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A Thesis entitled

Examining the Association Between Trait Mindfulness and How Positively an Exercise Bout Is Remembered

by

Bree A. Geary

Submitted to the Graduate Faculty as partial fulfillment of the

requirements for the Masters in Arts Degree in Psychology

Southern Methodist University

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Abstract

Introduction: Remembered affect is associated with future exercise behavior. Research suggests that trait mindfulness is associated with better emotion regulation, more positive affective memory of negative stimuli, and less rumination. Therefore, the purpose of this study was to examine the relation between trait mindfulness and remembered affect of an exercise bout. **Methods:** Undergraduate students from Southern Methodist University (N =94) completed baseline measures of trait mindfulness and physical activity, a 15-minute vigorous-intensity exercise bout, and post-exercise measure (remembered affect at 15 minutes post exercise session, 1-2 days post, and 1-week post). Multilevel modeling was used to test the association with remembered affect and linear regression was used to test the association with affective response during exercise. **Results:** Trait mindfulness was significantly associated with remembered affect (b = 21.28, SE = 7.66, p <.01). As secondary aims, none of the individual facets of trait mindfulness were associated with remembered affect (Aim 2a) and the pattern of results did not change with the observe facet was removed (Aim 2b). Trait mindfulness was also significantly associated with affect *during* exercise (Aim 3) (b =.69, t(93) = 2.08, p = .04). When neuroticism was included in the models (Aim 4), trait mindfulness no longer predicted remembered affect (replication of Aim 1 and Aim 2b) or during exercise affective response (replication of Aim 3). **Conclusion:** These findings suggest that the overlap between trait mindfulness and neuroticism are associated with remembered affect and supports the research on an affective response to physical activity as a phenotype.

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Introduction

The benefits of regular exercise include lower risk of heart disease (Taylor et al., 2004), diabetes (Sigal et al., 2006), high blood pressure (Fagard, 2006; Hagberg et al., 2000), depression (Herring et al., 2012; Rosenbaum et al., 2014), anxiety (Asmundson et al., 2013) and improved psychological well-being (Reynolds et al., 2016). Despite this compelling evidence for the benefits of regular exercise, more than half of U.S. adults do not exercise regularly (Garber et al., 2011; Troiano et al., 2008). Often people do not engage in exercise because they do not enjoy it, especially during early exercise initiation (Panteleimon Ekkekakis & Dafermos, 2012). Therefore, it is important to understand people's experiences with exercise to develop effective interventions to change behavior.

Research in various behavioral domains suggests that how an individual remembers an experience predicts future behavior (Kahneman, 2003; Kwan et al., 2017; Miron-Shatz et al., 2009, Redelmeier & Kahneman, 1996; Stone et al., 2005; Wirtz et al., 2003). These retrospective evaluations are known as remembered affect (Kwan et al., 2017), or how much pleasure or displeasure is remembered from an experience. Episodic memory of the specific details of an experience tends to decay fairly quickly (Schooler & Hertwig, 2005). Therefore, as time passes since the initial experience individuals tend to rely on a more global evaluation of the experience when making a decision about engaging in a behavior again (Ariely & Carmon, 2000), such as remembered affect, rather than specific details of the experience. For example, Kahneman and colleagues (1993) asked participants to complete two variations of a cold pressor task, the first task was 60 seconds and the second task was 60 seconds plus an additional 30 seconds at a slightly warmer (less aversive) temperature. Even though they rated the longer trial as more painful during the experience, they remembered the longer trial as less painful when asked to

recall 7 minutes later because the ending was less aversive. In addition, when given the option, participants were more likely to choose to repeat the longer but more positively remembered trial. Kahneman and colleagues (2003) also demonstrated this phenomenon in patients undergoing colonoscopies, an affectively unpleasant medical procedure. Half of the patients underwent a longer colonoscopy with a slightly less painful ending to the procedure. In the retrospective evaluations, these patients rated the procedure as less unpleasant and were 1.4 times more likely to return for their follow-up colonoscopy compared to those with a shorter procedure but more abrupt ending. Similarly, Wirtz and colleagues (2003) found that recall of enjoyment of a vacation, but not enjoyment experienced during, predicted the desire to repeat the vacation. This suggests that memory of experienced emotions is more influential on the decision to engage in the behavior again than how individuals felt during the experience.

Remembered affect has also been examined in experiences with exercise. Zenko and colleagues (2016) explored how changing the intensity during an exercise bout can influence remembered affect. They demonstrated that when intensity declines over the exercise bout it is associated with a more positive recall 15 minutes, 24 hours and one week later compared to increasing intensity. In another study of remembered exercise affect (Kwan et al., 2017), participants reported anticipated, experienced and remembered affect of a 30-minute exercise bout. Among the multiple measures of affect, only remembered affect was associated with the amount of exercise completed during the subsequent week. The findings from this study suggest that how someone *remembers* feeling, or their retrospective evaluation, is a better predictor of future exercise than their experienced affective response during an exercise bout (Kwan et al., 2017). Therefore, it is important to better understand what factors are associated with remembered affect of an exercise bout. Because vigorous exercise includes both positive and

negative sensations (Panteleimon Ekkekakis et al., 2011), factors that are associated with how people respond to and remember negative experiences and sensations may be associated with how someone remembers an exercise bout.

Trait mindfulness, an individual's dispositional tendency to maintain present moment awareness without judgment or evaluation (Carpenter et al., 2019), may be a predictor of remembered affect of an exercise bout. Trait mindfulness differs from state mindfulness, which is the nonjudgmental present-focused awareness at any given moment (Medvedev et al., 2017). Trait and state mindfulness also differ from mindfulness practice, which is the deliberate practice of mindful exercises with the intention of cultivating state mindfulness (Carpenter et al., 2019).

