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Examining the Protective Effects of Mindfulness Training on Working Memory Capacity and Affective Experience

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We investigated the impact of mindfulness training (MT) on working memory capacity (WMC) and affective experience. WMC is used in managing cognitive demands and regulating emotions. Yet, persistent and intensive demands, such as those experienced during high-stress intervals, may deplete WMC and lead to cognitive failures and emotional disturbances. We hypothesized that MT may mitigate these deleterious effects by bolstering WMC. We recruited 2 military cohorts during the high-stress predeployment interval and provided MT to 1 (MT, $n = 31$) but not the other group (military control group, MC, $n = 17$). The MT group attended an 8-week MT course and logged the amount of out-of-class time spent practicing formal MT exercises. The operation span task was used to index WMC at 2 testing sessions before and after the MT course. Although WMC remained stable over time in civilians ($n = 12$), it degraded in the MC group. In the MT group, WMC decreased over time in those with low MT practice time, but increased in those with high practice time. Higher MT practice time also corresponded to lower levels of negative affect and higher levels of positive affect (indexed by the Positive and Negative Affect Schedule). The relationship between practice time and negative, but not positive, affect was mediated by WMC, indicating that MT-related improvements in WMC may support some but not all of MT's salutary effects. Nonetheless, these findings suggest that sufficient MT practice may protect against functional impairments associated with high-stress contexts.

Keywords: working memory capacity, emotion regulation, mindfulness, prevention, military deployment

Mindfulness is a mental mode characterized by full attention to present-moment experience without judgment, elaboration, or emotional reactivity. Mindfulness training (MT) programs offer exercises and didactic guidance to help participants cultivate this mental mode. MT is now widely available, with more than 250 medical centers around the United States offering mindfulness-based stress reduction (MBSR) programs to community members (Kabat-Zinn, 1990, 2003). MBSR programs have also been adapted as clinical interventions for a broad range of physical and psychological disorders, and a large body of research now suggests that MT is efficacious at stress and symptom reduction (see Baer, 2003; Grossman, Neimann, Schmidt, & Wallach, 2004; Lush et al., 2009). In addition, there is growing evidence that MT may benefit patients who are currently asymptomatic by providing "psychological prophylaxis," or protection from future mental health disturbances (Ma & Teasdale, 2004). For example, receiving mindfulness-based cognitive therapy reduces the likelihood of subsequent depressive episodes in some patients at heightened risk for depression relapse (Teasdale et al., 2000). Yet, outside of clinical contexts, very little is know about MT's effectiveness at *protecting against* psychological disturbances in those at heightened risk for developing them.

In the current study, we consider MT as a prevention tool whose goal is to strengthen capacities that are at risk of being degraded over an interval of persistent demands and potent stressors. Specifically, we aimed to determine whether MT might be beneficial to military service members preparing for deployment. The military deployment cycle increases the likelihood of service members suffering acute and long-term psychological injury, in addition to

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physical harm (for review, see Stanley, Getsinger, Spitaletta, & Jha, in press). In the several months prior to their deployment, service members receive intensive training on mission-critical operational skills, physical training, and "stress-innoculation" training to habituate them to stressors they may experience during their impending mission. All the while, they must psychologically prepare to leave loved ones and face potentially violent and unpredictable situations during their deployment. Although the purpose of this predeployment preparation is to increase service members' readiness and confidence to engage in mission-specific tasks and manage deployment-related stressors (Dienstbier, 1989), several studies report decreases in cognitive functioning and increases in emotional disturbances over this interval (Bolton, Litz, Britt, Adler, & Roemer, 2001; MacDonald, Chamberlain, Long, Pereira-Laird, & Mirfin, 1998; Maguen et al., 2008; see also Stanley & Jha, 2009). Cognitive and affective functioning is further impaired on return from deployment (Marx et al., 2009; Vasterling et al., 2006), although recent studies suggest that the impact of deployment on mental health is quite variable across individuals (Hoge, Auchterlonie, & Milliken, 2006; King, King, Vogt, Knight, & Samper, 2006). In the current project, we recruited two predeployment cohorts of U.S. Marine reservists and offered MT to one but not the other cohort. We examined the influence of MT over the predeployment interval to minimize individual- and cohort-level variability and maximize our chances of uncovering MT's protective influence on cognitive and affective functioning.

Cognitive control refers to a family of attention-related regulatory processes needed to ensure that information processing is in accord with long- and short-term goals. *Emotion regulation* refers to regulatory processes involved in initiating or altering affective experiences and expression. Both of these regulatory processes are hypothesized to be engaged while actively performing concentrative mindfulness training exercises, which are included as "homework" in most MT protocols (see Bishop et al., 2004; Lutz, Slagter, Dunne, & Davidson, 2008). Concentrative exercises emphasize focus on a target object, such as a body sensation, visual image, phrase, or concept. During a breath-focused practice, for example, participants are instructed to sit in a relaxed upright posture and direct their full attention to the sensations of breathing. When they notice that attention has wandered, they are to gently return it back to those sensations. Novice participants report getting off-task and mind-wandering during this exercise. They also report feeling frustrated when this occurs. In these instances, they may upregulate cognitive control processes to ensure that they stay on-task and emotion regulation processes to overcome their sense of frustration at failing to do so. If cognitive control and emotion regulation are, indeed, centrally engaged while performing MT exercises, their repeated engagement over many MT practice sessions may strengthen both types of regulatory processes.

