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Optimizing Exposure: Between-Session Mental Rehearsal as an Augmentation Strategy

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Optimizing Exposure:

Between-Session Mental Rehearsal as an Augmentation Strategy

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Psychology

by

Anastasia Lara McGlade

2021

ABSTRACT OF THE DISSERTATION

Optimizing Exposure:

Between-Session Mental Rehearsal as an Augmentation Strategy

by

Anastasia Lara McGlade

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2021

Professor Michelle G. Craske, Chair

Background & Objectives: Exposure therapy is widely empirically supported as a treatment for anxiety disorders, but clinically significant response rates hover around 50%. This study explores strategies for consolidating the exposure memory as a way of improving efficacy. Between-session mental rehearsal of exposure learning was examined as a way of enhancing the effects of exposure therapy.

Methods: Sixty-two spider-fearful individuals completed baseline questionnaires and a behavioral approach test with a live tarantula, followed by two sessions of in vivo exposures, and a post-assessment one week later that repeated the baseline questionnaires and behavioral approach test. Skin conductance, subjective distress, and number of steps completed were recorded at each behavioral approach test. Participants were randomized to mental rehearsal or control (non-specific) rehearsal that was prompted on three occasions after each exposure session.

Results: Participants in both conditions improved from baseline to post-assessment, but mental rehearsal participants showed significantly greater improvement than control participants across questionnaire measurements of spider fear, subjective distress, and number of steps completed during the behavioral approach test.

Conclusions: Findings suggest that between-session mental rehearsal is an effective supplement to exposure therapy. As such, mental rehearsal may be a promising avenue toward increasing treatment response rates across many psychiatric disorders that benefit from exposure therapy.

The dissertation of Anastasia Lara McGlade is approved.

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2021

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Education

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Cornell University, Arts and Sciences May 2013
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Publications

McGlade, A.L., Zbozinek, T.D., Treanor, M., & Craske, M.G. (2019). Pilot for novel context generalization paradigm. *Journal of Behavior Therapy and Experimental Psychiatry*, *62*, 49-56. doi:10.1016/j.jbtep.2018.08.009

McGlade, A.L., Craske, M.G., & Niles, A.N. (2020). Temporal trends in attention disengagement from social threat as a function of social anxiety. *Journal of Behavior Therapy and Experimental Psychiatry*, *68*. doi:10.1016/j.jbtep.2019.101529

Smith, A.R., White, L.K., Leibenluft, E., **McGlade, A.L.**, Heckelman, A.C., Haller, S.P., Buzzell, G.A., Fox, N.A., & Pine, D.S. (2020). The heterogeneity of anxious phenotypes: Neural responses to errors in treatment-seeking anxious and behaviorally-inhibited youth. *Journal of the American Academy of Child and Adolescent Psychiatry*, *59*(6), 759-769. doi:10.1016/j.jaac.2019.05.014

McGlade, A.L., & Craske, M.G. (2021). Optimizing exposure: Between-session mental rehearsal as an augmentation strategy. *Behaviour Research and Therapy*, *139*. doi:10.1016/j.brat.2021.103827

McGlade, A.L., Treanor, M., Kim, R., & Craske, M.G. (under review). Does habituation predict treatment response to exposure for social anxiety disorder? *Journal of Behavior Therapy and Experimental Psychiatry*.

Sewart, A.R., **McGlade, A.L.**, Treanor, M., Fanselow, M., & Craske, M.G. (under review). Pre-treatment hippocampal functioning impacts context renewal for cholinergic modulated exposure therapy. *Biological Psychology*.

Leuchter, M.K., Rosenberg, B.M., Schapira, G., Wong, N.R., Leuchter, A.F., **McGlade, A.L.**, …. Craske, M.G., & Iacoboni, M. (under review). Treatment of spider phobia using repeated exposures and adjunctive transcranial magnetic stimulation (TMS): A randomized controlled pilot and feasibility study. *Neuromodulation*.

Khoddam, R., **McGlade, A.L.**, & Christie, N. (under review). IMPROVE: A program evaluation for a novel harm reduction intervention for veterans with substance use disorders. *Addictive Behaviors*.

SELECTION OF POSTERS & PRESENTATIONS

Sewart, A.R., **McGlade, A.L.**, Treanor, M., Fanselow, M., & Craske, M.G. (2019, Nov). *Hippocampal functioning as a predictor of response to pharmacological decontextualization of exposure therapy.* Association for Behavioral and Cognitive Therapies, Atlanta, GA.

McGlade, A.L., Niles, A.N., & Craske, M.G. (2018, May). *Temporal trends in attention disengagement from social threat as a function of social anxiety.* Association for Psychological Science, San Francisco, CA.

McGlade, A.L., Niles, A.N., & Craske, M.G. (2018, Apr). *Social anxiety and attention disengagement from threat: A temporal dynamics approach.* Society for Affective Science, Los Angeles, CA.

McGlade, A.L., Dixon, L., Granato, H., & McFarr, L. (2018, Apr). *Relations between emotion regulation and interpersonal functioning in Borderline Personality Disorder.* Scientific Sessions, Torrance, CA.

McGlade, A.L., Zbozinek, T.D., Treanor, M., & Craske, M.G. (2017, Nov). *The effects of stress, anxiety, and early life adversity on contextual fear generalization.* Association for Behavioral and Cognitive Therapies, San Diego, CA.

McGlade, A.L., & Craske, M. G. (2017, Mar). *The impacts of stress and anxiety on contextual fear generalization*. Clinical Area Program Meeting, Department of Psychology.

McGlade, A.L., Tanner, A.S., Taylor, K.B., Craske, M.G., Zinbarg, R.E., & Mineka, S. (2016, Oct). *The impact of childhood trauma, personality and temperament on psychopathology*. Association for Behavioral and Cognitive Therapies, New York, NY.

McGlade, A. L., White, L. K., Fox, N.A., & Pine, D.S. (2015, Mar). *Neural and behavioral correlates of conflict detection and behavioral monitoring*. Society for Research in Child Development, Philadelphia, PA.

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- Awarded annually to one second-year doctoral student for excellence in research

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- One-year funded research fellowship for doctoral study

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- Two-year funded research fellowship through the National Institute of Mental Health, Section on Development and Affective Neuroscience

Phi Beta Kappa 2013

- National Honor Society for high academic achievement

Cornell University Dean's Honors List 2009-2013

- Award of high academic achievement

INTRODUCTION

Overview & Aims

Anxiety disorders are the most common mental illness in the United States, affecting approximately one fifth of the population each year (National Institute of Mental Health; World Health Organization, 2018). Specific phobias, the most common anxiety diagnosis, have a lifetime prevalence estimated at 15.6% (Kessler, 2012). With regards to treatment, cognitive behavioral therapy (CBT) is considered to be the most effective and empirically supported psychological intervention for anxiety (Hofmann & Smits, 2008; Norton & Price, 2007; Tolin, 2010). Exposure therapy, often a critical element of CBT, offers an extinction-based behavioral protocol for the treatment of fears and phobias. It involves strategically exposing an individual to his or her feared stimulus in an effort to reduce distress and avoidance and to generate nonfear associations with that stimulus. Despite the demonstrated efficacy of CBT, treatment response rates across anxiety disorders are estimated to be 50% at post-treatment and follow-up, indicating a need for further development of treatment methodologies (Loerinc et al, 2015).

The overall aims of the current research were to evaluate a method of enhancing the effectiveness of exposure therapy, and to better understand cognitive and affective mechanisms underlying fear memory consolidation. At the intersection of clinical and cognitive psychology, researchers have sought to develop strategies that optimize the consolidation and long-term retention of learning that occurs during exposures (e.g., Lang, Craske, & Bjork, 1999). Building upon this literature, the current study tested the extent to which a novel between-session mental rehearsal intervention, characterized by technology-guided recall and rehearsal of critical aspects of in-session exposures, optimized treatment outcomes in highly spider-fearful individuals.

Mental rehearsal is a technique whereby information is reinstated using either a cue from extinction training or imaginal recounting of previous successful exposures (Craske et al, 2014). Prior research has assessed the effects of mental rehearsal via reinstatement of the extinction context (i.e., treatment context) or of cues/items from the treatment context that may indicate safety (Mystkowski et al, 2006; Culver, Stoyanova, & Craske, 2011). However, this research has produced inconsistent results. Moreover, the efficacy of this methodology is limited as retrieval cues may become safety signals and inhibit new learning (Dibbets, Havermans, & Arntz, 2008).

The current study sought to address these limitations by assessing the efficacy of mental rehearsal in a different, less context-dependent manner. Rather than rehearsing cues from the treatment context, participants in the current study specifically rehearsed the new learning contingency, that is, that their feared outcome did not occur when they approached a live spider. This violation of expectancies engenders new, secondary learning (e.g., "spiders are safe and will not bite me") that competes with the older memory representation (e.g., "spiders are dangerous and will bite me") (Craske et al, 2008; Bjork, 2003). As this secondary, nonfear learning is repeatedly retrieved, the original fear memory is gradually suppressed, rendering it less recallable in the future (Karpicke & Roediger, 2008; Bjork, 2011). Thus, in the current study, repeatedly retrieving the nonfear memory generated from exposures was expected to reduce participants' fear of spiders. Additionally, in contrast to prior methodologies, our mental rehearsal intervention was conducted *between* sessions in an effort to enhance consolidation of nonfear learning via multiple rehearsal trials in varied environments/contexts.

We tested the primary hypothesis that mental rehearsal, relative to control rehearsal of a recent unrelated and unemotional academic experience, would result in greater reduction of arachnophobia symptoms, marked by increased approach behaviors, increased confidence,

decreased fear and distress, and decreased physiological arousal toward spiders. Secondary analyses tested hypotheses concerning mechanisms that might increase or decrease the efficacy of mental rehearsal. Self-reported stress, sleep quality, and aerobic exercise were assessed as moderators in the association between mental rehearsal and clinical outcomes because of their association with memory processes (e.g., Maren & Holmes, 2016; Rasch & Born, 2013; Hotting et al, 2016; Kalueff, 2007). It was hypothesized that higher levels of stress and poorer sleep quality would undermine the positive impacts of mental rehearsal, while greater aerobic exercise would amplify treatment gains. Finally, it was hypothesized that across participants, greater post-exposure ratings of surprise (indicative of expectancy violation), lower ratings of post-expectancy (i.e., expectancy of the feared outcome occurring again with the same spider and exposure task), and lower ratings of fear generalization (i.e., expectancy of the feared outcome occurring with a different spider outside of the laboratory) would be associated with greater clinical improvement (Craske et al, 2014; Dunsmoor & Paz, 2015).

Understanding the extent to which mental rehearsal may augment exposure therapy gains may help to develop and improve evidence-based treatments for anxiety. Results of the current study may also assist in building upon our understanding of learning and memory mechanisms maintaining specific fears and phobias. Finally, we aimed to provide preliminary data concerning the effectiveness of between-session mental rehearsal as a supplement to exposure therapy in the hope that future research may utilize similar interventions to target a range of severe and impairing anxiety and stress-related disorders, such as social anxiety disorder and post-traumatic stress disorder.

Mental Rehearsal

Pavlovian fear learning, or the process through which a neutral stimulus comes to evoke fear due to its association with an aversive outcome, is thought to be central to the genesis, maintenance, and treatment of anxiety and traumatic-stress disorders (Vervliet & Raes, 2012). In the context of specific fears and phobias, fear develops when a neutral stimulus (e.g., spider) is paired with an aversive, unconditional stimulus (US; e.g., spider bite), resulting in a conditional fear response (CR) to the previously neutral stimulus. Thus, the previously neutral stimulus becomes a conditional stimulus (CS) because of its association with the US. For example, an individual who learns to associate being bitten/attacked (US) with spiders may demonstrate fear (CR) upon encountering a spider (CS).

Anxious individuals have demonstrated deviant processes in fear learning, including reduced encoding of safety cues, impaired retention of extinction learning, and heightened fear reactivity to both threatening and safe stimuli (Vervliet, Craske, & Hermans, 2013). Despite the demonstrated effectiveness of exposure in treating specific fears and phobias (Choy, Fyer, & Lipsitz, 2007; Wolitzky-Taylor et al, 2008), it is not uncommon for fears to return after treatment has concluded or from one exposure session to the next. “Return of fear” (Rachman, 1989) refers to the re-emergence of fear that has been fully or partially extinguished. Phenomena that explain this effect include spontaneous recovery, reinstatement, and renewal (Lang, Craske, & Bjork, 1999). *Spontaneous recovery* (Pavlov, 1927) refers to return of a previously extinguished CR after a delay; *reinstatement* occurs when a previously extinguished CR is revived by presentation of the US alone; and *renewal* refers to return of the CR when the feared stimulus is encountered in a context other than that in which extinction took place (Bouton & Swartzentruber, 1991). Due to high rates of return of fear during and after exposure therapy (Mineka et al, 1999;

Mystkowski, Craske, & Echiverri, 2002; Rodriguez et al, 1999), compounded by a lack of clear predictors thereof (Craske et al, 2008; Vasey et al, 2012), research efforts have sought to enhance exposure methodologies to undermine treatment nonresponse and relapse.