There is extant evidence for a positive association between trait mindfulness and physical activity (Sala et al., 2020; Yang & Conroy, 2020), however the association between mindfulness and remembered affect of an exercise bout has not yet been examined. Research suggests people who are higher in trait mindfulness are better able to regulate negative thoughts and sensations (Arch & Craske, 2006). Lyvers and colleagues (2014) found that people who were higher in trait mindfulness also reported greater ability to regulate their own negative mood states (emotion regulation). During an experience with negative sensations (e.g., exercise), the absence of judgment about that experience may reduce the negativity of the memory of the experience.

Research on mindfulness and memory suggests that people who are more mindful remember fewer negative stimuli and experiences (Alberts & Thewissen, 2011). Alberts and Thewissen (2011) investigated the effect of mindful practice on memory of positive and negative valanced stimuli. In this study, participants were randomized to either a brief mindfulness intervention or a control condition. Following the intervention, they completed a verbal learning test which included visual presentation of positive, negative and neutral words. After a 20-

minute filler task, participants were asked to recall as many words as possible. Participants in the brief mindful practice intervention group recalled fewer negative words compared to the control condition. Because mindful practice and state mindfulness during meditation predicts increases in trait mindfulness (Kiken et al., 2015), people who are higher in trait mindfulness may report more positive affective memory of experiences with negative stimuli.

People who are higher in trait mindfulness are also less likely to ruminate on their experiences (Brown & Ryan, 2003). Rumination is focused attention on the symptoms of one's distress (Nolen-Hoeksema, 1991). Raes and Williams (2010) found that even after controlling for depressive symptoms, mindfulness was significantly negatively correlated with rumination. Multiple randomized controlled trials have also demonstrated the relation between mindfulness meditation and ruminative thoughts, with mediation models suggesting that the effects of meditation on reducing distress were partially mediated by reducing rumination (Jain et al., 2007; Ramel et al., 2004). Additionally, rumination is associated with enhanced memory for negative stimuli (Moulds et al., 2007). Although higher trait mindfulness should not lead to experiencing fewer negative sensations during exercise, it might lead to being less likely to ruminate on the negative sensations and therefore less likely to remember them (Brown & Ryan, 2003; Moulds et al., 2007; Raes & Williams, 2010). Taken together, the evidence on memory and rumination suggests that the influence of trait mindfulness on remembered exercise affect might show a similar pattern.

It is possible that specific mindfulness facets might drive the association between mindfulness and remembered affect for exercise. Baer and colleagues (2006) developed the Five Facet Mindfulness Questionnaire (FFMQ) with five identifiable facets that are internally consistent and modestly correlated with each other (Anicha et al., 2012). The facets include

observe, describe, act with awareness, nonjudgment, and nonreactivity. Petrocchi and Ottaviani (2016) found that the nonjudgment facet of the FFMQ at baseline negatively predicted rumination two years after baseline, above and beyond the other four facets. Research has demonstrated that without the nonjudgment facet, mindfulness does not predict improvement in psychological functioning which suggests that nonjudgment is crucial to this association (Baer et al., 2006; Barnes & Lynn, 2010; Chin et al., 2019; Curtiss & Klemanski, 2014). Because rumination is linked to enhanced memory retrieval of negative memories (Moulds et al., 2007), nonjudgment could have a unique association with how someone remembers an experience due to the decrease in ruminative thinking. If there is an association between trait mindfulness and remembered affect, it is possible that it is driven by the nonjudgment facet. Therefore, it is important to examine associations at the facet-level for a more fine-grained perspective on how trait mindfulness is associated with remembered affect.

Although trait mindfulness is likely associated with remembered affect, it is possible that trait mindfulness is also associated with the affect individuals experience *during* exercise. Schneider and colleagues (2019) suggest that individuals who are more mindful may accept the negative sensations that are likely to occur during exercise, such as fatigue, and therefore be more likely to enjoy the experience of exercise. Other evidence indicates that participants who listen to a mindfulness audio recording during exercise report more positive affect valence and enjoyment during exercise (Cox et al., 2018).

On a conceptual level, trait mindfulness overlaps with multiple constructs including neuroticism, depressive symptoms, and anxiety symptoms. Research even suggests that the negative emotional reactivity that is characteristic of someone who is high in neuroticism may inhibit the development of a mindful disposition (Barnhofer et al., 2011; Brown & Ryan, 2003;

Feltman et al., 2009). Multiple studies have demonstrated the strong negative correlation between trait mindfulness and neuroticism (*rs* ranged from -.49 to -.60; (Barnhofer et al., 2011; Feltman et al., 2009; Hanley & Garland, 2017; Spinhoven et al., 2017). Additionally, Carpenter and colleagues' (2019) meta-analysis demonstrated that trait mindfulness is associated with lower symptoms of anxiety and depression. Due to relation of trait mindfulness with neuroticism and dysphoria (the core emotional and cognitive symptoms of depression and anxiety), it is important to consider whether trait mindfulness accounts for unique variance in remembered exercise affect when accounting for both neuroticism and dysphoria.

Current Study

Using secondary data from a brief intervention study on remembered affect, I examined associations between trait mindfulness and remembered affect of exercise at three timepoints following an exercise bout: 15-minutes post-exercise, 1-2 days post, and 7 days post-exercise. I hypothesized that higher levels of trait mindfulness would be positively associated with remembered affect valence (Aim 1a). However, given there is not any previous research on the associations between mindfulness and remembered affect, it was unclear whether the strength of the association might change across the three time points. I tested this possibility (Aim 1b). I did a facet-level analysis examining the association between each individual facet and remembered affect valence, while controlling for the other four facets (Aim 2a). I hypothesized that higher levels of nonjudgment would be significantly positively associated with remembered affect valence. The association between the four facets of mindfulness without the observe facet (nonjudgment, describe, act with awareness, and nonreactivity) and remembered affect valence was also examined (Aim 2b). I also examined the association between trait mindfulness and during-exercise affective response (Aim 3). Finally, I repeated the analyses from Aim 1, 2 and

Aim 3 with the addition of neuroticism and dysphoria, to determine if this changed the pattern of results (Aim 4).

