**Mental Imagery and Emotion Regulation: Positively Valenced Distraction in the Mind's Eye**

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**Abstract**

Attentional distraction, or the diversion of attention away from emotionally salient stimuli towards an innocuous distractor, has been shown to regulate negative emotion. Although converging evidence has indirectly supported the use of a positively valenced imagined distractor, no existing research has used positively valenced mental imagery to distract from a threatening stimulus. To address this gap in the literature, the present investigation recruited a sample of 50 University of Manitoba students. A differential fear association was first created, followed by a distraction manipulation where participants were instructed to either attend to the stimulus presented or visualize a neutral or positively valenced distractor. It was primarily hypothesized that imagining a distracting stimulus would downregulate one's fear response when presented with a threat cue, as measured through the skin conductance response (SCR) and self-reported fear. Additionally, positively valenced imagery was predicted to be more effective than neutral imagery in the regulation of fear. Self-report and SCR measures revealed the successful acquisition and persistence of differential fear. Whereas the self-reported fear results supported positively valenced imagery in the regulation of fear, neutral imagery was not supported. SCR results revealed that both positively valenced and neutral imagined distraction had downregulated the differential threat response, such that SCRs did not differ significantly when participants were shown a threat or safety cue. No direct evidence for the increased efficacy of positively valenced distraction was found. Together, the present investigation informs the use of an effective emotion regulation strategy for those who struggle with emotion dysregulation.

*Keywords: emotion regulation, attention, distraction, mental imagery, fear*

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**Mental Imagery and Emotion Regulation: Positively Valenced Distraction in the Mind's Eye**

As Epictetus (55 A.D. - ca. 135 A.D.) said, "you become what you give your attention to." When faced with threat, some may ruminate on the impending danger, initiating the fight, flight, or freeze response (Schmidt et al., 2008). Alternatively, imagine a fire fighter preparing to rush into a burning building. To proceed with their goal directed behaviours, the effective firefighter must regulate their fear and rush into the building regardless. To calm their fears, the firefighter might imagine a treasured memory, or the joy of seeing their favourite artist live. That is, the firefighter can divert their attention away from the threatening stimulus, focusing instead on a positively valenced distracting mental image, thereby inhibiting the fear response (Delgado et al., 2008; Ochsner & Gross, 2005). In this way, when faced with adversity, one may employ the cognitive emotion regulation strategy of attentional distraction, creating a positive mental image to facilitate the persistence of goal directed behaviours. However, such a strategy has received little empirical investigation. To address this gap in the literature, the present investigation explores positively valenced imagined distraction in the regulation of a differential fear response.

**Fear Conditioning**

Building on the basic principles of Pavlovian learning, differential fear conditioning is a common method used in the empirical investigation of emotion (Fullana et al., 2016; LeDoux, 2003). In this method, two innocuous conditioned stimuli (CS+ and CS-) are used. Whereas the CS+ is repeatedly paired with an aversive unconditioned stimulus (US) such as a mild electric shock, the CS- is never paired with the US. Through associative learning, subsequent exposure to the CS+ absent of the US may arouse a conditioned response (CR) as though the US had been delivered, while CS- exposure should produce a comparatively attenuated response. Common measures of the CR include psychophysiological indices of threat (e.g., increased perspiration; Jiang et al., 2021) and subjective feelings of fear (LeDoux, 2012). By measuring the differences in CRs to CS+ versus CS- exposure, researchers are afforded a valid method in the quantification of one's fear response.

**Attention**

When multiple stimuli are presented simultaneously, the neural representations of these stimuli compete for our limited information processing capacities in a mutually inhibitory fashion (Kamitani & Tong, 2005; Lee et al., 2014). Attentional selection regulates this competition, prioritizing the neural processing of relevant information while actively filtering out irrelevant stimuli (Akyürek et al., 2010; McNab & Klinberg, 2008). As per the biased competition model of attention (Desimone & Duncan, 1995), attentional selection is biased by a variety of bottom-up (e.g., stimulus novelty; Becker & Horstmann, 2011; Horstmann & Herwig, 2015) and top-down processes (e.g., goal relevance; Kamitani & Tong, 2005; Mazzietti et al., 2014). Supporting this divergence, Greene and Soto (2014) found that response times in a visual search task were greatest when the distracting stimulus was both perceptually salient (i.e., bottom-up attentional bias) and congruent with contents held in working memory (i.e., top-down attentional bias), suggesting an additive effect on response times when both forms of attentional bias were active. Furthermore, when observed independently, bottom-up and top-down mechanisms biasing attention showed different patterns of altered functional connectivity between the ventral and dorsal frontoparietal networks often implicated in attention control (Corbetta & Shulman, 2002).

Although attention selectively facilitates the processing of relevant information, attention's prioritization of information is not perfect. In fact, the presentation of irrelevant distractor stimuli may divide our attention and compete for further processing at the expense of goal relevant information (Rinne et al., 2007). For example, when participants were instructed to determine the orientation of a target stimulus, Kim and Hopfinger (2010) found that the presence of a sufficiently salient distractor stimulus delayed response times, increased task errors, and predicted increased functional activity in areas associated with attentional shifting (e.g., tempoparietal junction) at the expense of areas associated with task relevant information processing (e.g., ventral occipital cortex). That is, a sufficiently salient distractor can create a zero-sum game such that the processing of task relevant information may be disrupted by task irrelevant information. Load theory posits that susceptibility to attentional distraction may be altered under states of high cognitive and perceptual load, suggesting that the processing of task relevant information is inhibited in periods of high cognitive load and facilitated in periods of high perceptual load (Lavie, 2010; Lavie & De Fockert, 2005).

Attention is also biased towards affectively salient stimuli relative to neutral stimuli (Kousta et al., 2009; Vuilleumier, 2005), especially when in an emotionally aroused state (Greening et al., 2014; Lee et al., 2014). These attentional biases appear to be driven by both bottom-up (e.g., amygdala; Troiani et al., 2014), as well as top-down (e.g., frontoparietal cortex; Pourtois et al., 2006) processes that enhance the processing of affectively salient stimuli in early sensory cortices (Padmala & Pessoa, 2008). Such attentional capture may facilitate the detection and processing of both threat and reward relevant stimuli, promoting adaptive behaviours (Bradley, 2009). Despite their adaptive function, these mechanisms may facilitate emotional distraction—the processing of affectively salient stimuli at the expense of goal relevant information, thereby impairing goal-oriented behaviours (Dolcos & McCarthy, 2006; Gupta & Raymond, 2012). Most of this research has focused on the preferential processing of negatively valenced stimuli, particularly in the context of threat detection (Hartikainen et al., 2012; Koster et al., 2005; Vuilleumier, 2005). Further literature has posited a valence-general account of emotional distraction, suggesting preferential processing of both positive and negatively valenced stimuli at the expense of goal relevant information (Kim & Anderson, 2023; Straub et al., 2020). However, alternative literature has suggested that positively valenced stimuli may be less effective at capturing attention during a cognitive task relative to negatively valenced stimuli (Iordan & Dolcos, 2017), perhaps explained by research associating positive affect with enhanced attentional control and cognitive performance (Fredrickson, 2004; Yang et al., 2013). Ultimately, further research is required to disambiguate these mixed findings regarding positive valence and attentional capture.

**Mental Imagery**

Mental imagery is the neural representation and conscious experience of sensory information void of true perception (Pearson et al., 2015). Although researchers have investigated mental imagery across all sensory modalities, most mental imagery research has focused on visual experience in the "mind's eye" (Pearson et al., 2008; Pearson, 2019). Neuroimaging studies have suggested that visual mental imagery may function as an attenuated form of perception, finding significant neural overlap between visual perception and mental imagery tasks (Albers et al., 2013; Ganis et al., 2004; Reddy et al., 2010; Slotnick et al., 2005). Complementary research suggests that a mental image may compete with an externally presented percept for further processing (Smallwood et al., 2008; Villena-González et al., 2016), disrupting stimulus processing in early sensory cortices (Greening et al., 2022). In this way, mental imagery may be conceptualized as a form of attentional selection favouring internally generated information (Chun et al., 2011).

Extant research has highlighted the contributions of mental imagery in emotional experience (Andries et al., 2024; Cocquyt & Palombo, 2023; Mertens et al., 2020). For example, mental imagery may both amplify (Holmes & Mathews, 2005; Wicken et al., 2021) and downregulate (Opitz et al., 2015) an emotional response. Moreover, research suggests that an innocuous imagined stimulus may gain emotional significance through associative learning (Burleigh et al., 2022; Jiang & Greening, 2021; Lyons et al., 2024). Imagined stimuli have also been used to extinguish a learned fear response (Grégoire & Greening, 2019; Hoppe et al., 2022), as well as reduce fear in those living with a specific phobia using imagined exposure (Hoppe et al., 2021). Furthermore, altered mental imagery has been implicated in the etiology and symptomology of a variety of psychopathologies (Pearson et al., 2013), including posttraumatic stress disorder (Clark & Mackay, 2015), major depressive disorder (Weßlau & Steil, 2014), and generalized anxiety disorder (Tallon et al., 2020). Investigating how mental imagery interacts with emotion may therefore elucidate important theoretical and clinical implications.

**Emotion Regulation**

Although researchers have struggled to come to a unified definition of emotion (Mobbs et al., 2019), emotions may be understood as the internal states that drive alterations in physiology, behaviour, and subjective experience in response to one's environment (Mauss et al., 2005; Sheppes et al., 2015). These emotional responses are primarily adaptive, facilitating the avoidance of danger or motivating goal-directed behaviours (LeDoux, 2014; Tracy, 2014). However, a lack of control over one's emotions, or emotion dysregulation, has been associated with psychopathology and decreased well-being (Bradley et al., 2011; Gross & Jazaieri, 2014; Jazaieri et al., 2013; Wills et al., 2016). Cognitive emotion regulation, or the active modification of one's emotional state using cognitive strategies, has therefore become the subject of a large body of literature (Ochsner et al., 2012; Ochsner & Gross, 2008), often associating effective emotion regulation with decreased negative affect and positive psychological outcomes (Gruber et al., 2014; McRae, 2016).

One empirically supported cognitive emotion regulation strategy is attentional distraction (Koole, 2009; Webb et al., 2012). By diverting attention away from an emotionally salient stimulus, the processing of the emotional information may be disrupted, thereby inhibiting the emotional response (Hermann et al., 2017; Uusberg et al., 2014; Yates et al., 2010). Most research investigating attentional distraction in the context of emotion regulation has used cognitive tasks or artificial, neutral stimuli as distractors (Koole, 2009; Ochsner & Gross, 2005). For example, Kanske et al. (2011) found that when presented an emotionally salient image, a distracting arithmetic task decreased both subjective ratings of affect and neural correlates of emotion processing (e.g., bilateral amygdala activity) relative to passively viewing the emotional stimulus.

In addition to cognitive tasks and neutral stimuli, converging evidence supports the use of a positively valenced distractor in emotion regulation. For example, the presence of positively valenced stimuli may alter the fear response when presented with threat (McClay et al., 2020; Zbozinek & Craske, 2017). Furthermore, research has highlighted attentional biases prioritizing the processing of positively valenced stimuli (Straub et al., 2020), perhaps driven by top-down value modulation processes of the ventromedial prefrontal cortex (vmPFC; Harris et al., 2013; Motzkin et al., 2015). In this way, a positively valenced distractor may be particularly effective, activating both goal-directed and valence-driven attentional processes, facilitating attentional selection of the distractor at the expense of the threatening stimulus. However, literature investigating the use of positively valenced distractors in the downregulation of fear is sparse and remains inconclusive.

