The Effects of Mindfulness-Based Training on Fear Conditioning

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Abstract

The present study examined whether mindfulness training influences fear-learning processes beyond general therapeutic effects. A six-week Workplace Mindfulness Training (WMT) program was compared with an active control condition, the Health Enhancement Program (HEP), using a classical fear-conditioning paradigm in a non-clinical university sample. Physiological and self-report measures were used to assess fear acquisition, avoidance, and extinction learning. Skin conductance response (SCR) was used as a measure of physiological fear response, while self-reported avoidance and expectancy ratings of the aversive stimulus captured subjective and behavioral aspects of fear learning. Baseline anxiety and experiential avoidance were examined as potential moderators of training effects and fear conditioning. Results confirmed successful fear acquisition and avoidance learning, indicated by higher SCR, expectancy, and avoidance responses to the conditioned stimulus compared to the safety cue. However, the main analyses found no significant group differences in avoidance behavior or extinction learning operationalized by SCR and self-reported ratings. Neither baseline anxiety nor experiential avoidance moderated the effects of program type on fear learning outcomes. However, a significant four-way interaction involving SCR, stimulus type, time, and training condition emerged. Overall, the findings suggested that mindfulness training did not bring significantly different results compared to an active control. Future research is advised to expand on the topic of mindfulness and fear-conditioning further, including a wider sample, population comparisons, and alternative operationalizations of the moderators like anxiety.

Mindfulness was defined by Jon Kabat-Zinn, the founder of Mindfulness-Based Stress Reduction (MBSR), as a state of non-judgmental awareness, cultivated through intentional attention to the present moment with openness and curiosity (Kabat-Zinn, 1994). Mindfulness researcher Mark Williams emphasized the immediacy of this non-judgmental awareness, describing it as an ongoing connection to both internal and external experiences unfolding in the present time (Williams & Penman, 2011). In practice, mindfulness is typically practiced and cultivated through various forms of formal meditation, including sitting meditation, mindful walking, and mindful movement (Hölzel et al., 2011). Previous research has suggested that mindfulness enhances attentional skills (Crescentini et al., 2016), alleviates anxiety and depression (Yang et al., 2018), and increases overall psychological well-being (Aldbyani, 2025).

Over the years, mindfulness has been integrated into various mindfulness-based interventions (MBIs) and training programs (Aldbyani, 2025; Park et al., 2020). Among these, Mindfulness-Based Cognitive Therapy (MBCT) and MBSR were the most widely implemented. Both were structured programs designed to enhance self-regulation and reduce stress; however, MBCT placed greater emphasis on cognitive therapy techniques and psychoeducation, particularly concerning the relationship between thoughts, emotions, and behavior (Taub et al., 2024; Park et al., 2020). Mindfulness training has been increasingly adopted to help manage stress and improve mental well-being in both clinical and non-clinical populations (Kersemaekers et al., 2018). From these interventions, variations have emerged, including Workplace Mindfulness Training (WMT), developed by Marina Grazier and Juliet Adams, which specifically adapted the MBCT model for the workplace (Kersemaekers et al., 2018). WMT is a 6-week training program with weekly sessions lasting approximately 90 minutes, including an encouragement to practice short mindfulness exercises at home (Montero-Marin et al., 2020).

Focusing on typical mindfulness practices, such as body scans and meditation, WMT applies these practices in occupational settings to alleviate burnout symptoms and reduce workers' stress (Lomas et al., 2017). Hülsheger et al. (2012) investigated the role of mindfulness in occupational settings and found that higher mindfulness levels were associated with reduced emotional exhaustion, a key indicator of burnout. Studies specifically focusing on WMT have found that participants reported lower perceived stress, improved stress coping, increased mindfulness, and better well-being when comparing pre- and post-intervention reports, as well as when comparing results with those of control groups receiving general psychoeducation (Kersemaekers et al., 2018; Montero-Marin et al., 2020). Even though mindfulness-based programs (MBPs) have been increasingly studied and implemented in recent years, demonstrating effectiveness for a wide range of health outcomes and populations (Montero-Marin et al., 2020), research attempting to apply WMT in specific settings, such as among student populations, is still relatively scarce and highlights the need for continued exploration.

While evidence for the effectiveness of MBPs continues to grow, the question remains whether observed benefits can be attributed solely to mindfulness-specific mechanisms or to general therapeutic factors. With this goal, the Health Enhancement Program (HEP) was developed and subsequently validated as a structurally equal active control for mindfulness interventions, utilizing common therapeutic elements while excluding the unique mindfulness component (MacCoon et al., 2011). Delivered over 8 weekly sessions, it includes four core pillars: music therapy, functional movement, nutrition education, and physical activity (MacCoon et al., 2011). The validation study revealed that participants assigned to HEP showed improvements in mental and medical symptoms comparable to those undergoing MBSR (MacCoon et al., 2011). Valid active controls may therefore also lead to meaningful change in well-being without the need to include the mindfulness component. The present study employed HEP as an active control to explore whether mindfulness training had significant effects beyond general intervention-related benefits.

The current paper aimed to move beyond general comparisons of training programs and examine whether mindfulness could affect certain psychological and behavioral processes more strongly. One area that has received substantial attention in mindfulness research has been anxiety (Khoury et al., 2013; Malik & Perveen, 2021; Yang et al., 2018). Anxiety is defined as an anticipation of a perceived future threat, characterized mainly by vague and uncertain feelings that often intensify under prolonged or unresolved stress (Malik & Perveen, 2021). Given that mindfulness emphasizes a non-judgmental awareness of experience, individuals practicing mindfulness may develop greater emotional awareness and an improved capacity to regulate anxious states (Reangsing et al., 2023), making mindfulness-based approaches particularly valuable in anxiety-related contexts. Closely related to anxiety is fear, which has also been explored extensively within mindfulness research. Whereas anxiety refers to a future-oriented state of apprehension, fear is typically conceptualized as an immediate response to a present and identifiable threat (Daniel-Watanabe & Fletcher, 2021). Yang et al. (2018) hypothesized that the acceptance and curiosity cultivated in mindfulness practice may help individuals respond differently to both anxiety and fear, enhancing distress tolerance and reducing avoidance-driven behaviors. This observed shift was hypothesized to occur through deliberate exposure to unpleasant emotional states, such as fear, during which mindfulness practitioners learn to observe rather than suppress their internal experiences, thereby resisting the urge to engage in safety behaviors like avoidance (Hölzel et al., 2011).

Given mindfulness's role in enhancing emotional awareness and reducing reactivity, it may also influence maladaptive coping processes in response to various unpleasant experiences. For instance, emerging evidence suggests that mindfulness may shape pain and fear responses in experimental contexts. Research on pain catastrophizing, a tendency to interpret pain experiences with exaggerated negative affect, has found that dispositional mindfulness was associated with reduced pain sensitivity and intensity and uniquely predicted lower pain catastrophizing (Schütze et al., 2009). Catastrophizing has also been linked to avoidance and safety behaviors (Vlaeyen & Linton, 2000). Mindfulness may interrupt maladaptive fear-related cycles by promoting greater tolerance of distressing experiences. Hölzel et al. (2011) proposed that mindfulness-induced physiological relaxation created a calmer internal state, enabling individuals to face aversive stimuli without triggering automatic defensive responses. One type of defensive response, fear avoidance, involves evading perceived threats and plays a central role in anxiety and stress-related disorders (Leeuw et al., 2006; Wong & Pittig, 2020). Because avoidance limits exposure to feared stimuli, it is believed to disrupt corrective learning processes (Wong & Pittig, 2020). The current study, therefore, aimed to examine whether mindfulness training could influence fear learning and avoidance responses.

