Time 7 on a desktop computer.

The Multi-Source Interference Task (MSIT; Bush et al., 2003). The MSIT is a behavioral task designed to cognitively tax the cingulo-frontal parietal cognitive/attention network with two conditions (i.e., interference and control) and two performance scores (i.e., absolute and relative processing speed), although often only the relative processing speed score is used (Shin et al., 2011) since it is likely to be less prone to influence by uncontrolled factors such as sleep quality, time of day, and time of most recent caffeine intake. Specifically, in an fMRI study, Bush and colleagues (2003) showed that the MSIT activates the dACC, specifically, to a greater degree than any previously utilized behavioral task. To complete the MSIT, participants use their index, middle, and ring finger on their dominant hand to respond on the 1, 2, and 3 keys on a keyboard to indicate the number that was incongruent with other presented numbers, ignoring the position of the incongruent (target) number. Number sets are flashed on screen every 1.75 seconds. During the control condition, all target numbers always match the position on screen (e.g., for the set 223, the target number is 3), but during the interference condition, the target number never matches its position (e.g., for the set 322, the target number is 3). To calculate relative

processing speed, a difference score was calculated between the average reaction time during interference condition blocks and average reaction time during the control condition blocks (Darnell & Valentiner, 2020; Shin et al., 2011).

Previous research has found that higher MSIT scores (lower is better) are related to fear-based disorders. Specifically, Darnell and Valentiner (2020) found that MSIT scores moderated the relationship between trauma exposure and PTSS. They found that the relationship between trauma exposure and PTSS was weaker in individuals with better MSIT scores. This suggests that the MSIT would be able to validly assess the target construct of interest in the present study, particularly as it relates to fear-based psychopathology. Additional support for validity can be found in the neuroimaging literature. A meta-analysis of all MSIT fMRI studies found that the paradigm “evokes the dorsal anterior cingulate cortex (dACC) and cingulate–frontal–parietal cognitive-attentional networks” (Deng et al., 2018). Thus, the MSIT has shown to be sensitive both to attention networks as well as to fear-based psychopathology. Unfortunately, psychometric data on the reliability of the measure, has not been reported. The MSIT was presented to participants at Time 1, Time 4, and Time 7 on a desktop computer.

Focus of Attention Scale (Wells, 2009). The Focus of Attention Scale (FAS) is a single-item measure of whether an individual is attending to internal or external stimuli in the present moment. The single item asks participants, “at this moment in time how much is your attention focused on yourself or on your external environment?” In the standard measure, participants respond to this query using a 7-point scale that ranges from -3 to +3 where lower scores are indicative of a greater external focus of attention and higher scores are indicative of greater internal focus of attention (also referred to as “self-focused attention”). For the present study, this scale was reversed to aid in interpretation, as metacognitive theory indicates that a greater level

of external focusing is associated with positive outcomes (Wells, 2009). Additionally, the technology limitations in the study app used required that the scale work on a 1 to 100 scale where participants moved a scroll bar on a left-to-right positional response bar.

While a single item measure is not psychometrically ideal, the brevity of the measure is a distinct advantage. The present study already imposed a significant participant burden in terms of time required. Furthermore, an additional behavioral measure of attention (ATT) was used alongside the FAS to reduce the likelihood that psychometric issues would affect the study. Despite being a single item, the FAS has been used in several studies that sought to examine the effects of ATT (e.g., Fergus & Wheless, 2018; Fergus et al., 2014; Nassif & Wells, 2014; Sharpe et al., 2010), and in every case, the FAS moved in the expected direction in response to the intervention. Fergus et al. (2014) also found that the FAS was associated with reductions in anxiety in a condition that underwent the ATT intervention (partial $r^2 = .41$). The FAS was administered from T1 through T7 via the smartphone data collection app.

Metacognitions Questionnaires (MCQ-30); MCQ-30 Low Cognitive Confidence Subscale. The MCQ-30 is a 30-item measure of several metacognitive variables, many of which are conceptualized by Wells (2009) to be central to the metacognitive model of psychological disorder. The measure has good psychometric properties (Wells & Cartwright-Hatton, 2004) and measures 5 factors: *positive beliefs and worry, negative beliefs about worry concerning uncontrollability and danger, low cognitive confidence, need to control thoughts, and cognitive self-consciousness.* The MCQ-30 has the advantage of allowing the data obtained through this study to be applicable to a broad area of literature, as it is a fundamental measure to many metacognitive studies. Internal consistency for the subscales ranges from .72-.89 (Wells, 2009).

Participants rate their agreement with statements on a 4-item ordinal scale (1 = Do not agree, 2 = Agree slightly, 3 = Agree moderately, 4 = Agree very much).

Construct validity of the measure has been assessed in several studies that have found the MCQ-30 to be positively correlated with trait-anxiety, pathological worry, depressive symptoms, and OCD symptoms (Cartwright-Hatton & Wells, 1997; Gwilliam et al., 2004; Myers & Wells, 2005; Wells & Papageorgiou, 1998). The different subscales of the measure have also been shown to be able to differentially predict a variety of outcomes. For example, the uncontrollability and danger subscale was able to discriminate between GAD and OCD from patients with panic disorder or social phobia (Cartwright-Hatton & Wells, 1997). The need for control subscale is also tends to be higher in patients with GAD as opposed to panic or social phobia (Wells & Carter, 2001). Construct validity is highly important to this measure since it was used to apply the present study's results to the broader metacognitive theories. This is important to providing context for the results and elucidating important theoretical implications for the study as a whole. The full MCQ-30 was administered at Time 1, Time 4, and Time 7 and was reliable (α s = .923, .930, .813).

Time 0 Fear Symptom Survey

The Time 0 fear symptom survey included self-report questionnaires, all of which were administered together at Time 0 in a random order (although the LEC was always administered before the PCL-5). The following list of measures were all part of this survey which could be taken for partial course credit for anyone who signed up through the online SONA system.

NIH Toolbox for Assessment of Neurological and Behavioral Function - Fear Affect (NIHTB-FA; Salsman et al., 2013) Short Form. The NIH Toolbox is a multidimensional set of

brief measures designed to measure a variety of outcomes across the lifespan (ages 3-85) for use in prospective research to promote translation of findings across research studies and groups through identified Common Data Elements. The NIHTB-FA is nested within the emotion subdomain. The NIHTB has been validated and normed on a nationally representative sample. The present study will utilize Fear-Affect short form measure of the NIHTB-FA. Pilot data suggest that the short-form measure is a reliable and valid alternative to the full version in the PSYC 102 population (Laman-Maharg, Winder, & Orcutt, unpublished manuscript), and represents a single factor structure construct that is related to several different measures of fear-based psychopathology. The theoretical basis of the present study requires the use of a valid, general measure of fear that is associated with the fear-based disorders of interest. The dot-probe task in this study measures a more specific component of fear. Combined, both measures of fear bring unique strengths.

The Fear-Affect (NIHTB-FA) short form survey is a 7-item measure of anxiety symptoms that reflect the presence of autonomic arousal (e.g., I had a racing or pounding heart) and threat perception (e.g., I felt fearful). Participants typically rate their agreement within a 7-day timeframe for each item on a 5-point Likert scale from 1 (Never) to 5 (Always), with higher scores reflecting more fearful responding; a T score of 60 is recommended as the cut-off for high levels of fear responding (Slotkin et al., 2012), and as such will serve as the cut-off for inclusion criteria in the present study. For the present study, the Time 4 and Time 7 measures asked participants to reflect on the previous 4 days rather than the previous 7. The NIHTB-FA Short Form was administered at Time 0, Time 4, and Time 7. This measure was reliable at all time points (α s = .953, .973, .932).

Panic Disorder Self-Report (PDSR; Newman et al., 2006). The PDSR is a brief 24-item measure of panic disorder (PD) originally designed based on the DSM-IV (APA, 1994). The initial items assess if participants have experienced a panic attack as defined as a “sudden rush of intense fear or anxiety,” and if so, recency and frequency of the attack(s). If lifetime panic attacks exceed 1 attack, presence of physiological symptoms, fear of dying and losing control, as well as functional impairment and distress related to the panic attacks are assessed. The PDSR has demonstrated strong psychometric properties, with good test-retest reliability high internal consistency, and discriminant and convergent validity (Newman et al., 2006). A diagnostic cut-off score of 8.75 has demonstrated high agreement with a diagnostic interview in identifying those who meet criteria for PD ($k = .93$; Newman et al., 2006). The full PDSR was administered at Time 0, Time 1, Time 4, and Time 7. Hardly any participants in the sample endorsed experiencing any symptoms of panic disorder ($n = 4$), so this measure was dropped from the analyses.

Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998). The SIAS is a 20-item self-report measure of anxiety in social interactions, both in dyadic (e.g., I feel tense if I am alone with just one other person) and group settings (e.g., When mixing socially I am uncomfortable). Items are rated on a 5-point scale from 0 (Not at all) to 4 (Extremely) on how characteristic the statement is to the participant, with higher scores representing higher levels of social anxiety. The SIAS has demonstrated high internal consistency, with alphas greater than .88 in both clinical and non-clinical samples (Kählke et al., 2019; Mattick & Clarke, 1998), as well as good test-retest reliability (Mattick & Clarke, 1998). A cut-off score of 34 has reliably differentiated between those with and without a diagnosis of social anxiety disorder in the full

form version (Brown et al., 1997). The SIAS was administered at Time 0, Time 4, and Time 7. The SIAS was reliable at all time points of the study (α s = .887, .881, .909).

Life Events Checklist for DSM-5 (LEC-5; Weathers et al., 2013). The LEC-5 is a widely used screener for traumatic exposure as defined by the DSM-5 (APA, 2013). The LEC-5 consists of a checklist of 17 potentially traumatic events participants may have experienced in their lifetime (e.g., natural disaster, car accident, combat exposure, sexual violence). Participants are asked to identify if they have experienced each of the 17 items directly, witnessed the event, learned about it, or if they were exposed as part of their job. If at least one event is experienced, participants are then asked to briefly describe the worst event, when the worst event occurred and answer several questions regarding the nature of the event (e.g., Was someone's life in danger? Did it involve sexual violence?). The identified event was then the reference event for the assessment of posttraumatic stress symptoms using the PCL-5. The LEC-5 was administered only at Time 0 via Qualtrics.

PTSD Checklist for DSM-5 (PCL-5; Weathers, et al., 2013) *Past Week Version*. The PCL-5 is a 20-item self-report measure of symptoms of PTSD as defined by the DSM-5. Participants are instructed to keep in mind the worst event they identified on the LEC-5 when responding to the items. Ratings are made on a 5-point scale from 0 (Not at all) to 4 (Extremely) for how bothered the participant is by the symptom described, with higher scores reflecting greater PTSD symptoms. The PCL-5 has demonstrated strong psychometric properties including high internal consistency ($\alpha = .96$) and convergent validity between the PCL-5 and the Clinician Administered PTSD Scale for the DSM-5 (CAPS-5), a commonly used diagnostic tool (see Blevins et al., 2015; Keane et al., 2014; Wortmann et al, 2016 for more detailed descriptions of the PCL-5 psychometric properties). A total score clinical cut-off of 33 is recommended by

Wortmann et al. (2016) for identifying probable PTSD, with 93% sensitivity. The factor structure of the PCL-5 generally falls outside expectations of theory, with several factor studies finding 6 or 7 factor structures (Armour et al., 2015; Liu et al., 2014), rather than the expected 4 factor model. However, while potentially an issue for studies examining PTSD alone, the present study was less concerned with the consistency of PTSD diagnostic nosology because it is grouped among all fear-based disorders. The *past month* version of the PCL-5 was administered at Time 0, Time 4, and Time 7. The measure was reliable at all time points (α s = .930, .931, .949).

Circumscribed Fear Measure, Most Feared (CFM-MF; McCraw & Valentiner, 2015).

The CFM-MF is a 26-item measure of specific phobia, with subscales that reflect the DSM-5 diagnostic criteria. The measure consists of a screener item (i.e., Please check the box of the object or situation you are most afraid of), which allows for the identification of most feared stimuli, followed by 25 items assessing reactions to the feared stimuli. Participants rate their agreement with each of the 25 statements on 5-point Likert scale from 1 (Strongly disagree) to 5 (Strongly agree), with higher scores reflecting greater fear responding to the most feared stimuli. The CFM-MF has demonstrated high internal consistency (α = .94), as well as good criterion validity with a measure of functional impairment (McCraw & Valentiner, 2015). The CFM-MF was administered at Time 0, Time 4, and Time 7. The measure was reliable at all time points (α s = .899, .926, .943).

Procedures

Based on the results of the initial screener, individuals who met study inclusion criteria were invited to participate in the study via email. Time 1, 4, and 7 were administered in-person in an on-campus psychology lab or at the NIU Center for the Study of Family Violence and

Sexual Assault. Participants were drawn from two separate studies. In the Fall of 2021, participants were directly recruited for the study by the PI, while in the Spring of 2021, participants were recruited as part of a larger on-campus grant-funded study that already included all facets of the present study in addition to some additional questionnaires and experimental paradigms.

Consent and Debriefing. Due to the potentially complex and longitudinal nature of the present study design, the study included 2 consent forms. The first consent form was provided to participants before completing the screening questionnaire at Time 0. The second consent form was provided to participants before beginning Time 1. Debriefing forms were provided to participants after completion of Time 7 study activities or sent via email to individuals who completed all time points of the larger grant-funded study that included a one-month follow-up.

Time 0. The first study session included the initial screening survey to assess eligibility of participants. The Time 0 survey included the demographics questionnaire, other items to assess inclusion and exclusion criteria (e.g., *do you have a functional Android or iOS smartphone?*), and the fear symptoms survey, as well as the MCQ-30. Time 0 was administered via Qualtrics and was available to all undergraduate Psychology 102 students who were over the age of 18.

On a blocked basis (block size of 4), individuals who completed the Time 0 survey and who met study inclusion criteria were invited via email to participate in the remainder of the longitudinal study. Randomization and condition assignment occurred before Time 1. Based on previous work using similar samples, stratified sampling was not expected to be necessary, but the larger grant-funded study required that the control and experimental conditions were equal in terms of gender.

Time 1. Participants came in-person to the psychology lab to complete Time 1.

Participants received their second consent form which was verbally discussed with them. Once consent was obtained, the researcher initiated the brief cognitive battery consisting of the ANT and the MSIT. Following the cognitive battery, participants were introduced to the study app which prompted them to begin the study intervention, which in both the control and experimental conditions was described as a “guided meditation.” After the guided meditation, participants completed the FAS and were asked if they had any questions. Participants were then given the instructions for the rest of the week to complete the guided meditation once a day each day at around the same time, schedule permitting. Customized notifications were scheduled for each participant to work around their school, work, and sleep schedules.

In the ATT condition, the ATT audio recording was played, while in the sham control condition, only the background sounds of ATT were played without any instruction. A single session of ATT takes about 12 minutes. Sessions of ATT can be performed at home, and a handful of studies had already demonstrated the viability and feasibility of at home practice (Callinan et al., 2015; Fergus et al., 2014; Siegle et al., 2007; Siegle et al., 2014). Participants spent 5 minutes on a selective attention task wherein they attend to specific sounds in the recording and exclude other sounds (Fergus & Bardeen, 2016). In the subsequent 5 minutes, participants were instructed to perform an attention switching task in which they rapidly switch their attention from one sound to another. The final 2 minutes were spent on a divided attention task in which participants attempt to pay attention to multiple sounds at once.

Times 2-3, Times 5-6. The study app automatically prompted participants to listen to the ATT or sham ATT audio files depending on assigned condition once per day for the next 7 days. Following the audio file, the Study App will prompt participants to respond to the FAS. If study

participants indicated that they are not able to perform the study procedures at their designated time, the app reminded them through a system notification every half hour that they have not yet completed that day's procedure. Participants were reminded no more than four times per missed session, after which the data for that day was considered missing.

Time 4. Participants came in person to complete the cognitive test battery consisting of the ANT and the MSIT. They were also prompted to respond to the FAS, the MCQ-30, as well as the full fear symptoms survey.

Time 7. All procedures in Time 7 are identical to those of Time 4 with some additional procedures added following the completion of the symptom questionnaires. After completing the last survey, participants were given a message thanking them for their participation. They were told that their participation has been recorded and their course credit will not be affected by their response to the following question, "Did you actually pay attention to the audio file's instructions each day?". All participants indicated that they at least mostly paid attention to the study intervention.