Another novel method in the attentional distraction literature is the use of a mental image as a distracting stimulus. Should mental imagery function as an attenuated form of perception (Ganis et al., 2004; Reddy et al., 2010), Lavie (2010)'s load theory suggests that a distracting mental image may increase perceptual load, thereby disrupting the processing of the visually presented threat cue. To investigate mental imagery in attentional distraction, Delgado et al. (2008) used a differential fear conditioning paradigm where a fear association was created to a blue square (CS+), but not a yellow square (CS-). Participants were then instructed to either attend to the stimulus presented or distract themselves by imagining a scene in nature. Psychophysiological results suggested successful downregulation of fear using imagined distraction. Functional neuroimaging results corroborated these psychophysiological results, suggesting increased dorsolateral prefrontal cortex and vmPFC activity, as well as inhibited left amygdala activity in CS+ distract trials relative to CS+ attend trials.

Expanding these results, Greening et al. (2022) used a differential fear conditioning paradigm that paired one orientation of line patches with the US (i.e., CS+) while an orthogonal orientation of line patches never predicted US delivery (i.e., CS-). After fear acquisition, participants were visually presented the CS+ and were instructed to either attend to the presented CS+ or imagine the CS-. Greening et al. found that distracting oneself from a threatening stimulus by imagining a safety cue significantly downregulated the fear response as measured using self-reported fear, the skin conductance response (SCR), and neural activity in the fear network (e.g., anterior insula) relative to the attend CS+ condition. Furthermore, when participants were presented the CS+, Greening et al. found that imagined distraction attenuated the neural processing of the CS+ in early visual cortices, as predicted by the biased competition model of attention (Desimone & Duncan, 1995).

**The Current Investigation**

Attentional distraction appears to be an effective cognitive emotion regulation strategy (Ochsner & Gross, 2005). However, the attentional distraction literature has suffered from an overreliance on cognitive tasks and artificial, neutral stimuli as distractors (Hermann et al., 2017; Kanske et al., 2011). It remains unclear whether imagining a positively valenced, real-world stimulus may downregulate a learned fear response. Moreover, the relative efficacies of positively valenced and neutral distracting mental images in the downregulation of fear have never been directly compared. To address these gaps in the literature, the present investigation employed a differential fear conditioning paradigm. Next, attention was manipulated in a within-subjects manner, such that participants attended to the CS presented or distracted themselves by forming a mental image of either a neutral face or a positively valenced face. To quantify the fear response, participants' skin conductance response and self-reported fear were collected. To determine the efficacy of positively valenced imagined distraction, two central hypotheses were tested. Firstly, when presented a valid threat cue (i.e., the CS+), it was hypothesized that generating a distracting mental image would downregulate one's fear response relative to attending to the CS+. Secondly, it was predicted that the positively valenced distractor would be more effective in downregulating a learned fear response than the neutral distractor. In this way, the present investigation informs the use of a real-world emotion regulation strategy for those who struggle with emotion dysregulation.

# Methods

## Participants

Consistent with previous investigations of mental imagery and emotion (Hoppe et al., 2022; Jiang & Greening, 2021), 50 participants between the ages of 18 and 45 ($M_{\text{Age}}$ = 22.0, $SD_{\text{Age}}$ = 6.0) were recruited (33 female, 16 male, 1 preferred not to answer). Participants who reported any substance misuse, pacemaker use, pregnancy, or any neurological conditions were excluded from participating. All participants denied having previously sought psychological services for mental health concerns. Informed consent was obtained from all participants and the investigation's protocols were approved by the University of Manitoba's Research Ethics Board.

## Materials

### *Psychological Measures*

Before the experimental paradigm, participants were administered the series of questionnaires detailed below using Qualtrics. These questionnaires were evaluated to confirm the inclusion criteria were met and ensure the sample was free of any potential confounds of interest, such as low attentional control (i.e., sample mean < 30; Derryberry & Reed, 2002) or low imagery vividness (i.e., sample mean < 32; Keogh et al., 2021; Keogh & Pearson, 2018). A demographics questionnaire was first employed to gather relevant background information, such as participant age, gender, and mental health history (Appendix A).

Next, the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) was administered (Appendix B). The VVIQ is a 16-item questionnaire used to assess the vividness of one's visual imagery. Throughout the measure, participants are instructed to imagine a particular object or scene and rate the vividness of the mental image they have generated on a 5-point Likert scale, ranging from 1 (*No image at all, you only 'know' you are thinking of the object)* to 5 *(Perfectly clear and as vivid as normal vision*). The VVIQ has been shown to display strong reliability and is commonly used in mental imagery research (Campos et al., 2002).

Participants were then asked to complete the Attention Control Scale (ACS; Derryberry & Reed, 2002). The ACS is a 20-item questionnaire used to assess one's voluntary control of their attention (Appendix C). Throughout, participants are asked to report how often certain situations apply to themselves on a 4-point Likert scale, ranging from 1 (*Almost Never*) to 4 (*Always*). Previous research has supported the psychometric properties of the ACS, suggesting good internal consistency and construct validity (Judah et al., 2014; Reinholdt-Dunne et al., 2013).

Participants also completed the Center of Epidemiological Studies – Depression Scale (CES-D; Radloff, 1977). The CES-D is a 20-item questionnaire used to measure common depressive symptomology in the general population (Appendix D). Throughout the CES-D, participants are asked to report how often they felt or behaved in certain ways over the past week on a 4-point Likert scale ranging from 0 (*Rarely or none of the time*) to 3 (*Most or all of the time*). The CES-D has been shown to display high internal consistency, acceptable test-retest reliability, and strong construct validity across a variety of demographics (Radloff, 1977).

Participants were next asked to complete the Center of Epidemiological Studies Anxiety Scale (CESA; Faro & Eaton, 2020). The CESA is a three-part, 20-item questionnaire designed to screen for anxious symptomology in the general population (Appendix E). In all three parts, participants are asked to respond using a 4-point Likert scale. CESA responses may inform the sources of one's anxiety, the frequency of avoidance behaviours, the presence of specific cognitive and somatic symptoms, and the experiencing of panic attacks. Supporting the use of the CESA, research has demonstrated the measure's reliability and criterion validity as a measurement of general anxious symptomology, as well as a screening tool for specific anxiety disorders (Faro & Eaton, 2020).

***Stimuli***

Consistent with previous research (Lee et al., 2018), the two conditioned stimuli (CS) employed were gray-scaled house and building images, both obtained online using copyright-free sources (Figure 1). Which stimulus served as the CS+ was randomly assigned across participants in a counterbalanced fashion. Participants were given no explicit instructions regarding which CS was predictive of US delivery. The US was a mild electrical stimulation delivered for 500 ms at 50 Hz to the fingertips of the fourth and fifth digits of the participant's left hand using the BIOPAC MP-160 system and AcqKnowledge software. US intensity was tailored to the individual's pain threshold (Jiang & Greening, 2021; Jiang et al., 2021).

The distractor stimuli were two aggregated and gray-scaled face images from the Averaged Karolinska Directed Emotional Faces database (Lundqvist & Litton, 1998). One face image was a smiling face, representing the positively valenced distractor. The other face image was expressionless, representing the neutral distractor (Figure 2). These images were visually displayed during the Habituation phase, allowing participants to familiarize themselves with the images. Additionally, participants were auditorily cued to imagine these distractor stimuli in the Habituation and Emotion Regulation phases. Auditory cues were 1.5 s long and terminated with CS onset, prompting participants to either "imagine happy face" or "imagine neutral face". These auditory cues were created using notevibes.com (English, US - Ava).

**Figure 1**

*Conditioned Stimuli Place Images: House and Building*

*Note.* The two place images used as the Conditioned Stimuli. Which stimulus served as the CS+ was counterbalanced across participants. The other stimulus served as the CS-.

**Figure 2**

*Distractor Face Images: Positively Valenced and Neutral Distractors*

*Note.* Averaged and gray-scaled face images of a smiling and expressionless face from the Averaged Karolinska Directed Emotional Faces database. Images were cropped to the hairline and chin. To assess attentional distraction, participants were auditorily prompted to generate a mental image of either the positively valenced (left) or neutral (right) face image throughout the Emotion Regulation phase.

**Procedures**

Before the experimental paradigm, informed consent was obtained, and participants completed the series of questionnaires detailed above. Participants then completed a series of computerized tasks created using MATLAB R2023 and the Psychophysics Toolbox Version 3 (Kleiner et al., 2007). All tasks were delivered by a trained experimenter in a temperature-controlled room with the lights turned off. Participants sat in front of a computer screen with their chins placed on a chinrest approximately 40 cm from the screen. Participants were asked to keep their eyes open, hands still and rested on a flat surface, and attentions fixed on the task. Questionnaire and experimental task completion took approximately 75 minutes.

A thresholding procedure was first employed to determine US intensity. Beginning at a 0.01 mA intensity, the electrical stimulation was delivered at increasing intensities in a stepwise fashion until the participant rated the electrical stimulation as "uncomfortable, but not painful" (Jiang & Greening, 2021). Unless any adjustments were requested, US intensity remained constant throughout the experiment. Individualized US intensities ranged between 0.75 mA and 11.0 mA ($M$ = 1.83 mA, $SD$ = 0.76 mA).

***Habituation Phase***

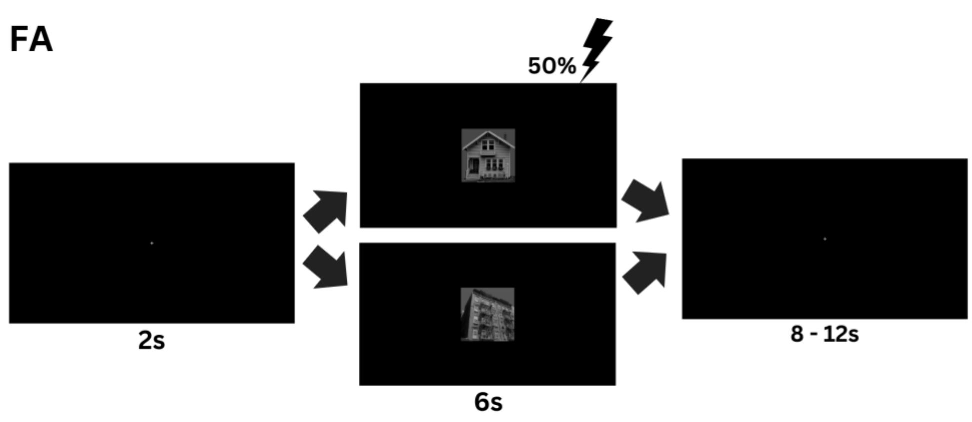
The Habituation phase was designed to expose participants to the various stimuli of the experiment, ensure baseline responding to all stimuli, and prompt participants to practice imagining the face distractor stimuli. This phase consisted of 10 trials administered in a fixed order. Each CS was administered once, followed by two view and two imagine trials for each face distractor image. Each trial began with 2 s of fixation cross display, followed by 6 s of stimulus display. Trials were separated by an intertrial interval of 4 s with fixation cross display. Auditory cues to imagine either the happy or neutral face were administered for imagine trials. No electrical stimulation was administered in this phase.