One such strategy, known as *mental rehearsal*, involves mentally reinstating information specific to the extinction context and/or training. Since mental rehearsal of the CS–US association sustains conditional fear responding (Joos, Vansteenwegen, & Hermans, 2012), rehearsal of the CS–noUS association is posited to increase retention of extinction learning (Craske, Hermans, & Vervliet, 2018). More generally, mental rehearsal has been identified as an important component of memory consolidation (Meeter & Murre, 2004). In prior studies, information has been reinstated using either a cue from extinction training or imaginal recounting of previous successful exposures (Craske et al, 2014). Given that extinction processes are partially context-dependent (Bouton et al, 2006), it is thought that either providing individuals with objects that serve as extinction retrieval cues, or instructing participants to recall aspects of the extinction context, may serve to bridge the extinction context with novel contexts where the feared stimulus may be encountered (Craske et al, 2008).

In a study investigating the effects of mental reinstatement on fear reduction and renewal, Mystkowski et al (2006) administered exposure therapy to 48 individuals with spider phobia. Participants returned to the laboratory after one week for a follow-up assessment. Half the participants, assigned to a mental reinstatement condition, were provided the following verbal instructions prior to spider exposure at follow-up: “Remember what happened and what you learned last time, and where all of that took place.” Participants in the control group were asked to recall what they did to get ready for work/school that morning. Results demonstrated that participants who mentally reinstated the treatment context before encountering a spider in a new

context reported less fear at follow-up relative to participants in the control condition. Researchers speculated that mental reinstatement allowed participants to access learning that took place during exposures, as well as to recall specific cues from the therapy room that served to activate fear inhibitory associations (Mystkowski et al, 2006).

In a series of studies similarly aiming to reduce context renewal of fear, Culver, Stoyanova, and Craske (2011) manipulated whether or not participants had access to retrieval cues from the treatment context when tested in a novel context one week later. Retrieval cues, designed to act as reminders of nonfear learning from exposures, were colored clipboards, pens, and lab coats from exposure sessions. Findings were mixed, indicating a weak effect of retrieval cues on attenuation of context renewal in one study, and no effect in a subsequent study. Results suggest limited effectiveness of retrieval cues in attenuating renewal of fear.

While prior research has assessed effects of mental reinstatement via rehearsal of the treatment context or reinstatement of safety cues (Mystkowski et al, 2006; Culver, Stoyanova, & Craske, 2011), the inconsistent nature of results and paucity of studies in this area render it difficult to draw conclusions about the impact of mental rehearsal on exposure treatment outcomes. Moreover, there are significant limitations with using retrieval cues to reduce return of fear. It is likely that repeated use of an object as a retrieval cue will prompt such cues to become safety signals, thus inhibiting new learning and safety generalization (Craske et al, 2008; Dibbets, Havermans, & Arntz, 2008). Additionally, given that feared stimuli and associated cues may be encountered in the absence of accessible retrieval objects (Mystkowski & Mineka, 2007), mental rehearsal may serve to be a more effective and practical intervention than use of retrieval objects.

In the current study, mental rehearsal exercises were designed based on an expectancy violation model, that is, that extinction learning is enhanced by a greater discrepancy between expectancy and experience (Craske et al, 2014). Thus, participants were instructed to mentally rehearse that their expectation was violated by imagining a previous exposure and rehearsing the inhibitory CS-no US association (Craske et al, 2014). In other words, participants were instructed to rehearse observed discrepancies between what they predicted and what actually occurred during exposures, as well as what they learned regarding the lack of occurrence of their feared outcome. Rehearsal exercises were thus designed to facilitate attention to the association between the CS (i.e., spider) and non-occurrence of the US (e.g., bite/attack). Critically, rehearsal exercises were administered *between* sessions in an effort to reduce context-dependency of extinction learning and to reduce between-session return of fear.

Learning & Memory Consolidation

Memory consolidation refers to the process of transferring new learning from short- to long-term memory storage (Carlson, 2010). On a cellular level, *synaptic consolidation* is thought to occur within several hours of learning (Bramham & Messaoudi, 2005; Dudai, 2004). During synaptic consolidation, a cascade of intracellular processes promotes protein synthesis, inducing synaptic changes and growth, and resulting in greater durability of a memory trace (Dudai, 2004). Subsequently, in a process known as *systems consolidation*, memories are distributed to cortical areas of the brain over the course of weeks to years, becoming increasingly independent of the hippocampus (Squire, 1992; Wiltgen et al, 2004; Frankland & Bontempi, 2005; Kirwan, Wixted, & Squire, 2008).

According to the New Theory of Disuse (Bjork & Bjork, 1992), a model of memory storage and decay, the strength of items in memory can be characterized by two indices, *storage strength* and *retrieval strength*. *Storage strength* refers to how entrenched or inter-associated an item is in memory, and *retrieval strength* refers to how accessible an item is in memory. During exposures, a new nonfear memory is generated (e.g., "spiders are not dangerous and will not attack me") that competes with the original fear memory (e.g., "spiders are dangerous and will attack me"). An important aim of exposure therapy is to increase the retrieval strength of the newly formed nonfear memory, which consequently increases the retrievability of learning that occurs during exposures (Lang, Craske & Bjork, 1999). After repeated exposures, competing responses from the original fear representation are gradually suppressed, facilitating retrieval of the nonfear response by reducing transfer from competing responses (Bjork, 2003). This process is known as *retrieval-induced forgetting*, whereby competing information that is selected against (e.g., the fear memory) becomes less accessible in the future (Anderson, Bjork, & Bjork, 1994). Retrieval thus acts as a memory modifier, increasing the recallability of selected items and decreasing the recallability of non-selected items by altering the relative strengths across a set of responses for a given cue (Karpicke & Roediger, 2008; Bjork, 2011). In the context of exposure therapy, it is thought that high rates of relapse may partially reflect lack of continued retrieval of nonfear learning (Lang, Craske, & Bjork, 1999). Without continued rehearsal of the nonfear learning acquired during exposures, its retrieval strength is diminished and the more well-entrenched fear memory resumes dominance (Bjork & Bjork, 1992). Accordingly, without continued practice and retrieval, treatment gains are not expected to be maintained.

The current study sought to enhance treatment gains by increasing the retrievability of nonfear learning via repeated rehearsal practices. Our mental rehearsal intervention provided a

forum to rehearse the new learning gained during exposures, in an effort to strengthen and reinforce the nonfear memory between treatment sessions. Contextual variability, as suggested by Lang, Craske, and Bjork (1999) to undermine context dependency of the nonfear memory, was integrated into the intervention as participants were instructed to complete mental rehearsal exercises outside of the laboratory (e.g., at home, in class).

Exposures in our study were additionally designed to optimize learning. Participants completed two sessions of exposures distributed across two to three days. Distributed, relative to massed, learning has been shown to enhance consolidation of new memories (Bjork & Bjork, 2011). Research suggests that distributed learning across a 24-hour interval, relative to a single massed learning session, slows the rate of forgetting by enhancing memory consolidation (Litman & Davachi, 2008; Bloom & Shuell, 1981; Underwood & Ekstrand, 1967). A meta-analytic review of the distributed practice effect reported a medium effect size, indicating that spaced learning conditions result in higher performance relative to massed learning conditions (Donovan & Radosevich, 1999). In a clinical study, spider-fearful individuals who completed exposures spaced over the course of one week, compared to one day of massed exposures, showed significantly less return of fear at a one-month follow-up assessment (Rowe & Craske, 1998a). Spaced learning is purported to increase long-term retention of material as a function of increased storage strength gained from greater difficulty retrieving information after a delay (Bjork, 2011; Bjork & Bjork, 2011). Thus, we anticipated that spaced exposure sessions would strengthen participants' long-term retention of nonfear learning.

Our study design was also informed by prior work suggesting advantages of variability in learning experiences. Variability is thought to enhance long-term retention of information by increasing storage strength as a function of accumulation of cues associated with the nonfear

representation (Bjork & Bjork, 1992; Estes, 1955). Accordingly, increasing the number of cues associated with a given memory representation increases the ease with which it is recalled. Moreover, varying the treatment context may assist participants in generating a schematic rule that enables them to generalize the nonfear response to different settings and situations (Schmidt & Bjork, 1992; Craske et al, 2008). Prior studies have shown that varied exposure practice is associated with greater retention of treatment gains (Rowe & Craske, 1998b; Lang & Craske, 2000). In the current study, exposure tasks varied from Session 1 to Session 2 in an effort to increase generalizability of nonfear learning (Craske et al, 2008; Lang, Craske, & Bjork, 1999). Session 1 exposures required hovering one's hand over the tarantula in its terrarium, while Session 2 exposures required placing one's fingertips on the bottom of the tarantula's terrarium.

Finally, our study design was informed by work documenting benefits of "overlearning" and "repeated learning" of new material (Bjork & Bjork, 1992). Repeated learning is thought to increase a memory's storage strength (Bjork & Bjork, 1992), while retrieval and recall are thought to slow the rate of forgetting (Karpicke & Roediger, 2008). A meta-analytic review of the effects of overlearning on retention reported an association of moderate effect size (Driskell, Willis, & Copper, 1992). Participants in the current study completed ten exposure trials during each exposure session and six rehearsal exercises over the course of the study, in an effort to "overlearn" and optimally consolidate new learning gained from exposures.

Stress, Sleep, & Exercise

Secondary analyses tested the impacts of stress, sleep quality, and aerobic exercise on symptom reduction, and the extent to which these factors interacted with Group (mental rehearsal, control rehearsal) to predict symptom change. Stress is thought to impair the

consolidation and long-term recall of extinction memories by impacting the functionality of implicated brain regions, including the amygdala, prefrontal cortex, and hippocampus (Aubry, Serrano, & Burghardt, 2016; Maren & Holmes, 2016; Deschaux et al, 2013). The medial prefrontal cortex is particularly instrumental in the consolidation and long-term retention of extinction memories (Milad & Quirk, 2002; Do-Monte et al, 2015), and stress has been shown to detrimentally affect this brain region (Radley et al, 2006). Accordingly, we predicted that greater reported stress would be associated with less symptom reduction across groups, with a more negative impact on participants in the mental rehearsal group as a function of interference with a greater number of consolidation efforts.

The benefits of sleep on memory retention are well-established. It has been suggested that sleep optimizes memory consolidation by reactivating recently encoded neural representations to facilitate integration into long-term memory (Rasch & Born, 2013). Thus, we predicted that better sleep quality would be associated with greater symptom reduction across groups, with a more positive impact on participants in the mental rehearsal group as a function of increased consolidation efforts that are expected to be benefitted by sleep.

Finally, aerobic exercise is thought to enhance memory processes. Regular aerobic exercise is associated with increased hippocampal volume and improvements in memory retention (Erickson et al, 2011). By stimulating the production of brain-derived neurotrophic factor (BDNF), exercise is thought to enhance synaptic plasticity and consolidation, thus impacting memory storage (Gomez-Pinilla & Hillman, 2013; Cotman, Berchtold, & Christie, 2007; Soulé, Messaoudi, & Bramham, 2006). We predicted that exercise would be associated with enhanced symptom reduction, particularly in the mental rehearsal group, as a function of facilitated consolidation of nonfear learning.

Exposure Mechanisms

Expectancy violation occurs when there is a greater mismatch between expectation and experience (Crake et al, 2014). This discrepancy is critical for new learning (Rescorla & Wagner, 1972) and for developing nonfear associations that compete with fear representations (Craske et al, 2014). Prior research has demonstrated that exposures designed to violate fear expectancies are associated with more optimal treatment outcomes than exposures designed to reduce fear (Baker et al, 2010; Deacon et al, 2013). We thus expected that greater post-exposure surprise, indicative of greater expectancy violation, would be associated with enhanced symptom reduction.

US expectancy, or expectancy of the feared outcome occurring, is a central component of fear (Hofmann, 2008). As such, reductions in CS-US expectancy (i.e., expectancy of the feared outcome tied to the feared stimulus) are correlated with reductions in fear responding (Biferno & Dawson, 1977; Lipp & Edwards, 2002) and are a critical element of exposure therapy (Hofmann, 2008). In the current study, expectancy was measured after each exposure session; it assessed perceived likelihood of the feared outcome (e.g., spider bite or attack) occurring if the same task were to be repeated with the same spider. We anticipated that reduced expectancy would be associated with greater symptom reduction and greater willingness to approach the feared stimulus (i.e., spider) at posttest.

Fear generalization occurs when conditional fear responding generalizes to stimuli related to the original threatening stimulus. Generalization has emerged as a defining feature of anxiety and traumatic-stress disorders (e.g., Jovanivic et al, 2012; Lissek et al, 2005, 2012; Dunsmoor & Paz, 2015; Dymond et al, 2015). In the current study, generalization was measured after each exposure session; it assessed perceived likelihood of the feared outcome occurring if the

participant were to encounter a different spider outside of the laboratory. These ratings determined the extent to which generalization of fear to other spiders was reduced as a function of treatment (i.e., in vivo exposure and/or mental rehearsal). We expected that reduced fear generalization would be associated with greater symptom reduction.

Specific Hypotheses

We tested the primary hypotheses that from baseline to post-treatment, Mental Rehearsal, relative to Control, would demonstrate 1) a greater reduction in scores on the Spider Phobia Questionnaire (SPQ) and Fear of Spiders Questionnaire (FSQ), 2) a greater reduction in anticipatory distress ratings prior to approaching a live spider, 3) a greater increase in confidence ratings prior to approaching a live spider, 4) a greater reduction in maximum distress ratings while interacting with a live spider, 5) a greater increase in number of test steps completed during a behavioral approach test, 6) a greater decrease in physiological arousal when anticipating approaching a live spider (anticipatory SCL), and 7) a greater decrease in physiological arousal while engaging with a live spider during a behavioral approach test.