Fear learning is commonly investigated using classical conditioning paradigms, in which an initially neutral stimulus (conditioned stimulus; CS+), such as a specific color, is repeatedly paired with an aversive unconditioned stimulus (US), for example, a loud noise or an electric shock (Wong & Pittig, 2020). A second neutral stimulus (CS-) is never followed by negative consequences. Across repeated trials, the CS+ begins to elicit a conditioned response (CR), such as heightened fear or threat anticipation. This process, referred to as fear acquisition (Stage 1), reflects the formation of an associative link between the CS+ and the US (Wong & Pittig, 2020).

During acquisition, associative learning has been observed across physiological and cognitive responses, including autonomic reactivity and threat expectancy (Constantinou et al., 2020).

Following the acquisition, some studies incorporate a fear-avoidance stage (Stage 2), during which participants can avoid the CS+ and its negative outcome (Delgado, 2009). Whereas acquisition reflects learning of the CS+- US association, avoidance reflects learned instrumental behavior aimed at minimizing contact with the conditioned threat cue. Experimental studies have modeled this by allowing participants to learn avoidance responses that prevent aversive outcomes (Delgado, 2009) and to avoid the CS+ even at the cost of missing rewards (Boschet et al., 2022). Excessive avoidance can maintain fear by preventing exposure to corrective experiences that signal safety and by limiting opportunities to learn new, non-threatening associations (Beckers et al., 2023).

The third stage is the extinction learning phase (Stage 3), during which the CS+ is repeatedly presented without the US, resulting in a gradual reduction of conditioned fear response (Lovibond et al., 2009). Rather than erasing the original memory, extinction is understood as the formation of a new memory that competes with the original or as the update of the original association through new contextual information (Kummar et al., 2019). Prior literature suggests that mindfulness may support extinction learning by promoting sustained attention and present-moment awareness toward feared stimuli, rather than habitual avoidance (Treanor, 2011). Non-judgmental observation was hypothesized to facilitate the processing of new safety information, weaken threat associations, and foster more adaptive responses (Hölzel et al., 2011). Consistent with this view, mindfulness meditation experience has been linked to improved attentional control (Chambers et al., 2007; Treanor, 2011) and reduced pain sensitivity as well as altered responses during fear-conditioning tasks (Taylor et al., 2018), suggesting that mindfulness may influence how individuals respond to aversive cues across fear learning.

Fear-conditioning experiments commonly use physiological measures to assess conditioned fear responses across learning stages. One such measure is skin conductance (SC), widely used in conditioning paradigms (Lissek et al., 2005). SC reflects changes in sweat gland activity by measuring the skin's electrical conductance, typically recorded using electrodes placed on the fingers or palm (Schiller & Delgado, 2010; Wickramasuriya & Faghih, 2020). In fear-conditioning, the skin conductance response (SCR) typically increases with repeated CS presentations, reflecting sympathetic activation and the fight-or-flight response (Wickramasuriya & Faghih, 2020). Individuals with higher state mindfulness show reduced sympathetic activation, measured by lower SCR, and greater reductions in stress-related arousal (Scavone et al., 2020). Hölzel et al. (2016) found that mindfulness-trained participants maintained distinct SCRs to conditioned versus unconditioned stimuli, whereas this distinction diminished in controls, indicative of improved emotional discrimination. The ability to differentiate threat (CS+) from safety (CS-) cues is central to adaptive fear learning, as impaired discrimination and heightened conditioned responses have been linked to anxiety and fear generalization (Lissek et al., 2005). Mindfulness may support the regulation of physiological arousal and extinction learning by promoting more context-sensitive threat appraisal (Constantinou et al., 2020; Taylor et al., 2018).

While SCR offers valuable insight into physiological responding, particularly the fear acquisition and extinction phases (Delgado, 2009; Krypotos, 2015), avoidance and threat expectancy are typically assessed using self-report measures. Because the present study aimed to examine fear learning across multiple stages and outcomes, both physiological and self-report measures were included. Oftentimes, self-reports utilize dichotomous measures to capture avoidance (e.g., yes/no), but Wong and Pittig (2021) introduced a continuous avoidance measure using a visual analog scale (VAS) ranging from 0% (no avoidance) to 100% (complete avoidance). The present study similarly employed a continuous avoidance measure to assess safety behavior following acquisition, alongside a continuous measure of US expectancy to capture subjective threat expectations across trials. Together, these measures provided a more comprehensive assessment of fear learning across stages.

In addition to examining the effects of training on fear learning, the present study investigated whether individual characteristics, particularly trait anxiety, influenced responses across fear-conditioning stages. Given the complexity of fear learning, increasing attention has been paid to factors that may account for variability in fear avoidance and extinction. Although mindfulness has been associated with reduced emotional reactivity (Britton et al., 2011), individual differences have also been emphasized as important influences on its effectiveness (Gu et al., 2015). Anxiety, traditionally studied as an outcome of mindfulness interventions (Hofmann et al., 2010; Khoury et al., 2013), has been shown to impact fear learning and generalization (Dunsmoor & Paz, 2015). Individuals high in trait anxiety exhibited increased neural hypersensitivity during fear extinction (Sehlmeyer et al., 2010) and poorer discrimination between threat and safety cues during conditioning (Dibbets & Evers, 2017), suggesting altered associative learning. Trait anxiety has also been linked to greater avoidance responses and less specific generalization in conditioning paradigms (Klein et al., 2020). At the same time, anxiety levels may change following mindfulness training. Despite the growing evidence linking anxiety with fear learning and mindfulness with emotional regulation, relatively little research has examined these processes simultaneously within fear-conditioning paradigms, which motivated the present study to investigate anxiety both as a potential moderator of fear learning and as an outcome of training over time.

The present study also examined experiential avoidance (EA) as an additional individual-difference factor potentially influencing responses to mindfulness training and fear conditioning. EA is characterized as a tendency to suppress or avoid uncomfortable thoughts, emotions, or physical sensations (Hayes et al., 1996). Whereas mindfulness promotes present-moment awareness and discomfort acceptance, individuals high in EA may be more likely to disengage from uncomfortable experiences. Indeed, EA has been linked to heightened negative affect (Pierson et al., 2019), and some individuals may defensively devalue mindfulness practices to avoid emotional confrontation (Gilbert et al., 2023). Because mindfulness emphasizes non-reactive engagement with distressing experiences, it has been proposed to support fear extinction processes, while EA may reinforce avoidance patterns and interfere with extinction-based learning (Kummar et al., 2019). However, findings regarding the relationship between mindfulness and EA remain complex. Petrova et al. (2021) found that higher trait mindfulness was associated with reduced anxiety and sadness in response to emotional stressors, mediated by lower avoidance and greater self-distanced engagement. McCluskey et al. (2020) reported negative associations between mindfulness, EA, and anxiety, with EA partially mediating this relationship. These findings suggest that the relationship between mindfulness and EA is multifaceted and warrants further investigation.

In light of current research, the present study aimed to examine the relationship between mindfulness training and fear learning processes, including fear acquisition, avoidance, and extinction. In addition to comparing training types, the study investigated whether baseline trait anxiety and experiential avoidance influenced training-related effects. Changes in anxiety and experiential avoidance over time were also examined to assess whether training type affected individual traits and habitual behaviors.