***Fear Acquisition Phase***

Participants then underwent a Fear Acquisition phase of 10 CS+ and 10 CS- trials (Figure 3). To form a differential fear association, 50% of CS+ trials were paired with a co-terminating US while the CS- was never paired with the US. Trials were administered in a pseudorandomized fashion, such that the phase always began with a CS- trial followed by a CS+ trial that was paired with the US. Each trial began with 2 s of fixation display, followed by 6 s of CS display. Trials were separated by an intertrial interval with fixation cross display that randomly lasted between 8-12 s (Lonsdorf et al., 2017).

**Figure 3**

*Fear Acquisition Phase Procedure*



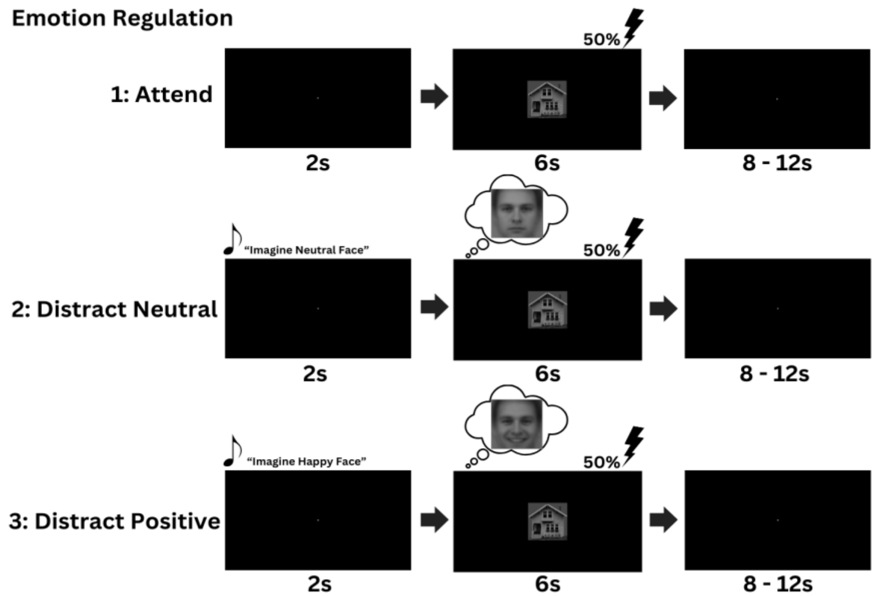

*Note.* The Fear Acquisition phase consisted of 10 CS+ and 10 CS- trials, where 5 CS+ trials were paired with a co-terminating mild electrical stimulation. In this example, the house place image serves as the CS+ while the building place image is the CS-.

***Emotion Regulation Phase***

The Emotion Regulation phase included four runs of 25 trials each. Trials were presented in a pseudorandomized fashion, such that each run began with an Attend CS- trial that was discarded from the SCR analyses. From there on, both the CS+ and CS- were presented 12 times. As with the Fear Acquisition phase, 50% of CS+ trials were paired with a co-terminating US. For eight trials each, CS presentation was paired with one of the following three attention manipulations in a within-subject fashion: Attend CS (i.e., no distraction instructions), Distract Neutral (i.e., auditorily cued to imagine the neutral distractor), and Distract Positive (i.e., auditorily cued to imagine the positively valenced distractor; Figure 4). In this way, each of the following six conditions were presented four times: CS+ Attend, CS- Attend, CS+ Distract Neutral, CS- Distract Neutral, CS+ Distract Positive, and CS- Distract Positive. Each trial began with 2 s of fixation cross presentation, followed by 6 s of CS display. For distraction trials, audio instructions to imagine either the neutral or happy face were delivered for 1.5 s, co-terminating with CS onset. Trials were separated by an intertrial interval of fixation cross display that randomly lasted between 8-12 s.

**Figure 4**

*Emotion Regulation Phase Procedure*



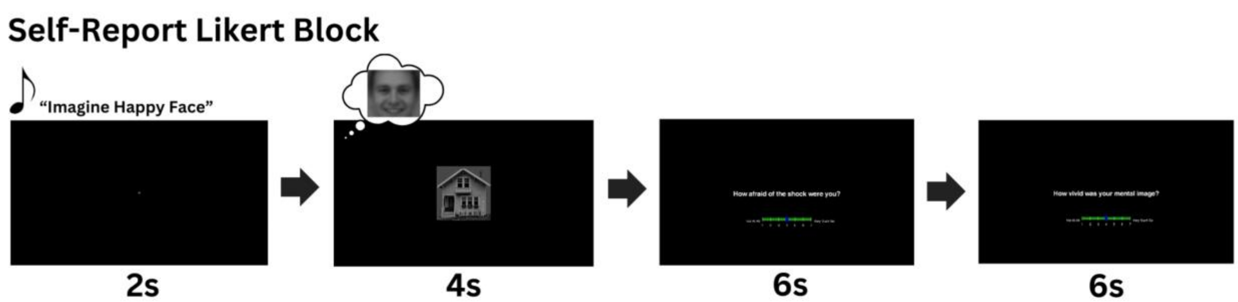

*Note.* Procedure of the Emotion Regulation phase and the three levels of its Attention manipulation. Participants either passively attended the CS presented (Attend) or were auditorily instructed to imagine either a neutral (Distract Neutral) or positively valenced (Distract Positive) face image. The house image serves as the CS+ in this example, being paired with co-terminating US delivery on 50% of trials.

***Self-Report Likert Blocks***

At three points during the experiment, participants were asked to report their subjective fear (i.e., "How afraid of the shock were you?) in response to each condition on a 7-point Likert scale, ranging from 1 (*Not at All*) to 7 (*Very Much So*). These subjective ratings were administered using a computerized task after the Fear Acquisition phase, as well as after the second and fourth runs of the Emotion Regulation phase (Figure 5). After the Fear Acquisition phase, participants were asked to report their subjective fear in response to both CS images and both distractor face images. For both Emotion Regulation phase Likert blocks, participants reported their subjective fear in response to both distractor face images, as well as CS+ Attend, CS- Attend, CS+ Distract Neutral, CS- Distract Neutral, CS+ Distract Positive, and CS- Distract Positive conditions. For the imagined distraction conditions of the Emotion Regulation phase, participants were also asked to report the vividness of their distracting mental image (i.e., “How vivid was your mental image?”) on a 7-point Likert scale, ranging from 1 (*Not at All*) to 7 (*Very Much So*).

**Figure 5**

*Likert Block Procedure*




*Note.* Likert block procedure example for the CS+ Distract Positive condition. In the Fear Acquisition phase Likert block, participants were prompted to report their fear of US delivery to both CSs and distractor face images using keyboard entry. In the Emotion Regulation Likert blocks, participants were prompted to report their fear of US delivery to CS+ Attend, CS- Attend, both distractor face images, as well as CS+ Distract Neutral, CS- Distract Neutral, CS+ Distract Positive, and CS- Distract Positive conditions. For the four distraction conditions, participants were also asked to rate the vividness of their mental imagery.

In all Likert blocks, trials were administered in a pseudorandomized fashion, such that each run began with Attend CS- and Attend CS+ conditions. Each trial began with 2 s of fixation display, followed by 4 s of stimulus display. For imagined distraction conditions, auditory prompts to imagine the distractor image were administered as they were in the Emotion Regulation phase. Next, the Likert scale appeared for 6 s, prompting participants to report their response using keyboard entry. For the distract trials of the Emotion Regulation phase Likert blocks, the self-reported fear question was followed by 6 s of Likert display prompting participants to report the subjective vividness of their mental imagery. Following the final Likert block, participants were asked to verbally report their effort rating on a scale of 1 (*did not follow the instructions at all*) to 10 (*followed the instructions perfectly*).

**Data Analysis**

***Exclusions and Data Cleaning***

No participants were excluded for failing to meet inclusion criteria. Group-level descriptive statistics were computed for the demographics questionnaire and four psychological measures completed. As missing values were followed by a request for a response, participants with missing values were excluded from these descriptive analyses to control for careless responding. One participant's ACS score was therefore excluded. No participants reported an effort rating lower than 6/10 ($M$ = 7.83, $SD$ = 0.97), and thus no participants were excluded based on their self-reported effort scores (Monzel et al., 2023).

Likert block responses were used to determine participants' self-reported fear and imagery vividness. No missing values were observed in these self-report Likert blocks. For final analyses, mean self-reported fear and imagery vividness scores for each condition were averaged across participants. To control for individuals living with aphantasia (i.e., individuals who report no ability to form a mental image; Dance et al., 2022; Keogh & Pearson, 2018), two participants were excluded from all Emotion Regulation phase analyses due to an average self-reported imagery vividness score of 1.5 or lower. As suggested by Lonsdorf et al. (2017), no further outlier exclusions were conducted on these self-report data. Moreover, one participant from the Fear Acquisition phase and three participants from the Emotion Regulation phase were excluded from the self-report analyses owing to experimenter error (e.g., failure to administer). Final samples of 49 and 45 were therefore obtained for the Fear Acquisition and Emotion Regulation phase self-report analyses, respectively.

Throughout the experiment, electrodermal activity was recorded using a BIOPAC MP-160 system and AcqKnowledge software. Electrodermal activity was collected by placing Ag/AgCl electrodes with saline-based gel (BIOPAC GEL101) on the fingertips of the second and third digits of the participant's left hand, sampling at a rate of 2000 Hz. SCR analyses were conducted using MATLAB R2023. To control for artifacts such as random noise and habituation drift, electrodermal data were pre-processed using a Butterworth bandpass filter with cut-off frequencies of .01 and 5 Hz (Bach et al., 2013; Jiang et al., 2021). Next, the time series was down sampled to 100 Hz. Consistent with previous research (Grégoire & Greening, 2019; Jiang & Greening, 2021), trial-by-trial SCRs were baseline corrected by zeroing the trial's electrodermal activity on the mean electrodermal response across 1 s preceding CS onset. A difference score was then calculated by subtracting the minimum response from CS onset to 1.0 s following CS onset from the peak response between 1.0–5.5 s after CS onset. This difference score was then square root transformed to facilitate the normality of these data. Baseline corrected, square root transformed SCRs failing to surpass a minimum of 0.2 microsiemens were then zeroed (Jiang & Greening, 2021; Jiang et al., 2021). Finally, SCRs were averaged across participants for each condition and analyzed as detailed below.

SCRs from the first trial of every Fear Acquisition and Emotion Regulation run were discarded to control for potential orienting effects (Jiang & Greening, 2021; Schiller et al., 2010). One participant was excluded from all SCR analyses as they displayed no detectable CR to US delivery (Jiang & Greening, 2021). Otherwise, no outlier exclusions were conducted on these data (Lonsdorf et al., 2017).

Experimenter error resulted in the exclusions of one participant from the Fear Acquisition phase and another participant from the Emotion Regulation phase. Final samples of 48 and 46 were therefore obtained for the Fear Acquisition and Emotion Regulation phases, respectively.