CHAPTER 4

RESULTS

Tests of MLM Assumptions, Normality, and Missing Data

All hypotheses and assumptions were evaluated using R statistical software with the exception of the correlation and descriptive statistics tables which were produced using SPSS version 25. Missing data were evaluated using the misty package. Assumptions of HLM were evaluated by hand calculations and the ggplot2, sjstats, and car packages. Mixed-effects models were evaluated using the lmer function of the lme4 package, with the addition of the lmerTest package to enable Satterthwaite's degrees of freedom method (Satterthwaite, 1946).

Satterthwaite's method was used in all mixed-effects models to estimate the effective degrees of freedom for the probability distributions generated by random slopes HLM models. Restricted maximum likelihood (REML) estimation was employed to reduce the potential bias inherent in maximum likelihood estimation (Cheang & Reinsel, 2000). Mediation was tested through the production of Sobel's Z-statistic (Sobel, 1982) by hand calculation and then confirming the calculation via an online calculator.

Prior to analyzing the hypotheses using the study data, multilevel modeling assumptions were examined. Assumptions of linearity were examined through visual inspection of plots of residuals. No obvious curvilinearity was observed for the null models. The null models also met the assumption of homogeneity of variance, as all p values for null model ANOVAs of squared residuals were not significant ($ps = .061 - .883$). QQ-plots revealed that the null models mostly

satisfied the assumption of normally distributed residuals, with some deviation typically occurring towards the tails of the plot, typically for 3 to 5 individual outliers (between 5-10% of the data). Instead of transformation, restricted maximum likelihood estimators were used to estimate the variance components of the mixed-effect HLM models to accommodate for slight non-normality. Little's Missing Completely At Random (MCAR) Test (Little, 1988) determined that the data were MCAR ($p = .09$) and missing data did not exceed 10%. The interclass correlations (ICC) of the null models were generally moderate to very high (.42 -.81), indicating that accounting for clustering was very important in the data. The design effects for the null models were also generally moderate to high (.32 - .76), which indicates that the squared standard error increases significantly due to clustering, which again is strong justification for accounting for that clustering within analyses. Furthermore, Table 1 and Table 2 were produced to determine whether there were any significant differences between the conditions.

Table 1

Categorical Variable Differences Between ATT and Sham ATT Groups (χ^2) – Time 1

	χ^2 Statistic	<i>df</i>	<i>p</i>
Sex	.385	1	.373
Race	9.910	5	.078

Table 2

Continuous Variable Differences Between ATT and Sham ATT Groups (ANOVA) – Time 1

	ATT Condition Mean (SD)	Sham ATT Condition Mean (SD)	F-Statistic	<i>df</i>	<i>p</i>
Age	19.25 (1.30)	19.72 (3.56)	3.722	66(1)	.463
ANT Alerting	41.88 (23.44)	37.35 (31.11)	.444	66(1)	.508
ANT Orienting	42.44 (31.34)	35.77 (27.34)	.825	66(1)	.367
ANT Executive	149.88 (71.99)	134.26 (52.20)	.987	66(1)	.324
ANT Total	615.91 (92.08)	615.48 (72.06)	.000	66(1)	.984
Fear	51.84 (24.66)	64.47 (29.23)	3.670	66(1)	.060
MSIT	113.53 (62.08)	98.92 (68.73)	.849	66(1)	.360
PTSS	8.27 (8.76)	10.41 (13.32)	.586	66(1)	.447
Specific Phobia	57.25 (14.41)	62.9 (20.96)	1.695	66(1)	.198
Social Anxiety	30.3 (13.57)	35.3 (13.09)	2.346	66(1)	.130
Cognitive Confidence	10.19 (3.43)	9.14 (4.54)	2.191	66(1)	.144

ANT = Attention Network Task; MSIT = Multi-Source Interference Task; PTSS = posttraumatic stress symptoms.

Testing the Hypotheses

Hypothesis 0

Correlation matrices were produced to examine all hypotheses that fell under hypothesis 0. A fear psychopathology composite score was generated for each participant at each time point by taking the mean of the Z-scores of the fear-based psychopathology self-reported measures for each participant. *Hypothesis 0.1*: Scores on the ANT at Time 1 will be significantly positively associated with self-reported focus of attention as measured by the FAS (0.1). This hypothesis was not supported. Self-reported external focus of attention at Time 1 was not significantly correlated with ANT alerting scores, $r(65) = .128$, $p = .311$, ANT orienting scores, $r(65) = .203$,

$p = .105$, ANT executive scores, $r(65) = -.127$, $p = .313$, or ANT total reaction times, $r(65) = -.140$, $p = .266$. *Hypothesis 0.2*: MSIT processing speed will be associated with increased self-reported levels of fear. This hypothesis was not supported. MSIT processing speed was not correlated with self-reported levels of fear, $r(67) = .013$, $p = .914$. *Hypothesis 0.3*: Initial ratings of Time 1 symptoms (anxiety, posttraumatic stress symptoms (PTSS), etc.) will be associated with symptom levels at Time 7. In other words, r^2 will be positive and significant for each symptom measure. This hypothesis was supported. Time 1 fear was correlated with Time 7 fear, $r(59) = .585$, $p < .001$. Time 1 social anxiety was correlated with Time 7 social anxiety, $r(59) = .807$, $p < .001$. Time 1 specific phobia was correlated with Time 7 specific phobia, $r(59) = .634$, $p < .001$. Time 1 PTSS was correlated with Time 7 PTSS, $r(57) = .406$, $p < .001$. *Hypothesis 0.4*: Time 1 cognitive confidence as measured by the MCQ-30 will be associated with decreased levels of self-reported fear and increased self-reported external focus of attention. This hypothesis was not supported. Time 1 cognitive confidence was not correlated with level of fear, $r(67) = -.199$, $p = .106$ and Time 1 cognitive confidence was not associated with self-reported external focus of attention, $r(67) = .021$, $p = .868$. Additional correlation matrices (Tables 3-6) for each time point and for each group were produced to explore these relationships over time. These tables all show similar results across timepoints and within each condition.

Hypothesis 1

Null Model 1.1

$$\text{Level 1: } \textit{Psychopathology} = \pi_{0i} + \pi_{1i}(\textit{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Table 3

Time 4 Attention, Fear, and Psychological Variables, ATT Group Only

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. T4 ANT Alerting	-											
2. T4 ANT Orienting	.377	-										
3. T4 ANT Executive	.311	-.100	-									
4. T4 ANT Total	.640**	.441*	.613**	-								
5. T4 MSIT	-.290	-.052	.107	.159	-							
6. T4 External Focus	.049	-.204	-.061	-.067	.010	-						
7. T4 Fear	-.243	-.071	.046	-.113	.214	.108	-					
8. T4 Social Anxiety	-.328	-.271	-.311	-.249	.189	.033	.497**	-				
9. T4 Specific Phobia	-.045	-.018	.166	.319	.149	.041	.272	.203	-			
10. T4 PTSS	-.260	.006	-.103	-.116	.147	-.022	.834**	.636**	.334	-		
11. T4 Cognitive Confidence	-.059	-.293	.198	-.041	-.079	-.185	-.554**	-.693**	-.141	-.707**	-	
12. T4 Fear Composite	-.288	-.135	-.111	-.014	.224	.026	.693**	.793**	.668**	.851**	-.665**	-
N	24	24	24	24	25	28	25	25	25	25	25	25
Mean	48.290	37.290	136.710	594.210	108.232	58.710	2.400	2.406	3.333	16.720	10.72	-0.131
SD	31.967	35.968	61.933	104.646	44.768	39.582	0.979	0.660	0.826	14.803	4.373	0.766

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task; PTSS = posttraumatic stress symptoms.

Table 4

Time 4 Attention, Fear, and Psychological Variables, Sham ATT Group Only

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. T4 ANT Alerting	-											
2. T4 ANT Orienting	.139	-										
3. T4 ANT Executive	-.142	.209	-									
4. T4 ANT Total	.246	.469**	.102	-								
5. T4 MSIT	-.202	.204	.061	.243	-							
6. T4 External Focus	.191	-.302	-.281	-.129	-.044	-						
7. T4 Fear	-.190	-.191	-.400*	-.068	.037	.203	-					
8. T4 Social Anxiety	-.141	.135	-.064	-.012	.185	.148	.332	-				
9. T4 Specific Phobia	-.291	-.107	.068	-.028	-.047	-.105	.239	.277	-			
10. T4 PTSS	-.483**	-.003	-.159	.178	.208	-.053	.661**	.383*	.278	-		
11. T4 Cognitive Confidence	.346	.045	.291	-.275	.031	-.035	-.510**	-.449*	-.515**	-.609**	-	
12. T4 Fear Composite	-.415*	.012	-.071	.064	.158	-.004	.560**	.753**	.700**	.755**	-.713**	-
N	30	30	30	30	29	31	28	28	28	28	28	28
Mean	41.200	38.630	114.930	582.670	91.511	59.520	2.923	2.588	3.426	21.070	9.39	0.094
SD	28.219	19.627	40.247	61.119	46.733	60.825	1.061	0.674	0.821	15.166	4.003	0.742

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task; PTSS = posttraumatic stress symptoms.