Based on the theoretical expectations and prior research, the following hypotheses were formulated: 1) Participants in the WMT training would report significantly lower avoidance toward CS+ vs. CS- in Stage 2 compared to HEP; 2a) WMT training would show greater reductions in SCR to the CS+ compared to the CS- from early to late extinction (Stage 3), in comparison to HEP; 2b) WMT training would show greater reductions in US expectancy ratings for the CS+ vs. CS- across extinction compared to the HEP; 3a) Baseline trait anxiety would moderate the relationship between training type and Stage 2 avoidance (CS+ vs CS-), where higher anxiety would be associated with stronger reductions in avoidance in the WMT participants compared to HEP; 3b) Baseline experiential avoidance would similarly moderate the relationship between training type and Stage 2 avoidance, with higher EA predicting greater reductions in CS+ avoidance relative to CS- in the WMT compared to HEP; 4a) Baseline trait anxiety would moderate the effect of training type on extinction learning (SCR and expectancy ratings during Stage 3), such that higher anxiety would be associated with greater extinction-related reductions in CS+ vs. CS- in the WMT group compared to HEP; 4b) Baseline experiential avoidance would similarly moderate the relationship between training and extinction learning, where higher anxiety would be associated with greater extinction-related reductions in SCR and expectancy ratings in in CS+ vs. CS- in the WMT group compared to HEP; 5a) Participants in the WMT training would show greater reductions in trait anxiety across T0, T1, and T2, compared to the HEP group; 5b) WMT training would also show greater reductions in experiential avoidance across the three time points compared to HEP.

In conclusion, the current study aimed to extend prior research on mindfulness and fear conditioning by integrating physiological and self-reported measures of fear learning. Specifically, it examined whether participation in a six-week WMT program would influence avoidance behavior and extinction learning more than the HEP training condition. The study further explored the moderating roles of baseline trait anxiety and EA, two factors previously linked to mindfulness effectiveness but less frequently examined within experimental fear-conditioning. By combining a longitudinal training design with a multi-stage laboratory conditioning paradigm, the present study aimed to investigate how individual characteristics and MBP interact to shape physiological and behavioral responses to threat.

Method

Participants

The original sample consisted of 60 participants, primarily from the student population. Recruitment took place both online (e.g., social media group chats) and in person at Erasmus University and local venues in Rotterdam. The study was also advertised through the EBL Research Administration System, where psychology students could earn eight research participation credits by attending at least four mindfulness sessions, participating in both lab sessions, and completing questionnaires at three time points.

Exclusion criteria were applied to ensure participant safety and data validity. Participants were required to be 18 years old with no current cardiovascular, respiratory, or neurological conditions, as well as psychiatric diagnoses (e.g., anxiety disorders, substance use disorders, schizophrenia). Additional exclusions included pregnancy, electronic implants, medical advice to avoid stress, regular mindfulness practice (more than three times per week), recent participation in mindfulness training (within the past year), and inability to attend at least four of the six sessions. Participation in both laboratory sessions was required for inclusion in the final dataset and for full research credit. All criteria were outlined in the study sign-up form.

The sign-up form collected demographic information (gender, ethnicity, age), included general study information without detailing the training content, and incorporated informed consent. A detailed study protocol was submitted to the Ethics Committee for approval prior to data collection.

After carefully reviewing the exclusion criteria and participants' attendance at the training and lab sessions, the final sample comprised 45 participants aged 18 to 29 (M = 20.978, SD = 2.667). In total, the sample consisted of 9 males (20%), 34 females (75,6%), 1 person identifying as a trans male (2.2%), and 1 person preferred not to specify (2.2%). The HEP group consisted of 22 participants (M = 20.5, SD = 2.949), and the WMT group consisted of 23 participants (M = 21.435, SD = 2.332).

An a priori power analysis was done using G*Power (Faul et al., 2009) to estimate sample size needed to obtain a medium-sized effect with a power of .80 and α = .05. The required sample size resulted in approximately 128 participants. Given the limited timeframe available for data collection, the study proceeded with the final sample of 45 participants.

Procedure

The study consisted of two parts. The first part consisted of two 6-week training programs, while the second part included two laboratory sessions scheduled 1-3 days apart. Participants also completed three surveys throughout the study. The first survey (T0) was administered before the training began, the second (T1) immediately after the training ended, and the final survey (T2) one month after the training.

Training

Participants were randomly assigned to one of two training conditions: HEP (active control) or WMT (mindfulness intervention). A minimization schedule ensured roughly equal group sizes while accounting for participants' availability. Each training program consisted of six weekly sessions, each lasting approximately 75 minutes, with an additional approximately 15 minutes of daily homework encouraged. In total, three HEP groups and three WMT groups were delivered, with two mindfulness groups and one HEP group delivered online. One or two supervisors guided the training.

Following training, participants were re-screened for lab eligibility, and individual lab sessions were scheduled based on participant and lab availability.

Fear conditioning

The second part of the study involved a laboratory fear-conditioning experiment. All laboratory equipment, including a Biopac MP150 system (Biopac Systems, Inc., 2020) with AcqKnowledge software (Version 5) and a constant-current shock delivery device (DS7A Digitimer), was set up before the participants' arrival. Upon arrival, participants were reminded of the study's general procedures, with an emphasis on the voluntary nature of their participation and their right to withdraw at any time without consequence.

Electrodes were attached to the participants' non-dominant hand to measure SCR. After the electrodes were efficiently attached, participants underwent a shock calibration procedure. The initial pulse intensity was set to 0.2 mA and gradually increased until participants rated the shock as an 8 or 9 on a 10-point discomfort scale. This allowed for individualized tailoring of the unconditioned stimulus (US) before the experimental task.

On Day 1, participants were randomly assigned to one of two color conditions (blue or pink). The experiment consisted of four stages: fear acquisition, fear avoidance, extinction learning, and a post-extinction test. The experiment was programmed so that no single condition appeared more than twice in a row. In Stage 1 (fear acquisition), participants completed 16 trials: eight trials featured a geometric shape paired with a neutral color not followed by a shock (CS-), while the remaining eight trials featured a geometric shape paired with the assigned CS+ color (blue or pink), which was followed by a shock. Participants also rated shock expectancy before each trial. Stage 2 (fear avoidance) repeated the same 16 CS trials. Participants were asked to indicate their desire to avoid the shock using a 0%-100% avoidance scale, where higher numbers reflected a stronger wish to avoid the stimulus (e.g., 50 = a 50% chance of avoiding the shock). Expectancy ratings were not collected. In Stage 3 (extinction learning), participants completed 32 trials (16 per stimulus type) without shock delivery. Participants could still choose to avoid stimuli, and both avoidance and expectancy ratings were recorded. Stage 4 (post-extinction test) assessed retention and generalization using 12 trials (four per stimulus: CS+, CS-, and a novel stimulus), without reinforcement. Expectancy ratings were recorded throughout. The Day 1 session lasted approximately 45 minutes.

On Day 2, participants returned for a brief follow-up session beginning with shock recalibration to assess retention and generalization of fear responses over time. The session consisted of two stages. First, a spontaneous recovery (SR) test was conducted, consisting of six trials (CS+, CS-, and the novel stimulus, each presented twice) without reinforcement, to assess the return of the conditioned fear response over time. This was followed by three reinstatement shocks. Finally, a reinstatement test was conducted, also consisting of six trials without reinforcement. This session consisted of 12 trials total and lasted approximately 10 to 15 minutes. After completing the task, participants were thoroughly debriefed and thanked for their participation.

Data processing

Analyses in the current paper were restricted to Day 1 Stages 1-3, as the study's primary focus was on fear acquisition, avoidance, and extinction learning. Data from the post-extinction test (Stage 4) were excluded as they primarily assessed generalization and longer-term retention, which were beyond the aims of the present study. Avoidance behavior was analyzed exclusively during Stage 2 of the experiment, which assessed the tendency to engage in safety behaviors following fear acquisition. Although avoidance rates were also recorded during the extinction learning stage, they were not included in the present analyses, as the study's main focus was on the onset of avoidance and group comparisons rather than temporal changes across stages.

