Mindfulness does not increase task performance:

A study into mindfulness, arousal, task focus, and memory workload.

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Abstract

Mindfulness refers to a trainable state of consciousness focused on accepting present experiences. Mindfulness meditation is increasingly popular and has found its way to organizations. On the one hand, mindfulness predicts well-being, which is well-documented. On the other hand, mindfulness could also affect task performance, which is less frequently researched. This research assumed that mindfulness training would reduce arousal and increase task focus, which should in turn be associated with better task performance on high workload tasks. Moreover, we examined the possible interactive effects of arousal reduction and memory workload. Ninety-five participants, in three experimental conditions (*Mindful, Mindless*, *Control*), performed a visual search task with two different workloads. A MANOVA was conducted to examine if mindfulness decreased arousal and increased task focus. The mindfulness condition reported lower arousal than the control condition, but not lower than the mindless condition. The groups did not differ in task focus. Hierarchical multiple regression was conducted to see if task focus and arousal predicted task performance and whether arousal interacted with memory workload. Contrary to the expectations, no main effect of task focus, and no interactive effects on task performance were found. Explanations of the results, alternative results, scientific and practical implications, strengths and limitations, and suggestions for future research are given in the discussion. While there does not seem to be much harm in mindfulness meditation for increasing individual workers' well-being, we see no reason to implement mindfulness programs to increase task performance.

Keywords: Mindfulness, Arousal, Focus, Memory Workload, Performance, Meditation

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Introduction

Mindfulness refers to a state of consciousness that is grounded in Eastern Buddhist traditions. This state revolves around attending to moment-to-moment experiences with awareness (Reid, 2011). The presumed positive effects of state mindfulness are that a person can be less reactive to experiences, and learning to accept all experiences, positive and negative. This acceptance, in turn, would reduce a person's overall suffering and should increase his or her sense of well-being (Germer, 2004). It is not surprising that these desirable effects have led to the development of mindfulness training programs.

Mindfulness meditation (from now on referred to as *mindfulness)* is a trainable skill that makes the practitioner focused on the present. Furthermore, it trains the user to be non-judgmental of the present. By reducing the attention for the future or the past and by detaching from stressors, a mindful person can be more focused on the current task or experiences (Germer, 2004; Hafenbrack & Vohs, 2018). Training mindfulness is presumed to lead to a more mindful state of mind, and thus to more well-being. Because mindfulness is inherently a state of mind, it is possible to induce state-mindfulness and examine its effects experimentally (Tuckey, Sonnentag, & Bryan, 2018).

A meta-analysis of the effects of a group-based mindfulness program called Mindfulness-based stress reduction showed that mindfulness had a medium positive effect on physical and mental health (Grossman, Niemann, Schmidt, & Walach, 2004). Further, mindfulness-based therapy has been found useful in clinical settings, especially in reducing anxiety, depression, and stress, as found in another meta-analysis (Khoury et al., 2013). Mindfulness can benefit patients with cancer by helping them adjust to the psychosocial distress caused by the disease (Ledesma & Kumano, 2009). Finally, Khoury, Sharma, Rush, and Fournier (2015) conclude in their meta-analysis that mindfulness has a small effect on burnout, a large effect on stress reduction along with moderate effects on anxiety, depression, distress, and quality of life. Thus, the intended positive outcomes of mindfulness are well-supported by research.

These positive outcomes might explain the popularity of mindfulness in society. A study showed that in 2012, 8.0% of the US population engaged in mindfulness practices (Clarke, Black, Stussman, Barnes, & Nahin, 2015). One of the most popular apps on mindfulness called *"Headspace"* has over 150 million downloads and is estimated to be worth 250 million US dollars, and generates revenue of 50 million US dollars a year (Chaykowski, 2017). Even children are engaging in mindfulness today (Black, Clarke, Barnes, Stussman, & Nahin, 2015).

Mindfulness at work

Just as mindfulness is big in society, the practice is also widespread in companies. In the US, 8% of the workforce practiced mindfulness techniques in 2007. Among white-collar workers, this figure is even higher, with over 12% of the workers engaging in mindfulness meditation. Similar numbers were found for the practice of yoga, which contains mindfulness elements (Kachan et al., 2017).