Table 5

Time 7 Attention, Fear, and Psychological Variables, ATT Group Only

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. T7 ANT Alerting	-											
2. T7 ANT Orienting	.149	-										
3. T7 ANT Executive	.380*	.371*	-									
4. T7 ANT Total	.305	.514**	.619**	-								
5. T7 MSIT	.085	.182	.254	.326	-							
6. T7 External Focus	-.305	.002	-.400	-.333	-.452*	-						
7. T7 Fear	-.236	.011	.009	-.222	-.070	-.060	-					
8. T7 Social Anxiety	-.312	-.033	-.150	-.166	-.041	.022	.709**	-				
9. T7 Specific Phobia	.218	-.056	.383*	.296	.293	-.489**	.226	.067	-			
10. T7 PTSS	-.094	.073	-.076	-.026	.048	-.025	.637**	.639**	.288	-		
11. T7 Cognitive Confidence	-.105	.103	-.009	.001	-.184	.152	-.203	-.252	-.123	-.358*	-	
12. T7 Fear Composite	-.089	-.013	.075	.046	.135	-.219	.706**	.774**	.612**	.846**	-.323	-
N	32	32	32	32	32	32	31	31	31	31	31	31
Mean	54.410	37.410	113.590	575.440	99.123	50.590	2.194	2.152	3.174	13.190	10.79	-0.111
SD	27.297	23.876	37.825	60.919	56.902	31.922	0.795	0.712	0.865	13.492	2.833	0.675

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task; PTSS = posttraumatic stress symptoms.

Table 6

Time 7 Attention, Fear, and Psychological Variables, Sham ATT Condition Only

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. T7 ANT Alerting	-											
2. T7 ANT Orienting	.146	-										
3. T7 ANT Executive	-.158	.113	-									
4. T7 ANT Total	.068	.475**	.196	-								
5. T7 MSIT	-.065	.100	.044	.034	-							
6. T7 External Focus	-.278	.023	-.098	.071	-.072	-						
7. T7 Fear	-.167	-.041	-.140	.017	-.125	.362	-					
8. T7 Social Anxiety	-.091	.128	-.037	.276	.027	.171	.449*	-				
9. T7 Specific Phobia	.022	.244	.075	-.044	-.295	-.021	-.004	.229	-			
10. T7 PTSS	-.166	-.274	-.171	-.060	-.354	.238	.569**	.302	.355	-		
11. T7 Cognitive Confidence	-.177	-.377*	.111	-.281	-.025	.010	-.022	-.331	-.348	-.125	-	
12. T7 Fear Composite	-.101	.046	-.066	.068	-.285	.178	.452*	.683**	.744**	.761**	-.372*	-
N	29	29	29	29	29	30	29	29	29	28	29	29
Mean	45.240	36.280	99.310	571.830	80.578	45.800	2.631	2.435	3.252	14.110	9.69	0.061
SD	26.856	21.545	31.746	64.856	41.640	29.752	1.028	0.686	0.975	16.969	2.983	0.735

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task; PTSS = posttraumatic stress symptoms.

Hypothesis 1.1

$$\text{Level 1: } \textit{Psychopathology} = \pi_{0i} + \pi_{1i}(\textit{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\textit{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\textit{Condition})$$

HLM was used to evaluate Hypothesis 1. The psychopathology composite was entered as the Level 1 outcome variable. Time was entered as a Level 1 predictor variable and experimental condition was entered as a dichotomous Level 2 predictor variable where 1 is the ATT condition and 0 is the sham control condition. *Hypothesis 1*: ATT will reduce the presence and severity of fear-based psychopathological symptoms relative to controls over time. This hypothesis was not supported. The null model indicated that the psychopathology composite did not significantly change over time, $\beta = -.022$, $t(85) = -.76$, $p = .449$. The full model indicated that experimental condition did not impact the relationship between psychopathology and time, $\beta = -.007$, $t(83) = -.117$, $p = .907$. Exploratory analyses revealed that social anxiety, $\beta = -.126$, $t(63) = -5.38$, $p < .001$, and specific phobia symptoms, $\beta = -.0925$, $t(63) = -2.07$, $p < .043$, did decrease significantly over time, but that PTSD symptoms increased over time, $\beta = 2.435$, $t(63) = 2.844$, $p = .006$. This led the fear psychopathology composite to appear as though there were no within-person changes occurring within the sample.

Hypothesis 2

Null Model 2.1

$$\text{Level 1: } \textit{AC} = \pi_{0i} + \pi_{1i}(\textit{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Hypothesis 2.1

$$\text{Level 1: } AC = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Null Model 2.2

$$\text{Level 1: } FAS = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Hypothesis 2.2

$$\text{Level 1: } FAS = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

HLM was used to evaluate Hypothesis 2.1 and 2.2. *Hypothesis 2.1:* ATT will improve attentional control as measured by the ANT executive score relative to controls. This hypothesis was not supported. Attentional control was entered as the Level 1 outcome variable predicted by time at Level 1. Experimental condition was entered into the model as a Level 2 predictor variable. The null model indicated that attentional control significantly improved over time (lower scores are better), $\beta = -15.377$, $t(62) = -6.535$, $p < .001$. However, the full model indicated that the relationship between time and attentional control did not differ by experimental condition, $\beta = -0.7187$, $t(61) = -0.152$, $p = .880$. HLM was used to evaluate Hypothesis 2.2. FAS score was entered as the Level 1 outcome variable predicted by time at Level 1. Experimental

condition was entered into the model as a Level 2 predictor variable. *Hypothesis 2.2*: ATT will shift self-reported foci of attention from internal to external relative to controls. The null model indicated that FAS did not significantly change over time, $\beta = -1.089$, $t(61) = -0.634$, $p = .528$. The full model indicated that the relationship between time and FAS did not differ by experimental condition, $\beta = 3.003$, $t(60) = 0.870$, $p = .388$.

Hypothesis 3

Null Model 3.1

$$\text{Level 1: } Tax = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Hypothesis 3.1

$$\text{Level 1: } Tax = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Null Model 3.2

$$\text{Level 1: } Fear = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Hypothesis 3.2

$$\text{Level 1: } Fear = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

HLM was used to evaluate Hypothesis 3.1 and 3.2. *Hypothesis 3.1*: ATT will increase taxed attention as measured by the MSIT absolute and relative processing speeds. Taxed attention was entered into the model as the Level 1 outcome variable predicted by time at Level 1. Experimental condition was entered into the model as a Level 2 predictor variable. This hypothesis was not supported. The null models indicated that MSIT processing speed marginally decreased over time, $\beta = -4.952$, $t(61) = -1.799$, $p = .077$. The full models indicated that the relationship between MSIT processing speed and time, $\beta = -1.515$, $t(59) = -0.271$, $p = .787$ did not differ between experimental condition. *Hypothesis 3.2*: ATT will reduce self-reported levels of fear relative to controls. Fear, as measured by the NIHTB-FA short form, was entered as the Level 1 outcome variable predicted by time at Level 1. Experimental condition was entered into the model as a Level 2 predictor variable. This hypothesis was not supported. The null model indicated that fear significantly decreased over time, $\beta = -0.23362$, $t(106) = -4.832$, $p < .001$ (Cohen's $d = .628$). However, the full model indicated that the relationship between fear and time was not significantly related to experimental condition, $\beta = .001$, $t(104) = .001$, $p = .999$. Because sex was significantly related to fear, it was entered as a covariate into the model. This did not impact overall findings in the full model, $\beta = -0.003$, $t(105) = -0.033$, $p = .974$.