Data reduction and computation

For all analyses, physiological and self-report measures were collected to capture average responses across specific stages, stimulus types, and temporal phases within each relevant stage. Mean SCR amplitudes were calculated separately for each participant, type (CS+ and CS-), and learning stage (Stage 1 and Stage 3). To capture temporal dynamics within conditioning stages, both acquisition (Stage 1) and extinction (Stage 3) phases were further divided into early and late periods. For SCR data, early and late phases were computed by averaging the first four trials (early phase), whereas the late phase was computed by averaging the final four trials for each stimulus type.

Self-reported avoidance and US expectancy rating were processed similarly. Avoidance ratings were averaged across Stage 2 per stimulus type to reflect overall avoidance behavior. Expectancy ratings were averaged within relevant stages and stimulus types, as well as internal phases of the extinction learning stage, to examine changes in subjective threat expectancy over time.

Measures

Questionnaires

Trait anxiety at baseline (T0) was measured using the 21-item Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995). Previous studies have provided evidence for the questionnaire's content and construct validity (Lee et al., 2019; Bibi et al., 2020), as well as acceptable reliability across different cultural contexts (Bibi et al., 2020). DASS-21 has also demonstrated good internal consistency (Dwight et al., 2024). Since the DASS-21 measures three distinct psychological states, only the anxiety statements were used in subsequent analyses. This resulted in seven statements total. Example items included: “I felt I was close to panic” and “I felt scared without any good reason.” Each statement was rated on a scale ranging from 'Never' to 'Almost Always'.

Experiential avoidance was assessed using the Brief Experiential Avoidance Questionnaire (BEAQ; Gámez et al., 2013). BEAQ has shown good internal consistency (Gámez et al., 2013) and adequate to high test-retest reliability across different samples (Schaeuffele et al., 2021; Vázquez-Morejón et al., 2019). Additionally, sensitivity to change has been observed when experiential avoidance was targeted in treatment interventions (Schaeuffele et al., 2021). The BEAQ consisted of 15 items with 6 subscales from the original Multidimensional Experiential Avoidance Questionnaire (MEAQ; Gámez et al., 2011): behavioral avoidance, distress aversion, procrastination, distraction and suppression, repression and denial, and distress endurance. Each item is rated on a Likert scale ranging from ‘Strongly Disagree’ to ‘Strongly

Agree'. Example items included: "I go out of my way to avoid uncomfortable situations" and "A big goal is to be free from painful emotions."

Skin Conductance Response

SCR was recorded during the laboratory sessions on both Day 1 and Day 2 using the BIOPAC system. Electrodes were placed on the hypothenar muscle of the participant's non-dominant hand using two disposable pads. To ensure the electrodes remained securely in place throughout the experiment, tape was applied over the pads. The SCR data scale was adjusted as needed (scale: 10; midpoint: 10). Participants' initial responsivity was tested by asking participants to take a deep breath. If no increase in the SCL occurred, the electrodes were carefully removed, and new pads were reattached after cleaning the hand and rerunning the responsivity check.

Once all SCR data were collected, they were processed using BrainVision Analyzer 2.3. Data recorded via the EDA 600C channel were visually inspected for each participant to ensure data quality. Potential deviations from typical response patterns, such as steep decreases or abnormal fluctuations, were documented and reviewed with the supervisor to determine whether the data remained within acceptable limits. Where necessary, filtering (an IIR filter) was applied to reduce noise. SCRs were extracted within a predefined time window ranging from -2000ms to +10000ms relative to stimulus onset. To retain only data corresponding to experimental trials, the segmentation function was applied, resulting in 76 segments for Day 1 and 12 for Day 2, consistent with the number of trials.

During data processing, three participants were identified as having partial data missing in stages or sessions outside the scope of the present analyses, namely, Stage 4 and Day 2.

Because these data were unrelated to the current paper's hypotheses, and all relevant measures of Stages 1-3 were complete, these participants were retained in the subsequent analysis.

Electrical pulses

Electrical stimulation was administered using the DS7A Digitimer shock device. A shock electrode was placed on the participant's non-dominant arm. Before calibration, the shock intensity was initially set to 0.2 mA. During the calibration process, the shock level was gradually increased until participants rated it 8-9 out of 10 on a discomfort scale. Both the final shock intensity and the participant's self-reported discomfort rating were recorded.

Behavioral avoidance measures

Behavioral avoidance was assessed during the fear avoidance and extinction learning phases of the experiment using a visual analog scale (VAS) ranging from 0% to 100%, where 0% represented 'Certainly Not Avoid' and 100% corresponded to 'Certainly Avoid'.

Expectancy measures

Expectancy ratings were also measured using VAS, allowing participants to indicate the extent (0-100) to which they expect a shock following a given stimulus.

Statistical analyses

To test hypothesis 1, a mixed repeated-measures ANOVA was conducted on Stage 2 avoidance ratings, with Stimulus (CS+, CS-) as the within-subjects factor and Group (WMT, HEP) as the between-subjects factor. For hypotheses 2a and 2b, two separate 2 x 2 x 2 mixed ANOVAs examined extinction learning during Stage 3, with Stimulus (CS+, CS-), Time (early, late extinction), and Group (WMT, HEP) as factors. SCR and expectancy ratings served as the dependent variables for hypotheses 2a and 2b, respectively. To test hypotheses 3a and 3b, two mixed ANCOVAs examined whether baseline anxiety or experiential avoidance moderated the relationship between training condition and Stage 2 avoidance responses. The same within- and between-subjects factors as in hypothesis 1 were used, with either anxiety or experiential avoidance entered as covariates. For hypotheses 4a and 4b, four mixed ANCOVAs examined moderation effects during extinction learning in Stage 3. The analyses used the same structure as in hypotheses 2a and 2b, with SCR or expectancy ratings as dependent variables and baseline anxiety or experiential avoidance as covariates. Finally, hypotheses 5a and 5b were tested using two repeated-measures ANOVAs examining longitudinal changes in experiential avoidance and anxiety across three time points (T0, T1, T2), with Group (WMT, HEP) as the between-subjects factor.

Assumptions check

Before conducting the analyses, all relevant statistical assumptions were examined for each selected test. Because several analyses shared similar designs and assumptions, the procedures were summarized together to avoid redundancy.

For paired-samples t-tests, repeated-measures ANOVAs (RM ANOVAs), mixed ANOVAs, and mixed ANCOVAs, assumptions of normality were assessed using Shapiro-Wilk tests and Q-Q plots. Visual inspection indicated approximate normality, with no severe violations detected. Outliers were inspected using boxplots; however, given the small sample size and ANOVA's robustness to mild deviations, no participants were excluded based solely on visual inspection.

For RM ANOVAs and mixed ANOVAs, Mauchly’s test indicated that the assumption of sphericity was met across all within-subject effects ($p > .05$), and standard F-values were therefore reported. Homogeneity of variances for mixed ANOVAs was assessed using Levene’s test and was satisfied across analyses ($p > .05$). For mixed ANCOVAs, the additional assumption of homogeneity of regression slopes was also met, as covariate-by-group interaction terms were non-significant. Overall, all assumption checks supported proceeding with the planned analyses.

Manipulation checks

To verify the effectiveness of the conditioning procedure, manipulation checks were conducted. These examined within-subject effects of stimulus type (CS+ vs. CS-) and changes across conditioning phases, independent of group allocation. Where applicable, early and late phases within stages were also compared to assess changes over time.