We tested the secondary hypotheses that 1) Stress would moderate the relationship between mental rehearsal and treatment outcomes, such that greater stress would reduce treatment gains across groups, with a more significant effect within the Mental Rehearsal group; 2) Sleep quality would moderate the relationship between mental rehearsal and treatment outcomes, such that lower sleep quality would reduce treatment gains across groups, with a more significant effect within the Mental Rehearsal group; 3) Aerobic exercise would moderate the relationship between mental rehearsal and treatment outcomes, such that greater aerobic exercise

would enhance treatment gains across groups, with a more significant effect within the Mental Rehearsal group.

Concerning post-exposure ratings, we tested the hypotheses that 1) Mental Rehearsal would show a greater decrease in post-expectancy and generalization ratings from Session 1 to Session 2 relative to Control; 2) Decrease in post-expectancy and generalization ratings would partially mediate the relationship between Group and treatment outcomes; 3) Greater post-exposure ratings of surprise, lower ratings of post-expectancy, and lower ratings of fear generalization would predict greater treatment gains (i.e., reduced scores on questionnaire measures, reduced distress, greater confidence, and reduced physiological arousal) across participants.

METHODS

Participants

Participants were 70 undergraduate students (59 females, 11 males) from the University of California, Los Angeles (UCLA) who obtained a total score of 17 or greater on the Spider Phobia Questionnaire (SPQ; Klorman et al, 1974). Eight participants dropped out of the study prior to completing all three sessions, resulting in 62 participants (53 females, 9 males) included in analyses. Participants were 31% Asian or East Indian, 24% Hispanic/Latino, 24% White/Caucasian, 11% Black or African American, 7% Other/Multi-racial, and 3% American Indian or Alaska Native. Age ranged from 18 to 28 years (M = 19.68, SD = 2.21). On a questionnaire assessing knowledge of spiders on a 5-pt scale (see *Appendix A*), participants reported low spider knowledge (M = 1.51, SD = .87).[1]

[1] Spider knowledge did not differ by Group (Mental Rehearsal, Control Rehearsal) (p = .93) and was not related to any outcome measure (ps > .19).

Research was conducted in UCLA's Anxiety and Depression Research Center. Participants were recruited from UCLA's undergraduate psychology department subject pool and were compensated for participation with credits toward course requirements. All participants provided informed consent prior to study participation. All face-to-face procedures were administered by four undergraduate research assistants who were blind to participants' group assignment. Research assistants were extensively trained on how to conduct exposures and administer behavioral approach tests prior to interacting with participants. This study was registered with Clinicaltrials.gov: NCT03934385 and approved by the UCLA Institutional Review Board.

Procedure

During a pre-screening phase conducted prior to Session 1, prospective participants completed the Spider Phobia Questionnaire (SPQ; Klorman et al, 1974) to determine eligibility (total score ≥ 17). Spider phobic individuals have obtained mean scores of 23.20 (*SD* = 2.90) and 23.76 (*SD* = 3.80) on the SPQ (Klorman et al, 1974; Muris & Merckelbach, 1996). Our sample reported comparable scores (see *Table 1*). The experiment then consisted of three sessions (see *Figure 1*). Two live tarantulas were used over the course of the study, one for pre- and post-treatment behavioral approach tests (BATs), and a second for exposures (see *Figure 2*). Tarantulas varied in size and color. On Session 1, after signing informed consent, participants completed questionnaires, a BAT with a live tarantula, and a series of ten exposures with a second live tarantula. On Session 2, occurring 2 to 3 days later (*M* = 2.26 days, *SD* = .44), participants completed a second series of ten exposures. On Session 3, occurring 5 to 7 days later (*M* = 6.42 days, *SD* = .78), participants completed a post-treatment BAT and self-report questionnaires to assess change in arachnophobia symptoms from pre-treatment. Participants

were instructed to complete a total of six rehearsal exercises over the course of the study, and were randomly assigned to rehearse information either from exposures (Mental Rehearsal) or from an unrelated recent academic experience (Control Rehearsal). Rehearsal completion rates were high and did not differ by group (M = 5.68, SD = .50).

Session 1

At Session 1, informed consent was obtained and eligibility was determined. Exclusion criteria included age < 18 years, lack of English fluency, and presence of severe bee, insect, or spider allergies. Participants then completed self-report questionnaires including the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995), Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995), Pittsburgh Sleep Quality Index (PSQI; Buysse et al, 1989), and two author-developed questionnaires assessing aerobic exercise and spider knowledge (see *Appendix A*).

Next, participants completed a behavioral approach test (BAT) with a live tarantula. They were instructed to approach the tarantula as closely as possible according to a series of 9 standardized steps each of 30 s duration (see *Appendix B*). The first step was to stand 5 ft. from the tarantula in its closed terrarium. The last step was to touch the back leg of the tarantula continuously with the index finger. Skin conductance was recorded throughout. Before beginning the test and after instructions were read, participants rated their confidence and anticipatory distress on a scale from 0 to 100 with respect to their ability to complete all 9 steps of the BAT. Subsequently, they rated their maximum distress after each step. During each step, the experimenter recorded the tarantula's movement on a categorical scale (0 = no movement, 1 = a little movement, 2 = a lot of movement) for inclusion as a covariate in later analyses given the potential of spider movement to influence willingness to approach during the BAT.

With a second live tarantula, participants completed a series of 10 exposures each of 30 s duration with 30 s inter-trial intervals. Participants were asked to hover their ungloved hand 3 in. above the tarantula in its terrarium. It was required that participants complete at least one exposure trial to remain in the study; no participants were excluded for this criterion. Prior to exposures, participants were asked to identify their feared outcome (i.e., what they were most concerned/afraid would happen) if they engaged with the tarantula. After all exposure trials were completed, participants were asked to rate their degree of surprise considering what happened during the exposures (1 = not at all surprised, 3 = somewhat surprised, 5 = extremely surprised), perceived likelihood of their feared outcome occurring if they were to repeat the same practice with the same spider again in the laboratory (1 = not at all likely, 3 = somewhat likely, 5 = extremely likely), and perceived likelihood of their feared outcome occurring if they were to encounter a different spider outside of the laboratory (1 = not at all likely, 3 = somewhat likely, 5 = extremely likely) (see Post-Exposure Questionnaire, *Appendix A*).

Session 2

At Session 2, occurring 2 to 3 days later (*M* = 2.26 days, *SD* = .44), participants completed a second series of 10 exposures. Procedures were identical to the first set of exposures, with the exception of task, which was to place a gloved hand inside the tarantula's terrarium with all five fingertips touching the bottom of the terrarium for 30 s. It was again required that participants complete at least one trial to remain in the study. On average, participants completed 19 trials (out of 20) across exposure sessions (*M* = 18.98, *SD* = 3.21, *Range* = 4 to 20).

Session 3

At Session 3, occurring 5 to 7 days later (*M* = 6.42 days, *SD* = .78), participants completed a post-assessment consisting of the SPQ, FSQ, and a nine-step BAT identical to that administered at pretest.

Rehearsal Exercises

Participants were randomly assigned to rehearse information either from exposures (Mental Rehearsal) or from an unrelated recent academic experience (Control Rehearsal) between sessions (see *Appendix C*). Rehearsal exercises were distributed by email 2h, 24h, and 48h after each exposure session, for a total of six times. They were programmed in Qualtrics, enabling completion on a cell phone, laptop, or desktop computer. Completion rates for the six rehearsal exercises were high and did not differ by group (*M* = 5.68, *SD* = .50, *Range* = 4 to 6).

Mental rehearsal exercises were designed to first retrieve the exposure memory, and second to rehearse the expectancy violation learning. Thus, they consisted of viewing an image of the tarantula used during exposures and completing short-answer and forced-choice questions focused on retrieving and consolidating exposure learning. Spider images were included to facilitate retrieval of the extinction memory (Baker, McNally, & Richardson, 2013). The reflective questions asked participants to recall their feared outcome identified prior to exposures, relay what they did during their practice with the spider and how the spider actually responded, describe what they learned from this experience, and identify two to three differences they observed between what they thought would happen and what actually happened when they engaged with the spider. Control rehearsal exercises were structured similarly to control for the cognitive load associated with retrieval and rehearsal of information. They included an image of

a UCLA academic building, followed by short-answer and forced-choice questions pertaining to a recently attended class.

Figure 1. Diagram of study procedures and timeline.

Figure 2. *Left:* Tarantula used during pre-treatment and post-treatment assessments (i.e., BATs); *Right*: Tarantula used during Session 1 and Session 2 exposures.

Measures

Behavioral Approach. Behavioral approach was measured as the number of test steps fully completed (0 to 9) at pretest and at posttest (Kircanski, Lieberman, & Craske, 2012). Participants were also categorized as having completed at least one additional step at posttest relative to pretest vs. completing the same number or fewer steps at posttest relative to pretest.

SCL. Skin conductance, measured in microsiemens (μS), was used to assess anxious arousal prior to and during BATs (Christopoulos, Uy, & Yap, 2019; Laine et al., 2009). It was

recorded from two electrodes attached to the middle and index fingers of the participant's non-dominant hand (i.e., the hand that was not put inside the tarantula's terrarium during test steps), using BIOPAC MP150 and AcqKnowledge version 4.3 software. Baseline skin conductance level (SCL) was collected during a two-minute period prior to the BAT. Average SCL was calculated from a one-minute anticipation period after BAT instructions were read and prior to starting the BAT (anticipatory-SCL), and for each 30 s BAT step completed (steps-SCL). With the exception of steps 8 and 9, entailing touching the spider, participants were stationary during the SCL measurement period at each step. Data were filtered using a finite impulse response (FIR) low pass filter with the frequency cutoff fixed at 2 Hz; no significant movement confounds emerged during data extraction.

Subjective Distress. At pretest and posttest, distress ratings were obtained using a visual analogue scale ranging from 0 to 100 (0 = no distress, 25 = mild distress, 50 = moderate distress, 75 = high distress, 100 = severe distress). Anticipatory distress ratings were obtained before beginning the BAT and maximum distress ratings were obtained after each step. Participants reported subjective distress ratings out loud to the experimenter when prompted.

Subjective Confidence. At pretest and posttest, prior to beginning the BAT, participants rated their confidence on a visual analogue scale ranging from 0 to 100 (0 = no confidence, 25 = mild confidence, 50 = moderate confidence, 75 = high confidence, 100 = complete confidence) with respect to their ability to complete all 9 steps of the BAT.

Spider Phobia Questionnaire. The Spider Phobia Questionnaire (SPQ; Klorman et al, 1974) is a 31-item True/False self-report measure that assesses fear and avoidance of spiders. It has demonstrated high internal consistency ($\alpha = .91$), high test-retest reliability ($r = .94$), and ability to significantly differentiate those with spider phobias from those without (Muris &

Merckelbach, 1996; Klorman et al, 1974; Fredrikson, 1983). Scores can range from 0 to 31. Clinical samples have obtained mean scores of 23.20 (*SD* = 2.90) (Muris & Merckelbach, 1996) and 23.76 (*SD* = 3.80) (Klorman et al, 1974). A cut-off score of 17 was used for participant inclusion in our study, representing approximately two standard deviations below the mean of prior spider phobic samples (Muris & Merckelbach, 1996).

Fear of Spiders Questionnaire. The Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995) is an 18-item self-report measure that assesses fear of spiders considering behaviors, cognitions, and physiological arousal. To increase specificity, each question is rated on a 7-point Likert scale (0 = 'totally disagree', 7 = 'totally agree') (Szymanski & O'Donohue, 1995). The FSQ has demonstrated high internal consistency (α = 0.88 to 0.97), high test-retest reliability (*r* = .91), and ability to significantly differentiate spider phobics from non-phobic controls (Muris & Merckelbach, 1996; Szymanski & O'Donohue, 1995). Scores can range from 0 to 126. In a prior study, a clinical sample obtained a mean score of 89.1 (*SD* = 19.6) on the FSQ (Muris & Merckelbach, 1996).

Depression Anxiety Stress Scales. The Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995) is a self-report measure of severity of symptoms of depression, anxiety, and stress using a shortened version of the original 42-item measure. The 21-item abbreviated version maintains internal consistency and concurrent validity, with α estimates of .91 to .97 for Depression, .81 to .92 for Anxiety, and .88 to .95 for Stress (Gloster et al, 2008). The DASS-Stress scale, evaluated in the current study, contains 7 items that assess nervous energy, agitation, over-reactions, and difficulty relaxing. Each question is rated on a 4-point Likert scale (0 = 'did not apply to me at all', 1 = 'applied to me to some degree or some of the time', 2 = 'applied to me to a considerable degree or a good part of the time', 3 = 'applied to me

very much or most of the time'). Items are summed to generate each subscale score. For the DASS-Stress subscale, scores can range from 0 to 21. Scores of 0-7 indicate normal stress, 8-9 mild stress, 10-12 moderate stress, 13-16 severe stress, 17+ extremely severe stress.

Pittsburgh Sleep Quality Index. The Pittsburgh Sleep Quality Index (PSQI; Buysse et al, 1989) is an 18-item self-report measure that assesses sleep quality and disturbances over the past month to yield a global sleep quality score and seven component scores. It has achieved high diagnostic sensitivity and specificity in distinguishing poor sleepers from good sleepers (Buysse et al, 1989). Symptoms are rated on a scale from 0 to 3 (0 = 'not during the past month', 1 = 'less than once a week', 2 = 'once or twice a week', 3 = 'three or more times a week'). Component scores are summed to generate a global score that can range from 0 to 21. Higher scores indicate reduced sleep quality, with scores above 5 indicating poor sleep quality.