Methods

Participants

This is secondary analysis from an intervention study that was designed to test the effect of an audio-recorded guided reflection on remembered affect. I controlled for effects of condition (audio-recording group vs. no audio-recording group) due to possible effects on remembered affect. Because this is an existing dataset, I had a sample of 94 participants available for analysis. With 94 participants, an alpha of .05, and five predictors (trait mindfulness, neuroticism, condition, baseline moderate-to-vigorous physical activity (MVPA), and time), there was sufficient power to detect a small-to-moderate effect size of $f^2 = .06$ with 80% power.

A sample of 94 undergraduate students were recruited through the psychology subject pool at Southern Methodist University (SMU) and received course credit for their participation. The SMU Institutional Review Board approved this study and data was collected between September 2018 and August 2019. Informed consent was obtained prior to participation in the study. Participants were healthy adults, capable of providing informed consent, and willing to comply with the protocol. Participants' risk to engage in vigorous intensity exercise was evaluated according to the American College of Sports Medicine guidelines (American College of Sports Medicine, 2017).

Inclusion & exclusion criteria. In order to be eligible, participants needed to be at least 18 years old, no history of cardiovascular or respiratory disease and physically capable of engaging in vigorous exercise activity. Specifically, participants indicated the presence or absence of (a) known cardiovascular, pulmonary, and/or metabolic disease, (b) signs or

symptoms suggestive of cardiovascular, pulmonary, and/or metabolic disease, or (c) CVD risk factors. Those who reported any of the risk factors were classified as moderate or high risk and not eligible to participate.

Measures

Trait mindfulness. The Five Facet Mindfulness Questionnaire (FFMQ; (Baer et al., 2006) was developed to assess trait mindfulness. Participants rated statements about themselves (see Table 8). Factor analyses of the FFMQ have identified five facets of mindfulness: (1) observing, noticing or attending to internal and external experiences; (2) describing, labeling internal experiences with words; (3) acting with awareness, attending to one's current experiences and avoiding automatic autopilot; (4) nonjudgment of inner experience, taking a nonevaluative stance towards thoughts and feelings; and (5) non-reactivity to inner experience, tendency to allow thoughts and feelings to come and go without getting caught up or carried away by them (Baer et al., 2006). The FFMQ has demonstrated adequate internal reliability (α = .75 to .91; α = .81 to .91; Baer et al., 2008; Van Dam et al., 2012). The FFMQ overall score was calculated as a mean score of the full scale. The individual mindfulness facets were calculated as a mean of each individual facet. Higher scores suggest higher levels of overall trait mindfulness or higher trait mindfulness at the individual facet level. Alpha for the FFMQ full scale was α = 0.88 and for the individual scales: observing: α = 0.84; describing: α = 0.87; acting with awareness: α = 0.86; nonjudging: α = 0.92; nonreactivity: α = 0.77. Average interitem correlation (AIC) was .16 for the full scale and for the individual scales: observing: AIC = 0.40; describing: AIC = 0.46; acting with awareness: AIC = 0.43; nonjudging: AIC = 0.62; nonreactivity: AIC = 0.30.

Recent publications have suggested possible psychometric concerns with the FFMQ (Lecuona et al., 2020; Rau & Williams, 2016; Van Dam et al., 2012). For example, Lecuona et al., (2020) tested the factor structure of the FFMQ and found that the exclusion of the observe facet provided improvement in the fit of the factor structure. There is also mixed evidence on whether the observe facet is positively correlated with the other facets and whether it is negatively correlated with psychological symptoms (Baer et al., 2006, 2008; de Bruin et al., 2012). Therefore, I plan to address this analytically by examining the association between trait mindfulness without the observe facet and remembered affect.

Neuroticism. The eight-item Big Five Inventory-Neuroticism (BFI-N; (John et al., 1991) is a well-validated, extensively used measure of neuroticism that has demonstrated construct validity (John & Srivastava, 1999). Participants rated statements about themselves (e.g., "can be tense; not always easy going,", "can be moody") on a scale from 1 (*disagree a lot*) to 5 (*agree a lot*) (see Table 9). It demonstrated adequate internal reliability ($\alpha = .79$).

Dysphoria. The Inventory of Depression and Anxiety Symptoms-II (IDAS-II) is an expanded version of the IDAS (Watson et al., 2012) which contains 18 nonoverlapping, factor analytically derived scales. Dysphoria is a 10-item scale within the IDAS-II that assesses the core emotional and cognitive symptoms of depression and anxiety (Watson et al., 2007). Participants rated statements about themselves (e.g., "I felt depressed") on a scale from 1 (*not at all*) to 5 (*extremely*). In this sample, the dysphoria scale of the IDAS demonstrated good internal reliability ($\alpha = .87$).

Affective response at baseline and during exercise. Affective response during exercise was assessed with the Feeling Scale (FS; Hardy & Rejeski, 1989), a single item asking participants "How do you feel?" with instructions that stated "answer the questions based on how

you are feeling right now". Response options were on an 11-point bipolar rating scale ranging from -5 (*very bad*) to +5 (*very good*) with verbal anchors at zero (neutral) and odd numbers. Though the single item measure limits the variance and sensitivity of the measure, it does minimize participant burden since data collection occurs during exercise bouts. Affective response was assessed every three minutes throughout the exercise bout. For Aim 3, affective response during exercise (FS during) was the average of FS at baseline, 3 min, 6 min, 9 min, 12 min, and 15 min.

Remembered affect. To minimize common method variance, remembered affect was assessed using a differently worded item and different response scale than the FS (Zenko et al., 2016). Participants responded to the question "How did the exercise session make you feel?" on a visual analog scale (VAS) from '+100' (*very pleasant*) to '-100' (*very unpleasant*) in intervals of 1. They responded using an iPad by moving an on-screen slider with the slider positioned in the middle (0) when they began. The verbal descriptors and slider were visible but the numbers were not.

Physical activity. To measure baseline physical activity, participants completed the International Physical Activity Questionnaire-Short Form (Craig et al., 2003) before they came in for the experimental session, which assessed moderate-to-vigorous physical activity (MVPA, moderate physical activity minutes + vigorous physical activity minutes*2) via self-report.