Results

Participant characteristics

General descriptive statistics for the final sample are presented in Table 1. The table included sample sizes per group and the mean age and standard deviation for each group. By ensuring randomized group allocation and personalized scheduling, roughly equal numbers of participants were assigned to each group.

Table 1

Participant characteristics

Group	*N*	Age *M* (*SD*)
WMT	23	21.435 (*2.332*)
HEP	22	20.5 (*2.949*)
Total	45	20.978 (*2.667*)

Note. *M* = mean, *SD* = standard deviation

Anxiety was assessed using the DASS-21 Anxiety subscale. Although the main analyses focused on baseline anxiety (T0), Table 2 presents mean scores across groups and time points for descriptive purposes.

Table 2

DASS-Anxiety scores across time

Time point	WMT *M* (*SD*)	HEP *M* (*SD*)	Total *M* (*SD*)
T0 (pre-training)	13.13 (*7.95*)	10.818 (*7.896*)	12 (*7.92*)
T1 (post-training)	13.478 (*8.867*)	10.182 (*7.878*)	11.867 (*8.468*)
T2 (follow-up)	13.826 (*7.837*)	11.273 (*10.999*)	12.578 (*9.493*)
Overall *M* (*SD*)	13.478 (*7.505*)	10.758 (*8.464*)	12.148 (*8.015*)

Experiential avoidance was assessed using the BEAQ. Table 3 presents mean scores across groups and time points.

Table 3

BEAQ scores across time

Time point	WMT *M* (*SD*)	HEP *M* (*SD*)	Total *M* (*SD*)
T0 (pre-training)	46.739 (*8.651*)	43.409 (*8.022*)	44.6 (*8.338*)
T1 (post-training)	43.13 (*7.606*)	41.727 (*9.346*)	42.444 (*8.433*)
T2 (follow-up)	41.478 (*12.09*)	41.409 (*9.09*)	41.444 (*10.608*)
Overall *M* per group	43.449 (*7.229*)	42.182 (*7.53*)	42.83 (*7.321*)

Manipulation checks

Fear acquisition

The first analyses assessed whether fear acquisition was successful. For physiological data, a 2 x 2 repeated-measures ANOVA (RM ANOVA) was conducted with Stimulus (CS+, CS−) and Time (early vs. late acquisition) as within-subjects factors, using average SCRs during Stage 1. A significant main effect of Stimulus was found, $F(1, 44) = 8.626$, $p = .005$, $\eta p^2 = .164$, indicating higher SCRs to the CS+ than to the CS-. There was also a significant main effect of Time, F(1, 44) = 4.546, p = .039, $\eta p^2 = .09$, with SCRs decreasing from early to late acquisition. The Stimulus x Time interaction was not significant, $F(1, 44) = .003$, $p = .962$, $\eta p^2 < .001$.

Fear acquisition was also assessed using expectancy ratings during Stage 1. A paired-samples t-test showed higher expectancy for the CS+ (*M* = 87.63, *SD* = 10.03) than for the CS- (*M* = 13.87, *SD* = 11.86), $t(44) = 25.55$, $p < .001$, indicating successful acquisition.

Fear avoidance

A manipulation check of avoidance behavior during Stage 2 compared avoidance ratings for CS+ and CS- using a paired-samples t-test. Avoidance was significantly higher for CS+ (*M* = 88.34, *SD* = 19.97) than for CS- (*M* = 23.23, *SD* = 37.54), $t(44) = 9.924$, $p < .001$, indicating successful selective avoidance of the conditioned threat.

Extinction learning

Extinction learning in Stage 3 was assessed using both SCR and expectancy data. For SCRs, a 2 x 2 RM ANOVA with Stimulus (CS+, CS-) and Time (early vs. late extinction) showed no significant effect of Stimulus, $F(1, 44) = .148$, $p = .702$, $\eta p^2 = .003$, no effect of Time, $F(1, 44) = .084$, $p = .773$, $\eta p^2 = .002$, and no Stimulus x Time interaction, $F(1, 44) = .947$, $p = .336$, $\eta p^2 = .021$.

Extinction learning was also examined using expectancy ratings. A 2 x 2 RM ANOVA revealed a significant main effect of Stimulus, $F(1, 44) = 285.518$, $p < .001$, $\eta p^2 = .866$, with higher expectancy for CS+ than CS-, and a significant main effect of Time, $F(1, 44) = 16.908$, $p < .001$, $\eta p^2 = .278$, indicating a decrease from early to late extinction. The Stimulus x Time interaction was also significant, $F(1, 44) = 10.153$, $p = .003$, $\eta p^2 = .187$, showing a greater reduction in expectancy for CS+ over time. Together, these results indicated extinction learning in expectancy ratings, but not in SCRs.

Main analyses

Fear Avoidance

Table 4 presents descriptive avoidance scores during Stage 2 across stimulus types and training conditions. Avoidance was higher for the CS+ than for the CS-, indicating successful acquisition, as confirmed by a manipulation check conducted prior to the main analyses.

Table 4

Self-reported avoidance rates - Stage 2

Measure	WMT *M* (*SD*)	HEP *M* (*SD*)	Total *M* (*SD*)
Avoidance CS+	86.609 (*24.425*)	90.148 (*14.28*)	88.339 (*19.97*)
Avoidance CS-	26.913 (*39.79*)	19.381 (*35.545*)	23.231 (*37.538*)
Overall avoidance	56.761 (*23.221*)	54.754 (*17.675*)	55.785 (*20.487*)

To test the first hypothesis regarding fear avoidance (Stage 2), an RM ANOVA was conducted with Stimulus (CS+, CS-) as a within-subjects factor and Group (WMT, HEP) as a between-subjects factor. Fear avoidance was measured using a self-reported behavioral scale ranging from 0 to 100. The analysis revealed a significant main effect of Stimulus, consistent with the omnibus check. However, there was no significant main effect of Group, $F(1, 43) = .105$, $p = .748$, $\eta p^2 = .002$, indicating no overall difference in avoidance behavior between WMT and HEP participants in Stage 2. The Stimulus x Group interaction was also not significant, $F(1, 43) = .707$, $p = .405$, $\eta p^2 = .016$, suggesting that both groups did not differ significantly in the avoidance patterns for CS+ and CS-.

Despite the non-significant findings reported above, moderation analyses were conducted as planned to examine whether baseline anxiety or experiential avoidance influenced the relationship between group membership and avoidance. Two separate ANCOVAs were performed to test hypotheses 3a and 3b. In the first analysis, baseline anxiety (T0) was entered as a covariate, along with the same factors as before. The interaction between anxiety and group was not statistically significant, $F(1, 41) = .024$, $p = .878$, $\eta p^2 = .001$. In the second analysis, baseline EA (T0) was included as a covariate to test the moderation, and the group x EA interaction likewise yielded no significant effects, $F(1, 41) = 3.102$, $p = .086$, $\eta p^2 = .07$. The results of the moderation analyses suggested that baseline anxiety and experiential avoidance did not influence avoidance levels across the groups. Participants' total scores on the moderator variable were mean-centered before analyses to make the main effects more interpretable for the current sample and to reduce multicollinearity between the moderators and their interactions.

Extinction Learning

SCR

Table 5 presents descriptive SCR averages across extinction phases, stimulus types, and training conditions.