Exercise Habits. The Exercise Habits questionnaire is a 4-item study-specific questionnaire that assesses average weekly aerobic exercise. Participants reported average number of minutes per week spent engaging in scheduled exercise (e.g., sports, gym) and unscheduled exercise (e.g., walking to class, walking a dog), with associated intensity ratings (mild, moderate, intense) per domain. Examples of moderate and intense aerobic activity were drawn from the Centers for Disease Control (CDC) and American College of Sports Medicine (ACSM) guidelines. Minutes spent engaging in moderate ('significant increase in heart rate') and intense ('very significant increase in heart rate') physical activity were summed to generate an index of average weekly aerobic exercise.

Spider Knowledge Questionnaire. The Spider Knowledge questionnaire is a brief study-specific questionnaire that assesses prior knowledge of spiders (e.g., knowledge of which species are most dangerous, most poisonous, most likely to bite).

Post-Exposure Questionnaire. The Post-Exposure Questionnaire is a 3-item self-report measure completed after each series of exposure trials (i.e., at the end of Session 1 and at the end of Session 2). Participants rated their degree of surprise considering what happened during exposures (1 = 'not at all surprised', 3 = 'somewhat surprised', 5 = 'extremely surprised'), their perceived likelihood of their feared outcome occurring if they were to repeat the same practice with the same spider and same laboratory conditions (1 = 'not at all likely', 3 = 'somewhat likely', 5 = 'extremely likely'), and their perceived likelihood of their feared outcome occurring if they were to encounter a different spider outside of the laboratory (1 = 'not at all likely', 3 = 'somewhat likely', 5 = 'extremely likely'). Ratings of surprise indicated expectancy violation during exposures (Craske et al, 2014), with greater surprise corresponding to greater expectancy violation. Ratings of likelihood of the feared outcome occurring again with the same spider and conditions provided a measure of US expectancy following exposures, with greater ratings indicating greater post-expectancy, and thus less clinical impact of the exposures. Ratings of likelihood of the feared outcome occurring with a different spider outside of the laboratory provided a measure of fear generalization, with greater ratings indicating greater generalization of fear (and thus less generalization of safety/nonfear learning).

Data Analysis

Primary Analyses

Data were analyzed using IBM SPSS Statistics 25.0, with the exception of analyses entailing multilevel models, which were analyzed in Stata 16.0. For primary hypotheses, univariate analyses of covariance (ANCOVAs) were used to test the extent to which Mental Rehearsal, relative to Control, demonstrated greater reduction in symptoms of arachnophobia, characterized by greater approach behavior, greater confidence, reduced fear and distress, and

reduced physiological arousal. Across primary analyses, the independent variable (IV) of interest was Group (Mental Rehearsal, Control), a categorical fixed factor. Dependent variables (DVs) included quantitative behavioral, self-report, and physiological indices of fear and avoidance of spiders, assessed at pretest (i.e., baseline) and posttest (i.e., post-treatment). Our behavioral DV was the number of steps completed in the BAT. Self-report DVs included scores on the Spider Phobia Questionnaire (SPQ) and Fear of Spiders Questionnaire (FSQ), confidence and anticipatory distress ratings prior to beginning the BAT, and maximum distress rating during the BAT. Physiological DVs included skin conductance level (SCL) in anticipation of the BAT, and SCL across completed BAT steps. DVs were posttest outcomes and were analyzed in separate univariate models; corresponding pretest measures were included as covariates (CVs) to control for baseline fear and avoidance. Maximum spider movement, assessed by experimenters at pretest and posttest, was entered as a CV in models in which it was correlated with the DV, as spider movement was significantly related to some outcome measures.[2] Number of BAT steps completed at posttest was included as a CV in our model assessing maximum distress at posttest as these variables were significantly correlated ($p = .045$). Finally, number of BAT steps completed at pretest was included as a CV in models assessing anticipatory distress, confidence, and physiological arousal, as steps completed at pretest was significantly related to these outcome measures ($ps \leq .03$).

ANCOVA models are more powerful than analysis of variance (ANOVA) models when assumptions of homogeneity of regression are met and when the relationship between the CV

[2] Spider movement during pretest was significantly correlated with number of BAT steps completed at posttest ($r = .31$, $p = .015$) and with overall confidence at posttest ($r = .29$, $p = .02$), and was thus included as a covariate in these analyses. It was not correlated with other DVs ($ps > .30$). Maximum spider movement during posttest was not correlated with any DVs ($ps > .13$) and was thus not included as a covariate in analytic models.

and DV is linear. To satisfy homogeneity of regression, CVs (i.e., pretest indices) must not be significantly related to the IV (Group). One-way ANOVAs thus tested for any group differences at pretest on all measures (SPQ, FSQ, number of BAT steps completed, overall confidence, anticipatory distress, maximum distress, SCL) to determine ANCOVA fit.

A second analytic approach was used to enhance our understanding of the impact of Group on reflective approach behavior. In this analysis, we aimed to determine the extent to which treatment group predicted likelihood of completing at least one additional BAT step at posttest relative to pretest. Participants were categorized as completing at least one additional BAT step at posttest relative to pretest, versus completing fewer or the same number of steps at posttest relative to pretest. Given the binary nature of the dependent variable, a logistic regression was used. Spider movement and number of BAT steps completed at pretest were included in the model as covariates.

Multilevel modeling was used to model physiological arousal across steps that were completed at both pretest and posttest. SCL measurements (i.e., average skin conductance during each 30s step completed) were modeled as repeated measures (Level 1) nested within individuals (Level 2). Group (Mental Rehearsal, Control) was a Level 2 categorical variable; Time (pretest, posttest) was a Level 1 categorical variable; Step (0 to 9) was a Level 1 continuous variable. Analyses tested the effect of Group on SCL measurements across BAT steps as a function of Time. Thus, model predictors included the three-way interaction between Group, Step, and Time as well as lower order effects.

The FSQ was added to the study mid-way through recruitment and thus 47 participants rather than the full sample of 62 are reflected in FSQ analyses. Four participants did not have measurable skin conductance and were excluded from SCL analyses. Additionally, one

participant was deemed an outlier on ratings of anticipatory distress due to large leverage and residual values resulting in undue influence on the DV, and was excluded from these analyses. There were no outstanding outliers on other measures.

Secondary Analyses

Secondary analyses tested the moderating roles of stress, sleep quality, and aerobic exercise on the association between mental rehearsal and symptom reduction. Analyses tested the extent to which symptom change across DVs was influenced by stress, sleep quality, and aerobic exercise, and the extent to which these variables interacted with Group (Mental Rehearsal, Control) to impact symptom change. Participants were split into two groups on measures of Stress, Sleep, and Exercise based on each measure's scoring guidelines and clinical cut-off. For Stress, the sample was split into two groups corresponding to normal to moderate stress (DASS-S $\leq$ 12; N = 35) and severe to extremely severe stress (DASS-S > 12; N = 27). For Sleep Quality, the sample was split into two groups corresponding to normal/good sleep quality (PSQI $\leq$ 5; N = 26) and poor sleep quality (PSQI > 5; N = 36). For Exercise, the sample was split into two groups corresponding to lower aerobic exercise (<200 min/wk; N = 30) and higher aerobic exercise (> 200 min/wk; N = 32). Stress and Sleep Quality were normally distributed in our sample, but aerobic exercise was not (Kolmogorov-Smirnov test of normality, $p < .001$), demonstrating a positive skew of 2.38.

In ANCOVA models, posttest behavioral, self-report, and physiological indices of fear were entered as DVs (assessed independently); Group was a fixed factor IV; Stress, Sleep Quality, and Exercise were random factor IVs; pretest measures corresponding to outcomes were CVs. As noted for primary analyses, we controlled for any variables significantly related to

outcome measures by including them as CVs in our ANCOVA models (i.e., maximum spider movement was covaried in models assessing confidence ratings and behavioral approach; number of BAT steps completed at posttest was covaried in our model assessing maximum distress; number of BAT steps completed at pretest was covaried in models assessing anticipatory measures of distress, confidence, and physiological arousal).

Model predictors included two-way interactions between Group and Stress/Sleep Quality/Exercise as well as lower order main effects if interactions were non-significant. We examined omnibus tests of two-way interactions for statistical significance and followed with t-tests of simple effects.

Post-Exposure Ratings

Mixed models in Stata 16.0 were used to test for effects of Group and Time on post-exposure ratings of surprise, expectancy, and generalization. Ratings on these measures were modeled as repeated measures (Level 1) nested within individuals (Level 2). Group (Mental Rehearsal, Control) was a Level 2 categorical variable and Time (Session 1, Session 2) was a Level 1 categorical variable. Analyses tested the effect of Group on the slope of surprise, post-expectancy, and generalization from Session 1 to Session 2. Model predictors included the two-way interaction between Group and Time as well as lower order main effects if interactions were non-significant.

Linear regressions were used to determine the extent to which surprise, post-expectancy, and/or generalization predicted symptom reduction. DVs were behavioral, self-report, and physiological measures of fear at posttest (assessed in independent models). IVs were average measures of surprise, post-expectancy, and generalization. Since these measures decreased

significantly over time, changes from Session 1 to Session 2 were also assessed as IVs. Group and pretest measures were included as covariates to control for between-session intervention and baseline fear, respectively.

Power Analysis

A priori power analysis in G*Power 3.1 (Faul et al, 2009) confirmed that our study was sufficiently powered (.80) to detect a medium to large effect size with $\alpha = .05$ for primary ANCOVA analyses. Power for secondary analyses assessing how the interaction of treatment group and stress/sleep quality/exercise impacted treatment outcomes was below .80 (approximately .60) due to smaller sample sizes per group. Additionally, we began assessment of post-exposure surprise, expectancy, and generalization mid-way through the study and thus these ratings were completed by fewer participants (n = 37). Therefore, power for our third set of analyses is also below .80 (approximately .45 to .66). Analyses outside of primary analyses should be considered exploratory.

RESULTS

Primary Analyses

There were no Group (Mental Rehearsal, Control) differences at pretest on the Spider Phobia Questionnaire (SPQ), Fear of Spiders Questionnaire (FSQ), number of BAT steps completed, overall confidence, anticipatory distress, maximum distress, baseline SCL, or anticipatory SCL (*p*s > .50). See *Table 1* for descriptive statistics.

		SPQ Total	FSQ Total	BAT Steps	Overall Confidence	Anticipatory Distress	Maximum Distress	Anticipatory SCL
Pretest	MR	23.23 (3.12)	99.30 (16.13)	5.45 (2.11)	37.55 (24.06)	72.50 (16.07)	75.45 (24.17)	18.26 (9.77)
	Control	22.68 (3.17)	96.38 (13.92)	5.58 (2.36)	35.81 (26.21)	71.13 (18.65)	71.00 (27.71)	17.32 (8.56)
Posttest	MR	18.52 (3.67)	68.96 (26.36)	7.60 (1.25)	51.23 (32.61)	51.50 (27.36)	40.67 (28.58)	15.47 (8.21)
	Control	20.35 (3.43)	84.92 (21.72)	6.52 (2.29)	40.81 (30.00)	63.19 (26.08)	48.39 (27.18)	12.84 (5.90)

Table 1. Means and standard deviations for self-report, behavioral, and physiological measures at pretest and posttest per group (MR = Mental Rehearsal). BAT steps were measured on a scale from 0 to 9 and reflect steps that were fully completed. Confidence and distress were rated on a scale from 0 (no confidence/distress) to 100 (complete confidence/severe distress). SCL was measured in microsiemens (μS). Anticipatory SCL reflects arousal during a 30s anticipation period prior to beginning the BAT.

Independently, both groups showed significant decreases in SPQ score from baseline to post-treatment (Mental Rehearsal: $t(30) = -6.72$, $p < .001$; Control: $t(30) = -4.07$, $p < .001$). Critically, after controlling for SPQ score at pretest, there was a significant effect of Group on SPQ score at posttest, $F(1,59) = 6.63$, $p = .01$, such that Mental Rehearsal reported significantly lower scores than Control at posttest (see *Figure 3*). The overall model fit was significant, $F(2,59) = 9.64$, $p < .001$, and explained 25% of the variance in SPQ score at posttest ($R^2 = .25$).

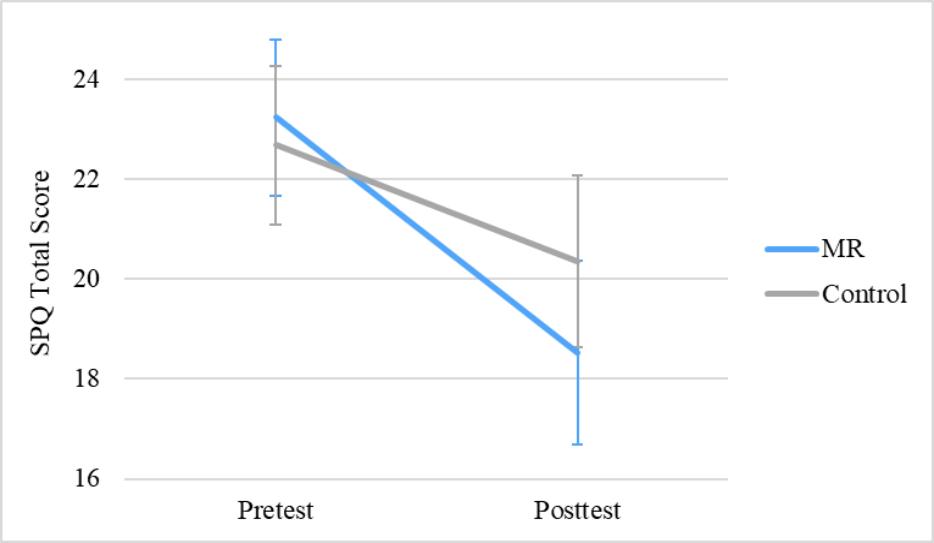

Figure 3. Average score on the Spider Phobia Questionnaire (SPQ; Klorman et al, 1974) per group at pretest and posttest. Mental Rehearsal (MR) reported significantly lower SPQ scores at posttest relative to Control, $p = .01$.