Hypothesis 4

Null Model 4.1:

$$\text{Level 1: } AC = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Hypothesis 4.1:

$$\text{Level 1: } AC = \pi_{0i} + \pi_{1i}(Tax) + \pi_{2i}(time) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10} + r_{1i}$$

$$\pi_{2i} = \beta_{20}$$

Flipped Null Model 4.1:

$$\text{Level 1: } Tax = \pi_{0i} + \pi_{1i}(time) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Flipped Hypothesis 4.1:

$$\text{Level 1: } Tax = \pi_{0i} + \pi_{1i}(AC) + \pi_{2i}(time) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10} + r_{1i}$$

$$\pi_{2i} = \beta_{20}$$

HLM was used to evaluate Hypothesis 4.1 and its inverse. *Hypothesis 4.1*: Attentional control and taxed attention will vary together over time in both the ATT and control groups. In the first model, attentional control was entered as the Level 1 outcome variable with Time and taxed attention entered as Level 1 predictor variables. In the flipped model, taxed attention was entered as the Level 1 outcome variable with Time and attentional control entered as Level 1 predictor variables. This hypothesis was not supported. In both the first model, $\beta = 7.127$, $t(72) = 1.381$, $p = .174$, and the flipped model, $\beta = -0.0501$, $t(86) = -0.918$, $p = .361$, the predictor variables did not vary over time together.

Hypothesis 5

Hypothesis 5.1

Step 1:

$$\text{Level 1: } Tax = \pi_{0i} + \pi_{1i}(time) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(Condition) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(Condition)$$

Step 2:

$$\text{Level 1: } AC_{ij} = \pi_{0i} + \pi_{1i}(time) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(Condition) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(Condition)$$

Step 3:

$$\text{Level 1: } Tax = \pi_{0i} + \pi_{1i}(time) + \pi_{2i}(AC) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(Condition) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(Condition) + r_{1i}$$

$$\pi_{2i} = \beta_{20}$$

Sobel's statistic was used to test for the significance of this effect:

$$Z = \frac{ab}{\sqrt{a^2\sigma_b^2 + b^2\sigma_a^2}}$$

Hypothesis 5.2

Step 1:

$$\text{Level 1: } Psychopathology = \pi_{0i} + \pi_{1i}(time) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Step 2:

$$\text{Level 1: } AC_{ij} = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Step 3:

$$\text{Level 1: } \text{Psychopathology} = \pi_{0i} + \pi_{1i}(\text{time}) + \pi_{2i}(AC) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition}) + r_{1i}$$

$$\pi_{2i} = \beta_{20}$$

Sobel's statistic was used to test for the significance of this effect:

$$Z = \frac{ab}{\sqrt{a^2\sigma_b^2 + b^2\sigma_a^2}}$$

HLM was used to evaluate Hypothesis 5.1 and 5.2 and a Sobel z-statistic was generated to evaluate the mediation effect. The Zhang et al. (2009) "2-1-1" model method was implemented to due to the status of attentional control as a Level 1 mediator of a cross-level relationship between condition and taxed attention. *Hypothesis 5.1:* Attentional control as measured by the ANT executive score will mediate the relationship between ATT and taxed attention over time. In step 1, the effect of experimental condition on the change in taxed attention was evaluated. This effect was not significant $\beta = 0.02748$, $t(59) = -0.271$, $p = .787$. In

step 2, the effect of experimental condition on the change in attentional control was evaluated.

This effect was not significant $\beta = -0.01324$, $t(61) = -0.152$, $p = .880$. In step 3, attentional control and time were entered as Level 1 predictors of taxed attention while experimental condition was entered as a Level 2 predictor. The adjusted effect of attentional control on taxed attention was not significant $\beta = 0.12604$, $t(68) = 1.267$, $p = .213$. The mediation effect of this 3-step model was -0.0408 . Sobel's Z-statistic was $.15$, $p = .880$. Thus, no mediation effect was observed.

Hypothesis 2: Attentional control as measured by the ANT executive score will mediate the relationship between ATT and symptom improvement over time. In step 1, the effect of experimental condition on the change in fear-related psychopathology was evaluated. This effect was not significant $\beta = -0.009234$, $t(84) = -0.117$, $p = .907$. In step 2, the effect of experimental condition on the change in attentional control over time was evaluated. This effect was not significant $\beta = -0.01324$, $t(61) = -0.152$, $p = .880$. In step 3, time and attentional control were entered as Level 1 predictors of fear-based psychopathology while experimental condition was entered as a Level 2 predictor. The adjusted effect of attentional control on fear-based psychopathology was not significant $\beta = -0.06353$, $t(57) = -0.959$, $p = .345$. The mediation effect of this 3-step model was -0.0408 . Sobel's z-statistic was $.15$, $p = .881$. Thus, no mediation effect was observed.

Hypothesis 6

Hypothesis 6.1

Step 1:

$$\text{Level 1: } \textit{Psychopathology} = \pi_{0i} + \pi_{1i}(\textit{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\textit{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Step 2:

$$\text{Level 1: } \text{Dot}_{ij} = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Step 3:

$$\text{Level 1: } \text{Psychopathology} = \pi_{0i} + \pi_{1i}(\text{time}) + \pi_{2i}(\text{Dot}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition}) + r_{1i}$$

$$\pi_{2i} = \beta_{20}$$

Sobel's statistic was used to test for the significance of this effect:

$$Z = \frac{ab}{\sqrt{a^2\sigma_b^2 + b^2\sigma_a^2}}$$

Hypothesis 6.2

Step 1:

$$\text{Level 1: } \text{Psychopathology} = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Step 2:

$$\text{Level 1: } \text{Fear}_{ij} = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition})$$

Step 3:

$$\text{Level 1: } \text{Psychopathology} = \pi_{0i} + \pi_{1i}(\text{time}) + \pi_{2i}(\text{Fear}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\text{Condition}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition}) + r_{1i}$$

$$\pi_{2i} = \beta_{20}$$

Sobel's statistic was used to test for the significance of this effect:

$$Z = \frac{ab}{\sqrt{a^2\sigma_b^2 + b^2\sigma_a^2}}$$

HLM was used to evaluate Hypothesis 6.1 and 6.2 and a Sobel z-statistic was generated to evaluate the mediation effect. As in Hypothesis 5.1 and 5.2, the Zhang et al. (2009) “2-1-1” model method was implemented due to the status of self-reported fear as a Level 1 mediator of a cross-level relationship between experimental condition and taxed attention. *Hypothesis 6.1:* Taxed attention will mediate the relationship between ATT and symptom improvement over time. In step 1, the effect of experimental condition on the change in self-reported fear was evaluated. This effect was not significant $\beta = -0.009234$, $t(84) = -0.117$, $p = .907$. In step 2, the effect of experimental condition on the change in taxed attention was evaluated. This effect was not significant $\beta = -0.02748$, $t(59) = -0.271$, $p = .787$. In step 3, time and taxed attention were entered as Level 1 predictors of fear-based psychopathology while experimental condition was entered as a Level 2 predictor. The adjusted effect of taxed attention on fear-based psychopathology was not significant $\beta = 0.091146$, $t(58) = 0.414$, $p = .683$. The mediation effect

of this 3-step model was -0.0025. Sobel's z-statistic was .23, $p = .821$. Thus, no mediation effect was observed. *Hypothesis 6.2*: Reduced self-reported fear as measured by the NIHTB-FA will mediate the relationship between ATT and symptom improvement over time. In step 1, the effect of experimental condition on the change in self-reported fear was evaluated. This effect was not significant $\beta = -0.009234$, $t(84) = -0.117$, $p = .907$. In step 2, the effect of experimental condition on the change in self-reported fear was evaluated. This effect was not significant $\beta = -0.00003$, $t(104) = 0.0001$, $p = .999$. In step 3, time and self-reported fear were entered as Level 1 predictors of fear-based psychopathology while experimental condition was entered as a Level 2 predictor. The adjusted effect of self-reported fear on the change in fear-based psychopathology over time was not significant $\beta = -0.06064$, $t(58) = -0.435$, $p = .6657$. The mediation effect of this 3-step model was 0.00002. Sobel's z-statistic was 0.001, $p = .999$. Thus, no mediation effect was observed. *Hypothesis 6.3*: The relationships described in 6.1 and 6.2 was moderated by gains in attentional control, such that individuals with high gains in attentional control over time will experience greater improvement in taxed attention and symptom improvements, while individuals with low gains in attentional control over time will experience fewer taxed attention and symptom improvements. The full moderation model would not converge using the restricted maximum likelihood estimator or the non-restricted maximum likelihood estimator, likely due to being over-specified without a sufficient sample size (Kwok, West & Green, 2007).