Table 5

SCR - Stage 3

Stimulus type		WMT *M* (*SD*)	HEP *M* (*SD*)	Total *M* (*SD*)
CS+	Early extinction	.276 (*.86*)	.502 (*2.146*)	.387 (*1.606*)
	Late extinction	.185 (*.322*)	.304 (*.803*)	.243 (*.603*)
	Total average	.231 (*.441*)	.403 (*1.111*)	.315 (*.833*)
CS-	Early extinction	.223 (*.656*)	.069 (*.172*)	.147 (*.485*)
	Late extinction	.448 (*1.539*)	.291 (*1.067*)	.372 (*1.317*)
	Total average	.336 (*.849*)	.18 (*.574*)	.26 (*.724*)

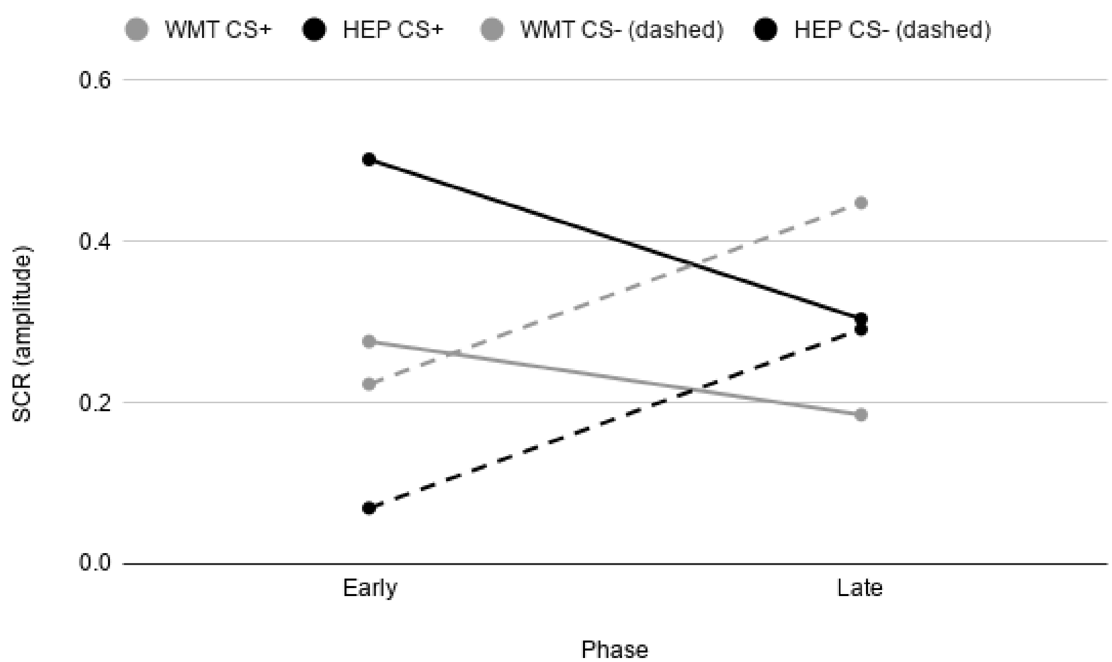
To test the 2a hypothesis regarding extinction learning, a 2 (Stimulus: CS+, CS-) x 2 (Time: Early, Late) x 2 (Group: WMT, HEP) mixed ANOVA was conducted on SCR averages for each phase within Stage 3 of the experiment. The analysis revealed that SCR responses to CS+ and CS- were comparable during extinction and did not differ significantly, $F(1, 43) = .08$, $p = .779$, $\eta p^2 = .002$. The main effect of Time was also not significant, $F(1, 43) = .17$, $p = .682$, $\eta p^2 = .004$, indicating that responses did not decrease from early to late extinction. Extinction learning did not differ between CS+ and CS- across time, $F(1, 43) = .93$, $p = .340$, $\eta p^2 = .021$.

WMT and HEP participants did not differ in overall SCR levels during the extinction phase, $F(1, 43) = .002$, $p = .964$, $\eta^2 p < .001$. Additionally, the extinction pattern was similar across groups, with no evidence that training condition influenced differential responding to CS+ and CS-, $F(1, 43) = .04$, $p = .846$, $\eta p^2 = .001$, or changes in extinction across early and late phases, $F(1, 43) = 1.3$, $p = .261$, $\eta p^2 = .029$.

SCR responses did not differ significantly across stimulus type or time. Figure 1 was included to provide a visual inspection of SCR patterns across extinction-learning phases.

Figure 1

SCR during early and late extinction for CS+ and CS- in the WMT and HEP groups.



Although the analysis did not lead to statistically significant results, the moderation analyses to test hypotheses 4a and 4b were conducted as planned. Two separate mixed ANCOVAs were conducted to examine whether baseline anxiety and EA moderated extinction learning. The design included the same factors as the main analysis on extinction learning, with anxiety and EA entered as covariates in the individual analyses.

The analysis showed that anxiety did not moderate group differences in extinction learning responses. No higher-order interactions involving anxiety showed significant results, suggesting that extinction patterns were similar across participants regardless of baseline anxiety levels.

As with the anxiety variable, EA scores at T0 were mean-centered before analysis. In the second moderation analysis exploring the role of EA (T0), the EA x Group interaction was not significant. However, the test revealed a significant four-way interaction, Stimulus x Time x Group x EA, $F(1, 41) = 4.668$, $p = .037$, $\eta p^2 = .102$, indicating a medium-to-large effect. This result suggested that extinction learning patterns (i.e., changes in SCR responses across CS+ and CS- from early to late extinction) differed between groups depending on participants' baseline EA scores. No other interactions involving EA were significant.

Given that the four-way interaction indicated that the Stimulus x Time x EA relationship also varied across groups, follow-up analyses were conducted separately for the WMT and HEP groups to examine this in more detail. Two 2 (Stimulus: CS+, CS-) x 2 (Time: Early, Late) mixed ANCOVAs were performed, with baseline EA included as a covariate. Given that the groups were assessed separately this time, the dataset file was temporarily split by group. The analyses revealed no significant main or interaction effects within either group. This finding suggested that the significant four-way interaction observed earlier likely reflected nuanced differences in how EA moderated extinction learning across groups, rather than strong within-group effects.

Expectancy ratings

Table 6 presents descriptive expectancy ratings across extinction phases, stimulus types, and training conditions.