Similar results emerged for FSQ score. Independently, both groups showed significant decreases in FSQ score from baseline to post-treatment (Mental Rehearsal: $t(22) = -5.16$, $p < .001$; Control: $t(23) = -3.79$, $p = .001$). Controlling for FSQ score at pretest, there was again a significant effect of Group on FSQ at posttest, $F(1,44) = 7.67$, $p = .008$, such that Mental Rehearsal reported significantly lower scores than Control at posttest (see *Figure 4*). The overall model fit was significant, $F(2,44) = 7.83$, $p = .001$, and explained 26% of the variance in FSQ score at posttest ($R^2 = .26$).

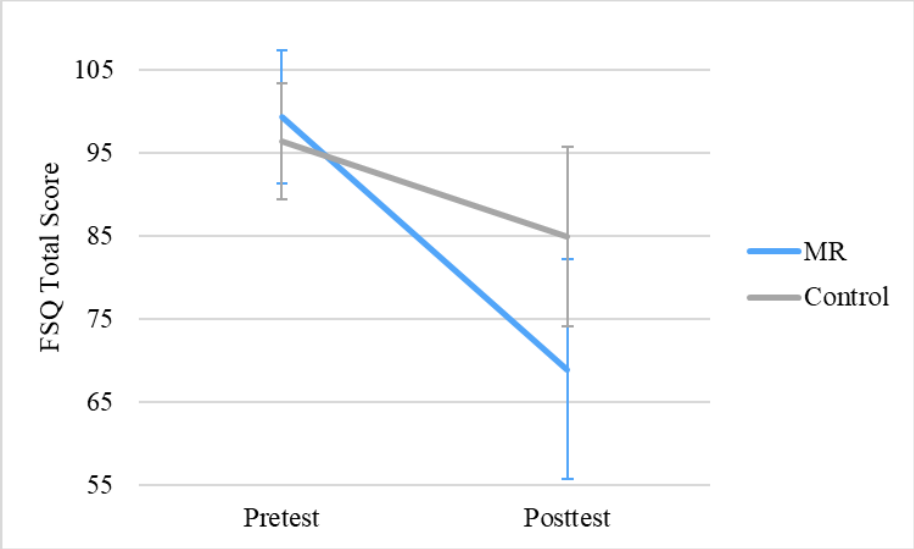

Figure 4. Average score on the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995) per group at pretest and posttest. Mental Rehearsal (MR) reported significantly lower FSQ scores at posttest relative to Control, $p = .008$.

Independently, both groups showed a significant increase in number of BAT steps completed from pretest to posttest (Mental Rehearsal: $t(29) = 6.32$, $p < .001$; Control: $t(30) = 3.04$, $p = .005$). Controlling for spider movement at pretest and number of BAT steps completed at pretest, there was a significant effect of Group on number of BAT steps completed at posttest, $F(1,57) = 9.64$, $p = .003$, such that Mental Rehearsal completed a greater number of steps at posttest relative to Control (see *Figure 5*). The overall model fit was significant, $F(3,57) = 17.28$, $p < .001$, and explained 48% of the variance in number of BAT steps completed at posttest ($R^2 = .48$).

In our subsequent analysis of approach behavior, we tested the extent to which Group predicted likelihood of completing at least one additional step on the BAT at posttest relative to pretest. Among participants in the Mental Rehearsal group, 24 completed at least one additional step at posttest and 6 did not; among participants in the Control group, 17 completed at least one

additional step at posttest and 14 did not. Controlling for spider movement at pretest and number of steps completed at pretest, Group significantly predicted the likelihood of completing at least one additional step at posttest, $X^2(1) = 4.02$, $p = .045$. The odds of completing an additional step at posttest increased by 229% when a participant was assigned to Mental Rehearsal rather than Control.

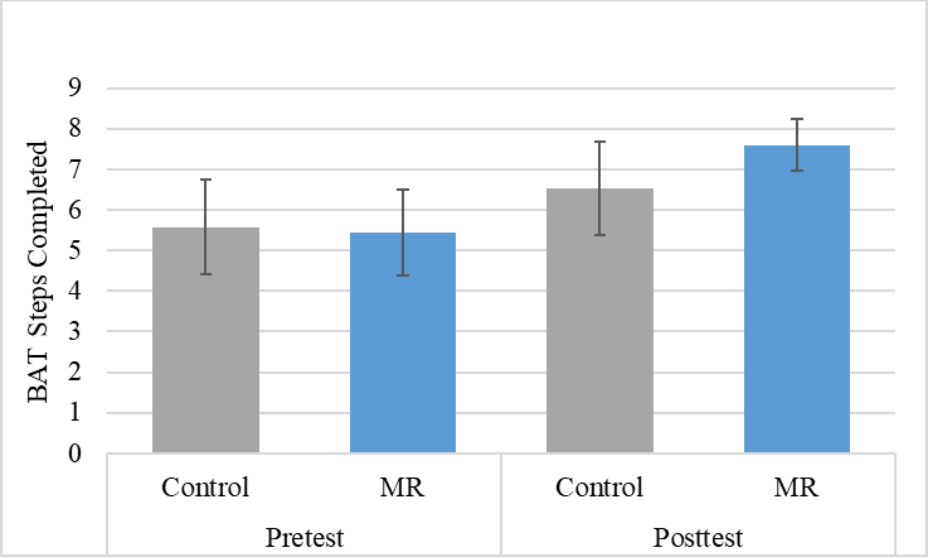

Figure 5. Average number of BAT steps completed by each group at pretest and posttest. Mental Rehearsal (MR) completed significantly more steps at posttest compared to Control ($p = .003$).

There was also a significant effect of Group on anticipatory distress, such that after controlling for pretest anticipatory distress and number of BAT steps completed at pretest, Mental Rehearsal reported significantly reduced anticipatory distress at posttest relative to Control, $F(1,57) = 5.01$, $p = .029$ (see *Figure 6*). The overall model fit was significant, $F(3,57) = 9.10$, $p < .001$, and explained 32% of the variance in anticipatory distress at posttest ($R^2 = .32$). Independently, Mental Rehearsal showed a significant decrease in anticipatory distress from pretest to posttest, $t(29) = -4.90$, $p < .001$, while Control did not ($p = .12$).

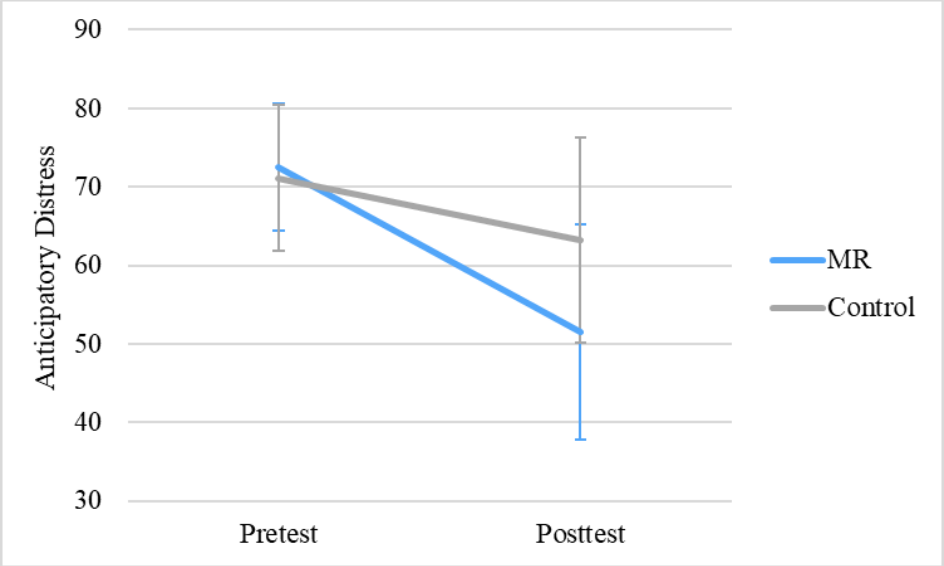

Figure 6. Average ratings of anticipatory distress per group at pretest and posttest. Mental Rehearsal (MR) reported significantly lower anticipatory distress at posttest compared to Control (p = .029).

No Group differences emerged for confidence reported at posttest after controlling for spider movement, confidence, and number of BAT steps completed at pretest (p = .10). Across all participants, confidence significantly increased from pretest to posttest, $t(61) = 2.32$, p = .02. Assessed independently, Mental Rehearsal showed a significant increase in confidence from pretest to posttest, $t(30) = 2.84$, p = .008, while Control did not (p = .44).

No Group differences emerged for maximum distress reported during the BAT at posttest after controlling for maximum distress at pretest and number of BAT steps completed at posttest (p = .38). Across all participants, maximum distress significantly decreased from pretest to posttest, $t(60) = -7.70$, $p < .001$. Independently, both groups also showed a significant decrease in maximum distress from pretest to posttest (Mental Rehearsal: $t(29) = -7.19$, $p < .001$; Control: $t(30) = -4.13$, $p < .001$).

Concerning physiological arousal, there was no effect of Group on anticipatory SCL at posttest after controlling for anticipatory SCL at pretest and number of steps completed at pretest (p = .12). Across all participants, anticipatory SCL decreased significantly from pretest to posttest, $t(57) = -4.12$, $p < .001$. Independently, both groups also showed a significant decrease in anticipatory SCL from pretest to posttest (Mental Rehearsal: $t(29) = -2.36$, $p = .025$; Control: $t(27) = -3.46$, $p = .002$).

In multilevel analyses of SCL across BAT steps, the three-way interaction between Group, Time, and Step was not significant (p = .57). The two-way interaction between Group and Time was also non-significant (p = .24). There was a significant interaction between Step and Time, $X^2(1) = 11.80$, $p = .0006$. For Steps 1 through 6, participants showed reduced physiological arousal at posttest relative to pretest (ps < .02) (see *Figure 7*).

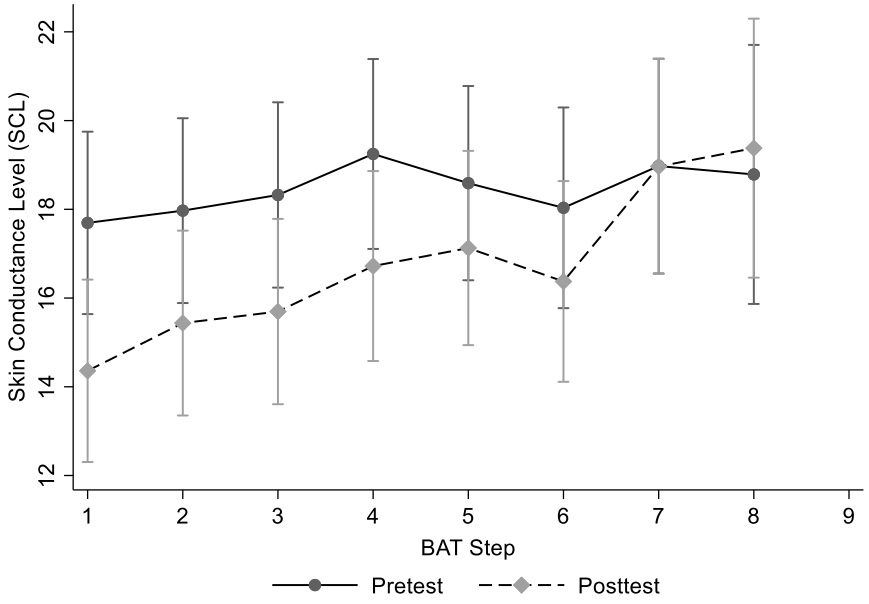

Figure 7. Average SCL at each BAT step collapsed across all participants. Across participants, SCL was significantly reduced at posttest relative to pretest for Steps 1 through 6 (ps < .02).

Secondary Analyses

Stress

See *Table 2* for descriptive statistics for measures of Stress, Sleep Quality, and Aerobic Exercise. There was a significant interaction between Stress and Group on maximum distress reported during the BAT at posttest after controlling for maximum distress at pretest and number of BAT steps completed at posttest, $F(1,55) = 6.72$, $p = .01$. There were no differences in pretest maximum distress as a function of Group or Stress (ps > .39). Among participants with normal to moderate stress levels, Mental Rehearsal reported significantly reduced maximum distress at posttest relative to Control, $t(33) = -2.68$, $p = .01$. Among participants with severe to extremely severe stress levels, there was no effect of Group on maximum distress at posttest ($p = .18$). While Mental Rehearsal participants with both low levels and high levels of stress showed significantly reduced maximum distress from pretest to posttest (ps < .004), those with lower levels of stress showed a significantly *greater* reduction in maximum distress than those with severe levels of stress, $t(28) = -2.34$, $p = .03$. For Control, maximum distress at posttest did not vary as a function of stress level ($p = .12$). See *Figure 8*.