Procedures

Participants first completed an online screener via Qualtrics in which inclusion and exclusion criteria were assessed. Eligible participants were asked to come to the experimental session for approximately 1.5-2 hours and were asked to wear exercise attire and athletic shoes. After consenting and prior to the exercise session, they completed a baseline questionnaire on an

iPad via Qualtrics that included demographics and the measures of trait mindfulness and physical activity. The primary study included a randomization to either a control or an intervention group, which included listening to an audio recording during the cool-down. Therefore, I will include condition as a covariate in the analysis.

Exercise session. After completing the baseline questionnaire, each participant was given a heart rate monitor to measure their heart rate during the exercise bout to standardize the intensity. All participants began with a 3-minute warm-up, exercised on a treadmill for 15 minutes followed by a 3-minute cool down. Research assistants increased the speed every 3 minutes by 7% HR_{max} in order to reach vigorous intensity at the 12-minute mark (91% maximum heart rate). We followed the same protocol utilized in Zenko et al. (2016). Throughout the exercise session, participants reported their affective response (FS) every five minutes. All questionnaires during the exercise session were administered on an iPad to minimize experimenter bias.

Follow-up. Fifteen minutes post-exercise, participants completed the remembered affect measure. Participants were also contacted via email at the end of the day and one week later to complete the remembered affect measurement.

Statistical Analysis

I ran descriptive analyses on age, gender, race, body mass index (BMI), baseline MVPA, FFMQ mean, FFMQ facets, neuroticism, dysphoria, remembered affect valence, and FS mean. I then ran bivariate correlations between trait mindfulness (FFMQ mean), the five facets of the FFMQ, neuroticism (BFI subscale), and dysphoria (IDAS dysphoria subscale). For all of the MLM models and linear regressions described below, I included baseline MVPA and condition as covariates. Controlling for baseline MVPA allowed us to control for any influence physical

activity level might have on RA scores. For Aim 4 only, I also included neuroticism and dysphoria in order to determine if adding them changes the associations with remembered affect valence.

Multilevel modeling was used to examine the relation between trait mindfulness (FFMQ) and remembered affect valence (RA) to account for repeated assessments within participants. Predictors were centered at the sample mean. Time 1 was 15 min post exercise, Time 2 was 1-2 days post, and Time 3 was one week later.

To address Aim 1a, the level-1 (within person) portion modeled individual-level remembered affect valence scores (RA_i). In this model, $b0_i$ is the intercept for individual *i* or the predicted value of RA for individual *i* when FFMQ is at the sample mean and ε_{ij} is the error for individual *i* at specific assessment *j*. The level-1 model is:

$$RA_i = b0_i + \varepsilon_{ij}$$

The level-2 (between person) equations modeled the level 1 regression coefficient for individuals as a function of hypothesized predictors. Trait mindfulness was entered as a level-2 predictor of the intercept ($b0_i$). This model included treatment condition and baseline MVPA as predictors of the intercept, effectively treating these as covariates in the model.

Within the level-2 intercept model ($b0_i$), Υ_{00} represents the average intercept for RA in the sample at time 1, Υ_{01} represents the effect of FFMQ on RA at time 1, Υ_{02} represents the effect of neuroticism on RA, Υ_{02} represents the effect of BaselineMVPA on RA (BaselineMVPA $_i$ represents baseline physical activity for individual *i*), Υ_{03} represents the effect of treatment condition on RA ($Condition_i$ represents condition for individual *i*), μ_{0i} represents the difference between the individual's actual intercept and predicted intercept for individual *i*. The leve1-2 equation will be:

$$b0_i = \Upsilon_{00} + \Upsilon_{01}*FFMQ_i + \Upsilon_{02}*BaselineMVPA_i + \Upsilon_{03}*Condition_i + \mu_{0i}$$

In order to address Aim 1b, the level-1 (within person) portion modeled individual-level remembered affect valence scores (RA_i) as a function of time ($Time_{ij}$). In this level-1 model, $b0_i$ is the intercept for individual *i* or the predicted value of RA for individual *i* when FFMQ is at the sample mean, $b1_i$ is the change in RA over time, and ε_{ij} is the error for individual *i* at specific assessment *j.* This level-1 model is:

$$RA_i = b0_i + b1_i*TD2_{ij} + b2_i*TD3_{ij} + \varepsilon_{ij}$$

I looked at the differences in -2 Log Likelihood (-2LL) between the two above models and use a chi-square analysis to determine if the difference is significant. The comparison of these two leve1-1 models will determine if the strength of the association between trait mindfulness and RA changes over time (Aim 1b). If the model with time has a significantly smaller -2LL, I will use the model with time for all subsequent models. If the model without time has a significantly smaller -2LL, I will use the model without time for all subsequent models.

To address Aim 2a, I entered the nonjudgment facet of FFMQ as a level-2 predictor, along with condition, baseline MVPA, and the other four mindfulness facets as covariates. The other facets are included as covariates in order to determine if nonjudgment facet uniquely predicts remembered affect valence controlling for the variance shared with the other facets. This model is:

$$b0_i = \Upsilon_{00} + \Upsilon_{01}*Nonjudge_i + \Upsilon_{02}*BaselineMVPA_i + \Upsilon_{03}*Condition_i + \Upsilon_{04}*Observe_i +$$
$$\Upsilon_{05}*Describe_i + \Upsilon_{06}*ActAware_i + \Upsilon_{07}*Nonreact_i + \mu_{0i}$$

To determine if trait mindfulness without the observe facet is associated with RA (Aim 2b), I also re-ran the same model above without the observe facet and looked at the pattern of change.

For Aim 3, I used a linear regression to examine trait mindfulness as a predictor of during-exercise affective response (mean of FS from baseline to 15 minutes). This model controls for condition and baseline MVPA only. The equation for model 2 is:

DuringAffectiveResponse = b0 + b1*FFMQ + b2*BaselineMVPA + b3*Condition

Lastly, for Aim 4 I replicated all four analyses (Aim 1a, Aim 2a, Aim 2b, and Aim 3) with the addition of neuroticism and dysphoria in the models.