Indeed, both the subjective sense of attentional control and the likelihood of everyday cognitive failures correspond to individual differences in trait mindfulness (Baer, Smith, Hopkins, Krietmeyer, & Toney, 2006; Herndon, 2008). Behavioral performance and neural activity patterns on attention tasks using nonaffective stimuli, such as symbols, digits, and letters, corroborate these self-reported effects. For example, behavioral results suggest that MT improves attentional orienting and conflict monitoring (Chan & Woollacott, 2007; Heeren, Van Broeck, & Philippot, 2009; Jha, Krompinger, & Baime, 2007; Tang et al., 2007; Wenk-Sormaz, 2005) and reduces the attentional blink (Slagter et al., 2007). Changes in attention-sensitive neuroelectric components and oscillatory profiles have also been reported with MT (Cahn & Polich, 2009; Lutz et al., 2009). In addition, both increases in cortical thickness within attention-related subregions of prefrontal cortex (PFC; Lazar et al., 2005) and "more efficient" functional activity profiles within these subregions during attention-demanding tasks (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007) correspond to lifetime hours of MT practice. Thus, not only do subjective, behavioral, and neural results suggest that MT improves specific attentional components of cognitive control, but the magnitude of these improvements appears to have a "dose-response" relationship with the amount of time spent engaging in MT practice.

There is ample evidence that MT's salutary effects on affective experience are also commensurate with the amount of time spent engaging in formal MT exercises (Carmody & Baer, 2008; Shapiro, Oman, Thoresen, Plante, & Flinders, 2008). Higher levels of positive affect and well-being, and lower levels of negative affect and rumination, have been reported with MT (Anderson, Lau, Segal, & Bishop, 2007; Carmody & Baer, 2008; Davidson et al., 2003; Jain et al., 2007). Furthermore, behavioral results suggesting decreased emotional reactivity to affective images (Ortner, Kilner, & Zelazo, 2007) are consistent with MT-related decreases in neural activity elicited by affective distractors within the amygdala and other brain regions involved in emotional processing (Brefczynski-Lewis et al., 2007; see also Farb et al., 2007). Collectively, these results converge on the view that MT may improve affective experience via improved regulatory control over affective mental content.

Thus, several lines of research support MT's ability to improve cognitive–attentional control operations and affective experience. Yet, very little empirical work has investigated the relationship between these MT-related changes. One recent study in patients with social anxiety disorder proposed that patients' reductions in negative affect following MT may have occurred via MT-related improvements in their ability to deploy attention (Goldin & Gross, in press). This directional hypothesis of affective benefits contingent on improvements in cognitive–attentional control is in line with process models of emotion regulation. These models suggest that the most powerful and flexible forms of emotion regulation involve cognitive control of emotion (McRae & Gross, 2007; McRae et al., in press).

Consistent with these models, examination of individual differences in emotion regulation reveals that individuals with better cognitive control are better able to regulate their emotions (Schmeichel, Volokhov, & Demaree, 2008). Schmeichel and colleagues (2008) indexed cognitive control using measures of working memory capacity (WMC). Working memory is a cognitive system closely related to attention (see Jha, 2002; Redick & Engle, 2006), and WMC is the capacity to selectively maintain and manipulate goal-relevant information without getting distracted by irrelevant information over short intervals.

The operation span (Ospan) task, which involves remembering nonaffective stimuli such as letters over short intervals while performing simple arithmetic, is frequently used to index WMC (Unsworth, Heitz, Schrock, & Engle, 2005). Ospan performance is highly correlated with performance on other cognitive tasks indexing attentional orienting (Redick & Engle, 2006; Unsworth, Schrock, & Engle, 2004), conflict monitoring (McVay & Kane, 2009; Redick & Engle, 2006), attentional blink (Colzato, Spape, Pannebakker, & Hommel, 2007), abstract problem solving, and general fluid intelligence (Gray, Chabris, & Braver, 2003; Halford, Cowan, & Andrews, 2007; Kane & Engle, 2002).

In addition, those with low versus high WMC are more likely to suffer from emotionally intrusive thoughts and are less successful at suppressing positive and negative emotions (Brewin & Smart, 2005; Schmeichel et al., 2008). These laboratory results have led some researchers to consider individuals with low WMC to be at greater risk for deleterious mental health outcomes (Unsworth, Heitz, & Engle, 2005). In line with this view, individuals with lower WMC appear to have increased affective dysregulation in real-world contexts and have a greater likelihood of prejudicial behavior toward personally disliked groups, as well as higher incidences of substance abuse, posttraumatic stress disorder, and anxiety disorders (see Brewin & Smart, 2005; Conway et al., 2005).

Thus, several lines of research suggest that WMC corresponds to one's success at willfully guiding behavior while overcoming cognitive or affective distraction and prepotent response tendencies in the laboratory and in the real world (see Conway et al., 2005). Yet, WMC is not an immutable individual differences factor. Persistent and intensive engagement of WMC in response to "cold" or "hot" regulatory demands may deplete capacity. Recent studies report that WMC is reduced within individuals following high cognitive demands, such as performing a color–word Stroop task, or affective demands, such as inhibiting emotional expressions while watching an emotionally evocative video (Schmeichel, 2007) or suppressing the experience of anxiety (Johns, Inzlicht, & Schmader, 2008).

Although WMC may become depleted after engaging in demanding tasks, recent studies suggest that working memory can be improved through mental training. These studies report that working memory processes are bolstered with computer-based training methods, which involve performing attention and working memory tasks over several training sessions (e.g., Buschkuehl et al., 2008; Olesen, Westerberg, & Klingberg, 2004; Persson & Reuter-Lorenz, 2008). In patients with affective disorders, similar training techniques reduce anxiety (Siegle, Ghinassi, & Thase, 2007) and depression symptoms (Papageorgiou & Wells, 2000), suggesting that improving cognitive control processes, such as WMC, may reduce emotional disturbances in clinical contexts.

In the current study, we investigated the utility of MT as a prevention tool to protect against cognitive failures and emotional disturbances suffered by military service members over the high-stress predeployment interval. WMC, positive affect, and negative affect were examined in two predeployment military cohorts before and after one of the groups received MT. We examined three main questions: (a) Is WMC depleted over the predeployment interval? We predicted that the intensive and persistent demands of the predeployment interval would degrade WMC in the absence of MT. (b) Can MT bolster WMC? Given that WMC is highly interrelated with attentional control processes found to be strengthened with MT (see Jha et al., 2007; Moore & Malinowski, 2009), we predicted that WMC would be bolstered with MT. (c) What is the correspondence between MT-related changes in WMC and affective experience? We hypothesized that MT would improve cognitive control of emotion, and predicted that MT-related changes in WMC would mediate changes in affect over the predeployment interval.