Table 6

Expectancy ratings - Stage 3

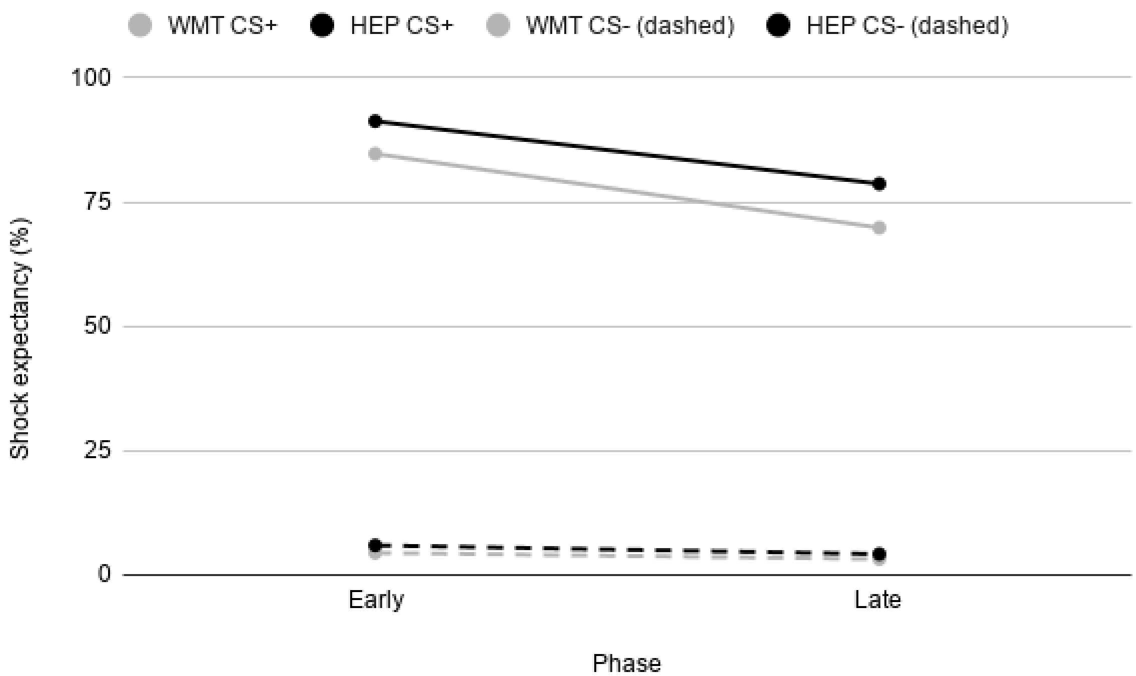
Stimulus type		WMT *M* (*SD*)	HEP *M* (*SD*)	Total *M* (*SD*)
CS+	Early extinction	84.701 (*22.858*)	91.261 (*19.963*)	87.908 (*21.505*)
	Late extinction	69.799 (*36.257*)	78.636 (*35.829*)	74.119 (*35.916*)
	Total average	77.25 (*27.77*)	84.949 (*25.843*)	81.014 (*26.823*)
CS-	Early extinction	4.451 (*10.636*)	5.955 (*14.741*)	5.186 (*12.683*)
	Late extinction	3.201 (*10.686*)	4.21 (*13.812*)	3.694 (*12.182*)
	Total average	3.826 (*10.415*)	5.082 (*14.126*)	4.44 (*12.243*)

To test hypothesis 2b, a mixed RM ANOVA was conducted to examine whether threat expectancy ratings differed significantly across groups. Stimulus (CS+, CS-) and Time (early, late extinction) were within-subject factors, and Group (WMT, HEP) was a between-subject factor. The analysis revealed no significant Group effect across all variables, including Stimulus x Group, Time x Group, and Stimulus x Group x Time interactions. These findings indicated that expectancy ratings did not differ significantly between the WMT and HEP groups.

Figure 2 was included to provide a clearer visual overview of expectancy patterns across extinction-learning phases.

Figure 2

Expectancy during early and late extinction for CS+ and CS- in the WMT and HEP groups.



Hypothesis 4a examined whether trait anxiety moderated the relationship between intervention group and extinction learning (SCR, expectancy ratings). In addition to the mixed ANCOVA conducted for SCR, a parallel mixed ANCOVA was performed on expectancy ratings. No significant interactions involving trait anxiety were observed, indicating that baseline anxiety did not moderate extinction learning in either physiological or subjective measures.

Lastly, hypothesis 4b examined experiential avoidance as a potential moderator of the relationship between group type and extinction learning, measured by SCR and expectancy ratings. In addition to the earlier mixed ANCOVA for SCR, a second mixed ANCOVA was conducted on expectancy ratings. No significant interactions concerning EA were found, suggesting that EA did not moderate the relationship between extinction learning and group type.

Changes in Anxiety Over Time

To test hypothesis 5a and explore potential changes in anxiety over time and between groups, a 3 x 2 mixed ANOVA was conducted. Specifically, the within-subjects variable was Time, with 3 levels (T0, T1, T2), and the between-subjects variable was Group membership, with 2 levels (WMT, HEP). DASS-21 scores on the anxiety sub-scale were used as a DV. Results showed that anxiety levels did not change significantly across the three time points, $F(2, 86) = .402$, $p = .67$, $\eta p^2 = .009$, and the changes in anxiety over time did not differ between the WMT and HEP groups, $F(2, 86) = .182$, $p = .834$, $\eta p^2 = .004$.

For the between-subjects effects, there was no overall difference in anxiety between groups, $F(1, 43) = 1.305$, $p = .26$, $\eta p^2 = .029$.

Changes in Experiential Avoidance Over Time

Similarly, to test the 5b hypothesis that EA changes across the three time points and that there is a difference between groups, another 3 (T0, T1, T2) x 2 (WMT, HEP) mixed ANOVA was conducted. BEAQ totals per participant served as a dependent variable (DV). The output showed that participants' experiential avoidance scores did not change significantly across time points, $F(2, 86) = 2.456$, $p = .092$, $\eta p^2 = .054$. Moreover, changes across time did not differ between the WMT and HEP groups, $F(2, 86) = .31$, $p = .735$, $\eta p^2 = .007$.

The between-subjects effects output showed that the Group effect was non-significant, $F(1, 43) = .332$, $p = .568$, $\eta p^2 = .008$, indicating no overall differences in EA between the groups.

Discussion

The current study explored whether a 6-week Workplace Mindfulness Training would lead to lower avoidance responses and better extinction learning when participants were presented with uncomfortable stimuli in the fear-conditioning experiment, compared with those undergoing a 6-week Health Enhancement Program. Moderators that could potentially buffer the relationship between program type and fear-learning processes were hypothesized to be the participants' baseline anxiety (T0) and experiential avoidance (T0). Both variables have been identified in the prior literature as relevant factors in the context of mindfulness effectiveness (Baer, 2003; McCluskey et al., 2020). The final hypothesis aimed to explore any possible longitudinal changes in anxiety and EA across the three time points of the study: before training, after training, and one month after training.

The results showed that general fear conditioning and fear acquisition were successful, suggesting that the electric shock levels used as the uncomfortable stimulus in the lab were sufficient to distinguish between the CS+ and the CS-, eliciting significantly different responses in self-reported ratings and physiologically (SCR). These general findings were consistent with other studies on fear conditioning paradigms. Current research also revealed that participants across both groups avoided CS+ significantly more than CS-. This indicated successful avoidance acquisition, consistent with fear-conditioning paradigms (Krypotos, 2015). However, analyses failed to find any evidence for an effect of training type on fear-avoidance responses. Contrary to the hypothesis, participants in the mindfulness training did not exhibit significantly lower avoidance rates compared to the HEP control group. Although the mindfulness group showed a slightly lower CS+ avoidance mean score ($M = 86.609$, $SD = 24.425$) than the control group ($M = 90.148$, $SD = 14.28$), this difference was not statistically significant, indicating similar behavioral unwillingness to avoid discomfort with the conditioned stimulus across groups.

It is important to note that the present study assessed avoidance exclusively during Stage 2 (fear-avoidance stage), with the aim of examining the onset of initial avoidance following fear acquisition. This approach was consistent with previous literature viewing avoidance as a distinct behavioral process and independent learning stage (Delgado, 2009; Krypotos, 2015). However, by excluding Stage 3 avoidance scores, the present study was unable to examine temporal changes in avoidance behavior across extinction learning. As a result, the findings provide limited insight into the persistence or reduction of avoidance over time. Future research may therefore benefit from adopting a multi-stage approach to better capture temporal patterns of avoidance throughout the fear-conditioning process.

Analysis of expectancy ratings during the extinction learning phase showed that expectancy ratings for the CS+ were significantly higher than for CS- and decreased from early to late extinction. Lower expectancy ratings at the end of extinction are commonly interpreted as a finding of successful extinction learning (Hofmann et al., 2019). Similar patterns of reduced threat expectancy across extinction trials have also been reported in fear-conditioning paradigms (Gromer et al., 2023). However, the main analysis revealed no significant group differences, contrary to the hypothesis. Interestingly, participants in the mindfulness group showed slightly lower expectancy ratings across extinction phases than those in the HEP group; however, these differences were not statistically significant.