***Fear Acquisition Phase***

To evaluate the presence of differential fear, planned comparison paired samples *t*-tests compared self-reported fear and SCRs to the CS+ versus CS- stimuli. Self-reported fear in response to the positively valenced and neutral distractors were also assessed with a paired samples *t*-test. To uncover how fear learning may progress over time, SCRs were analyzed with an exploratory 2 (CS Type: CS+ vs. CS-) x 2 (Time: First Half vs. Second Half) within-subjects repeated measures Analysis of Variance (ANOVA). Of note, CS- trials of the First Half level only included trials 2-5 to control for potential orienting effects.

***Emotion Regulation Phase***

As a manipulation check, the persistence of differential fear was first assessed with a paired samples *t*-test comparing self-reported fear and SCRs to Attend CS+ versus Attend CS- conditions. A 2 (CS Type: CS+ vs. CS-) x 3 (Attention: Attend vs. Distract Positive vs. Distract Neutral) x 2 (Time: First Half vs. Second Half) within-subjects repeated measure ANOVA was conducted to evaluate distraction efficacy in both self-reported fear and SCR dependent variables. All significant interaction effects were followed up with post hoc paired samples *t*-tests with Holm-Bonferroni corrections to control for family wise error rate inflation. To ensure the emotion regulation manipulation was not systematically biased by differences in imagery vividness across conditions, self-reported imagery vividness of the distract conditions were compared using a 2 (CS Type: CS+ vs. CS-) x 2 (Distractor Valence: Positive vs. Neutral) within-subjects repeated measures ANOVA. To evaluate how individual differences in constructs of interest (i.e., VVIQ, ACS, CES-D, and CESA scores) may be associated with emotion regulation efficacy, Holm-Bonferroni corrected Pearson's *r* correlation coefficients were calculated between the self-report measure scores and the differential scores in self-reported fear (Attend CS+ vs. Attend CS-, Attend CS+ vs. Distract Neutral, and Attend CS+ vs. Distract Positive) and SCR (Attend CS+ vs. Attend CS-, Distract Neutral CS+ vs. Distract Neutral CS-, and Distract Positive CS+ vs. Distract Positive CS-).

# Results

## Psychological Measures

See Table 1 for a summary of the sample's demographic information and VVIQ, ACS, CES-D, and CESA scores. Of note, the present sample endorsed scores largely consistent with previous research conducted with university undergraduates in regards to self-reported imagery vividness (Dance et al., 2022), attention control (Reinholdt-Dunne et al., 2013), and depressive symptomology (Mills et al., 2016). Although little existing research has employed the CESA in an experimental design, the present sample endorsed less anxiety than what has been observed in clinical out-patient convenience samples (Faro & Eaton, 2020).

## Fear Acquisition Phase

### *Self-Reported Fear*

A paired samples *t*-test was conducted to evaluate the presence of differential fear in the Fear Acquisition phase. Results revealed that participants reported significantly greater fear to the CS+ condition than the CS- condition, $t(48) = 7.49$, $p < .001$, d = 1.07 (Figure 6a). No significant differences were found in self-reported fear between the positively valenced ($M = 2.25$, $SD = 1.51$) and neutral ($M = 2.57$, $SD = 1.54$) distractor images prior to the Emotion Regulation phase, $t(48) = 1.83$, $p = .07$, d = 0.26.

**Table 1**

*Participant Demographics and Descriptive Statistics of the Measures Employed*

| Measure | N | Minimum | Maximum | *Range* | *M* | *SD* |
|---|---|---|---|---|---|---|
| Age | 50 | 18 | 65 | 18-45 | 22.0 | 6.0 |
| VVIQ | 50 | 16 | 80 | 17-80 | 60.6 | 13.4 |
| ACS | 49 | 20 | 80 | 36-66 | 51.6 | 6.1 |
| CES-D | 50 | 0 | 60 | 3-37 | 14.6 | 7.7 |
| CESA | 50 | 0 | 60 | 0-29 | 11.2 | 7.1 |

*Note.* Participant age and scores on psychological measures employed to evaluate self-reported imagery vividness (VVIQ), attention control (ACS), depressive symptomology (CES-D), and anxious symptomology (CESA). For all measures, higher scores reflect a greater presence of the construct measured. The lowest and highest possible scores for each measure are reported in the minimum and maximum columns, respectively. Range scores depict the lowest and highest scores observed for each measure within the sample.

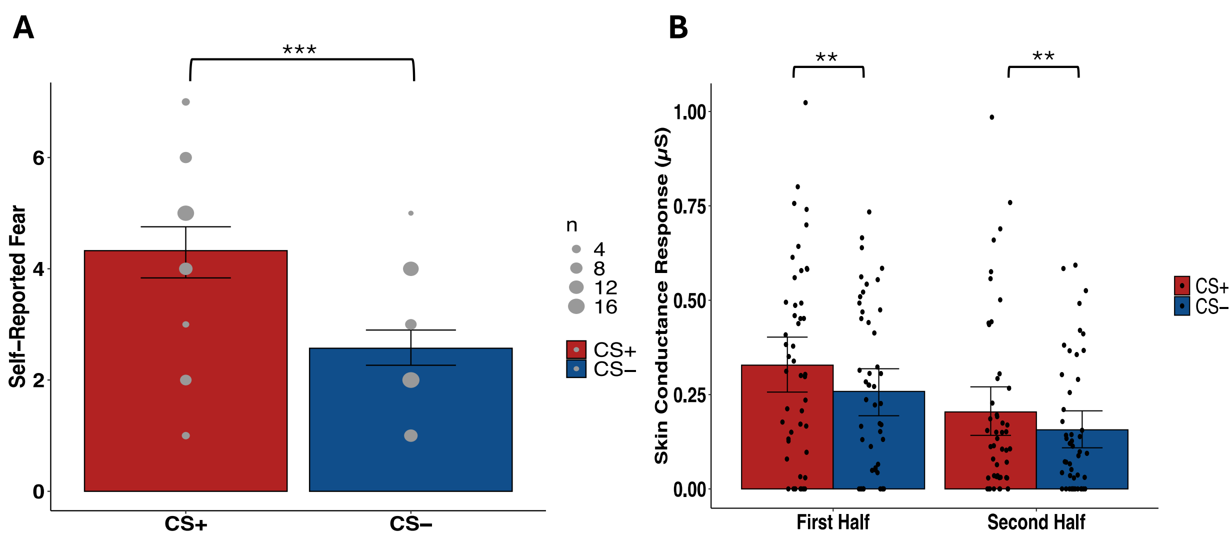
***Skin Conductance Response***

Corroborating the self-reported fear results, paired samples *t*-tests revealed elevated SCRs in response to the CS+ condition relative to the CS- condition, $t(47) = 3.20$, $p = .002$, d = 0.46. To elucidate the presence of any potential time effects, a 2 (CS Type: CS+ vs. CS-) x 2 (Time: First Half vs. Second Half) within-subjects repeated measures ANOVA was conducted (Figure 6b). Main effects of CS Type, $F(1, 47) = 8.98$, $p = .004$, $\omega^2 = .018$, and Time, $F(1, 47) = 28.17$, $p < .001$, $\omega^2 = .067$, were revealed. The CS Type x

Time interaction proved non-significant, $F(1, 47) = 0.56$, $p = .457$, $\omega^2 < .001$. When collapsing across the CS Type factor, a paired samples *t*-test revealed greater SCRs in the First Half of the Fear Acquisition phase than the Second Half, $t(47) = 5.31$, $p < .001$, d = 0.50. In all, these results suggest the successful acquisition of differential fear irrespective of time.

**Figure 6**

*Fear Acquisition Phase Results: Self-Reported Fear and Skin Conductance Response*




*Note.* Self-reported fear and Skin Conductance Response results confirming the successful acquisition of differential fear. Red bars represent the CS+ condition. Blue bars represent the CS- condition. Error bars reflect 95% confidence intervals. Asterisks denote statistical significance (* $p < .05$, ** $p < .01$, *** $p < .001$). A) Self-reported fear results to CS+ and CS- conditions. Participants reported fear of US delivery on a 7-point Likert scale ranging from 1 (*Not at* All) to 7 (*Very Much* So). Size of dots reflects the number of individual participants who endorsed each value. B) Participant SCRs in response to CS+ and CS- conditions in the First (left) and Second (right) halves of the Fear Acquisition phase. SCRs are square root transformed and reported in microsiemens. Each dot represents one participant's average SCR in response to each condition.

**Emotion Regulation Phase**

***Self-Reported Imagery Vividness***

Self-reported imagery vividness scores of the regulation conditions were evaluated using a 2 (CS Type: CS+ vs. CS-) x 2 (Distractor Valence: Positive vs. Neutral) within-subjects repeated measures ANOVA. Effects of CS Type, F(1, 44) = 0.09, $p$ = .76, $\omega^2 < .001$, Distractor Valence, F(1, 44) = 0.05, $p$ = .83, $\omega^2 < .001$, and the CS Type x Distractor Valence interaction, F(1, 44) = 0.10, $p$ = .75, $\omega^2 < .001$, were all non-significant. These results suggest that potential differences in distraction efficacy across CS Type and Distractor Valence are not best explained by differences in self-reported imagery vividness.

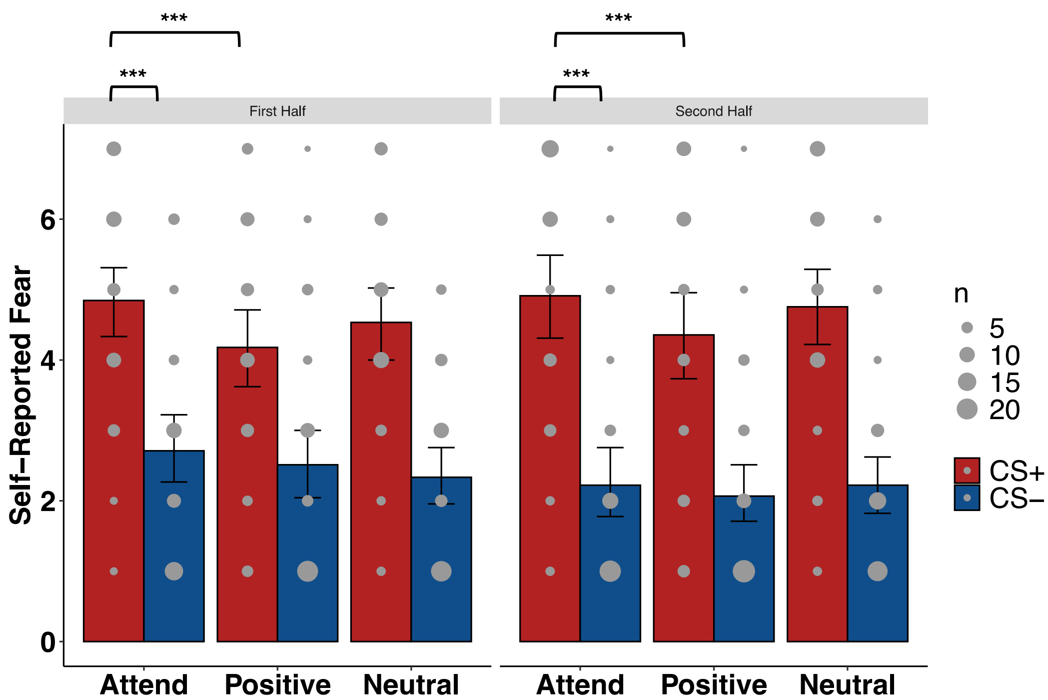
***Self-Reported Fear***

As a manipulation check, participants' self-reported fear in response to CS+ and CS- conditions void of any distraction manipulation (i.e., Attend conditions) were evaluated with a planned comparison paired samples *t*-test. Supporting the persistence of differential fear into the Emotion Regulation phase, participants reported significantly greater fear in response to the Attend CS+ condition than the Attend CS- condition, $t(44) = 6.68$, $p < .001$, d = 1.00.