Results

Participant Characteristics

The sample consisted of 94 primarily White or Caucasian (71%) females (66%) with an average BMI of 22.90 (SD = 3.68). The sample reported an average of 209.28 minutes per week (*SD* = 293.78) of MVPA at baseline. Means and standard deviations of the full scales and facet level scales are similar to previous studies (Baer et al., 2006; DeYoung et al., 2007; John et al., 1991; Rochefort et al., 2018). The average remembered affect valence score for the full samples was 50.55 (*SD* = 37.94) at 15 min post, 44.04 (*SD* = 39.43) at 1-2 days post, and 45.85 (*SD* = 38.61) at 7 days post in-lab exercise session. See Table 1 for complete descriptive information on participants characteristics and study variables for the entire sample.

Bivariate Correlations

Table 2 shows the bivariate correlations among mindfulness, mindfulness facets, neuroticism, dysphoria, remembered affect valence, and FS mean. Trait mindfulness mean score and three of the five facets, including describe, act with awareness and nonjudgment, were moderately to strongly correlated with neuroticism (*rs* ranged from -.30 to -.55) and with dysphoria (*rs* ranged from .31 to -.52). The observe facet was not significantly correlated with neuroticism or dysphoria.

As preliminary support for Aim 1, trait mindfulness had a small positive correlation with remembered affect valence (*rs* ranged from .21 to .27). Neuroticism also had a similar size negative correlation with remembered affect valence (*rs* ranged from -.20- to -.22). Dysphoria was not correlated with remembered affect valence (*rs* ranged from -.06 to -.08). As expected, remembered affect valence at 15 min post was strongly correlated with the same measure of remembered affect valence 1-2 days post ($r = .70$), and 7 days post ($r = .84$). Remembered affect valence 15 min post, 1-2 days post, and 7 days post were also strongly correlated with FS Mean ($r = .66$, .51 and .64, respectively).

Multilevel Models

Aim 1a: Higher levels of trait mindfulness will be positively associated with remembered affect valence after completing an exercise bout. As hypothesized, trait mindfulness was significantly associated with remembered affect valence when controlling for baseline MVPA and condition ($b = 21.28$, $SE = 7.66$, *95 % CI* = [6.08, 36.58], $p = .007$), indicating that higher trait mindfulness is positively associated with higher levels of remembered affect valence (see Table 3).

Aim 1b: Does the association between trait mindfulness and remembered affect valence change across the three timepoints after the exercise bout? The interaction between time and remembered affect valence with not significant indicating the strength of the association did not change over time. The main effect of time was also not significantly associated with remembered affect valence ($b = -2.60$, $SE = 1.89$, *95 % CI* = [.17, 1.13], $p = .17$). Although the effects of time were not significant, it was retained in the models as a covariate to account for the decrease in mean levels of RA over time (see Table 1).

Aim 2a: Are specific facets of trait mindfulness associated with remembered affect valence? Contrary to the hypothesis that the nonjudgment facet would be positively associated with remembered affect valence above the other four facets, none of the individual five trait mindfulness facets were significantly associated with remembered affect valence when controlling for baseline MVPA and condition (Table 4).

Aim 2b: Does the association between the other four facets of trait mindfulness and remembered affect valence change when observe facet is removed? After removing the observe facet from the trait mindfulness mean full scale score, trait mindfulness was still significantly associated with remembered affect valence when controlling for baseline MVPA and condition (b = 17.68, SE = 6.61, *95 % CI* = [4.56, 30.79], $p < .001$; Table 5).

Linear Regression

Aim 3: Is trait mindfulness associated with affective response during an exercise bout? Trait mindfulness was significantly associated with affect during exercise while controlling for baseline MVPA and condition (b =.69, $t(93) = 2.08$, p = .04; see Table 6).

Aim 4: Is trait mindfulness associated with remembered affect valence and affective response during exercise after controlling for neuroticism and dysphoria? In all four of these models, dysphoria did not significantly predict the outcome or change the significance in any of the models and therefore was dropped from the models below. Adding neuroticism as a predictor did significantly alter the pattern of results (results of the models including neuroticism are in Table 7). Specifically, trait mindfulness no longer predicted remembered affect valence or during exercise affective response when neuroticism was included in the models. Interestingly, when trait mindfulness was removed from the models, neuroticism negatively significantly predicted remembered affect valence (b =-10.29, SE = 4.41, *95 % CI* = [-19.05, -1.54], p = .02)

and during exercise affective response (b = -.46, SE = .19, $t(93)$ = -2.44, p = .02), but neither trait mindfulness nor neuroticism significantly predicted the outcomes when both were included in the models (see Table 7). This pattern suggests trait mindfulness and neuroticism are accounting for overlapping variance in the affective outcomes.

Discussion

This was the first study to investigate the extent to which trait mindfulness is associated with remembered affect from an exercise bout. The findings indicate that trait mindfulness is positively associated with affective response to an exercise bout and how it is remembered. There was no evidence that specific facets of trait mindfulness were associated with remembered affect indicating that it is total score of trait mindfulness, not the individual facets, that predict remembered affect. However, when neuroticism was included in the models the association between trait mindfulness and both affective response variables was no longer significant. Overall, this pattern suggests that trait mindfulness does not explain variance in remembered affect that is not shared with neuroticism.

As predicted, trait mindfulness was positively associated with remembered affect. The positive association between trait mindfulness and remembered affect suggests that people who tend have a more mindful disposition report a higher affective memory of an exercise bout. To date, this study is the first to examine the association between trait mindfulness and remembered affect. Because previous research suggests remembered affect predicts future exercise behavior (Kwan et al., 2017), these findings indicate increases in trait mindfulness may lead to increases in physical activity via its effect on remembered affect. This is consistent with the research on the association between trait mindfulness and emotion regulation (Lyvers et al., 2014), memory

of fewer negative stimuli (Alberts & Thewissen, 2011; Jha et al., 2019), and rumination (Brown & Ryan, 2003; Moulds et al., 2007; Raes & Williams, 2010).