Hypothesis 7

Null Model 7.1:

$$\text{Level 1: } \textit{Psychopathology} = \pi_{0i} + \pi_{1i}(\textit{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10}$$

Hypothesis 7.1:

$$\text{Level 1: } \textit{Psychopathology} = \pi_{0i} + \pi_{1i}(\textit{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(AC_{\textit{Baseline}}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(AC_{\textit{Baseline}})$$

HLM was used to evaluate Hypothesis 7.1. *Hypothesis 7*: Lower scores on the ANT executive control measure will attenuate the effect of ATT on psychological symptom improvement. Time 1 attentional control scores from the ANT were entered into the model as a Level 2 predictor of the effect of time on psychopathological symptoms. Fear psychopathology was entered as the Level 1 outcome variable predicted by time at Level 1. Baseline attentional control was entered into the model as a Level 2 predictor variable. The null model indicated that fear psychopathology did not significantly change over time $\beta = .03702$, $t(48) = 1.525$, $p < .134$. Additionally the full model indicated that there was no attenuation effect for baseline attentional control, $\beta = .00031$, $t(47) = 0.602$, $p = .550$.

Hypothesis 8

Example formula:

$$\text{Level 1: } AC = \pi_{0i} + \pi_{1i}(\textit{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + \beta_{01}(\textit{Sex}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\textit{Sex}) + r_{1i}$$

HLM was used to evaluate Hypothesis 8.1. *Hypothesis 8.1*: Sex will not significantly affect the relationship between experimental condition and fear, attention, or psychopathological symptoms over time. This hypothesis was supported. Experimental condition and sex were

entered into a model as Level 2 predictors of the Level 1 relationship between time and fear, attention, or psychopathological symptoms. The impact of sex was not significant on these relationships, $\beta_s = 0.0753; -2.2778; .1834; ts(84) = 1.513; -0.381; 0.0753; ps = .133; .705; .313$.

Exploratory post-hoc analyses.

Example formula:

Step 1:

$$\text{Level 1: } SIAS = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10} + r_{1i}$$

Step 2:

$$\text{Level 1: } Fear_{ij} = \pi_{0i} + \pi_{1i}(\text{time}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10} + r_{1i}$$

Step 3:

$$\text{Level 1: } SIAS = \pi_{0i} + \pi_{1i}(\text{time}) + \pi_{2i}(\text{Fear}) + e_{ti}$$

$$\text{Level 2: } \pi_{0i} = \beta_{00} + r_{0i}$$

$$\pi_{1i} = \beta_{10} + r_{1i}$$

$$\pi_{2i} = \beta_{20} + r_{2i}$$

Sobel's statistic was used to test for the significance of this effect:

$$Z = \frac{ab}{\sqrt{a^2\sigma_b^2 + b^2\sigma_a^2}}$$

Because results showed no difference between the ATT condition and the sham control condition, exploratory mediation models were run collapsed across condition to examine the change in social anxiety (SIAS) and specific phobia (CFMMF) scores over time that occurred in both conditions. Furthermore, Table 7 shows the correlations of all participants across all time points. Fear was found to partially mediate the relationship between time and SIAS (Sobel's $Z = -3.43, p = .001$), but time remained a significant predictor, $\beta = -0.121, t(68) = -3.495, p = 0.001$, and fully mediated the relationship between time and CFMMF (Sobel's $Z = -2.52, p = .012$). Time was not a significant predictor, $\beta = -.012, t(58) = -.312, p = 0.756$. However, ANT executive attention did not mediate these relationships (Sobel's $Zs = .18, .19, ps = .861, .850$), nor did ANT alerting scores (Sobel's $Zs = .75, .95, ps = .450, .341$).

Table 7

Correlations of All Data Points Across Time, Condition, and Participant

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. External Focus	-												
2. ANT Alerting	-.076	-											
3. ANT Orienting	.074	.252**	-										
4. ANT Executive	-.134	.062	.085	-									
5. ANT Total	-.128	.215**	.301**	.511**	-								
6. ANT Accuracy	.128	-.181*	-.065	-.083	-.065	-							
7. MSIT	-.028	-.093	.191*	.191*	.279**	.021	-						
8. Fear	.062	-.199**	-.081	-.032	.002	-.041	.017	-					
9. Social Anxiety	.113	-.256**	-.095	-.128	.009	.107	-.016	.494**	-				
10. Specific Phobia	-.154*	-.052	-.049	.095	.162*	-.138	.030	.274**	.259**	-			
11. PTSS	.119	-.250**	-.120	-.143	-.025	.053	-.015	.511**	.428**	.344**	-		
12. Cognitive Confidence	-.004	.089	.003	.191*	-.132	-.074	-.017	-.326**	-.441**	-.258**	-.422**	-	
13. Fear Composite	.039	-.244**	-.117	-.080	.068	-.004	-.002	.567**	.750**	.715**	.787**	-.498**	-
N	181	174	174	174	174	174	174	173	173	173	170	173	173

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task; PTSS = posttraumatic stress symptoms.

CHAPTER 5

DISCUSSION

The results of this study are generally null. The hypotheses were not supported by the data collected via the one-week study protocol. All of the major hypotheses predicted differences between the two conditions, but this was not supported in the data. While there were several significant changes in symptoms, fear, and attention over time, these changes were not impacted by regular practice of ATT vs regular practice of sham ATT. The primary focus of this discussion will be on an investigation of the potential causes of null results. Additionally, exploratory analyses uncovered promising avenues for further research.

Beginning with Hypothesis 0, scores on the ANT at Time 1 were not significantly associated with self-reported focus of external attention, and MSIT score was not associated with fear. However, self-reported measures appeared to function as expected. All self-reported measures displayed good-to-excellent internal consistency and were related to each other in the expected directions. Furthermore, Time 1 symptom measures were related to Time 7 symptom measures as expected in the ATT condition (Table 8) and in the control condition (Table 9). An *N* of 68 is not able to detect small effects, and it is possible that because the present study used a multi-method, multi-source design that smaller effects than expected were present. To explore this possibility, Table 8 was produced which shows the scores of the cognitive tests as well as psychological variables collapsed across groups and across time. This table must be interpreted with extreme caution because it violates independence assumptions (each participant

Table 8
Cognitive Variables Across Time, ATT Condition Only

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. T1 ANT Alerting	-														
2. T1 ANT Orienting	.145	-													
3. T1 ANT Executive	.217	.189	-												
4. T1 ANT Total	.250	.134	.567**	-											
5. T1 MSIT	-.045	.313	.312	.329	-										
6. T4 ANT Alerting	.317	-.420*	-.023	.274	-.025	-									
7. T4 ANT Orienting	.257	.010	-.296	.311	-.211	.377	-								
8. T4 ANT Executive	.419*	-.089	.880**	.608**	.318	.311	-.100	-							
9. T4 ANT Total	.306	-.247	.400	.843**	.306	.640**	.441*	.613**	-						
10. T4 MSIT	-.078	.437*	.254	.521**	.665**	-.290	-.052	.107	.159	-					
11. T7 ANT Alerting	.298	.089	.190	.118	.213	.344	-.106	.423*	.307	-.019	-				
12. T7 ANT Orienting	.357*	.328	.298	.579**	.045	.473*	.436*	.418*	.648**	.412*	.149	-			
13. T7 ANT Executive	.295	.130	.837**	.631**	.282	.350	.009	.933**	.609**	.162	.380*	.371*	-		
14. T7 ANT Total	.223	-.018	.427*	.882**	.278	.562**	.287	.601**	.877**	.292	.305	.514**	.619**	-	
15. T7 MSIT	-.045	.284	.186	.308	.692**	.093	-.245	.139	.271	.457*	.085	.182	.254	.326	-
N	34	34	34	34	36	24	24	24	24	25	32	32	32	32	32
Mean	41.880	42.440	149.880	615.910	113.532	48.290	37.290	136.710	594.210	108.232	54.410	37.410	113.590	575.440	99.123
SD	23.444	31.438	71.992	92.075	62.077	31.967	35.968	61.933	104.646	44.768	27.297	23.876	37.825	60.919	56.902

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task.