To test the primary research question, distraction efficacy was evaluated with a 2 (CS Type: CS+ vs. CS-) x 3 (Attention: Attend vs. Distract Positive vs. Distract Neutral) x 2 (Time: First Half vs. Second Half) within-subjects repeated measures ANOVA. Main effects of CS Type, F(1, 44) = 55.22, $p < .001$, $\omega^2 =$ .391, and Attention, F(2, 88) = 5.88, $p$ = .004, $\omega^2 = .019$, were found (Figure 7). Interaction effects of CS Type x Attention, F(2, 88) = 3.13, $p$ = .049, $\omega^2 = .006$, and CS Type x Time, F(1, 44) = 4.59, $p$ = .038, $\omega^2 =$ .012, were also uncovered. The main effect of Time, F(1, 44) = 0.46, $p$ = .50, $\omega^2 < .001$, the Attention x Time interaction, F(2, 88) = 0.80, $p$ = .45, $\omega^2 < .001$, and the three-way interaction, F(2, 88) = 0.32, $p$ = .724, $\omega^2 < .001$, were all non-significant.

**Figure 7**

*Emotion Regulation Phase Results: Self-Reported Fear*




*Note.* Participants reported subjective fear in response to each condition on a 7-point Likert scale, ranging from 1 (*Not at* All) to 7 (*Very Much* So). Red bars reflect CS+ conditions while blue bars reflect CS- conditions. The attention manipulation is reflected across the x-axis. In the Attend condition, participants passively attended to the CS displayed. Whereas in the Positive condition participants were instructed to imagine the positively valenced distractor while presented the CS image, participants were instructed to imagine the neutral distractor while presented the CS image in the Neutral condition. Size of dots reflect the number of participants who reported each value. First Half results show participant responses in the Likert block administered after the second run of the Emotion Regulation phase. Second Half results show participant responses in the Likert block administered after the fourth run of the Emotion Regulation phase. Error bars reflect 95% confidence intervals.

To evaluate the CS Type x Attention interaction, post-hoc paired samples *t*-tests with Holm-Bonferroni corrections at the familywise error rate of 15 were conducted. Collapsing across the Time factor, participants reported significantly greater fear in response to the Attend CS+ condition than the CS+ Distract Positive condition, $t(44) = 4.09$, $p < .001$, d = 0.36. No difference in self-reported fear was found between the CS+ Attend and the CS+ Distract Neutral conditions, $t(44) = 1.56$, $p = .481$, d = 0.14. Moreover, no significant difference was found between CS+ Distract Positive and CS+ Distract Neutral conditions, $t(44) = -2.53$, $p = .062$, d = 0.22. No significant differences were found between the CS- Attend condition and the CS- Distract Neutral, $t(44) = 1.26$, $p = .624$, d = 0.11, or CS- Distract Positive, $t(44) = 1.19$, $p = .624$, d = 0.10, conditions.

To explore the CS Type x Time interaction, post-hoc paired samples *t*-tests with Holm-Bonferroni corrections at a familywise error rate of 6 were conducted. When collapsing across the Attention factor, CS+ conditions elicited significantly greater self-reported fear than the CS- conditions in both the First, $t(44) = 6.15$, $p < .001$, d = 1.16, and Second halves, $t(44) = 7.70$, $p < .001$, d = 1.45. No significant differences were found between the First and Second Half CS+, $t(44) = -0.84$, $p = .40$, d = 0.09, or CS- conditions, $t(44) = 1.89$, $p = .125$, d = 0.20.

To further evaluate how individual differences in constructs of interest may have influenced these findings, exploratory Pearson's *r* correlation coefficients with Holm-Bonferroni corrections evaluated the associations between CES-D, CESA, VVIQ, and ACS scores against CS+ Attend - CS- Attend, CS+ Attend - CS+ Distract Neutral, and CS+ Attend - CS+ Distract Positive differential scores. Self-reported depressive symptomology was not associated with Attend CS+ versus Attend CS- differential fear scores, $r(43) = -.09$, $p = .59$. CES-D scores were also uncorrelated with the downregulation of self-reported fear via both neutral, $r(43) = .25$, $p = .10$, and positively valenced, $r(43) = -.22$, $p = .15$, distraction. Similarly, anxious symptomology showed no association with the persistence of differential fear, $r(43) = .24$, $p = .11$, nor the extent of downregulation achieved via either neutral, $r(43) = .26$, $p = .09$, or positively valenced, $r(43) = -.12$, $p = .44$, distraction. Self-reported imagery vividness was found to be uncorrelated with differential fear, $r(43) = .02$, $p = .92$, neutral distraction efficacy, $r(43) < .01$, $p = .99$, and positively valenced distraction efficacy, $r(43) = -.19$, $p = .23$. Self-reported attention control scores also showed no associations with differential fear, $r(42) = .01$, $p = .94$, or downregulation via either neutral, $r(42) = -.07$, $p = .67$, or positively valenced distraction, $r(42) = .04$, $p = .81$.

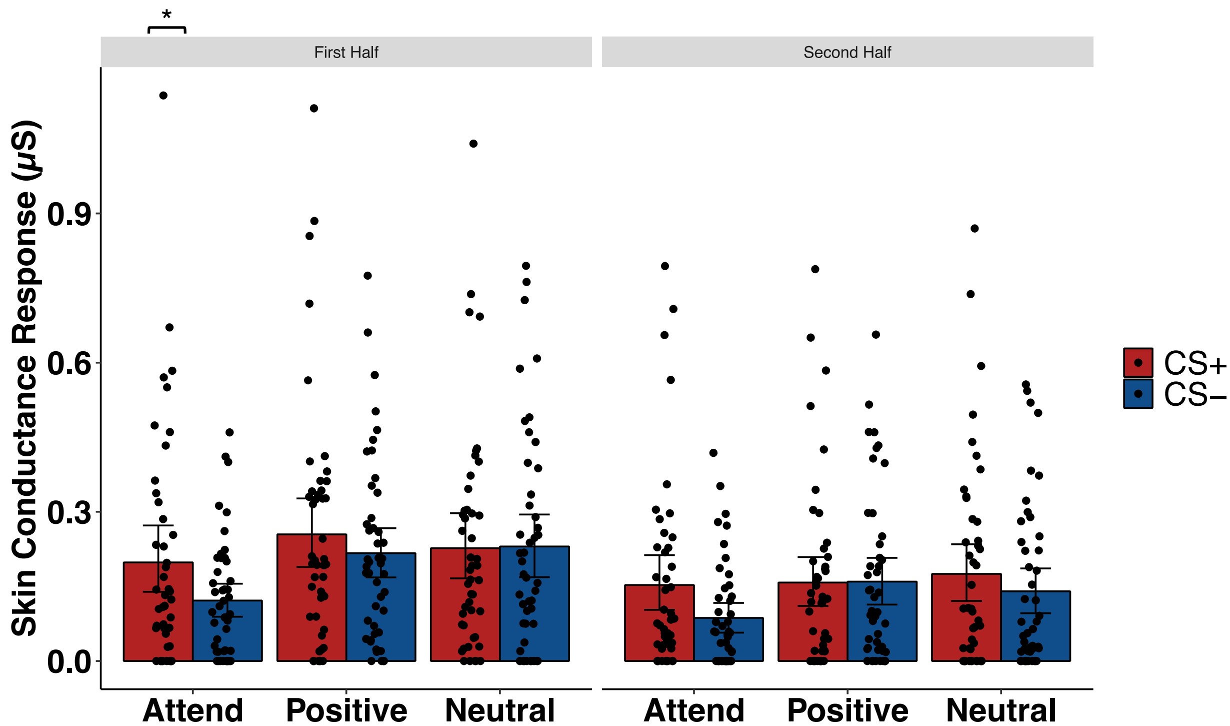
***Skin Conductance Response***

To ensure the persistence of differential fear into the Emotion Regulation phase, a paired-samples *t*-test evaluated participant SCRs in response to the Attend CS+ versus Attend CS- conditions. Void of any distraction manipulation, participants showed an elevated response to the CS+ relative to the CS- condition, $t(45) = 3.17$, $p = .003$, d = 0.47. Importantly, these results corroborate the self-report findings and suggest the persistence of differential fear into the Emotion Regulation phase.

To evaluate the efficacy of imagined distraction, a 2 (CS Type: CS+ vs. CS-) x 3 (Attention: Attend vs. Distract Positive vs. Distract Neutral) x 2 (Time: First Half (Runs 1 and 2) x Second Half (Runs 3 and 4)) within-subjects repeated measures ANOVA was conducted (Figure 8). The main effects of CS Type, $F(1, 45) = 5.97$, $p = .019$, $\omega^2 = .009$, Attention, $F(2, 90) = 14.15$, $p < .001$, $\omega^2 = .022$, and Time, $F(1, 45) = 18.73$, $p < .001$, $\omega^2 = .031$, were all significant. The CS Type x Attention, $F(2, 90) = 6.10$, $p = .003$, $\omega^2 = .005$, Attention x Time, $F(2, 90) = 4.60$, $p = .012$, $\omega^2 = .002$, and the three-way interactions, $F(2, 90) = 3.50$, $p = .035$, $\omega^2 = .002$, were also significant. Alternatively, the CS Type x Time, $F(1, 45) = 0.04$, $p = .84$, $\omega^2 < .001$, interaction was non-significant.

**Figure 8**

*Emotion Regulation Phase Results: Skin Conductance Response*




*Note.* Trial-by-trial SCRs were averaged across participants for each condition. SCRs displayed are square root transformed and reported in microsiemens. Red bars reflect CS+ conditions while blue bars reflect CS- conditions. The attention manipulation is depicted across the x-axis. In the Attend condition, participants passively attended to the CS displayed. Whereas in the Positive condition participants were instructed to imagine the positively valenced distractor while presented the CS image, participants were instructed to imagine the neutral distractor while presented the CS image in the Neutral condition. Dots represent each participant's average SCR to each condition. First Half results show participant responses across runs one and two of the Emotion Regulation phase. Second Half results show SCRs across runs three and four of the Emotion Regulation phase. Error bars reflect 95% confidence intervals. Asterisks denote significance in the post-hoc paired samples *t*-tests following the CS-Type x Attention x Time interaction with Holm-Bonferroni corrections at a familywise error rate of 66.

To explore the main effect of Attention, post hoc paired samples *t*-tests with Holm-Bonferroni corrections at a family rate of 3 were employed. These *t*-tests revealed that, collapsing across the factors of Time and CS Type, SCRs were elevated in both Distract Positive, $t(45) = 4.80$, $p < .001$, d = 0.30, and Distract Neutral, $t(45) = 4.42$, $p < .001$, d = 0.28, trials relative to Attend trials. No significant difference between Distract Positive and Distract Neutral trials, $t(45) = 0.35$, $p = .73$, d = 0.02, was found. These results suggest that the imagined distraction manipulation elicited an increase in participant SCRs independent of both the affective salience of the image presented (i.e., CS+ versus CS-) and the distracting mental image generated (i.e., positive versus neutral).