When examined at the facet level, none of the individual facets of trait mindfulness were associated with remembered affect or affective response to exercise. This suggests that none of the individual facets, while controlling for the other four facets, predict remembered affect. Therefore, the hypothesis that the nonjudgment facet specifically would predict remembered affect was not supported. This is inconsistent with the previous findings on the nonjudgment facet's inverse association with rumination (Petrocchi & Ottaviani, 2016). Perhaps nonjudgment does not predict remembered affect because individuals who judge daily experiences (low in nonjudgment facet), do not also judge or ruminate on an exercise bout. Perhaps judgment of an exercise experience is unique and more closely related to body image and criticism of appearance rather than judgment of internal events and all experiences. Overall, none of the individual facets of trait mindfulness alone, while controlling for the variance of the other four facets, were associated with remembered affect of an exercise bout. Rather, the shared variance across multiple facets predicted remembered affect.

Previous research suggested the observe facet of mindfulness may behave differently than the other facets in predicting remembered affect (Baer et al., 2006, 2008; de Bruin et al., 2012; Lecuona et al., 2020). However, the exclusion of the observe facet from the analyses did not change pattern of results. Previous research suggests that the observe facet items may vary based on meditation experience (Baer et al., 2006, 2008; de Bruin et al., 2012). Specifically, de Bruin and colleagues (2012) found that the four-factor model (without the observe facet) of mindfulness was a better fit than the five-factor model. The pattern of correlations between facets of the FFMQ in our study suggests that the observe facet is operating similar to how it

operates in samples without meditation experience. For example, the observe facet had a small negative correlation with the nonjudgment facet (r = -.15) and a small correlation with the acting with awareness facet (r = -.08). Contrary to de Bruin et al.'s (2012) sample without meditation experience, the observe facet in our sample had a large positive correlation with the nonreactivity facet (r = .30**). These findings support the multifaceted theoretical conceptualization of mindfulness. These findings also support the ongoing concern with assuming that all five facets perform the same in all samples (Baer et al., 2008; de Bruin et al., 2012; Lecuona et al., 2020).

When trait mindfulness predicted affective response *during* exercise (Aim 3), there was a similar pattern of results where trait mindfulness was positively associated with affective response during exercise. This suggests that trait mindfulness is associated not only with how an exercise bout is remembered but also with exercise-related affect more generally.

The findings highlight the importance of considering both neuroticism and trait mindfulness in order to understand individual differences in affective response to exercise. Specifically, the findings indicate that trait mindfulness does not predict any unique variance in remembered affect or affective response that is not shared with neuroticism. This overlap likely includes experiences and reactions to negative internal events. Conceptually, trait mindfulness (positive valence) and neuroticism (negative valence) are similar because they describe the tendency to experience and respond to negative thoughts and feelings (Fetterman et al., 2010). Someone who is high in neuroticism is prone to experience more negative internal events. If someone is low in trait mindfulness, they will be less likely to observe, describe, act with awareness, not judge, and not react to these negative internal events. Examination of previous research on the overlap between trait mindfulness and neuroticism suggests that there is considerable overlap between these two constructs (Feltman et al., 2009; Fetterman et al., 2010;

Rochefort et al., 2018; Wenzel et al., 2015). Neuroticism includes the tendency to ruminate on past events and worry about future events (Fetterman et al., 2010) which is similar (inversely related) to the present moment awareness characteristic of trait mindfulness. Future research could investigate this overlap by including trait positive affect (e.g., IDAS Wellbeing or BFI Extraversion) in the models to determine if this changes the pattern of results. By controlling for both trait positive affect and trait negative affect (neuroticism) in the analysis, we could further understand if the present moment awareness variance of trait mindfulness is predicting affective memory valence and affective response to exercise.

Given the findings, it is important to unpack how mindfulness and neuroticism are related. At the trait level, there is a large degree of overlap and their effects on the exercise-related affective experiences examined here were redundant. Mindful practice, however, may be an effective behavioral approach to decrease neuroticism (Armstrong & Rimes, 2016) and increase remembered exercise affect.

Limitations

There are limitations to consider. First, the sample was primarily healthy, young (*M*=19.99, *SD*=2.75), average BMI (*M*=22.90, *SD*=3.68), above recommended baseline MVPA (*M*=209.28, *SD*= 293.78), and White or Caucasian (71%). Descriptively, affective response during exercise of this sample was higher than we expected. Previous research demonstrates that individuals who are obese, compared to individuals who are normal weight or overweight, report lower affective response ratings during exercise (Ekkekakis & Lind, 2006; Ekkekakis et al., 2010). Ekkakakis and colleagues (2010) suggest this may due to differences in cognitive appraisal of the physiological sensations. Therefore, this normal weight sample may have contributed to a more positive affective response than anticipated. Future research could address

this by conducting a similar study in a sample with a higher BMI and additional health concerns (e.g., cardiovascular, metabolic, or pulmonary disease). This is important to consider because a sample with a higher BMI and additional medical diagnoses is more representative of the individuals who are not exercising regularly and trying to initiate a regular exercise routine (Ekkekakis & Lind, 2006). Therefore, the nonrepresentative sample limits strength of the conclusion and the generalizability of the findings. Additionally, the sample size of 94 may have also limited the power to look at facet-level associations.

Second, because this was a secondary analysis this study was not primarily designed to ideally answer these research questions. Therefore, there were limitations in measurement. This study utilized 1-item measures of remembered affect valence and affective response that did not include the direction of change in affect (e.g., more positive or less negative). However, affective response to exercise measures were designed this way due to in-task assessment. Additionally, since these affective measures were on different scales we did not create and compare individual changes scores (e.g., remembered affect valence minus affective response during). However, future research could use remembered affect valence and affective response during measures on the same scale to understand accuracy. We also did not have measures of: 1) state mindfulness during the exercise bout or measures of meditation practice or experience, 2) longer term measures of affective memory, and 3) longer-term measures of physical activity. A third limitation is that the exercise bout data collection was conducted in a laboratory setting which may not replicate affective memory and affective response to exercise in a real-world setting.