Table 9

Cognitive Variables Across Time, Sham ATT Condition Only.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. T1 ANT Alerting	-														
2. T1 ANT Orienting	.431*	-													
3. T1 ANT Executive	-.174	-.163	-												
4. T1 ANT Total	-.085	.180	.345	-											
5. T1 MSIT	-.218	.183	-.040	.133	-										
6. T4 ANT Alerting	.588**	.380*	-.117	.046	-.072	-									
7. T4 ANT Orienting	-.087	.473**	.169	.447*	.360	.139	-								
8. T4 ANT Executive	-.096	-.074	.593**	.010	-.178	-.142	.209	-							
9. T4 ANT Total	.019	.292	.175	.720**	-.020	.246	.469**	.102	-						
10. T4 MSIT	-.461*	-.065	.032	.238	.649**	-.202	.204	.061	.243	-					
11. T7 ANT Alerting	.457*	.250	-.072	.191	-.392*	.566**	.113	.032	.132	-.474*	-				
12. T7 ANT Orienting	.216	.500**	.084	.510**	-.010	.256	.404*	.097	.603**	-.30	.146	-			
13. T7 ANT Executive	-.170	-.050	.541**	.189	-.096	-.460*	.315	.748**	.135	.040	-.158	.113	-		
14. T7 ANT Total	-.001	.361	.098	.622**	-.041	-.054	.366	.241	.724**	.221	.068	.475**	.196	--	
15. T7 MSITr	-.069	.290	.074	.008	.436*	.071	.006	.130	-.007	.307	-.065	.100	.044	.034	-
N	31	31	31	31	32	30	30	30	30	29	29	29	29	29	29
Mean	37.350	35.770	134.260	615.480	98.918	41.200	38.630	114.930	582.670	91.511	45.240	36.280	99.310	571.830	80.578
SD	31.112	27.344	52.202	72.061	68.734	28.219	19.627	40.247	61.119	46.733	26.856	21.545	31.746	64.856	41.640

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task.

has up to three data points within each cell), and individual correlations should probably not be remarked upon. However, several significant correlations emerge between the self-report and objectively measured variables in the combined data, such as a “significant” relationship between ANT Alerting Score and the Fear Composite, $r = -.244, p < .001$.

The remaining hypotheses were various permutations of the expectation that there would be group differences between the experimental conditions in the study. The data indicated that there were no significant group differences whatsoever. That said, there were significant changes over time in both groups. For instance, ANT executive control scores decreased in both groups over time (lower is better), overall level of fear decreased in both groups over time, and fear-based psychopathology decreased over time in both groups. The finding that ANT scores decreased in both groups is consistent with one other study that compared a brief mindfulness meditation and a relaxation intervention and found that the two equivalently produced changes in the ANT executive attention score (Vieth & von Stockhausen, 2022). It is possible that merely participating in a relaxing or focusing activity impacts an individual’s performance on the ANT. One other potential factor that may have produced null results is that the analysis implemented in the study design assumed linear relationships between the variables when some relationships may be curvilinear. It could be easily imagined that, particularly for performance tasks, there exists a non-zero optimum level of anxiety (e.g., the Yerkes Dodson Law; Yerkes & Dodson, 1908). In a non-clinical population, one adaptive function of anxiety is motivation (Lang et al., 1998), which may otherwise be somewhat lacking within a sample of undergraduate students.

Yet another factor that may have produced the null results would be that the completion of the ANT and of the MSIT at multiple time points throughout the course of a week could have functioned similarly to the ATT intervention. Both the ANT and the MSIT contain elements of a

flanker task that may mimic the first portion of ATT in which participants are selectively attending to stimuli. The ANT's spatial cuing may also function similarly to the selective attention portion of ATT, since participants are instructed to only attend to the arrow stimuli. However, ATT and the ANT are not entirely the same. The ANT is an auditory attention exercise while the ATT is visual. Evidence from the literature indicates that auditory and visual attention are associated with different pathways in the brain, particularly for selective attention (Salo et al., 2017). Currently, there is no data that would suggest whether auditory, visual, or combined attentional processes would be more important to psychopathology or to fear. An additional important difference is that the ANT utilizes a variety of recognizable and semantically significant sounds (e.g., a church bell, vehicle traffic, etc.) that may also evoke simultaneous visual attention processes and may produce more generalizable learning (see Shinn-Cunningham, 2008, for a brief review of the overlap between auditory and visual attention).

One variable that did not decrease significantly over time in either condition was MSIT scores. It appeared as though the MSIT did not function as expected, because in theory, MSIT performance would change if all of the other variables changed (e.g., Darnell & Valentiner, 2020). Instead, MSIT scores remained consistent over time within participants. It may be that MSIT performance reflects more trait-like abilities while ANT performance and symptom measures are more susceptible to change over time due to external factors. The MSIT requires a greater degree of semantic information to be integrated into working memory while performing the task (e.g., matching the third position on the with the number 3 on the keyboard), and cognitive tests of semantic memory tend to be more stable than those of processing speed alone (Brett et al., 2016).

Encouragingly, decreases in fear-based psychopathology over time were mediated by self-reported fear. This is consistent with the fear-based literature such as Duits et al. (2015), Dymond, et al. (2015), and Lissek et al. (2010), that all found that a transdiagnostic factor of fear was directly related to the presence and severity of common anxiety disorders. As previously discussed, future studies may focus on a mixed-method approach to assessing fear responding. Fear potentiated startle paradigms are the gold-standard methodology to study transdiagnostic fear, and a combination of subjective and objective experiences of fear may enhance findings (Maples-Keller et al., 2022).

Several rigorous features of the present study's design increase confidence that the null findings are a reflection of reality within this population, and that the study is generally of higher quality than what has previously been published on ATT. Multi-trait, multi-method studies are recommended due to their ability to avoid method effects (Campbell & Fiske, 1959). However, it follows that the overall relation between two variables derived from different methods is likely to be smaller than the relationship between two variables derived from the same method (e.g., two self-report variables). Many models examined by this study utilize a multi-method approach. The power analysis for the present study was based on a moderate-to-large effect size (Cohen's $d = .75$) given the 10 RCTs of ATT included in part of a meta-analysis (Fergus & Bardeen, 2016). These studies included non-active control conditions and utilized self-report outcome measures only. The present study included a highly similar active control condition in an effort to isolate only the theorized active ingredient in ATT, guided attention switching. It may be the case that individuals in the control condition naturally performed attention switching over the course of their 12-minute listening exercise and therefore received the same benefit as the ATT condition. Future research attempting to isolate the active ingredient in ATT might consider instructing

participants specifically not to perform attention switching while listening to the sham control audio. The present study also evaluated ATT over a longer period of time than studies in the literature that typically examine the immediate effect of one, two, or three ATT trials.

One underlying and fundamental assumption of the proposed study is that objective, behavioral measures of constructs are preferable to subjective self-report measures. However, previous research suggests that this assumption may be flawed and may have contributed to the null results of this study. Less popular theories of psychopathology that emphasize the importance of subjective, conscious human experience in the face of ever-increasing emphasis on psychophysiological processes suggest that “fear” and other proposed translational mechanisms of psychopathology are poorly defined (Braslow et al., 2020). For example, it has been proposed that the term “fear” actually comprises three separate constructs—subjective, behavioral, and physiological fear—and that the assumption that, for example, subjective experiences and psychophysiological experiences of fear have a common etiology is incorrect. It has instead been proposed that psychophysiological fear and subjective experience of fear are not as related as medical models of psychopathology suggest (Taschereau-Dumouchel et al., 2022). These theories cite several studies that have attempted to link psychophysiological fear and subjective DSM-5 symptoms and have failed or have found a smaller link than expected (e.g., LeDoux, 2017; LeDoux & Pine, 2016). Alternatively, other research groups simply suggest that, when psychophysiological measures of fear and self-report of fear do not overlap, the psychophysiological measures are the more “objective” measure and, therefore, should take precedence (e.g., Fanselow & Pennington, 2018). Fanselow and Pennington (2018) go so far as to plainly state that any consideration of subjective experience as equally valid to psychophysiological measures sends psychology back to the “dark ages.”