	Mean	*SD*	*Min*	*Max*
Stress	12.58	8.13	0	32
Sleep Quality	6.26	2.98	0	16
Aerobic Exercise	311.02	340.07	0	1890

Table 2. Descriptive statistics for measures of Stress, Sleep Quality, and Aerobic Exercise. Stress was measured with the Stress subscale of the Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995). Sleep quality was measured with the global score of the Pittsburgh Sleep Quality Index (PSQI; Buysse et al, 1989). Aerobic exercise values correspond to number of minutes of aerobic exercise per week, defined as a significant increase in heart rate.

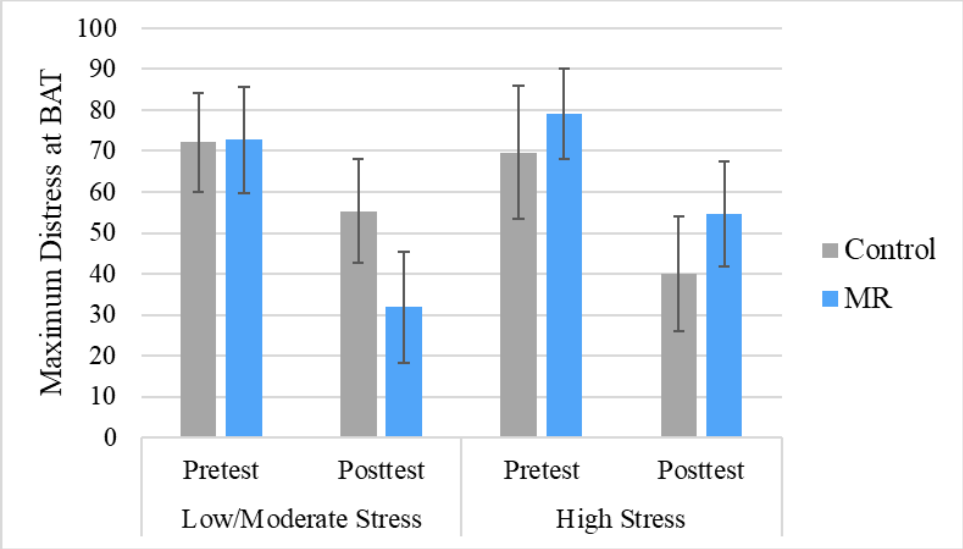

Figure 8. Maximum distress at pretest and posttest as a function of Group (Control, Mental Rehearsal) and Stress (Low/Moderate, High). Low/Moderate stress was defined as normal to moderate levels on the DASS-Stress subscale (Lovibond & Lovibond, 1995). High stress was defined as severe to extremely severe levels on the DASS-Stress subscale.

Stress did not interact with Group to influence SPQ, FSQ, number of BAT steps completed, confidence ratings, anticipatory distress, or SCL (*p*s > .10) and did not have a main effect on these variables (*p*s > .13).

Sleep Quality

There was a significant interaction between Sleep Quality and Group on maximum distress reported during the BAT at posttest after controlling for maximum distress at pretest and number of BAT steps completed at posttest, $F(1,55) = 7.81$, $p = .007$. There were no differences in pretest maximum distress as a function of Group or Sleep Quality (*p*s > .49). Among participants who reported normal/good sleep quality, Mental Rehearsal reported significantly reduced maximum distress at posttest relative to Control, $t(24) = -2.07$, $p = .05$. Among

participants who reported poor sleep quality, there was no effect of Group on maximum distress at posttest (p = .33). Additionally, participants in the Mental Rehearsal group who endorsed normal/good sleep quality reported a significantly greater reduction in maximum distress at posttest relative to those who endorsed poor sleep quality, $t(28) = -2.34$, p = .03. For Control, maximum distress at posttest did not vary as a function of Sleep Quality (p = .12). See *Figure 9*.

Sleep Quality did not interact with Group to influence SPQ, FSQ, number of BATS steps completed, confidence ratings, anticipatory distress, or SCL (ps > .34) and did not have a main effect on these variables (ps > .59).

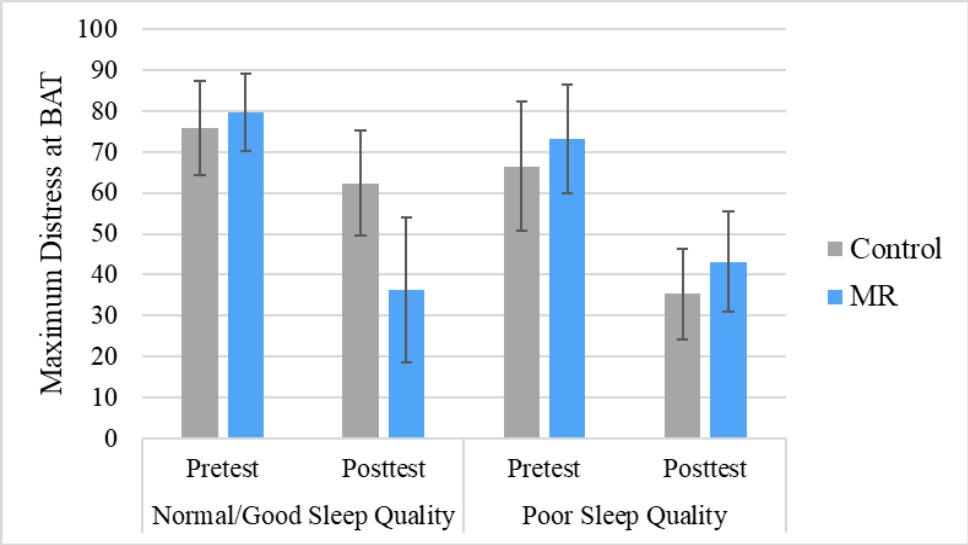

Figure 9. Maximum distress at pretest and posttest as a function of Group (Control, Mental Rehearsal) and Sleep Quality (Normal/Good, Poor). Normal/good sleep quality was defined as total score ≤ 5 on the Pittsburgh Sleep Quality Index (PSQI; Buysse et al, 1989). Poor sleep quality was defined as total score >5 on the PSQI, per interpretive guidelines for this measure.

Aerobic Exercise

Controlling for pretest measures, aerobic exercise did not interact with Group or have a main effect on any outcome measures (ps > .44).

Post-Exposure Ratings

Surprise

The 2-way interaction between Group and Time was not significant (p = .35). There was no main effect of Group on surprise ratings overall (p = .16). There was a main effect of Time such that surprise ratings decreased from Session 1 to Session 2, $X^2(1) = 5.25$, p = .02. See *Table 3* for descriptive statistics of post-exposure ratings.

Average surprise rating did not predict any outcome measures (ps > .12). Change in surprise ratings was a significant predictor of confidence at posttest after controlling for Group, confidence at pretest, spider movement at pretest, and number of BAT steps completed at pretest, $t(30) = -3.14$, p = .004. A greater decrease in surprise from Session 1 to Session 2 exposures was predictive of greater confidence at posttest (see *Figure 10*). The overall model fit was significant, $F(5,30) = 8.40$, $p < .001$, and explained 58% of the variance in confidence at posttest (R^2 = .58). Change in surprise did not predict any other outcome measures (ps > .11).

	Session 1	*Session 2*
Surprise	3.67 (.96)	3.19 (1.27)
Post-Expectancy	2.78 (1.07)	2.36 (.96)
Generalization	3.42 (1.05)	3.09 (.86)

Table 3. Means and standard deviations for post-exposure ratings of surprise, expectancy, and fear generalization at Session 1 and Session 2. Higher scores indicate greater surprise concerning the outcome of exposures, greater expectancy that the feared outcome would occur if the same exposure task was repeated with the same spider, and greater generalization of the feared outcome to spiders outside of the laboratory. All ratings were obtained on a 5-pt Likert scale. Scores ranged from 1 to 5.

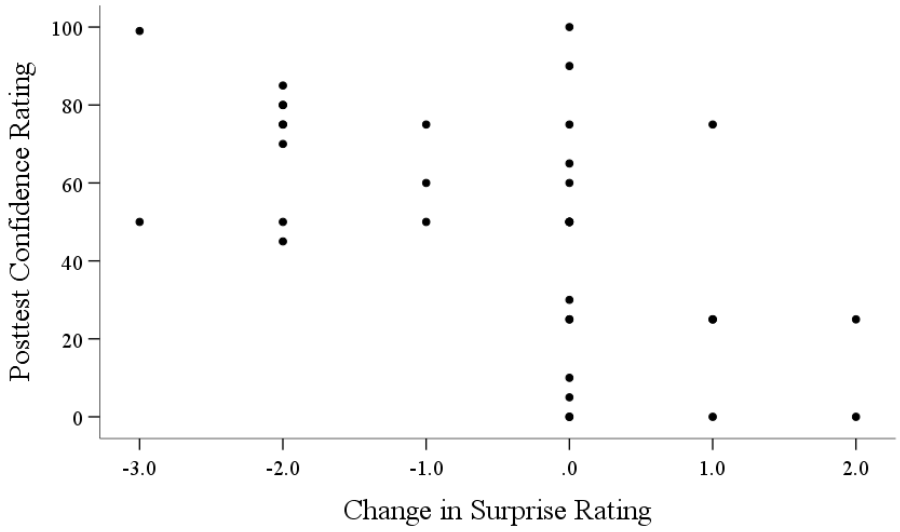

Figure 10. Scatterplot of change in post-exposure surprise rating from Session 1 to Session 2 against posttest confidence rating. Negative values for change in surprise indicate a *decrease* in surprise from Session 1 to Session 2, whereas positive values indicate an *increase* in surprise from Session 1 to Session 2. Surprise was rated on a 5-pt Likert scale (1 = 'not at all surprised', 5 = 'extremely surprised'). Confidence was rated on a 100-pt visual analog scale (0 = 'no confidence', 100 = 'complete confidence').

Post-Expectancy

The 2-way interaction between Group and Time was not significant (p = .43). There was a marginally significant main effect of Group on post-expectancy ratings overall, $X^2(1) = 3.15$, p = .08, such that Mental Rehearsal reported lower post-expectancy relative to Control. There was also a main effect of Time such that post-expectancy overall decreased from Session 1 to Session 2, $X^2(1) = 5.73$, p = .02. Since the 2-way interaction between Group and Time was non-significant, mediational models testing whether increment decrease in post-expectancy mediated the relationship between Group and Time were not assessed.

Across participants, average post-expectancy marginally predicted SPQ at posttest after controlling for Group and SPQ at pretest, $t(33) = 1.87$, p = .07, such that lower post-expectancy

predicted reduced questionnaire scores at posttest (see *Figure 11*). The overall model fit was significant, $F(3,33) = 2.93$, $p = .048$, and explained 21% of the variance in SPQ score at posttest ($R^2 = .21$). Average post-expectancy did not predict any other outcome measures (*p*s > .10). Change in post-expectancy ratings did not predict any outcome measures (*p*s > .26).

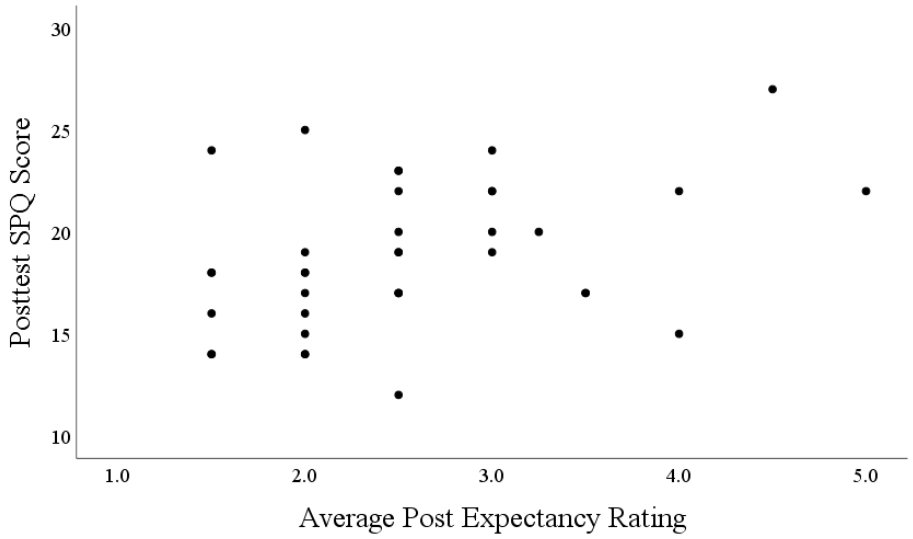

Figure 11. Scatterplot of average post-exposure expectancy rating against Spider Phobia Questionnaire (SPQ) score at posttest. Post-expectancy was rated on a 5-pt Likert scale (1 = 'not at all likely', 5 = 'extremely likely').

Generalization

The 2-way interaction between Group and Time was not significant ($p = .12$). There was no main effect of Group on generalization ratings ($p = .76$). There was a marginally significant main effect of Time such that generalization decreased from Session 1 to Session 2, $X^2(1) = 3.66$, $p = .06$. Average generalization rating did not predict any outcome measures (*p*s > .21), nor did change in generalization ratings (*p*s > .22).

Discussion

The current study investigated the extent to which a novel between-session mental rehearsal intervention augmented exposure therapy outcomes for highly spider-fearful individuals. Specifically, we evaluated whether subjective, behavioral, and physiological indices of fear were reduced to a greater extent in participants who completed repeated mental rehearsal exercises relative to control rehearsal exercises after exposure sessions. Prior research is limited to a single trial of recounting (Mystkowski et al, 2006) or reinstatement of retrieval cues from extinction training (Culver, Stoyanova, & Craske, 2011). Our paradigm focuses on consolidating learning gained from exposures. It is the first study to test the effects of mental rehearsal conducted *repeatedly* and *between* exposure sessions to optimally reduce fear. Notably, Control participants completed identical laboratory sessions and in vivo exposures to Mental Rehearsal participants, enabling a powerful test of whether mental rehearsal provides clinical benefits beyond those attained from exposure therapy.