Implications

These findings inform our understanding of how dispositional tendencies are associated with affective response and affective memory of exercise. These findings help us further

understand the extent to which trait mindfulness may be redundant with neuroticism, and inform the conceptualization of the overlap between trait mindfulness and neuroticism. They also support the findings on a possible psychological individual differences in affective response (Bryan et al., 2017; Lee et al., 2018). If we know there are particular aspects of personality that are associated with affective memory and affective experience of exercise, interventions can be tailored to target these dispositional tendencies. Future research is needed to determine if mindfulness interventions increase affective memory and affective experience of exercise.

Conclusions

Overall, the present study is the first to examine the relation between the overlap of trait mindfulness and neuroticism with affective memory and affective response to an exercise bout. Overall, further research is needed to understand the specific overlap between trait mindfulness and neuroticism and if this overlap represents an affective response to exercise phenotype.

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Table 1

Demographics and Descriptives

	Full Sample (N = 94) M (*SD*) or *n* (%)
Age (years)	19.99 (2.45)
Gender	
Male	32 (34%)
Female	62 (66%)
Race	
White or Caucasian	67 (71%)
Asian	19 (21%)
Black or African American	3 (3%)
Hispanic or Latino	2 (2%)
Other	1 (1%
Did not respond	2 (2)
BMI (kg / m^2)	22.90 (3.68)
Baseline MVPA	209.28 (293.78)
Trait Mindfulness	3.28 (.44)
Observing Facet	3.40 (.76)
Describing Facet	3.43 (.71)
Act with Awareness Facet	3.14 (.74)
Nonjudgement Facet	3.43 (.90)
Nonreactivity Facet	2.94 (.66)
Neuroticism	2.89 (.77)
Dysphoria	19.94 (7.44)
Remembered Affect Valence 15 min post (n=93)	50.55 (37.54)
Remembered Affect Valence 1-2 days Post (n=83)	44.04 (39.43)
Remembered Affect Valence 7 Days Post (n=92)	45.85 (38.51)
Feeling Scale Mean	1.27 (1.42)

Note. Trait mindfulness and the mindfulness facets range from 1 (*never or very rarely true*) to 5 (*very often or always true*). Neuroticism ranges from 1 (*disagree strongly*) to 5 (*agree strongly*). Dysphoria ranges from 1 (*not at all*) to 5 (*extremely*). Remembered affect valence ranges from +100 (*very pleasant*) to -100 (*very unpleasant*). FS Mean (of Baseline, 3 min during, 6 min during, 9 min during and 12 min during and 15 min of affect during exercise) ranges from -5 (*very bad*) to +5 (*very good*).

Table 2

Correlations between Mindfulness, Mindfulness Facets, Neuroticism, Dysphoria, Remembered Affect Valence, and FS Mean

	α (AIC)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. FFMQ Full Scale	.88 (.16)	-	.39**	.68**	.60**	.68**	.54**	-.55**	-.44**	.27**	.21	.24*	.22*
2. FFMQ Observe	.84 (.40)		-	.15	-.08	-.15	.30**	.06	.20	.09	.00	.09	.13
3. FFMQ Describe	.87 (.46)			-	.26*	.35**	.22*	-.30**	-31**	.14	.08	.09	.12
4. FFMQ Act with Awareness	.86 (.43)				-	.43**	.05	-.43**	-.52**	.22*	.24*	.14	.16
5. FFMQ Nonjudge	.92 (.62)					-	.16	-.48**	-.50**	.21*	.10	.20	.12
6. FFMQ Nonreact	.77 (.30)						-	-.46**	-.07	.11	.23*	.20	.12
7. BFI Neuroticism	.79 (.32)							-	.51**	-.21*	-.22*	-.20	-.25*
8. IDAS Dysphoria	.87 (.40)								-	-.07	-.08	-.06	-.14
9. RA 15 Min Post	-									-	.70**	.84**	.66**

	α (AIC)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
10. RA 1-2 Days Post	-										-	.74**	.51**
11. RA 7 Days Post	-											-	.64**
12. FS During	-												-

Note. *p <.05. **p <.01. α = Cronbach's alpha. AIC = average inter-item correlation. α and AIC were not calculated for RA measures because they are 1-item measures. α and AIC were also not calculated for FS During because FS During is the average of a 1-item measure repeated 6 times.

Table 3

Aim 1a: Trait Mindfulness as a Predictor of Remembered Affect Valence

Predictor	*b*	*SE*	*95% CI*	*p*
Mindfulness	21.28	7.66	[6.08, 36.58]	.007**
Baseline MVPA	.00	.01	[-.02, .02]	.69
Condition	.55	.07	[-.08, .19]	.42
Time	-2.60	1.89	[.17, 1.13]	.17

Note. Time is coded as 1 = 15 min post, 2 = 1-2 days post and 7 = 7 days post. All covariates were mean centered.

*p <.05. **p <.01

Table 4

Aim 2a: MLM Individual Mindfulness Facets as Predictors of Remembered Affect Valence

Predictor	*b*	*SE*	*95% CI*	*p*
Individual mindfulness facets				
Observe	4.39	4.98	[-5.50, 14.27]	.38
Describe	.02	5.31	[-10.52, 10.56]	.99
Act with awareness	5.70	5.22	[-4.66, 16.06]	.28
Nonjudgment	6.50	4.53	[-2.48, 15.49]	.15
Nonreactivity	4.49	5.58	[-6.59, 15.57]	.42
Baseline MVPA	.01	.01	[-.02, .02]	.64
Condition	.05	.07	[-.09, .19]	.46
Time	-2.59	1.89	[-6.33, 1.15]	.17

Note. Time is coded as 1 = 15 min post, 2 = 1-2 days post and 7 = 7 days post. All covariates were mean centered.