Being the interaction most relevant to the primary predictions, the CS Type x Attention interaction was evaluated with post-hoc paired samples *t*-tests with Holm-Bonferroni corrections. Collapsing across the effects of Time, these *t*-tests revealed significantly greater responding to the CS+ versus CS- conditions when attending to the CS, $t(45) = 4.03$, $p = .001$, d = 0.37. However, no significant CS+ versus CS- differential was observed in the Distract Positive, $t(45) = 1.02$, $p = 1.0$, d = 0.09, or Distract Neutral, $t(45) = 0.71$, $p = 1.0$, d = 0.06, conditions. Despite the relatively elevated SCRs during distract conditions relative to the Attend condition, these results suggest that both distraction manipulations had successfully thwarted differential responding between CS+ and CS- stimuli. However, Holm-Bonferroni post-hoc paired samples *t*-tests corrected at a family wise error rate of 66 revealed that differential fear between Attend CS+ versus Attend CS- trials were observed in the First Half, $t(45) = 3.63$, $p = .019$, d = 0.40, but not the Second Half, $t(45) = 3.13$, $p = .089$, d = 0.35, of the Emotion Regulation phase, seemingly driving the three-way interaction. Moreover, the Attend CS- condition elicited significantly lesser SCRs than the CS+ Distract Positive, $t(45) = 5.25$, $p < .001$, d = 0.53, CS+ Distract Neutral, $t(45) = 4.98$, $p < .001$, d = 0.51, CS- Distract Positive, $t(45) = 5.59$, $p < .001$, d = 0.44, and CS- Distract Neutral, $t(45) = 5.39$, $p < .001$, d = 0.42, conditions. No significant difference was found between CS+ Distract Positive and CS+ Distract Neutral conditions, $t(45) = 0.89$, $p = 1.0$, d = 0.08.

To evaluate the Attention x Time interaction, post hoc paired samples *t*-tests with Holm-Bonferroni corrections were conducted. When collapsing across CS Type in the First Half, Attend CS trials elicited significantly weaker SCRs than both the Distract Positive, $t(45) = 5.54$, $p < .001$, d = 0.40, and Distract Neutral, $t(45) = 5.02$, $p < .001$, d = 0.36, conditions. Similarly, when collapsing across CS Type in the Second Half, SCRs of the Attend CS conditions were elevated relative to both the Distract Positive, $t(45) = 2.85$, $p = .035$, d = 0.20, and Distract Neutral, $t(45)= 2.77$, $p = .039$, d = 020, conditions. Comparing the distraction conditions between the First and Second halves, both the Distract Positive, $t(45) = 4.72$, $p < .001$, d = 0.40, and Distract Neutral, $t(45) = 4.35$, $p < .001$, d = 0.37, conditions had elicited significantly greater SCRs in the First Half than the Second Half of the Emotion Regulation phase. No significant difference was found between the Attend trials of the First and Second halves, t(45) = 2.46, $p = .081$, d = 0.21. No significant differences were found in the SCRs elicited by Distract Positive and Distract Neutral conditions in either the First, $t(45) = 0.52$, $p = 1.0$, d = 0.04, or the Second Half, $t(45) = 0.09$, $p = 1.0$, d = 0.01.

Exploratory Pearson's *r* correlation coefficients corrected for multiple comparisons were computed between the measured constructs of interest (i.e., CES-D, CESA, ACS, and VVIQ scores) and CS+ vs. CS- differential SCRs at the Attend, Distract Neutral, and Distract Positive levels of the Attention factor. Self-reported depressive symptomology was not associated with CS+ vs. CS- differentials at the Attend, $r(44) = -.04$, $p = .77$, Distract Neutral, $r(44) = -.01$, $p = .95$, or Distract Positive, $r(44) = .10$, $p = .50$, levels of Attention. Similarly, anxious symptomology was not significantly correlated with levels of differential fear in the Attend, $r(44) < .01$, $p = .99$, Distract Neutral, $r(44) = -.01$, $p = .96$, or Distract Positive, $r(44) = -.02$, $p = .91$, conditions. Self-reported attention control also showed no significant relationship with CS+ vs. CS- differentials whether attending to the CSs, $r(43) = -.06$, $p = .72$, or distracting using a neutral, $r(43) = .19$, $p = .23$, or positively valenced, $r(43) = -.11$, $p = .47$, mental image. Finally, self-reported imagery vividness scores were uncorrelated with differential fear at the Attend, $r(44) = -.01$, $p =$

.95, Distract Neutral, $r(44) = .20$, $p = .18$, and Distract Positive, $r(44) = .02$, $p = .89$, levels of the Attention factor.

## Discussion

The present investigation evaluated the efficacy of a novel emotion regulation strategy, using affectively valenced imagery in the downregulation of a learned fear response. As predicted, self-reported fear and SCR analyses revealed the successful acquisition and persistence of differential fear. Regarding emotion regulation, the self-reported fear results were mixed, supporting only positively valenced imagined distraction in the downregulation of subjective fear. Contrary to prediction, no differences in SCRs between Attend CS+ and distract CS+ trials were found in either neutral or positively valenced imagined distraction. However, indirectly supporting the hypothesized regulatory effects of imagined distraction, differential SCRs to CS+ versus CS- stimuli were successfully downregulated when visualizing either a neutral or a positively valenced distractor. No direct evidence for the hypothesized increased efficacy of positively valenced distraction was found. Taken together, these findings add to the body of literature suggesting the efficacy of imagined distraction in emotion regulation, particularly supporting the use of positively valenced imagery in the downregulation of fear.

Fear Acquisition phase data showed robust evidence of differential fear acquisition in both self-reported fear and SCR measures. These results are consistent with a broad literature uncovering successful differential fear conditioning to real-world, neutral visual stimuli (Ahrens et al., 2016; Kunze et al., 2015). Importantly, Attend CS+ versus Attend CS- comparisons in both self-reported fear and SCR analyses revealed that differential fear persisted into the Emotion Regulation phase. However, the SCR results of the Emotion Regulation phase revealed a significant three-way interaction, such that the Attend CS+ versus Attend CS- differential was significant in the First Half of the Emotion Regulation phase only. However, considering the small-to-medium effect size, significant *t*-test when ignoring Time, and lack of a CS Type x Time interaction, this Time effect may reflect the relatively stringent statistical correction employed (i.e., familywise error rate of 66) more than a true extinction of differential fear. Alternatively, these results may exemplify a floor effect induced by habituation drift (Lonsdorf et al., 2017), as evidenced by significantly lesser SCRs regardless of CS Type or Attention in the Second Half of the Emotion Regulation phase. As both Greening et al. (2022) and Delgado et al. (2008) did not evaluate time effects in their SCR results, it is unclear whether these findings are consistent with past imagined distraction research.

Self-reported fear results of the Emotion Regulation phase uncovered a critical CS Type x Attention interaction, such that relative to the Attend CS+ condition, only Distract Positive CS+ conditions had successfully down-regulated subjective feelings of fear. These findings are consistent with research suggesting the efficacy of attentional distraction in the regulation of self-reported fear (Hermann et al., 2017; Kanske et al., 2011) and the attenuating effects of positive valence in fear responding (McClay et al., 2020; Zbozinek & Craske, 2017). Importantly, the present investigation expands both these lines of research by incorporating imagined stimuli. Both contrary to prediction and inconsistent with previous imagined distraction research, no evidence was found for neutral imagery in the downregulation of self-reported fear. One explanation could be that the distracting mental images employed by both Greening et al. (2022) and Delgado et al. (2008) may have carried implicit positive valence, as opposed to being purely neutral mental images. Whereas the present investigation used a distracting mental image that was independent of the fear conditioning paradigm, Greening et al. (2022) had participants imagine the CS- as the distractor. This use of an established safety cue as the imagined distractor may have given Greening et al.'s seemingly neutral distracting stimulus positive valence, therefore aligning our self-report findings. While Delgado et al. did not measure self-reported fear, the observed lack of support for neutral distraction in the downregulation of self-reported fear ostensibly fails to corroborate their conclusion that upon CS+ presentation, imagining a nature scene downregulated psychophysiological and functional neuroimaging measures of differential fear. Although Delgado et al.'s distraction manipulation was not explicitly framed as positively valenced imagery, past research has found that visualizing nature scenes can induce positive affective states (Koivisto & Grassini, 2023). Delgado et al.'s results may therefore align with the present investigation's, underscoring the efficacy of positively valenced imagery in the downregulation of subjective fear. Future research evaluating safety cues and nature scenes within an emotion regulation context could inform the validity of these speculations.

Although no significant difference in self-reported fear was observed between Distract Positive CS+ and Distract Neutral CS+ conditions, the downregulation of self-reported fear in only positively valenced distraction provides partial support for the hypothesized increased efficacy of positively valenced distraction relative to neutral imagery. Speculatively, the additional regulatory benefits of positively valenced imagery may reflect the recruitment of additional inhibitory pathways in the brain. Whereas both forms of attentional distraction would recruit goal-directed attentional networks in the downregulation of threat (e.g., tempoparietal junction; Kim & Hopfinger, 2010), positively valenced distractors may concurrently recruit value modulation regions of the brain (e.g., vmPFC; Winecoff et al., 2013), which have been shown to downregulate areas associated with the threat response in both the fear extinction (Phelps et al., 2004) and emotion regulation literatures (Delgado et al., 2008; Hermann et al., 2017). Additionally, the positively valenced distractor may have benefited from biased competition favouring the attentional selection of emotional stimuli (Straub et al., 2020), thus more effectively inhibiting the early visual processing of the threat cue.

Regarding the SCR findings, a main effect of Attention suggested that both distract conditions showed elevated SCRs relative to the Attend conditions regardless of CS Type. Though unexpected, these findings are in line with previous fear conditioning and mental imagery research finding a general elevation of SCRs during a mental imagery task (Burleigh et al., 2022; Lyons et al., 2024). The observed elevation of SCRs when distracting from versus passively viewing the affectively neutral CS- image suggest that this elevation in SCRs may reflect a confounding effect of cognitive demand induced by the imagery task. Although little research has investigated how mental imagery tasks may influence SCRs, extant literature has suggested that electrodermal activity may increase with cognitive demand independently of changes in affective states (Ayres et al., 2021; Nourbakhsh et al., 2017). Moreover, past emotion regulation research has measured self-reported cognitive demand and its psychophysiological correlates (Strauss et al., 2016; Urry et al., 2006), commonly associating emotion regulation with greater cognitive load relative to passive viewing. However, the observed Attention x Time interaction suggests that this elevation of SCRs in the distract conditions was most pronounced in the First Half of the Emotion Regulation phase, perhaps reflecting practice effects where the emotion regulation manipulation became less demanding upon repetition.