In line with hypotheses, Mental Rehearsal participants showed a greater reduction in scores from pre- to post-treatment on two questionnaires assessing fear and avoidance of spiders relative to Controls. For Mental Rehearsal, this reduction represented approximately a 1.5-standard deviation decrease. Mental Rehearsal participants also reported a greater reduction than Controls in anticipatory distress prior to approaching a live spider. Findings are particularly compelling as Mental Rehearsal participants showed significantly greater improvement on subjective measures of fear than the already-significant improvement that Controls demonstrated. Also in line with hypotheses, Mental Rehearsal participants completed a significantly greater number of steps during the behavioral approach test at posttest compared to Controls. Moreover, Mental Rehearsal participants took at least one additional step at posttest

more than twice as often as did Controls. Increased willingness to approach opens up the opportunity for further exposure and extinction after treatment has concluded, thus increasing the likelihood of continued learning.

In contrast to hypotheses, whereas both groups showed significant decreases in maximum distress as well as anticipatory and in vivo skin conductance level during the behavioral approach test, we did not find group differences on the rate of improvement in these variables. Mental rehearsal targets modification of spider 'schemas' through consolidation of inhibitory learning (i.e., the spider does not predict danger). Since schemas are thought to automatically influence cognitive processes (Teachman & Woody, 2003), it is possible that changes in declarative knowledge as a function of mental rehearsal had a greater impact on reflective measures of anticipation and approach, rather than reactive measures of emotional responding and physiological arousal. As such, physiological arousal may be more optimally targeted through repeated in vivo exposure as opposed to mental rehearsal.

Similarly, we found no significant group differences for change in confidence ratings from pretest to posttest. When groups were assessed independently, however, Mental Rehearsal showed a significant increase in confidence from pretest to posttest, while Control did not. As our analyses were not sufficiently powered to detect small effect sizes, which would have required 780 participants per a priori power analysis, it is possible that between-group differences for confidence ratings would have emerged with greater power. Nonetheless, it seems that the impact of mental rehearsal on confidence may be of lower magnitude than its effect on other aspects of fear.

Overall, the present study demonstrated that mental rehearsal between exposure sessions is associated with additional treatment gains above and beyond those attained from standard

exposure therapy with non-specific rehearsal. Findings suggest that mental rehearsal may be an effective and practical supplement to exposure therapy to assist in increasing treatment response. It offers a simple, noninvasive procedure that can easily be implemented and yet may improve long-term outcomes. Further research is needed to determine the precise mechanisms underlying the effects of our intervention, as multiple processes may be implicated. Our methods were derived from the theory that structured mental rehearsal facilitates consolidation of the exposure memory, with repeated rehearsal and reconsolidation strengthening its retrievability over time, resulting in less fear at posttest. Yet, it also conceivable that mental rehearsal disrupted reconsolidation of the original fear memory trace (Monfils et al., 2009; Tronson & Taylor, 2007). That is, viewing of an image of the spider from exposures could have served as a brief CS reminder trial, and subsequent mental rehearsal may have prompted modification of the original fear memory trace prior to reconsolidation.

It is also possible that an extension of exposure through imagery may have explained the effects of the mental rehearsal condition, since prolonged imaginal exposure is moderately effective for posttraumatic stress disorder (Arntz et al., 2007; Bryant et al., 2003) and obsessive-compulsive disorder (Foa et al., 1985). On the other hand, prior studies found that continuing exposure to the extent that fear is reduced by 100% rather than by 50% resulted in *greater* return of fear after four weeks (Rachman, Robinson, & Lopatka, 1987) and that overlearning with supplemental nonfear modeling provided no advantage in reducing return of fear (Rachman & Lopatka, 1988). Extinction research with rodents similarly indicated no advantageous effect of additional trials beyond those necessary to extinguish fear (Rauhut, Thomas, & Ayres, 2001). Thus, the observed effects of mental rehearsal on fear reduction in our study may not be solely attributable to extended exposure.

Secondary analyses aimed to investigate moderating roles of stress, sleep quality, and aerobic exercise on the association between mental rehearsal and treatment outcomes. We found that both stress levels and sleep quality influenced the effect of mental rehearsal on maximum distress ratings. Among participants with normal to moderate stress levels, Mental Rehearsal reported a significantly greater reduction in maximum distress relative to Control. However, among participants who reported severe to extremely severe stress levels, there was no advantage of being in the Mental Rehearsal vs Control group for maximum distress. Similar results emerged for sleep quality. Among participants with normal/good sleep quality, Mental Rehearsal reported a significantly greater reduction in maximum distress relative to Control. However, among participants who reported poor sleep quality, no group differences emerged. These results are difficult to interpret as our analyses were underpowered (.60) and findings were not replicated across other outcome measures. Still, our findings indicate that high levels of baseline stress and poor sleep quality may interfere with maximal benefits of mental rehearsal. Given prior research detailing the negative impacts of stress and sleep deprivation on memory processes (Aubry, Serrano, & Burghardt, 2016; Maren & Holmes, 2016; Deschaux et al, 2013; Rasch & Born, 2013), it is plausible that high stress and poor sleep quality interfered with consolidating nonfear learning, which was the target of mental rehearsal exercises. It is suggested that future research continue to investigate environmental and lifestyle factors that may interfere with between-session interventions targeting memory consolidation.

Contrary to hypotheses, we found no effect of aerobic exercise on any of our outcome measures. It is possible that we would have observed more effects with greater power. It is also possible that effects would have been observed if we had achieved a wider distribution of scores on this measure. While measures of stress and sleep quality were normally distributed in our

sample, aerobic exercise exhibited a large positive skew, which limited the extent to which we were able to test the effects of varying levels of aerobic exercise on treatment outcomes.

Finally, we assessed the extent to which post-exposure ratings (surprise, post-expectancy, generalization) varied by treatment group and impacted treatment outcomes. Contrary to hypotheses, post-expectancy and generalization did not vary as a function of Group over time. Each of our post-exposure measures significantly decreased from Session 1 to Session 2, indicating reduced surprise considering the outcome of exposures, reduced expectancy of the feared outcome, and reduced generalization of fear to spiders outside of the laboratory. With regard to treatment outcomes, change in surprise ratings predicted one outcome measure (confidence), but was not predictive of other outcomes. Average post-expectancy rating was also a marginally significant predictor of SPQ score at posttest, but was not predictive of other outcomes. Similar to moderation analyses, these analyses were underpowered (.45 to .66) and were treated as exploratory. It is possible that more significant effects would have emerged with greater statistical power and a greater number of measurement occasions.

There are several limitations to consider. First, in order to evaluate mental rehearsal of expectancy violation, we included an exposure retrieval cue in the form of a visual image of the spider that was used during in vivo exposure. Participants were instructed to view the image and answer a series of questions. While there are no studies showing that brief imagery alone following in vivo exposure facilitates subsequent in vivo exposure to phobic stimuli, future investigations might compare the mental rehearsal procedure with versus without the spider image to better understand underlying mechanisms of the intervention. Second, our sample was predominantly female undergraduates, so it is unclear how generalizable results are to males and older adults. Third, our design included two exposure sessions, which could be increased to

optimize ecological validity as exposure therapy is typically 12 to 16 weeks in duration. There is a need for a greater number of exposure and rehearsal occasions to test the extent to which mental rehearsal still augments outcomes with a sufficient amount of exposure. Fourth, we only assessed the impact of mental rehearsal on short-term treatment outcomes, and thus it is unclear whether treatment gains would be maintained over time. Additionally, our study was not sufficiently powered to detect small effect sizes, and thus other significant effects may have emerged with a greater sample size. Finally, it is unclear how results would generalize to other psychiatric disorders.

It is recommended that future research incorporate more exposure sessions and a longer-term follow-up to determine whether continued mental rehearsal practice reduces post-treatment relapse. Moreover, more data is needed to determine optimal intervals of time (e.g., weekly, bi-weekly) for rehearsal practice following treatment. Replication of findings among other psychiatric disorders is also warranted. Additionally, future research would benefit from evaluating mechanisms underlying mental rehearsal to determine whether its impacts are better explained by facilitated retrieval of extinction memories, disruption of reconsolidation, or extension of exposure through between-session imagery. As mentioned in the Introduction, the exact window of time in which it is most critical to consolidate memories is unclear. Participants in our study completed the first mental rehearsal exercise two hours following in vivo exposure given findings from related research (Baker, McNally, & Richardson, 2013). However, we did not systematically vary the timing of mental rehearsal across groups, rendering it unclear whether timing of rehearsal influenced outcomes. Future research may benefit from further assessment in this area, which may assist in optimizing the effects of mental rehearsal and clarifying important mechanisms underlying its effects. In addition, inclusion of expectancy

ratings of participants' feared outcomes may be useful in future studies to determine the extent to which expectancy mediates the effects of mental rehearsal on treatment outcomes (Boddez et al., 2012; Mertens et al., 2018). We also recommend manipulating the content of the mental rehearsal intervention to determine whether focus on expectancy violation learning is a critical mechanism. Finally, we recommend investigation into the most practical means of delivering mental rehearsal. Implementing rehearsal practice through a phone application that enables reminders and behavioral monitoring may reinforce high completion rates and prove to be an optimal forum.

Conclusions

The present study demonstrated that mental rehearsal between exposure sessions is associated with additional treatment gains above and beyond those attained from standard exposure therapy with non-specific rehearsal (i.e., our control condition). Findings were observed on questionnaire and in vivo measures of subjective fear, as well as on a behavioral measure of approach. Our findings suggest that mental rehearsal is an effective supplement to exposure therapy, and may assist in increasing retention of nonfear learning. Exposure is used across a range of severe and impairing disorders, including specific phobias, social anxiety disorder, agoraphobia, posttraumatic stress disorder, and obsessive-compulsive disorder. As such, mental rehearsal may be a promising avenue toward increasing treatment response rates across many anxiety and stress-related disorders, which represent some of the most common mental illnesses in the United States.

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APPENDIX A

SELF-REPORT QUESTIONNAIRES

Spider Phobia Questionnaire (SPQ)

Answer each of the following statements either True or False as you feel they generally apply to you. If the statement is true most of the time or mostly true for you, you should answer **True.** If it is mostly false or false most of the time, mark it **False**. Indicate your answer by placing a mark **(X)** in the appropriate column.

TRUE	FALSE	
		1. I avoid going to parks or on camping trips because there may be spiders about.
		2. I would feel some anxiety holding a toy spider in my hand.
		3. If a picture of a spider crawling on a person appears on the screen during a motion picture, I turn my head away.
		4. I dislike looking at pictures of spiders in a magazine.
		5. If there is a spider on the ceiling over my bed, I cannot go to sleep unless someone kills it for me.
		6. I enjoy watching spiders build their webs.
		7. I am terrified by the thought of touching a harmless spider.
		8. If someone says that there are spiders anywhere about, I become alert and edgy.
		9. I would not go down to the basement to get something if I thought there might be spiders down there.
		10. I would feel uncomfortable if a spider crawled out of my shoe as I took it out of the closet to put it on.
		11. When I see a spider, I feel tense and restless.
		12. I enjoy reading articles about spiders.
		13. I feel sick when I see a spider.

		14. Spiders are sometimes useful.
		15. I shudder when I think of spiders.
		16. I don't mind being near a harmless spider if there is someone there in whom I have confidence.
		17. Some spiders are very attractive to look at.
		18. I don't believe anyone could hold a spider without some fear.
		19. The way spiders move is repulsive.
		20. It wouldn't bother me to touch a dead spider with a long stick.
		21. If I came upon a spider while cleaning the attic I would probably run.
		22. I'm more afraid of spiders than of any other animal.
		23. I would not want to travel to Mexico or Central America because of the greater prevalence of tarantulas.
		24. I am cautious when buying fruit because bananas may attract spiders.
		25. I have no fear of non-poisonous spiders.
		26. I wouldn't take a course in biology if I thought I might have to handle live spiders.
		27. Spider webs are very artistic.
		28. I think that I'm no more afraid of spiders than the average person.
		29. I would prefer not to finish a story if something about spiders was introduced into the plot.
		30. Even if I was late for a very important appointment, the thought of spiders would stop me from taking a shortcut through an underpass.
		31. Not only am I afraid of spiders but millipedes and caterpillars make me feel anxious.

Fear of Spiders Questionnaire

Directions: For each item, please record a number to indicate how much you agree with the statement. Ratings can include any number between 0 (totally disagree) and 7 (totally agree).