Method

Participants

None of the participants in any of our cohorts had any prior experience with mindfulness techniques. The study was approved by the University of Pennsylvania Institutional Review Board, and informed consent was obtained from each participant prior to entry into the study.

The military control (MC) sample comprised 17 male participants (mean age = 25 years, SD = 4.30) recruited from a detachment of U.S. Marine Corps reservists. The MC group was drawn from the same parent unit as the MT intervention group. Although this group had a different deployment date than the MT group, participants were tested at the same time points relative to their own deployment date and were preparing for the same deployment mission to Iraq. A civilian control (CC) group comprised 12 participants (mean age = 34 years, SD = 5.04) who participated in a separate study on MT for teachers. Both groups participated in two testing sessions and performed the Ospan. The MC group also performed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) at each testing session.

The MT group comprised 31 male participants (mean age = 30 years, SD = 8.06) who were recruited from a detachment of U.S. Marine Corps reservists to complete an 8-week MT course specifically designed for military members before deployment. The group was a convenience sample in that the detachment's commanding officers requested the training. Of the 31, one participant was excluded from the analysis for failing to submit any practice logs and another was excluded for failing to follow task instructions. Thus, 29 participants were included in the final analysis.

Mindfulness-Based Mind Fitness Training (MMFT)™

The MT course, referred to as mindfulness-based mind fitness training (MMFT, pronounced M-Fit), was created and delivered by a former U.S. Army officer with many years of mindfulness practice and training in MBSR and trauma resilience. The course matched many features of the well-established (see Grossman et al., 2004) and well-documented MBSR protocol developed by Kabat-Zinn (1990). Similar to MBSR, the course involved 24 hr of class instruction over 8 weeks, with weekly 2-hr meetings (on average) and a full-day silent retreat.

In addition to topics covered in MBSR, MMFT covered topics of central relevance to this population, including how to use mindfulness skills in a group context, integrate practices into the ongoing predeployment training, and apply these skills to counterinsurgency missions. Moreover, MMFT included didactic content to highlight parallels between physical and mental fitness for deployment readiness. The course also added a stress resilience skills section, drawing on concepts from sensorimotor regulation (Ogden, Minton, & Pain, 2006), Somatic Experiencing (Levine, 1997), and the Trauma Resilience Model (Leitch, 2007; Leitch, Vanslyke, & Allen, 2009), which provided specific guidance for using focused attention to reregulate physiological and psychological symptoms following an experience of extreme stress. Thus, MMFT blended mindfulness skills training with concrete applications for the operational environment and information and skills about stress, trauma, and resilience in the body.

To highlight the integration of these three components, each class session consisted of didactic instruction, a group discussion of the didactic topics applied concretely to the deployment environment, and interactive mindfulness-based exercises. At first, exercises emphasized attention on a single focus, such as the breath (e.g., breath awareness practice), "contact points" between body parts and the floor or chair, or sensations within specific body parts (body scan exercise). Later in the course, exercises were added that required attention to body sensations during movement and "shuttling" the attention between inner sensations and outer experiences (i.e., sights or sounds).

MMFT was taught on-site at the unit's various training locations during its predeployment training and certification. Marines were divided into two class groups, organized around the unit's organizational teams, which remained constant throughout the course. To accommodate the military training schedule, MMFT class sessions varied in terms of session length, time of day, and location. During the third and fourth weeks, each participant completed one mandatory 15-min personal interview with the instructor about his progress with mindfulness techniques. Because of conflicts with their predeployment training field exercises, 12 Marines missed some of the class sessions. Some of these Marines were able to attend make-up classes with the other group, and others received personal instruction through phone interviews. Thus, all 31 participants received all course instructions and content.

Participants were instructed to complete 30 min of "homework" each day, practicing MT exercises with audio CDs specifically created by the instructor for this cohort. The homework was comparable to that given in MBSR courses but was frequently completed in a group setting and in short sessions throughout the day. Concentrative focus skills were predominant in the homework exercises, and participants reported that body scan and breath awareness practice were most frequently practiced. Participants were encouraged to be completely candid and accurate in their reporting of individual practice times. It is important to note that the instructor did not have knowledge of individual practice logs. Logs were placed in a sealed envelope, opened only by other members of the research team to track minutes of daily practice. There was a wide degree of variation in participants' homework completion. Participants anecdotally reported being most successful completing homework when there was time scheduled for it during the duty day and they completed it with the group. More details regarding the intervention are available in Stanley, Kiyonaga, Schaldach, and Jha (2010).

Stimuli and Design

All participants took part in two testing sessions, occurring 9 weeks apart for the CC and MC groups and 10 weeks apart (1 week before and 1 week after the MMFT course) for the MT group. Stimuli were presented via E-Prime (Version 1.2; Psychology Software Tools, Pittsburgh, PA), using Dell Vostro 1000 laptops. All participants were given an automated version of the Ospan (Unsworth, Heitz, Schrock, et al., 2005). In addition, both military cohorts were given the PANAS, as well as other instruments outside the scope of this article.

Ospan. Full details of task structure and timing can be found in Unsworth, Heitz, Schrock, et al. (2005). Briefly, the Ospan required participants to solve a series of math problems while trying to remember a sequence of unrelated letters, ranging from three to seven letters in length. At the completion of the task, five scores were calculated. The Ospan score, which is the measure used herein and is most commonly used to index WMC (see Conway et al., 2005), is the sum of all recalled letters from letter sets that were recalled completely in the correct order. For instance, if a participant correctly recalled four letters in a set size of four, five letters in a set size of five, and four letters in a set size of seven, his Ospan score would be 9 (i.e., $4 + 5 + 0$).