Evaluating the downregulation of autonomic threat responding via imagined distraction, SCR results revealed a critical CS Type x Attention interaction, such that differential fear was observed only when attending to the CS images. That is, when presented a relevant threat cue, both positively valenced and neutral distracting imagery had downregulated differential threat responding. Importantly, these results are consistent with both Delgado et al. (2008) and Greening et al. (2022), supporting imagined distraction in the downregulation of differential threat responding. However, inconsistent with previous research, no significant downregulation in the distract CS+ versus Attend CS+ comparisons was found. Although speculatively confounded by the effects of cognitive demand discussed above, this comparison is commonplace in the emotion regulation literature (e.g., Winecoff et al., 2013; Hermann et al., 2017). The primacy of this comparison appears to underlie the fact that most emotion regulation research has used aversive images as the emotion elicitor, which fails to provide a representative baseline score, as opposed to the present investigation's use of a differential fear conditioning paradigm and the baseline response it is afforded by the distract CS- condition. Therefore, it remains unclear how consistent the present investigation's SCR findings are with the greater emotion regulation literature. More broadly, these results are consistent with the biased competition model of attention (Desimone & Duncan, 1995) while highlighting the regulatory effects of goal-directed attention. Moreover, converging evidence suggesting the efficacy of both visually presented and imagined distractors in the downregulation of fear furthers the depictive theory of mental imagery (Pearson et al., 2015), suggesting converging mechanisms between true bottom-up perception and top-down generated sensory experiences such as visual mental imagery.

One peculiarity in the present investigation is the disaccord between the self-reported fear and SCR findings regarding neutral imagery in the downregulation of a learned fear response. This observed difference in downregulation efficacy across self-report and SCR dependent variables may implicate the dual-process framework, which posits a dissociation between the related, yet distinct constructs of conscious feelings of fear as measured through self-report and the autonomic threat response measured through psychophysiology (LeDoux, 2014; LeDoux & Hofmann, 2018). Past research has reported similar divergences when investigating both self-reported fear and SCRs in fear conditioning, for example finding differences between conscious and autonomic measures of fear in the extinction (Jiang & Greening, 2021) and generalization (Lyons et al., 2024) of a learned fear response. Functional neuroimaging studies have furthered this distinction, finding that although brain activity predicting self-reported fear and SCRs were largely overlapping, distinctions were evident, such as improved prediction of SCRs by bilateral anterior insula and amygdala activity and enhanced prediction of self-reported fear by activity in higher-order prefrontal areas (e.g., dorsomedial prefrontal cortex; Taschereau-Dumouchel et al., 2020). Although translational neuroscience has enjoyed relative success in an experimental setting, these findings highlight the importance of considering conscious feelings of fear when evaluating emotion regulation and its clinical applications, given the centrality of subjective feelings of distress across transdiagnostic psychopathology (Dalgleish et al., 2020).

Although significant, the present investigation is not without its limitations. Principally, the present methodology was unable to address the issue of cognitive demand in imagined distraction.

Previous research investigating emotion regulation (Strauss et al., 2016) and mental imagery in associative learning (Burleigh & Greening, 2023) have explicitly queried the potential effects of cognitive demand. As past research has implicated the availability of cognitive resources in emotion regulation choice (Sheppes et al., 2014; Urry & Gross, 2010), furthering our understanding of cognitive demand in imagined distraction may uncover the feasibility and subsequent clinical utility of this novel emotion regulation strategy. Similarly, the present investigation's Habituation phase would have benefited from the inclusion of more trials and the alteration of trial structure (i.e., longer intertrial intervals) to promote the feasibility of SCR analyses. These alterations would have allowed for further exploration into the effects of the mental imagery task independent of the emotion regulation manipulation and address current unknowns in the literature, such as autonomic reactivity to imagining neutral versus positively valenced stimuli. Additionally, although the present investigation focused on the efficacy of imagined distraction in the downregulation of differential fear, no existing research has directly compared the efficacies and underlying neural mechanisms of distraction when employing a visually presented versus imagined distractor. Whereas the depictive theory of mental imagery would posit that they converge on similar underlying pathways (Dijkstra et al., 2019), this conclusion in an emotion regulation context remains largely speculative. The inclusion of functional neuroimaging techniques would also allow for the evaluation of potential divergences in the neural mechanisms underlying neutral versus positively valenced imagined distraction. Such methodologies would address various remaining unknowns, such as the potential additional recruitment of valence modulation areas in positively valenced distraction and the extent to which positively valenced face images can modulate visual processing of the CS+ in early visual cortices, as shown by Greening et al. (2022) using imagery of the CS-.

Finally, these findings hold notable clinical relevance. As emotion dysregulation is ubiquitous in transdiagnostic psychopathology (Bradley et al., 2011; Gross & Jazaieri, 2014), the development of a novel, effective, and relatively ecologically valid emotion regulation strategy encourages further investigation. However, as the present investigation excluded those who reported having previously sought psychological services, positively valenced imagined distraction should first be replicated in a clinical sample. Although self-reported depressive and anxious symptomology failed to predict distraction efficacy, thus suggesting that positively valenced imagined distraction may be similarly effective in a clinical sample, the use of a non-clinical sample ignores the possibility that group differences in psychopathology symptomology may influence the efficacy of imagined distraction in the downregulation of a learned fear response. Research underscoring a dearth of positive imagery in those living with major depressive disorder (Holmes et al., 2016) and literature using fear conditioning as a model for altered fear learning in posttraumatic stress disorder (Garfinkel et al., 2014; Norrholm & Jovanovic, 2018) suggest that these two populations may especially benefit from further investigation. Crucially, further research into how positively valenced imagery may be leveraged in established clinical interventions which employ mental imagery such as imagery rescripting, positive imagery mood induction, and prolonged exposure (Dibbets et al., 2012; Ji et al., 2017; McLean et al., 2022; Pictet et al., 2011) promise to expand our understanding of how to best support those struggling with emotion dysregulation.

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## Appendices

### Appendix A: Demographics Questionnaire

1. How old are you? ______
2. What is your gender?
    a. Female
    b. Male
    c. Transgender/Gender Non-Conforming
    d. Other
    e. Prefer not to answer
3. Which is your dominant hand (i.e., the hand you do most activities with, such as writing)?
    a. Right hand
    b. Left hand
4. Have you ever been diagnosed with a psychological condition? (e.g., Major Depression, Bipolar, Generalized Anxiety, Social Phobia, Specific Phobia, Obsessive-Compulsive Disorder)
    a. Yes
    b. No
    c. Prefer not to answer
5. If you answered "yes" to Question 4, please specify which from the options below:
    a. Mood Disorders (e.g., Major Depression, Bipolar Disorder)
    b. Anxiety Disorders (e.g., Social Phobia, Generalized Anxiety, Specific Phobia, Panic Disorder, Obsessive Compulsive Disorder)
    c. Trauma- and Stressor-Related Disorders (e.g., Post-Traumatic Stress Disorder)
    d. Attention-Deficit/Hyperactivity Disorder (e.g., ADHD, ADD)
    e. Personality Disorders (e.g., Borderline Personality, Antisocial Personality)
    f. Schizophrenia Spectrum and other Psychotic Disorders
    g. Autism Spectrum Disorder
    h. Other
    i. Prefer not to answer
6. Have you ever seen a mental health professional (e.g., psychiatrist, psychologist, counsellor) for problems with your emotions, nerves, or use of alcohol or drugs:
    a. Yes, in the past year
    b. Yes, over a year ago
    c. No
    d. I do not know
    e. Prefer to not answer
7. If you answered "Yes, over a year ago" to question 6, how long ago:
    (Open-ended answer)

**Appendix B: Vividness of Visual Imagery Questionnaire**

There are four parts, each contain four questions. For each question, read the situation carefully and then take a moment to close your eyes and think about it. Then select the answer that is the nearest description to your mental image.

Part 1: For items 1-4, think of some relative or friend whom you frequently see (but who is not with you at present) and carefully consider the picture that comes before your mind's eye.

1) The exact contour of face, head, shoulders, and body
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

2) Characteristic poses of head, attitudes of body, etc.
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

3) The precise carriage, length of step, etc. in walking
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

4) The different colors worn in some familiar clothes
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

Part 2: For items 5-8, visualize a rising sun. Carefully consider the picture that comes before your mind's eye.

5) The sun is rising above the horizon into a hazy sky
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

6) The sky clears and surrounds the sun with blueness
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

7) Clouds. A storm blows up, with flashes of lightning
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

8) A rainbow appears
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

Part 3: For items 9-12, think of a shop which you often go to. Consider the picture that comes before your mind's eye.

9) The overall appearance of the shop from the other side of the road.
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

10) A window display including colors, shapes, and details of individual items for sale.
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

11) You are near the entrance. The color, shape, and details of the door.
    1. No image at all, you only 'know' that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

12) You enter the shop and go to the counter. The counter assistant serves you.
    1. No image at all, you only ‘know’ that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

For items 13-16 think of a country scene which involves trees, mountains, and a lake. Consider the picture that comes before your mind’s eye.

13) The contours of the landscape
    1. No image at all, you only ‘know’ that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

14) The color and shape of the trees
    1. No image at all, you only ‘know’ that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

15) The color and shape of the lake
    1. No image at all, you only ‘know’ that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

16) A strong wind blows on the trees and on the lake causing waves
    1. No image at all, you only ‘know’ that you are thinking of the object
    2. Vague and dim
    3. Moderately clear and vivid
    4. Clear and reasonably vivid
    5. Perfectly clear and as vivid as normal vision

**Appendix C: Attention Control Scale**

Here are some different ways that people can feel about working and concentrating. Please indicate how strongly each statement applies to you.

1 = Almost never
2 = Sometimes
3 = Often
4 = Always

| | |
|---|---|
| 1. It's very hard for me to concentrate on a difficult task when there are noises around. | 1 2 3 4 |
| 2. When I need to concentrate and solve a problem, I have trouble focusing my attention. | 1 2 3 4 |
| 3. When I am working hard on something, I still get distracted by events around me. | 1 2 3 4 |
| 4. My concentration is good even if there is music in the room around me. | 1 2 3 4 |
| 5. When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me. | 1 2 3 4 |
| 6. When I am reading or studying, I am easily distracted if there are people talking in the same room. | 1 2 3 4 |
| 7. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts. | 1 2 3 4 |
| 8. I have a hard time concentrating when I'm excited about something. | 1 2 3 4 |
| 9. When concentrating I ignore feelings of hunger or thirst. | 1 2 3 4 |
| 10. I can quickly switch from one task to another. | 1 2 3 4 |
| 11. It takes me a while to get really involved in a new task. | 1 2 3 4 |
| 12. It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures. | 1 2 3 4 |
| 13. I can become interested in a new topic very quickly when I need to. | 1 2 3 4 |

| | |
|---|---|
| 14. It is easy for me to read or write while I'm also talking on the phone. | 1 2 3 4 |
| 15. I have trouble carrying on two conversations at once. | 1 2 3 4 |
| 16. I have a hard time coming up with new ideas quickly | 1 2 3 4 |
| 17. After being interrupted or distracted, I can easily shift my attention back to what I was doing before. | 1 2 3 4 |
| 18. When a distracting thought comes to mind, it is easy for me to shift my attention away from it. | 1 2 3 4 |
| 19. It is easy for me to alternate between two different tasks. | 1 2 3 4 |
| 20. It is hard for me to break from one way of thinking about something and look at it from another point of view. | 1 2 3 4 |

**Appendix D: Center of Epidemiological Studies – Depression**

INSTRUCTIONS FOR QUESTIONS: Below is a list of the ways you might have felt or behaved. Please indicate how often you have felt this way during the past week by circling the number at the end of each statement corresponding to the four numbered statements listed between the lines below.