The SCR results did not provide evidence of extinction learning at the physiological level during Stage 3. In fear-conditioning paradigms, extinction learning is typically reflected in a reduction in conditioned responses over time and a loss of differential responding between CS+ and CS- (Hofmann et al., 2019; Shechner et al., 2014). In the present study, SCR responses remained relatively low and showed minimal differentiation between CS+ and CS- across extinction phases, providing limited evidence of reductions in physiological responses over time. Moreover, contrary to the hypothesis that mindfulness training would facilitate extinction learning, no significant group differences in SCR reactivity were observed, as both groups showed no significant differences throughout extinction. Similar results were observed in the paper by Björkstrand et al. (2019), which likewise reported no significant reductions in SCR during extinction following mindfulness training on Day 1 of the experiment, with group differences becoming apparent at a later training session on Day 2. The findings of the current paper should therefore be interpreted with caution, particularly given a relatively small sample size and the exclusive focus on Day 1 data. Future research could replicate the present design while incorporating multi-stage and longitudinal comparisons to better examine the potential influence of mindfulness on extinction learning processes.

The current study also examined longitudinal changes in two variables, experiential avoidance and anxiety, which have been closely examined in mindfulness and fear-conditioning research (Khoury et al., 2013; Kummar et al., 2019; McCluskey et al., 2020; Sehlmeyer et al., 2010). However, the findings of the present paper were not significant. This was consistent with prior studies reporting mixed or null changes in anxiety following brief mindfulness interventions among non-clinical student samples (Kang et al., 2009; Quach et al., 2015). Although some prior analyses have shown that mindfulness interventions were effective in reducing anxiety (Khoury et al., 2013) and experiential avoidance (Garcia-Toro et al., 2023; He et al., 2023), these effects varied by intervention type, program duration, and sample characteristics. For instance, He et al. (2023) found reductions in EA over just three weeks in a high-distress sample using online MBI, while Garcia-Toro et al. (2023) observed moderate-to-large within-group improvements in EA in a treatment-resistant depression sample using online MBCT. It is possible that the current study's six-week intervention with a non-clinical student sample characterized by moderate baseline anxiety and experiential avoidance (EA $M = 44.6$; Anxiety $M = 12$), and potential limitations in engagement, may have constrained the extent of change. Since engagement and adherence are considered important moderators of MBI effectiveness (Parsons et al., 2017), attendance requirements were monitored, and home practice was verbally discussed during sessions. However, engagement with home practice and intrinsic motivation for participation were not formally assessed. Future studies may therefore benefit from incorporating more explicit measures of home practice adherence and participant motivation when evaluating MBI effectiveness.

A practical implication of the present findings is that future research should directly compare clinical and non-clinical populations when evaluating MBIs. The current sample consisted primarily of university students screened to exclude individuals with formal psychiatric diagnoses, which may limit generalizability to populations with higher baseline symptom severity. Previous research suggests that MBIs may produce stronger effects in clinical populations experiencing greater distress (Galante et al., 2021), whereas findings in non-clinical student samples have been more mixed, with effects often ranging from small to moderate depending on the outcomes examined (Dawson et al., 2019). Future studies may therefore benefit from stratifying participants by baseline clinical status and examining whether MBIs operate differently across groups varying in anxiety or experiential avoidance levels.

Previous research has primarily examined anxiety as an outcome of MBIs, with many studies reporting reductions in self-reported anxiety symptoms following MBI participation (Hofmann et al., 2010; Khoury et al., 2015). Far fewer studies have investigated whether anxiety moderated fear learning or extinction processes. The present study, therefore, examined whether baseline anxiety (T0) moderated the effects of mindfulness training on fear-conditioning outcomes; however, no significant moderation effects were observed for avoidance responses or extinction learning measured via SCR and expectancy ratings. Importantly, these null findings should be interpreted alongside the broader absence of significant mindfulness-training effects across fear-conditioning stages. Anxiety scores in the current sample were generally low (M = 12, SD = 7.92 on the multiplied DASS-21 Anxiety scale), ranging from 0 to 28 (possible range: 0-42), resulting in limited variability within a non-clinical student sample. Although university students often report somewhat elevated anxiety compared to older adults (Ramón-Arbués et al., 2020), levels typically remain subclinical. Accordingly, anxiety may not exert a strong moderating effect in short-term mindfulness interventions conducted in non-clinical populations, whereas stronger effects are more commonly observed in clinically anxious groups characterized by dysregulated fear learning and extinction processes (Duits et al., 2015).

Similarly to the anxiety moderator findings, baseline EA did not significantly affect behavioral fear avoidance. However, when examined in relation to extinction learning, a significant four-way interaction emerged for SCR responses across stimulus type, training condition, time, and baseline EA levels. Previous research has linked higher EA to reduced emotional flexibility, heightened distress reactivity, and difficulties tolerating aversive experiences, all of which may interfere with extinction learning (Chawla & Ostafin, 2007; Craske et al., 2014). Mindfulness-based interventions were thought to possibly counteract these tendencies by increasing tolerance of internal discomfort (Hölzel et al., 2016). However, the significant interaction found did not yield consistent follow-up patterns in either intervention group. The findings may suggest that the relationship between EA and extinction learning is context-dependent and influenced by multiple interacting factors. Future research using larger samples and more targeted analyses is needed to clarify the reliability of these effects. More targeted analytic approaches, such as simple-slope analyses and EA cut-off scores, may help clarify how different levels of EA influence extinction learning and identify individuals most likely to benefit from mindfulness-based interventions.

It's important to note that the current study had limitations that should be taken into account. Firstly, the sample size was relatively small (*N*=45), which limited generalizability and increased the likelihood that the results would be influenced by individual variability or outliers. Recruitment and retention may have been affected by the intensive study design, which required participation in a six-week intervention, repeated questionnaires, and two laboratory sessions without monetary compensation. Similar challenges have been reported in MBI research, particularly among student populations balancing academic demands (Vøllestad et al., 2011). Reduced engagement and adherence may therefore have further limited observable intervention effects (Parsons et al., 2017). Future research should aim to employ larger, more diverse samples and explore strategies to improve adherence, such as simplifying study designs or providing additional incentives for sustained participation.

Several methodological factors could also have influenced the findings. The relatively small sample size may have limited statistical power to reliably detect higher-order interaction effects, particularly in the moderation analyses. Furthermore, SCR responses did not show a clear extinction pattern by stimulus type or over time, limiting conclusions about physiological extinction learning. Finally, the use of four early and four late extinction trials may also have reduced sensitivity to more gradual changes in extinction responding across the learning phase.

In conclusion, the present study investigated whether WMT would lead to stronger effects on fear avoidance and extinction learning than the HEP control group, and whether these effects were moderated by baseline anxiety and experiential avoidance. Overall, the analyses did not show significant group differences or moderation effects, apart from a general distinction in responses between the conditioned and neutral stimuli. However, a significant higher-order interaction involving EA suggested that the relationship between mindfulness training and extinction learning may be more nuanced than initially expected. No significant longitudinal changes were found in either anxiety or experiential avoidance across time points.

Despite predominantly nonsignificant findings, the present study contributed to emerging research examining the relationship between mindfulness-based interventions and fear-learning processes. By integrating physiological, behavioral, and self-report measures within a longitudinal design, the study provided a broader and more detailed perspective on the complexity of fear conditioning and potential individual differences influencing these processes.

Future research is encouraged to employ larger, more diverse samples, refine the operationalization of the moderator constructs, and incorporate multi-stage comparisons to better capture changes over time in fear-related processes. Additionally, comparing different mindfulness-training formats and levels of participant engagement may help clarify conditions under which MBIs meaningfully influence fear learning.

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