PANAS. The PANAS (Watson et al., 1988) consists of two 10-item self-report mood scales measuring the distinct dimensions of positive and negative affect. Participants were asked to rate, on a scale from 1 (*very slightly* or *not at all*) to 5 (*extremely*), to what extent they felt a certain way over the past week. The Positive Affect scale reflects the extent to which a person feels enthusiastic, active, and alert; the Negative Affect scale reflects unpleasant mood states, such as anger, disgust, and fear. The two scales have been shown to be highly internally consistent, uncorrelated, and stable over time.

Data Analysis

Analysis of variance (ANOVA) in control cohorts. To investigate our first question regarding functional impairments that may emerge because of the intensive and persistent demands of the predeployment interval, we conducted an ANOVA on Ospan scores with two factors: time (T1 vs. T2) and group (CC vs. MC). Interaction contrasts were employed for specific paired comparison.

ANOVA in military cohorts. To investigate our second question about the impact of MT practice duration on WMC, we conducted mixed ANOVAs for the Ospan with two factors: time (T1 vs. T2) and group (MC, MT–high practice time, MT–low practice time). The MT subgroups were determined by performing a median split of participant practice times. Our examination of subgroups based on practice time was motivated by several previous reports on the correspondence between MT practice time and beneficial effects on attention (e.g., Brefczynski-Lewis et al., 2007) and affect (e.g., Carmody & Baer, 2008). The range of practice time was 25 to 1,685 min of total practice over the 8 weeks of the course (overall, $M = 400$ min, $SD = 377$; high practice group, $M = 634$ min, $SD = 401$; low practice group, $M = 151$ min, $SD = 62$). We predicted a Time $\times$ Group interaction such that T1 scores would not differ, but T2 scores would differ in favor of the MT–high practice group. Furthermore, we predicted that the MT–high practice group would improve or show minimal changes in Ospan from T1 to T2, but the MC and MT–low practice groups would demonstrate degradations. To address these latter two points, we conducted interaction contrasts for Ospan scores. Although the main question regarding affect was to determine whether changes in affective experience were influenced by MT-related changes in WMC, we conducted ANOVAs for the Positive and Negative Affect scores and group for completeness.

Mediation analyses. To investigate our third question and test our hypothesis that MT may improve cognitive control of emotions, we conducted two mediation analysis. These were conducted on the results of the MT group via Amos 7.0 (Arbuckle, 2006) structural equation modeling software, using maximum likelihood estimation for model fitting. Here, we investigated total minutes of practice as a continuous, rather than as a dichotomous (high vs. low practice time), variable. To reduce a severe right skew in the distribution of minutes of practice, we conducted mediation analyses using the square root of each participant's total minutes of

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reported practice; we refer to this transformed measure as *practice time*. Practice time scores were entered as the independent variable and Ospan scores as the presumed mediator. In two separate analyses, Positive and Negative Affect scores were entered as dependent variables. T1 measures for the dependent variables and the presumed mediator were included as covariates in order to model autoregressive effects (Reichardt & Gollob, 1986).

Results

Control Groups

To explore the potentially depleting nature of the predeployment interval on WMC, we compared CC and MC groups on T1 versus T2 Ospan performance. An ANOVA revealed no main effect of group or time and a marginally significant Group × Time interaction, $F(1, 27) = 3.37$, $p < .08$, for Ospan score. While Ospan scores were higher in the CC vs. MC group at T2 but not T1, these group differences did not reach significance. Nonetheless, the near-significant group × time interaction corresponds with significant deterioration in Ospan scores in the MC group from T1 to T2,
F1 $t(27) = -2.37$, $p < .05$, but not the CC group. Figure 1A illustrates the change-over-time scores (T2 Ospan – T1 Ospan).

Military Groups

To explore whether MT might protect against depletion in WMC over the predeployment interval, we conducted an ANOVA in only the military groups. The ANOVA for Ospan revealed a marginal main effect of time, $F(1, 43) = 3.86$, $p < .06$, no main effect of group, and a significant Group × Time interaction, $F(2, 43) = 7.18$, $p < .01$. While Ospan scores were higher in the high practice group relative to both other groups at T2 but not T1, these group differences were significant for only the high vs. low practice group contrast, $t(43) = 3.17$, $p < .01$. Ospan scores improved from T1 to T2 in the high practice group, $t(43) = 1.82$, $p < .08$. In contrast, Ospan scores deteriorated over time in the MC group, $t(43) = -1.81$, $p < .08$, and the Low Practice group, $t(43) = -3.39$, $p < .01$. (see Figure 1A).

The ANOVA for Negative PANAS revealed no main effect of group, a main effect of time, $F(1, 43) = 13.26$, $p < .001$, with an overall increase in negative affect from T1 to T2, and a significant Group × Time interaction, $F(2, 43) = 3.96$, $p < .05$. The ANOVA for Positive PANAS revealed no main effect of group or time nor an interaction between the two.

To investigate whether our pattern of results could be due to our dichotomization of practice time, we examined correlations between practice time, coded as a continuous variable, and the other measures. The means, standard deviations, and correlations for all variables for the MT group are reported in Table 1. Greater T1
practice time was associated with higher T2 Ospan scores (see Figure 1B), lower T2 Negative PANAS scores (see Figure 2A), F2
and higher T2 Positive PANAS scores (see Figure 2B). Higher T2 Ospan scores were associated with lower T2 Negative PANAS scores (see Figure 2C) but not related to T2 Positive PANAS (see Figure 2D). None of the correlations between T2 Ospan scores and affect were significant for the MC group. These results suggest that at T2, greater practice time is associated with beneficial effects on WMC, positive affect, and negative affect, and that greater WMC is beneficial for negative but not positive affect in only the MT group. Although these results are in line with our hypothesis that MT may improve affective experience via improvements in cognitive control (indexed here by WMC), correlation analyses do not allow for examination of directional relationships. To do so, we conducted the mediation analysis that follows.