Totally Disagree — Totally Agree

0 ---------- 1 ---------- 2 ---------- 3 ---------- 4 ---------- 5 ---------- 6 ---------- 7

_____ 1. If I came across a spider now, I would get help from someone else to remove it.

_____ 2. Currently, I am sometimes on the look out for spiders.

_____ 3. If I saw a spider now, I would think it will harm me.

_____ 4. I now think a lot about spiders.

_____ 5. I would be somewhat afraid to enter a room now, where I have seen a spider before.

_____ 6. I now would do anything to try to avoid a spider.

_____ 7. Currently, I sometimes think about getting bit by a spider.

_____ 8. If I encountered a spider now, I wouldn't be able to deal effectively with it.

_____ 9. If I encountered a spider now, it would take a long time to get it out of my mind.

_____ 10. If I came across a spider now, I would leave the room.

_____ 11. If I saw a spider now, I would think it will try to jump on me

_____ 12. If I saw a spider now, 1 would ask someone else to kill it.

_____ 13. If I encountered a spider now, I would have images of it trying to get me

_____ 14. If I saw a spider now I would be afraid of it.

_____ 15. If I saw a spider now, I would feel very panicky.

_____ 16. Spiders are one of my worst fears.

_____ 17. I would feel very nervous if I saw a spider now.

_____ 18. If I saw a spider now, I would break out in a sweat and my heart would beat faster.

DASS21

Name: *Date:*

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found it hard to wind down	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5	I found it difficult to work up the initiative to do things	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I experienced trembling (eg, in the hands)	0	1	2	3
8	I felt that I was using a lot of nervous energy	0	1	2	3
9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting agitated	0	1	2	3
12	I found it difficult to relax	0	1	2	3
13	I felt down-hearted and blue	0	1	2	3
14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15	I felt I was close to panic	0	1	2	3
16	I was unable to become enthusiastic about anything	0	1	2	3
17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life was meaningless	0	1	2	3

The Pittsburgh Sleep Quality Index (PSQI)

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of day and nights in the past month. Please answer all questions. During the past month:

1. When have you usually gone to bed? _____
2. How long (in minutes) has it taken for you to fall asleep each night? _____
3. When have you usually gotten up in the morning? _____
4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) _____

5. During the past month, how often have you had trouble sleeping because you….	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):				
6. During the past month, how often have you taken medicine prescribed or "over the counter" to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)
9. During the past month, how would you rate your sleep quality overall?				

Exercise Habits

Subject ID: _____ Date: _____

Please answer the following questions to the best of your ability. If you choose to record time in hours rather than minutes, please specify so.

Examples of mild activity include walking to class, walking a dog, light housework, stretching, playing catch. Examples of moderate activity include water aerobics, bicycling <10mph, tennis, speed walking, yoga, elliptical or stair master at a moderate pace. Examples of intense activity include jogging/running, swimming laps, bicycling >10mph, jumping rope, heavy gardening, hiking uphill or with a heavy backpack, circuit weight training, elliptical or stair master at a vigorous pace.

1.) How much time in minutes do you spend in *scheduled* exercise activities (e.g., gym, sports) on average each week? _____

2.) How would you rate the average intensity at which you participate in *scheduled* exercise activities? (reference above examples)

- ☐ Mild *(small increase in heart rate)*
- ☐ Moderate *(significant increase in heart rate)*
- ☐ Intense *(very significant increase in heart rate)*

3.) How much time in minutes do you spend in *unscheduled/incidental* exercise activities (e.g., walking to class, walking a dog) on average each week? _____

4.) How would you rate the average intensity at which you participate in *unscheduled* exercise activities? (reference above examples)

- ☐ Mild *(small increase in heart rate)*
- ☐ Moderate *(significant increase in heart rate)*
- ☐ Intense *(very significant increase in heart rate)*

Spider Knowledge

Subject ID: _____ Date: _____

Please check off the following statements that are TRUE for you:

□ I have heard about spiders on the news or in a TV show.

□ I know which spiders are poisonous and which are not.

□ I know which spiders are likely to bite and which are not.

□ I have read a magazine or article about spiders.

□ I know which species of spiders are the most dangerous to humans.

Post-Exposure Questionnaire

Subject ID: _____ Date: _____

How surprised were you by what happened during these exposure practices?

1 ---------- 2 ---------- 3 ---------- 4 ---------- 5

Not at all surprised | Somewhat surprised | Extremely surprised

If you were to do these same practices again with this same spider, how likely do you think it is that your biggest concern/fear with the spider would happen?

1 ---------- 2 ---------- 3 ---------- 4 ---------- 5

Not at all likely | Somewhat likely | Extremely likely

If you were to encounter a different spider today outside of the lab, how likely do you think it is that your biggest concern/fear with the spider would happen?

1 ---------- 2 ---------- 3 ---------- 4 ---------- 5

Not at all likely | Somewhat likely | Extremely likely

APPENDIX B

BAT ADMIN SCRIPT

BAT Steps (30s each)

1. Stand 5 feet away from the tarantula in its closed terrarium.
2. Stand 1 foot away from the tarantula in its terrarium with the top removed.
3. Place both hands on the side of the terrarium with the top removed.
4. Touch nose against the glass of the terrarium while looking at the tarantula with the top removed.
5. Place gloved hand halfway inside the terrarium (2-3 inches above tarantula).
6. Place gloved hand inside the terrarium with all fingertips touching the base of the terrarium.
7. Place bare hand inside the terrarium with all fingertips touching the base in front of the tarantula.
8. Touch the back of the tarantula's leg continuously with a Q-tip.
9. Touch the back of the tarantula's leg continuously with the tip of the index finger.

SCRIPT

This part of the experiment consists of 9 steps, each lasting 30 seconds. Instructions for each step will be read aloud before you proceed to the next step. Each step must be completed before moving on to the next step, and steps must be completed in sequential order.

After I read the instructions for a step and before you complete it, you will be asked to rate your confidence level to complete the step on a scale from 0 to 100 (0= no confidence, 25= mild confidence, 50= moderate confidence, 75= high confidence, 100 = complete confidence) and your level of distress anticipating the step on a scale from 0 to 100 (0=no distress, 25=mild distress, 50=moderate distress, 75= high distress, 100= severe distress). After completing a step, you will be asked to rate the maximum level of distress that you experienced during the step, again on a scale from 0 to 100. You are entitled to withdraw at any step if you do not wish to continue. Do you have any questions before we begin?

The first step of the experiment is to stand 5 feet away from the tarantula while it is in its closed container for 30 seconds. The final step of the experiment is to touch the back of the tarantula's leg with the tip of your index finger continuously for 30 seconds.

On a scale from 0 to 100, please rate how confident you are in your ability to complete all 9 steps of the experiment: _____

On a scale from 0 to 100, please rate your current level of distress anticipating your ability to complete all 9 steps of the experiment: _____

*****EXPERIMENTER: RECORD SCR ANTICIPATION PERIOD FOR 60 SECONDS*****

<u>STEP 1</u> - You will now stand 5 feet away from the tarantula while it is in its closed terrarium for 30 seconds. You must keep your eyes on the tarantula for the duration of this step.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 2</u> - You will now move to stand 1 foot away from the tarantula while it is in its terrarium with the lid open for 30 seconds. You must keep your eyes on the tarantula for the duration of this step.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 3</u> - You will now place your hands flatly and firmly on either side of the tarantula terrarium for 30 seconds. You must keep your hands on the terrarium and keep your eyes on the tarantula for the duration of this step.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 4</u> - You will now place your face against the terrarium with your nose touching the glass for 30 seconds while the lid is open. You must keep your nose on the glass of the terrarium and keep your eyes on the tarantula for the duration of this step.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 5</u> - You will now put on this glove [give participant glove] and place your hand halfway into the terrarium so that your hand is hovering 2-3 inches over the tarantula for 30 seconds.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 6</u> - You will now put your gloved hand inside of the tarantula terrarium and place all five of your fingertips on the glass at the bottom of terrarium. Your fingertips must remain touching the bottom of the terrarium for 30 seconds.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 7</u> - You will now remove the glove from your hand. Place your bare hand inside the terrarium and place all five of your fingertips on the bottom of the terrarium, anywhere <u>in front</u> of the tarantula. Your fingertips must remain touching the bottom of the terrarium for 30 seconds.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 8</u> - You will now touch the tarantula's back leg with a Q-tip for 30 seconds. If the tarantula moves, you must to the best of your ability keep the Q-tip on its leg.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

<u>STEP 9</u> - For the last step, you will touch the tarantula's back leg with the tip of your index finger for 30 seconds. If the tarantula moves, you must to the best of your ability keep your finger on its leg.

[BEFORE STEP]:
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

[AFTER STEP]:
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

EXPERIMENTER: Spider movement _____

Number of Steps Completed: _____

RATING SCALES

Confidence
On a scale from 0 to 100, please rate how confident you are in your ability to complete this step: _____

0= no confidence, 25= mild confidence, 50= moderate confidence, 75= high confidence, 100 = complete confidence

Anticipatory Distress
On a scale from 0 to 100, please rate your current level of distress anticipating this step: _____

0=no distress, 25=mild distress, 50=moderate distress, 75= high distress, 100= severe distress

Subjective Units of Distress (SUDS)
On a scale from 0 to 100, please rate the maximum level of distress you experienced while completing this step: _____

0=no distress, 25=mild distress, 50=moderate distress, 75= high distress, 100= severe distress

Spider Movement (during each step)

0= no movement, 1= little movement, 2= a lot of movement

APPENDIX C

MENTAL REHEARSAL

1. Please look at this photo as you consider the following questions. Two hours ago, you were exposed to this spider. Put yourself back in that moment, replaying your practice with the spider.

2. On which of the spider's legs is the circle?

a) Front
b) Middle front
c) Middle back
d) Back

3. Before you engaged with the spider in the lab, you were asked to identify what you were most concerned would happen. You responded that you were most concerned [PARTICIPANT'S FEARED OUTCOME FROM EXPOSURES]. Please type the response you provided in your own words.

4. Before you approached the spider, how convinced were you that [PARTICIPANT'S FEARED OUTCOME] would happen?

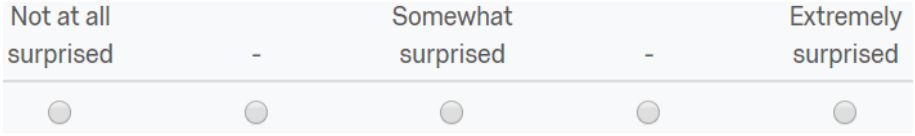
Not at all convinced	-	Somewhat convinced	-	Extremely convinced
○	○	○	○	○

5. What did you do during your practice with the spider?

6. What did the spider actually do during the practice?

7. Did the thing that you were most worried about actually happen? If not, how was the outcome different?

8. How surprised were you by what happened?

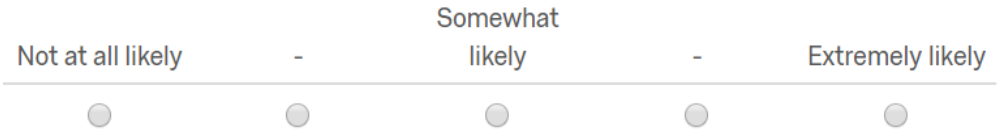


9. What did you learn from this experience?

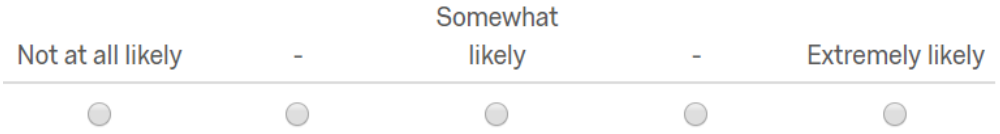
a) The thing that I expected the spider to do did NOT happen.
b) The thing that I expected the spider to do did happen.

10. In your own words, what did you learn from this experience?

11. If you were to do this same practice again with the same spider and same conditions, how likely do you think it is that [PARTICIPANT'S FEARED OUTCOME] would happen?



12. If you were to encounter a different spider today outside of the lab, how likely do you think it is that [PARTICIPANT'S FEARED OUTCOME] would happen?



13. Please spend a moment reliving your experience with the spider you approached in the lab. Write 2-3 sentences, reflecting on any differences you observed between what you thought would happen and what actually happened when you engaged with the spider.

CONTROL REHEARSAL

1. Please look at this photo as you consider the following questions. Bring to mind the last time you were in class. Put yourself back in that moment, replaying your experience in the classroom.

2. When you first walked into the classroom, what were your thoughts?

3. Before you walked into the classroom, how confident were you that you would learn something new?

Not at all confident	-		Somewhat confident	-	Extremely confident
○	○	○	○	○	○

4. What did you do during the class?

5. What did the professor or TA lecture about?

6. Was your experience in the classroom different than you thought it would be? If yes, how was it different than you anticipated?

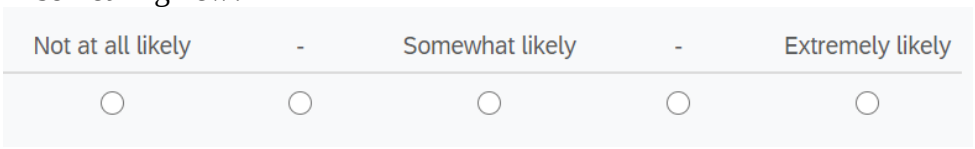
7. How surprised were you by your experience in the classroom?

Not at all surprised	-		Somewhat surprised	-	Extremely surprised
○	○	○	○	○	○

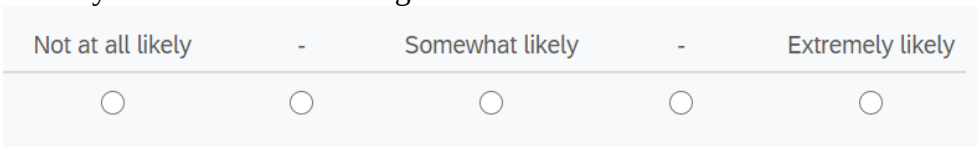
8. What was your overall impression of this class?

9. What did you learn from this experience?

10. When you return to this class the next time it meets, how likely do you think it is that you will learn something new?



11. When you attend a different class at UCLA taught by a different professor, how likely do you think it is that you will learn something new?



12. Please spend a moment reliving your experience in this class. Write 2-3 sentences, reflecting on any differences you observed between what you thought the class would be like and what it was actually like.