<u>During the past week:</u>

0. Rarely or none of the time (less than 1 day)
1. Some or a little of the time (1-2 days)
2. Occasionally or a moderate amount of the time (3-4 days)
3. Most or all of the time (5-7 days)

1. I was bothered by things that don't usually bother me.
2. I did not feel like eating; my appetite was poor.
3. I felt that I could not shake off the blues even with help from my family or friends.
4. I felt that I was just as good as other people.
5. I had trouble keeping my mind on what I was doing.
6. I felt depressed.
7. I felt that everything I did was an effort.
8. I felt hopeful about the future.
9. I thought my life had been a failure.
10. I felt fearful.
11. My sleep was restless.
12. I was happy.
13. I talked less than usual.
14. I felt lonely.
15. People were unfriendly.
16. I enjoyed my life.
17. I had crying spells.
18. I felt sad.
19. I felt that people dislike me.
20. I could not get "going".

## Appendix E: Center of Epidemiological Studies – Anxiety Scale

### A. Over the last six months:

0 = No, never
1 = Yes, but never enough to change what I was planning or doing
2 = Yes, and sometimes I avoided the situation
3 = Yes, and I avoided the situation almost all the time

1. Were you afraid of being in a crowd or standing in line?
2. Were you afraid of going outside?
3. Were you afraid of being alone?
4. Were you afraid of speaking in public?
5. Were you afraid of being with people, even friends?
6. Were you afraid of seeing blood or getting shot?
7. Were you afraid of seeing a doctor or dentist?

### B. When you were in these situations, did you…

0 = No, Never
1 = Yes, sometimes
2 = Yes, often
3 = Yes, almost every time

8. Get sweaty?
9. Feel your heart pound?
10. Get short of breath?
11. Feel dizzy or like fainting?
12. Tremble?
13. Feel pain in your chest?
14. Feel like you might die?
15. Feel like throwing up?
16. Feel like you were choking?
17. Feel like you were smothering?
18. Feel like everything was unreal?
19. Feel tingling in your hands or feet?

C. **20. Did these feelings ever happen suddenly—say, over 5-10 minutes—with no clear explanation—that is, even you were not in one of the situations above?**

0 = No, Never
1 = Once or twice
2 = Three times or more
3 = Many times

**Appendix F: Consent Form**

**Consent Form**

Project Title: Emotion Regulation and Mental Imagery

Investigators and contact information:
Principal Investigator: McKenzie Andries, Masters Student, Dept. of Psychology, University of Manitoba, email:
Advisor: Steven Greening, Ph.D., Associate Professor, Dept. of Psychology, University of Manitoba, email:
General Lab email:

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

1. The overall purpose of this research project is to better understand the interaction between our imaginations and our emotions. Specifically, this project aims to understand how imagined distraction can regulate an emotional response when presented with a potential threat.

2. All undergraduate students from the University of Manitoba who are in the department of psychology, between the ages 18 to 65, are without any neurological conditions (e.g. stroke, dementia), significant head trauma, alcohol or drug dependence, pace maker or pregnancy are eligible to participate. **However,** neurological conditions (e.g., stroke, dementia), psychological conditions (e.g., major depression, schizophrenia), significant head trauma, alcohol or drug dependence, pacemaker, pregnancy, or having sought psychological services for one's mental health in the past are criteria that would make an individual ineligible to participate. Furthermore, in the event of not finding any pain threshold for a participant, even after reaching the highest safe intensity, the participant will be excluded from the experiment.

Study Procedures: You will be asked to complete a series of computerized tasks where you will see or imagine either a building or a face, along with other stimuli meant to evoke an emotional or emotion-related response. You will also be asked to respond via button press. The emotional stimulus will be mild electrical stimulation, which is described below. You may also be asked to react, think about, or rate your feelings towards these stimuli at various times throughout the experiment. This experiment will take 90 minutes.

Session Site: This experiment will take place in Room D or F, Department of Psychology P234 Duff Roblin Bldg, 190 Dysart Rd University of Manitoba, Winnipeg, MB R3T 2N2

3. Several different types of data, data recording devices and research equipment will be used throughout the experiment. Each is described below.

Mild electrical stimulation: You will be asked to wear a device attached to the fingertips of the ring and pinky fingers of your non-dominant hand or your non-dominant forearm/wrist that gives you mild electrical stimulation (i.e., mild electrical shocks). The purpose of these shocks is to understand how your brain processes the anticipation of discomfort. These electrical shocks are carefully controlled so that they make you feel uncomfortable but not in pain. The device is also designed so that the electricity does not cross your body. Before we begin the experiment, we will adjust the settings on the device so that it makes you feel unpleasant but not painful'. To determine the stimulation level, we will set the current control of the stimulator (e.g., range of 0.01 mA to 50.0 mA with 12 steps) to the lowest possible setting. Then, we will increase the stimulation level by a single increment (e.g., one click clockwise") until the unpleasant-but-not-painful level has been attained. If more precise control of the intensity is needed, we can also adjust the percentage of a given intensity (e.g., 90% of 10.0 mA). Throughout the experiment the intensity of the stimulation will be maintained at a level that is unpleasant-but-not-painful. **However, IF you experience undue discomfort, wish to terminate the study, or want to decrease the level of stimulation, you may do so AT ANY TIME.**

Self-report Questionnaires: You will be asked to complete a small test battery of self-report questionnaires at the beginning of the study. Specifically, we will ask that you complete the following: A basic demographic information questionnaire, the Vividness of Visual Imagery Questionnaire, the Center for Epidemiologic Studies-Anxiety Scale, the Center for Epidemiologic Studies-Depression Scale, and the Attention Control Scale. Your responses will be de-identified and kept confidential.

Physiological measurements: You will be asked to provide non-invasive physiological measurements including, pulse rate, sweat response, and pupil eye-tracking. Although the equipment being used is reliable, it is not valid for medical diagnoses, nor are the researchers' trained diagnosticians; therefore, you cannot be diagnosed or informed of any abnormal readings. To measure your pulse rate, we will use photoplethysmography (PPG) using a Bionomadix PPG probe that is gently secured to your thumb using Velcro. To measure your sweat we will record your electrodermal activity (EDA) using electrodes connected to your index finger and middle finger. The Bionomadix transmitter will also be attached to your wrist, which is a small device that wireless sends the physiological information to our BIOPAC recording device. You will also be asked to stabilize your head (placing it on a chinrest) to help facilitate the recording of your eye movements and pupil dilation using a BIOPAC remote screen-based eye tracking bar. After setting up all the equipment, we will begin the experiment.

4. Benefits: There is no direct benefit from participating in this study. Your participation will help researchers find out more information about interactions between how we think and our emotions.

5. Risks: No foreseen psychological or physical discomfort is anticipated beyond that encountered in everyday life. In some parts of the experiment, you may be exposed to mild electrical stimulation (i.e., mild shock). The intensity will be set to a level that is 'unpleasant but not painful' as described above. Your physiological responses will also be measured using recording equipment. In rare cases, the gels and stickers used for these measurements (placed on your fingers) can cause skin irritation.

To minimize risk of the electrical stimulation, the threshold for each individual will be set to the level of 'unpleasant but not painful'. The BIOPAC STIMISOC module that is used for mild electrical stimulation meets the international safety specification IEC 60601-2-10: 2015 pertaining to maximum allowable electrical stimulation voltages or currents. The unit output is physically limited to a maximum of 160 mJ (milli-Joules) using isolation transformers, which is a value well below the standard's maximum allowable energy output of 300 mJ. This means that the highest output voltage possible is 200V, under 500-ohm load conditions, and the maximum pulse width is 2 milliseconds, though multiple pulses will be used for longer stimulation times. The usage protocol will dictate that both electrodes will ALWAYS be placed on the same hand (e.g., ring and pinky finger) or on the same wrist adjacent to each other. This keeps the current away from the heart, and avoids any cross-body current (i.e., current passing from left to right past the heart). Investigators will be vigilant to signs of anxiety and terminate studies if undue levels of stress are observed. Investigators will maintain communication with you at regular intervals throughout the experiment (approximately every 4-10 min).

6. Privacy: All information obtained in this study will be kept confidential. Any information that is obtained in this study, will be identified only by an identification number, not your name. When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity. Any identifying information will remain confidential and will only be disclosed with your permission or as required by law. Only members of the research team will have access to the records pairing your identification number with your identifiable information, such as your name or contact information. This information will be kept for approximately three years following your participation in the study and will be stored in a location separated from study data. Electronic data will be entered without identifying information and be stored on password protected computers/servers in a locked room. All confidential information will be destroyed by 09/2026.

Results of this research may be presented for only scientific purposes (e.g., student thesis in MSpace, journal articles, and presentations) in which none of your identity or personal information will be revealed.

The study data (your responses to questionnaires) will be stored indefinitely. Your permission to use the data in future research studies will not be obtained, since the data will not contain any identifiers. Data from this project may be shared with other researchers or made publicly available for scientists to use in future work. If data is shared, it will be shared with your encrypted study identification number and not with any of your personal information. By participating in this study, you agree to allow the researchers to use the data for future, as yet unknown research studies. The consent form will be destroyed three years after this research study has been completed.

Should you withdraw from the study prior to completing the full experiment, your data will be deleted and will not be included in the study. Should you wish to withdraw after completing the full experiment, you will have until April 2024 to notify the research team of your wish to withdraw (see point 8). If so, we will delete your data. Otherwise, your data will be retained. Please note that you will still receive compensation should you wish to withdraw.

7. If you are participating in a study for course credit, you will receive credit per the study advertisement and the Psychology Subject pool (SONA) rules and regulations. Specifically, you will receive 1 credit for each half-hour of participation and three credits for completion of the in-person study. Therefore, you will receive 3 credits for participation.

8. Right to Refuse/Withdrawal: Participation in this study is voluntary. You may withdraw from this study at any time without penalty. Should you wish to not be contacted in the future regarding research opportunities in the lab you can email us at any of the emails provided in the contact information section. Should you wish to withdraw, the experimenter will immediately stop the experiment and remove the physiological equipment from you. Should you ask to withdraw after you have completed the study, you have until 04/24 to withdraw from the study. After this date, the nature of the data analysis will make it impossible for you to withdraw. Should you only want to withdraw from

consideration in future studies, we will retain your data for the present study but note in the coded spreadsheet that you do not wish to be contacted for future studies. In all cases, you may contact the principal investigator (andriesm@myumanitoba.ca) to withdraw. Please note that you will still receive compensation should you wish to withdraw.

9. At the end of the experiment, you will be presented with a short debriefing containing details of the experiment. You can always contact investigators if you wish to receive a non-technical summary of results or if you have any further questions.

10. Results of this research may be presented in student theses, journal articles, presentations, and posters. When the results of the research are published or discussed, no information will be included that would reveal your identity.

11. You are entitled to receiving a brief, non-technical summary of results. Should you wish to receive this, please email the Principal Investigator briefly noting that you would like to receive this summary. The approximate date for receiving the results would be 09/2024.

12. The behavioral data (your responses to questionnaires and computerized tasks) will be stored indefinitely. By participating in this study, you agree to allow the researchers to use the data for future, yet unknown research studies. The consent form will be destroyed three years after this research study has been completed.

**Digital Signature: Clicking the button below will stand-in as your digital signature. Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.**

**The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way. This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact any of the above-named persons or the Human Ethics Officer at 204-474- 7122 or HumanEthics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.**