Mediation Results

Mediation analyses were conducted for only the MT group. Figure 3 depicts the partial mediation model fitted for the two F3

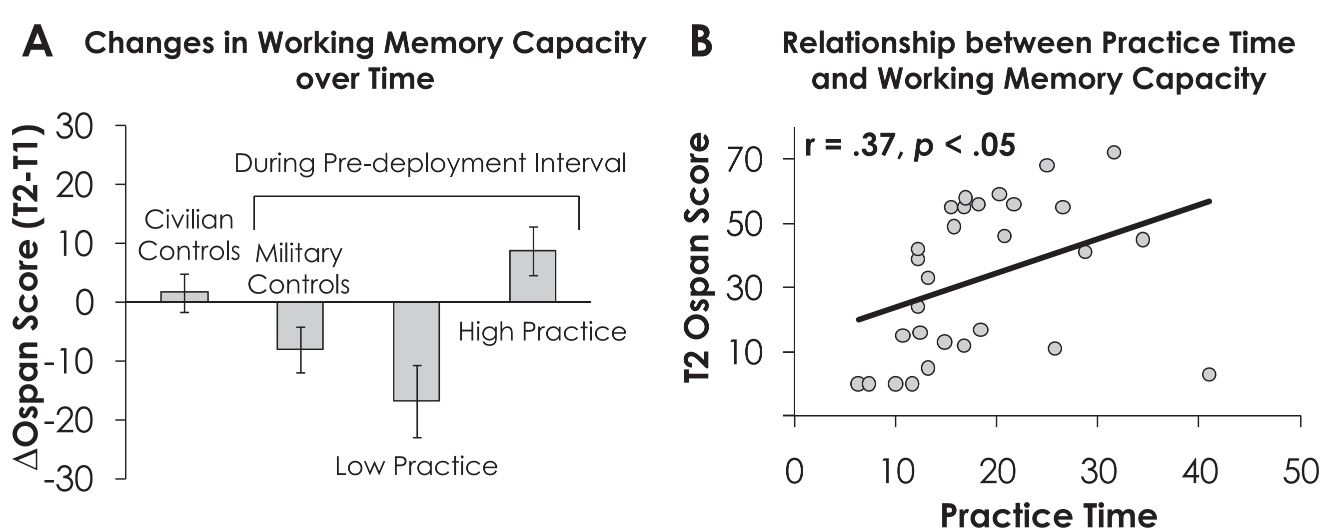

Figure 1. (A) Changes in Ospan scores over time (Time 2 score – Time 1 score) for all four groups. Error bars represent 1 standard error above and below the mean. (B) Scatterplot of practice time (*x*-axis) and Time 2 Ospan score (*y*-axis) for mindfulness training (MT) group. Practice time refers to the square root of the number of minutes spent engaging in formal mindfulness exercises over the duration of the MT course.

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Table 1
Means, Standard Deviations, and Correlations for All Variables

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Practice	18.29	8.27	—	−.112	.373*	−.228	−.357	.379*	.514**
2. Ospan T1	36.17	17.83		—	.384*	−.228	−.337	.381*	−.041
3. Ospan T2	32.59	23.62			—	−.416*	−.572**	.357	.191
4. PANAS Negative Affect T1	36.59	5.28				—	.638**	−.166	−.181
5. PANAS Negative Affect T2	34.07	7.74					—	−.141	−.135
6. PANAS Positive Affect T1	17.72	5.52						—	.495**
7. PANAS Positive Affect T2	20.55	6.79							—

Note. Ospan = operation span task; PANAS = Positive and Negative Affect Schedule; T1 = Time 1; T2 = Time 2.
* $p < .05$, ** $p < .01$.

mediation analyses. In our first analysis, we entered practice time as the independent variable, T2 Ospan score as the potential mediator, and T2 Negative PANAS scores as the dependent variable. The second mediation analysis was identical except that T2 Positive PANAS scores were the dependent variable. Both analyses also included Ospan and PANAS scores at T1 to model autoregressive effects. Standardized coefficients corresponding to the mediation-relevant paths labeled in Figure 3 are shown in