*p <.05. **p <.01

Table 5

Aim 2b: MLM Trait Mindfulness Without Observe Facet as a Predictor of Remembered Affect Valence

Predictor	*b*	*SE*	*95% CI*	*p*
Mindfulness without observe facet	17.68	6.61	[4.56, 30.79]	.009**
Baseline MVPA	.01	.01	[-.02, 30.79]	.56
Condition	.06	.07	[-.07, .20]	.36
Time	-2.60	1.89	[-6.33, 1.14]	.17

Note. Time is coded as 1 = 15 min post, 2 = 1-2 days post and 7 = 7 days post. All covariates were mean centered.

*p <.05. **p <.01

Table 6

Aim 3: Trait Mindfulness Predicting Affective Response During Exercise

Predictor	*b*	*df*	*t*	*p*
Mindfulness	.69	93	2.08	.04*
Baseline MVPA	.00	93	.98	.33
Condition	.04	93	.14	.89

Note. All covariates were mean centered. *p <.05. **p <.01

Table 7

Aim 4: Determining Overlap with Neuroticism

Predictor	*b*	*SE*	*95% CI*	*p*
Aim 1				
Mindfulness	16.21	9.27	[-2.19, 34.61]	.08
Neuroticism	-5.07	5.30	[-15.58, 34.61]	.34
Baseline MVPA	.00	.01	[-.02, 03]	.70
Condition	.07	07	[-.07, .20]	.34
Time	-2.59	1.89	[-6.33, 1.14]	.17

Predictor	*b*	*SE*	*95% CI*	*p*
Aim 2a				
Individual mindfulness facets				
Observe	5.04	5.05	[-5.00, 15.08]	.32
Describe	-.28	5.33	[-10.87, 10.31]	.96
Act with awareness	4.38	5.49	[-6.52, 15.28]	.43
Nonjudgment	5.34	4.75	[-4.10, 14.78]	.26
Nonreactivity	2.00	6.40	[-10.71, 14.71]	.76
Neuroticism	-4.93	6.16	[-17.16, 7.30]	.43
Baseline MVPA	.00	.01	[-.02, .03]	.70
Condition	.06	.07	[-.08, .20]	.39
Time	-2.59	1.90	[-6.34, 1.15]	.17

Predictor	*b*	*SE*	*95% CI*	*p*
Aim 2b				
Mindfulness without observe facet	13.04	8.52	[-3.89, 29.96]	.13
Neuroticism	-4.83	5.66	[-16.06, 6.41]	.40
Baseline MVPA	.01	.01	[-.02, .03]	.61
Condition	.07	.07	[-.06, .20]	.29
Time	-2.60	1.90	[-6.33, 1.15]	.17

Predictor	*b*	*df*	*t*	*p*
Aim 3				
Mindfulness	.36	93	.91	.36
Neuroticism	-.35	93	-1.55	.13
Baseline MVPA	.00	93	.97	.34
Condition	.04	93	.15	.89

Note. Time is coded as 1 = 15 min post, 2 = 1-2 days post and 7 = 7 days post. All covariates were mean centered.

*p <.05. **p <.01

Table 8

FFMQ Items by Facet

1 = never or very rarely true
2 = rarely true
3 = sometimes true
4 = often true
5 = very often or always true

Facet	Description of Facet	Items
Observe (8 items) No reverse coding	Noticing or attending to internal and external experiences	When I'm walking, I deliberately notice the sensations of my body moving.
		When I take a shower or bath, I stay alert to the sensations of water on my body. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions. I pay attention to sensations, such as the wind in my hair or sun on my face. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing. I notice the smells and aromas of things. I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow. I pay attention to how my emotions affect my thoughts and behavior.
Describe (8 items) 3 reverse coded	Labeling internal and external experiences with words	I'm good at finding words to describe my feelings.
		I can easily put my beliefs, opinions, and expectations into words. It's hard for me to find the words to describe what I'm thinking. I have trouble thinking of the right words to express how I feel about things. When I have a sensation in my body, it's difficult for me to describe it because I can't find the right words.

		Even when I'm feeling terribly upset, I can find a way to put it into words. My natural tendency is to put my experiences into words. I can usually describe how I feel at the moment in considerable detail.
Act with Awareness (8 items) All reverse coded	Attending to one's activities in the moment as opposed to "autopilot"	When I do things, my mind wanders off and I'm easily distracted.
		I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted. I am easily distracted. I find it difficult to stay focused on what's happening in the present. It seems I am "running on automatic" without much awareness of what I'm doing. I rush through activities without being really attentive to them. I do jobs or tasks automatically without being aware of what I'm doing. I find myself doing things without paying attention.
Nonjudgment (8 items) All reverse coded	Accepting and not evaluating one's thoughts and feelings	I criticize myself for having irrational or inappropriate emotions.
		I tell myself I shouldn't be feeling the way I'm feeling. I believe some of my thoughts are abnormal or bad and I shouldn't think that way. I make judgments about whether my thoughts are good or bad. I tell myself that I shouldn't be thinking the way I'm thinking. I think some of my emotions are bad or inappropriate and I shouldn't feel them. When I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about. I disapprove of myself when I have irrational ideas.

Nonreactivity (7 items) No reverse coding	Allowing one's thoughts and feelings to come and go without becoming involved and getting carried away with them	I perceive my feelings and emotions without having to react to them.
		I watch my feelings without getting lost in them.
		When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.
		In difficult situations, I can pause without immediately reacting.
		When I have distressing thoughts or images, I feel calm soon after.
		When I have distressing thoughts or images, I am able just to notice them without reacting.
		When I have distressing thoughts or images, I just notice them and let them go.

Table 9

BFI-Neuroticism Items

1= disagree a lot; 5 = agree a lot

BFI Items
Is sad, depressed
Is relaxed, handles stress well
Can be tense, not always easy going
Worries a lot
Doesn't get upset easily; steady
Can by moody
Stays calm in difficult situations
Get nervous easily