These debates are raging in the emotion literature, but seem to be nearly non-existent in the attention literature, another construct with major differences between objective and subjective measures. In the attention literature, it is taken as a matter of fact that self-reported cognitive abilities are unrelated to objectively measured cognitive performance (e.g., O’Neil et al., 2019). In fact, this author’s unpublished manuscript indicating that a self-report measure of attentional control was unrelated to a commonly-used standard behavioral measure of attentional control was once rejected because “it is pretty typical for self-reported cognition to have low correlation with actual cognitive performance so the current finding would be the norm rather than the exception” (K. Naragon-Gainey, personal correspondence, Feb 15, 2021). The Attentional Control Scale (ACS; Derryberry and Reed, 2002), a subjective measure of attentional control, and the ANT (Fan et al., 2002), an objective measure purportedly measuring nearly the exact same construct by name, does not appear to be a contentious debate in the literature (i.e., there are no published accusations, to this author’s knowledge, that utilization of the ACS pushes psychology research back to the dark ages). That said, if Taschereau-Dumouchel and colleagues’ (2022) proposal that subjective and objective experiences of fear uniquely contribute to psychopathology, the same may be the case for executive functioning and other cognitive abilities.

The above debate may be resolved by future research that explores the possibility that psychophysiological and subjective experiences of transdiagnostic mechanisms of change make up distinct aspects of a latent, broader construct. A future study may compare two predictive models of change in psychopathological symptoms, one that includes variables like “fear” and “attention” as latent predictors of psychological change and one that includes only objective measures of these constructs. This type of study may be able to bridge the gap between the

HiTOP research group and research like Gorka et al (2017). HiTOP uses almost entirely self-report measures of psychopathology to determine the factor structures of its “Superspectrum,” although efforts are underway to integrate additional modalities of measurement (Waszczuk et al., 2020), while Gorka et al. (2017) based their conclusions only on psychobiological data. The present study did include both a subjective and an objective measure of cognitive ability and found that the subjective measure was in some cases more predictive of psychopathology than the objective measure, common method variance notwithstanding (Table 10). The most parsimonious explanation for this may be that psychopathology is generally defined as a subjective experience (APA, 2013), and the idea that it can be more clearly observed through “objective” behavioral measurement rather than subjective self-report (e.g., RDoC) is a misguided oversimplification. Additionally, behavioral measures are unable to encompass more than a small moment in time, while self-report measures can, and frequently do ask participants to respond in a way that captures a period of time that is much greater in length. Unfortunately, the present study lacks sufficient power to produce the aforementioned latent growth model to examine these constructs together (Wolf et al., 2013). Furthermore, the present study did not include an objective measure of fear and relied only on self-report, which also precludes the present study’s ability to investigate this important research question.

Limitations

There are several limitations to the study. The study sample was homogeneous in a few different ways which may limit the generalizability of findings. Participants were, for the most part, between the ages of 18 and 22 and may be better educated than the general population.

Table 10

Time 1 Attention, Fear, and Psychological Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. T1 ANT Alerting	-											
2. T1 ANT Orienting	.291*	-										
3. T1 ANT Executive	.043	.074	-									
4. T1 ANT Total	.084	.151	.488**	-								
5. T1 MSIT	-.128	.263*	.177	.240	-							
6. T1 External Focus	.128	.203	-.127	-.140	.049	-						
7. T1 Fear	-.029	-.059	-.054	.031	.013	-.055	-					
8. T1 Social Anxiety	-.220	-.167	-.214	.010	-.122	.087	.436**	-				
9. T1 Specific Phobia	-.036	-.119	-.061	.179	.000	-.022	.327**	.264**	-			
10. T1 PTSS	-.356**	-.208	-.021	.132	.083	.080	.427**	.510**	.377**	-		
11. T1 Cognitive Confidence	.162	.152	.209	-.225	.000	.021	-.199	-.377**	-.296*	-.371**	-	
12. T1 Fear Composite	-.249*	-.210	-.132	.139	-.024	.068	.518**	.774**	.715**	.815**	-.665**	-
N	65	65	65	65	68	68	67	67	67	65	67	67
Mean	39.720	39.260	142.43	615.71	106.655	50.570	2.996	2.635	3.399	9.32	9.70	0
SD	27.246	29.519	63.337	82.495	65.215	29.833	0.948	0.674	0.717	11.200	3.949	0.726

Note: * $p < .05$, ** $p < .01$. ANT = Attention Network Task; MSIT = Multi-Source Interference Task; PTSS = posttraumatic stress symptoms; Fear Composite is the mean Z score of the social anxiety, specific phobia, and posttraumatic stress symptom measures

Scores on executive reaction time tasks like the ANT and the MSIT are related to the construct of general intelligence (McGrew, 2005) and age (Brett et al., 2016). The relatively restricted age and education characteristics of the sample may reduce the between-persons variability in the analyses by restricting the range of scores on these measures. However, the student sample was representative in terms of race/ethnicity and may be more closely aligned with the income distribution of the US than typical university students.

The active control condition selected, sham ATT, could have theoretically been very close in terms of mechanism of action to the intervention, ATT. Both sham ATT and full ATT likely manipulated and exercised participants' attention in qualitatively distinct ways. However, these differences may not have sufficiently differentiate the two protocols for the purposes of comparing mechanisms of change.

The study did not have an adequate sample size to identify small effects. This was especially problematic for hypothesis 0 which was seeking to uncover relatively small r^2 values. This was less of a problem for hypotheses that compared the two experimental conditions, since it appears as though any actual difference between the conditions is likely to be extremely small. Furthermore, the sample size did not allow for complex moderated mediation models. Future research could consider collecting larger samples.

PTSD was measured differently at some time points. The initial PCL-5 was administered alongside the LEC. However, subsequent administrations of the measure were not, in an effort to reduce participant burden. This may have caused the PCL-5 scores to spuriously increase in the sample due to participants responding to less-specific questions (thereby introducing a greater risk of the PCL-5 becoming a measure of negative affect rather than of PTSS). Future research must anchor the PCL-5 at all time points to a specific criterion A event.

The present study did not include a behavioral measure of fear such as FPS (Jovanovic et al., 2014). The exploratory analysis revealed that self-reported subjective experience of fear at least partially mediated the relationship between time and fear-based psychopathology. Recent debates in the emotion literature suggests that emotion constructs may be best measured by multiple methods and future research should consider including both modalities.

The PDSR generally does not allow for the measurement of subthreshold symptoms of panic in a non-clinical sample. Future research may consider removing the skip logic in the measure and having participants respond to all items. Alternatively, future research may utilize a different measure of panic symptoms altogether.

Finally, it was not possible for the study design to control the environment in which the participants completed their daily tasks. It is possible that participants were often distracted while listening to the interventions, limiting the overall effectiveness in terms of reducing psychological symptoms and increasing attentional control. It is also possible that participants were not fully engaged with the interventions, limiting their effectiveness. This is broadly a limitation of unsupervised interventions. Many cognitive-behavioral therapies that aim to promote unsupervised, at-home practice provide structured homework that is then discussed in person upon completion (e.g., CPT; Resick et al., 2017). No such in-person accountability was required in this study protocol.

Conclusions

The present study was, to this author's knowledge, the most methodologically rigorous evaluation of ATT yet undertaken. The intervention dose was higher than is typical for studies of ATT, and the active control was designed to specifically isolate the purported active ingredient

in the intervention. Furthermore, objective performance-based measures of attention were utilized whereas previous studies have used self-report measures of attention (Fergus & Bardeen, 2016) or chose not to evaluate attention at all. Based on the results of the study, the ATT condition was not distinguishable from the active control condition. However, despite the strong methodology employed by this study, one cannot definitively conclude that ATT offers no benefit above and beyond a daily thought-wandering routine based on these results alone. Several of the study's limitations need to be addressed in the future in order to permit stronger conclusions. In particular, as ATT was designed to be used in a clinical population, future research should evaluate ATT in a sample with higher baseline levels of psychopathology. Furthermore, the possibility that attention and fear are nonlinearly related should be explored further. Additionally, future research in this area must consider the measurement questions discussed above as unresolved and should include both subjective and objective measures of all variables of interest. Finally, exploratory analyses in the present study provide support for the HiTOP model of psychopathology that categorized PTSD as separate from other fear-based disorders. The measures of specific phobia and social anxiety generally functioned similarly, both in terms of their trajectory over time and their interaction with fear. However, PTSS, which the present study conceptualized as also grouped with fear-based symptoms, functioned rather differently with respect to its changes over time. In sum, despite null results and some limitations, the present study made significant contributions to the literature by producing methodologically-sound results that indicated that ATT does not differ from an active control within the general (but slightly anxious) student population.

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