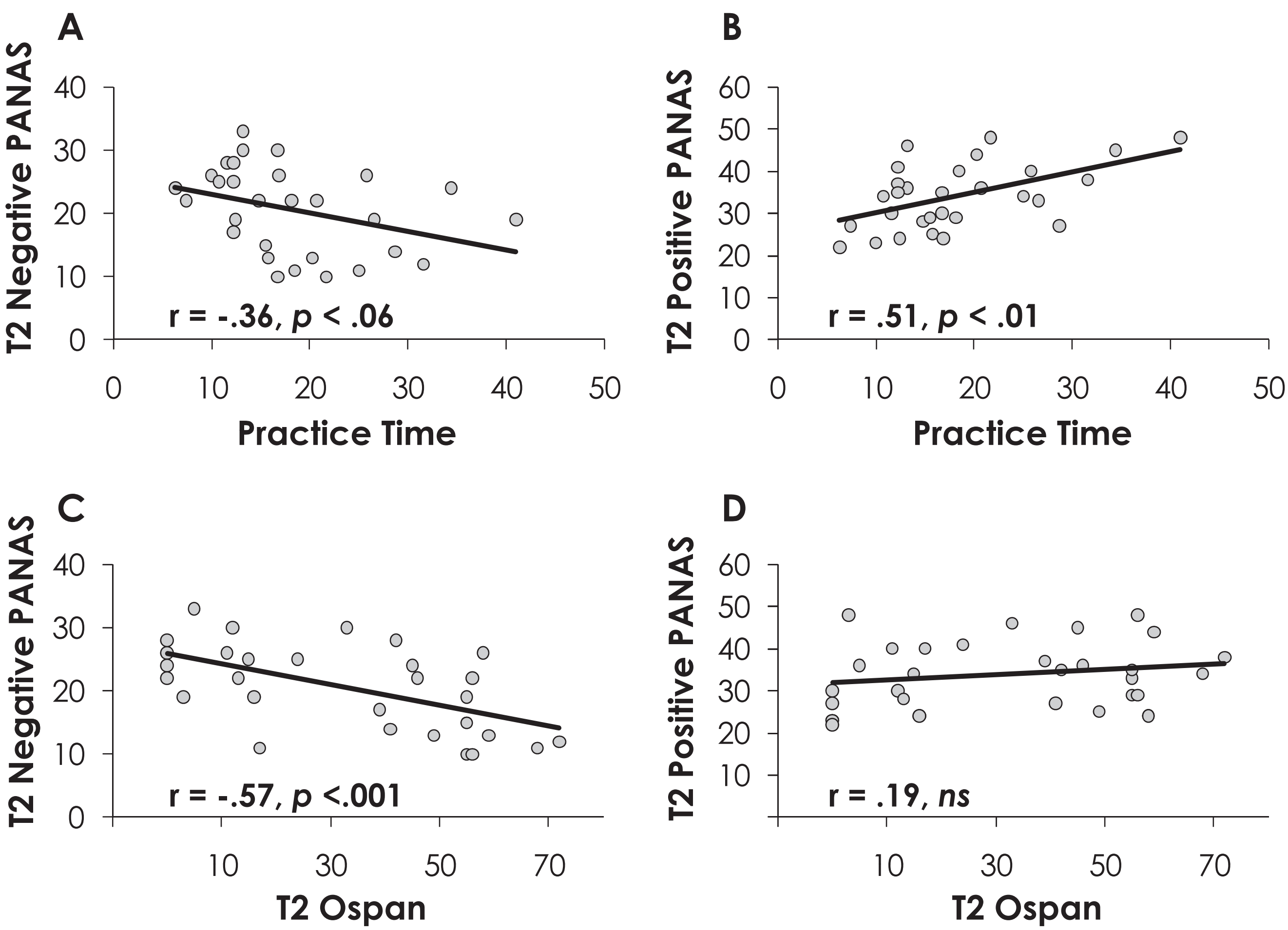

Figure 2. Scatterplots of the relationships between variables among the mindfulness training (MT) group. Practice time refers to the square root of the number of minutes spent engaging in formal mindfulness exercises over the duration of the MT course. (A) Practice time (*x*-axis) and Time 2 Negative PANAS scores (*y*-axis). (B) Practice time (*x*-axis) and Time 2 Positive PANAS scores (*y*-axis). (C) Time 2 Ospan score (*x*-axis) and Time 2 Negative PANAS scores (*y*-axis). (D) Time 2 Ospan score (*x*-axis) and Time 2 Positive PANAS scores (*y*-axis).

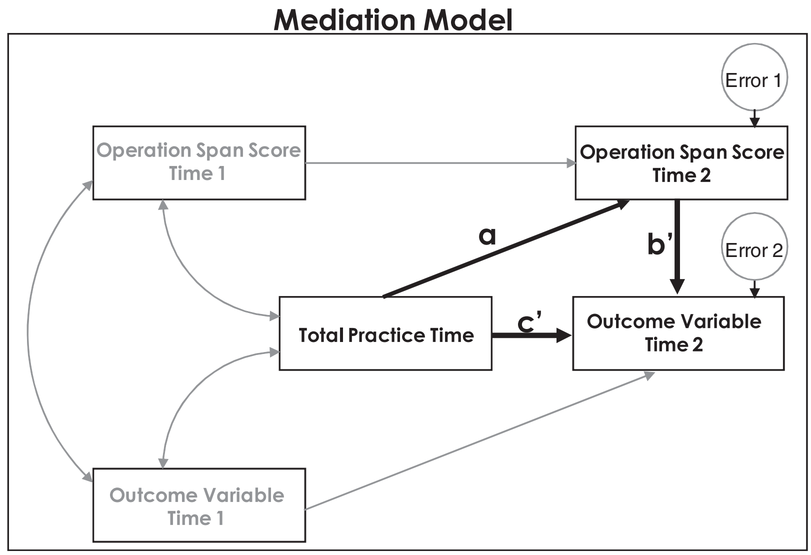

Figure 3. Path diagram depicting the two mediation models. In each case, the independent variable, total practice time, is the square root of minutes of reported practice, and the proposed mediator is the Ospan score measured at Time 2. In one model, the outcome variable is the Positive PANAS score measured at Time 2, and in the other model the outcome variable is the Negative PANAS score measured at Time 2. In both analyses, the independent and outcome variables at Time 1 are included to model autoregressive effects. Paths relevant to mediation analysis are labeled with lowercase letters (unprimed representing total effects and primed representing direct effects) and are depicted with heavy lines.

T2 Table 2. In Figure 3 and Table 2, unprimed letters (i.e., *a, c*) refer to paths corresponding to hypothesized total effects, and primed letters (i.e., b', c') refer analogously to direct effects.

The first step of the Baron and Kenny (1986) method for assessing mediation examines the relationship of the independent variable to the dependent variable without taking into account the purported mediator. The estimate for this relationship is not illustrated in Figure 3, but is represented by *c* in Table 2 (estimate = −.27, $p < .10$). The second step examines the relationship between the independent variable and proposed mediator (path *a*); time spent practicing significantly predicted Ospan scores, such that more practice was associated with Ospan score improvements (estimate = .42, $p < .01$). The third step examines the relationship between the proposed mediator and dependent variable while statistically controlling for the independent variable (path b'); with MT practice time and T1 scores held statistically constant, T2 Ospan scores significantly predicted T2 negative affect. The higher the T2 Ospan score, the lower the T2 Negative PANAS score (estimate = −.34, $p < .05$). The results of these latter two tests are consistent with the presence of a nonzero indirect effect (cf. MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Path c' (estimate = −.13, $p > .3$) was smaller than path *c*, which is consistent with mediation rather than suppression (MacKinnon, Krull, & Lockwood, 2000), and was not statistically significant, which is consistent with complete mediation.

When Positive PANAS scores were entered as the dependent variable, MT practice time alone (controlling for T1 scores) significantly predicted positive affect (path *c*), such that more formal practice time was associated with higher T2 Positive PANAS scores (estimate = .37, $p < .05$). The relationship between MT practice time and T2 Ospan score (path *a*) was the same as that for the previous analysis (estimate = .42, $p < .01$), in which practice time significantly predicted Ospan score. However, the relationship between practice time and T2 Positive PANAS was not mediated by T2 Ospan scores, because when MT practice time and T1 scores were held constant, T2 Ospan scores were not significantly associated with T2 Positive PANAS score (estimate = −.09, $p > .6$).

Thus, there is preliminary support for the hypothesis that MT practice time, WMC, and affect are directly *and* indirectly interrelated. Specifically, mediation analysis results were consistent with direct effects of MT practice time on Positive PANAS scores, and indirect effects, mediated via WMC, of MT practice time on Negative PANAS scores. Finally, to test for an alternative directional hypothesis involving Negative PANAS scores, we entered Negative PANAS scores as mediator and Ospan as dependent variable but we found no support for mediation.

Table 2
Standardized Coefficient Estimates Corresponding to Mediation Analysis Paths

Outcome variable	Path *c*	Path *a*	Path b'	Path c'
PANAS Negative	$-.27^{\dagger}$	$.42^{**}$	$-.34^{*}$	−.13
PANAS Positive	$.37^{*}$	$.42^{**}$	−.09	$.41^{*}$

Note. $n = 29$; PANAS = Positive and Negative Affect Schedule. For outcome variable = PANAS Positive Affect, $\chi^2(2) = 0.79$, $p > .10$; Tucker–Lewis Index (TLI) = 1.23; Incremental Fit Index (IFI) = 1.04; comparative fit index (CFI) = 1.00; root-mean-square error of approximation (RMSEA) = .00. For outcome variable = PANAS Negative Affect, $\chi^2(2) = 0.79$, $p > .10$; TLI = 0.75; IFI = .96; CFI = 0.95; RMSEA = .16.
* $p < .05$. ** $p < .01$. † $p < .05$ (one-tailed).

Discussion

In the current study, we investigated the impact of MT on WMC and affective experience in two military cohorts as they prepared for deployment to Iraq. We investigated three main questions. (a) Do the intense demands of the predeployment interval deplete WMC? We compared changes in Ospan performance over time between a civilian cohort and a predeployment military cohort, neither of which received MT. Whereas Ospan scores were stable in civilians, they degraded over time within the military cohort. The civilian group's pattern of stability is consistent with other studies reporting high Ospan test–retest reliability (e.g., Unsworth, Heitz, Schrock, et al., 2005). Thus, it is unlikely that the military group's pattern of degradation was driven by measurement instability. (b) Might MT bolster WMC and protect against its predeployment-related degradation? We found that similar to the pattern observed in the MC group, those who spent little time engaging in MT exercises (low practice group) saw significant degradation in their Ospan scores over time. In contrast, the high practice group demonstrated modest improvements over time. In addition, when MT practice time was indexed as a continuous measure, greater practice time corresponded to greater WMC at T2. These results are consistent with the view that spending more time engaging in MT exercises may protect against degradation in WMC over the predeployment interval. (c) Do these MT practice-related improvements in WMC correspond to improvements in affective experience? Our mediation analyses revealed that whereas there was a direct benefit of greater practice time on positive affect, the relationship between practice time and negative affect was indirect and mediated by WMC. That is, MT practice-related improvements in WMC corresponded with reductions in negative but not positive affect. These results suggest that the salutary effects of MT practice on negative and positive affect may be engendered by distinct MT-related mechanisms.

Prior studies of individual differences in WMC and emotion regulation report that WMC does not correspond to the natural expression or experience of emotion, but instead corresponds to the ability to successfully regulate emotion (Schmeichel et al., 2008). Perhaps greater MT-related availability of WMC benefited negative affect but not positive affect in the context of the predeployment interval because only the expression or experience of negative affect required regulation. Further examination is warranted to determine whether the differences between MT's influence on positive and negative affect reported here may generalize to other contexts and training regimens (e.g., Fredrickson et al., 2008).

Although our mediation results for negative affect are consistent with the hypothesis that MT may improve cognitive control of emotion, we did not inquire about the specific cognitive strategies our participants used to regulate emotion. Prior work suggests that WMC is beneficial for a variety of cognitive emotion regulation strategies (Schmeichel et al., 2008). As such, we do not know whether WMC was used to bolster selective attentional filtering of negative affective content, executive attention to overcome habitual emotional response tendencies such as rumination, reappraisal processes to reframe negative experiences as more neutral, or whether WMC was used to bolster any number of other possible cognitive strategies. Prior studies of MT report reduced processing of negative distractors (e.g., Ortner et al., 2007) and reduced rumination (e.g., Jain et al., 2007), as well as improvements in selective attention (Jha et al., 2007) and executive attention (e.g., Tang et al., 2007). Given these prior results, future studies should examine whether there may be MT-related improvements in attention-related cognitive strategies for emotion regulation more so than others.

We acknowledge several limitations to our study. Given limited access to military cohorts during the predeployment interval, the MT group was a convenience sample, consisting of a detachment for which the command structure requested the training. The MC group was recruited after the MT group, from the same parent unit, to match many of the MT group's characteristics, including time until deployment and mission during deployment, but there was no random assignment to training conditions. In addition, there was no active comparison intervention and no blinding to condition. Although all studies of MT are limited in the ability to precisely control (and thus randomly assign) the degree and manner in which individuals will engage in MT exercises, we acknowledge that our study design does not allow us to make strong causal inferences about the influence of MT practice on WMC or affect, either in the context of the ANOVAs or mediation analyses. Furthermore, we cannot draw strong causal inferences from the mediation analyses about the influence of WMC on affect. This latter issue is not a weakness of our study, per se, but a limitation of mediation analysis, which can only provide provisional support for such directional hypotheses and serve as a basis for corroborative investigations. In addition, our limited access to predeployment military cohorts resulted in a small sample size; these results should be replicated in larger samples.

Our interpretation of results hinges on the view that MT practice time corresponds to changes in information processing developed through repeated engagement in MT exercises. Yet, confounded with actual practice time are several other potentially crucial factors, each of which might have caused part or even all of the changes observed in WMC and affect. One factor that could be confounded with MT practice time is applied mental effort, the amount of hypothetical nonspecific mental effort that a participant engages during task performance. Individuals may have varied in the amount of mental effort they expended during performance of the experimental battery at T2 for several reasons. For example, their belief that the intervention was beneficial or that it is socially desirable to follow instructions could lead to greater time spent engaging in MT exercises and more applied effort during the T2 test battery. In either case, improvements in performance that correspond with greater MT practice time might not reflect MT-related alterations in cognitive or affective functioning. Instead, they may reflect greater applied effort expended during performance of the T2 test battery.

Although it is logically plausible that performance benefits appearing to correspond with MT practice time resulted from changes in applied effort as opposed to MT-related functional changes, we would expect applied effort to influence performance globally on all performance measures. We have no a priori prediction to explain why effort would have specific effects, altering some but not other performance measures. In the current study, changes in Ospan scores corresponded to changes in negative but not positive affect. Thus, because MT practice corresponds to changes in only a subset of interrelationships between measures, the applied effort argument is somewhat weakened. Nonetheless,

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future studies should examine whether there are specific effects (as opposed to global benefits across all measures) associated with MT practice time to ensure that differences are not due to differences in applied mental effort.

Another factor that could be confounded with MT practice time is intrinsic individual differences in coping, resilience, and sensitivity to stress. Intrinsic resilience in the face of high-stress circumstances has been proposed to be a composite of many biologically determined variations in individuals' ability to perform well under cognitively and affectively demanding circumstances (Parkes, 1986). From this point of view, high-resilience individuals might be identified as those who demonstrate improvements or no change in Ospan scores, whereas low-resilience individuals might demonstrate decrements in Ospan scores over the course of the predeployment interval. Moreover, individuals with high versus low resilience should demonstrate better negative emotion regulation at T2 when predeployment stressors are potentially greatest. We found that MT practice time corresponded with improvements in WMC over time and lower negative affect at T2. Perhaps practice time itself was epiphenomenal and unessential in producing this pattern of results. That is, perhaps high- versus low-resilience individuals happen to spend more time engaging in MT exercises simply because they have the capacity to do so. If the correspondence between Ospan scores and negative affect reflects intrinsic resilience as opposed to MT-related functional changes, similar individual differences should have been found in the MC group. Yet, they were not observed. The correlation between changes in Ospan scores over time and negative affect at T2 was not significant in the MC group. Thus, the lack of correspondence between individual difference profiles across the MT and MC groups somewhat undermines the argument that intrinsic differences alone can explain our results.

If MT practice time was not epiphenomenal but did, in fact, lead to functional changes, it would be useful to understand the factors that determined how much time individuals spent engaging in MT exercises. In a companion paper (Stanley et al., 2010), we examine several demographic variables that may correspond to practice time. Personal history, personality profiles, coping styles, and other individual differences of participants receiving MT should be examined in greater detail in the future.

Apart from our analyses of the MT group, our analyses of data from the civilian versus military control groups highlight the apparent costs of the predeployment interval. These are striking, given that the intention of predeployment training is to cognitively, physically, and emotionally prepare service members for deployment. It is important to note that whereas no other studies have reported depletion of WMC over the predeployment period, there is ample evidence of degradation in other cognitive functions as well as changes in negative and positive affect during this interval in other cohorts (Bolton et al., 2001; MacDonald et al., 1998; Maguen et al., 2008).

Although our study was concerned with exploring whether MT might provide prophylaxis from functional impairments experienced in specific military contexts, the protective effects of MT observed herein suggest that MT might be effective as a resilience training protocol more generally. For example, MT may be beneficial to a number of professions who require periods of intensive physical, cognitive, and emotional demands, such as firefighters, police officers, other first responders, and crisis workers. Similarly, individuals who are about to face intensive increases in cognitive and affective challenges, such as impending eldercare or childbirth, may likewise benefit. A feature shared by all of these contexts is that situational demands are likely to tax and potentially deplete WMC. Reduced WMC may increase the likelihood of cognitive failures and affective dysregulation (Brewin & Smart, 2005; Schmeichel, 2007; Schmeichel et al., 2008). Our findings suggest that MT practice might serve as a way to cultivate a WMC "reserve" that could be used in demanding contexts to protect against such functional impairments. The concept of "cognitive reserve" (Stern, 2002) has been productive for understanding how to protect against age-related functional decline; it may provide a parallel framework to clarify the putative protective effects of MT.

In sum, the current study suggests that WMC may be bolstered by MT practice and that MT practice-related improvements in WMC may mitigate negative affect. In addition, our results suggest that MT practice may support positive affect, although through other mechanisms that should be further explored. To our knowledge, this is the first study to empirically examine MT's protective effects within the context of predeployment military training. Although our results are preliminary, they do suggest that more research is warranted to determine whether MT could be a broadly accessible and easy to disseminate prevention intervention in military cohorts. Not only might MT reduce the likelihood of long-term psychological dysfunction such as posttraumatic stress and anxiety disorders (Brewin & Smart, 2005; Robinson, 2007), but MT could provide greater cognitive resources for soldiers to act ethically and effectively in the morally ambiguous and emotionally challenging counterinsurgency environment.

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