As may be expected, the primary benefit of mindfulness practice at work is health-related. Mindfulness reduces the adverse effects of stress (Kachan et al., 2017) and Brown and Ryan (2003) state that mindfulness helps workers regulate positive emotions and health behavior, leading to positive health outcomes for workers. Mindfulness has the potential to counter some of the current work challenges such as burnout, stress, and long workdays (Reb & Choi, 2014). Therefore, being socially responsible, i.e., taking care of the well-being of their employees, is one reason why companies implement mindfulness programs. However, mindfulness could also lead to tangible benefits for organizations in terms of their profitability. That is, profit is the incentive for many companies to develop new solutions to societal problems, host employees, and care for their employees (Friedman, 1970). The *happy-productive worker hypothesis* predicts that higher psychological well-being is tied to higher individual task performance (Cropanzano & Wright, 2001) and that lower well-being, such as high levels of emotional exhaustion, leads to lower individual task performance. Ultimately, higher individual task performance will also lead to better organizational outcomes (Taris & Schreurs, 2009) such as profit. Furthermore, health promotion on the workplace can lead to a financial return on investment by increasing productivity (Bertera, 1990), while health problems can lead to lower worker productivity (Davis, Collins, Doty, Ho, & Holmgren, 2005). Thus, implementing well-being programs can be in the interest of organizations.

Because mindfulness increases well-being, these findings suggest an indirect link between mindfulness promotion in the workplace and organizational outcomes; mindfulness could improve individual performance, which will, in turn, lead to higher organizational performance. Thus, whereas the possible individual health benefits of mindfulness at work look promising, for organizations implementing mindfulness is even more interesting if mindfulness also improves organizational goals such as societal impact, innovation, and profit.

The present focuses on the associations among mindfulness training and performance, assuming that the beneficial effects of mindfulness on task performance are due to higher levels of task focus and lower levels of arousal. Moreover, we examine whether the effects of arousal on performance are moderated by workload. If there is a link between being mindful and task performance, understanding this link might help create guidelines for mindfulness at work, e.g., if state mindfulness predicts short term task performance and long term health outcomes, it might affect the timing of mindfulness practice during the day of an employee. Furthermore, as the practice of mindfulness continues to grow, understanding more of the processes responsible for the effects of mindfulness becomes increasingly important, to ensure that organizations can use it in a beneficial, non-harmful, way.

Mindfulness, task focus, and task performance

Thus far, little research has been done on the effect of mindfulness on task performance. Hafenbrack and Vohs (2018) set out to research the effect in a series of experiments. The researchers used different tasks, including anagram solving, a creativity task, and editorial tasks. In four out of five experiments, participants in the mindfulness condition scored comparably on task performance to the participants in other conditions. However, the participants in the mindfulness condition reported higher task focus but lower task motivation. The higher task focus of participants in the mindfulness condition may be explained due to the nature of mindfulness meditation. By being mindful, someone is in the present in a non-judgemental way and can, therefore, detach from stressors in the past or future (Germer, 2004). This rationale was tested with serial mediation analysis, showing that mindfulness led to a detachment from stressors in the future or past, which in turn increased task focus. Task focus, in turn, was a predictor for task performance (Hafenbrack & Vohs, 2018).

Mindfulness, arousal, and task performance

The increased focus and the subsequent expected increase in task performance were negated by a decrease in task motivation in mindful participants (Hafenbrack & Vohs, 2018). Task motivation is the desire to change the present and wanting a different future state. If a person strives to achieve such a state, he or she will try hard to attain that state (Locke & Latham, 2006). Ajzen (1991) showed that the *intention*, or *motivation*, to perform well on a task is positively correlated to the actual performance on the said task. This link is a common theme in psychological theory and has been demonstrated in a large body of empirical research (Locke & Latham, 2002). The reduction in motivation can be explained by the non-judgment part of mindfulness (Germer, 2004), with being non-judgemental of the present meaning that one will not experience the desire to change the present. However, Hafenbrack and Vohs (2018) showed that the reduction in future focus predicted a reduction in arousal, which in turn predicted reduced motivation in their studies. Concluded was that since mindfulness both increases task focus and decreases task motivation, its net effect on task performance is absent.

Arousal, workload, and task performance

In the experiments of Hafenbrack and Vohs (2018), mindfulness effect on motivation was serially mediated by reducing the future focus, which in turn lowered arousal. The circumplex model of affect by Russell (1980) shows arousal as a spectrum ranging from tired and sleepy to alarmed, tense, and aroused. Arousal is defined as non-specified physiological activity and contains the directional component of alertness. It can be manipulated and measured in different ways (Anderson & Revelle, 1983). One way to increase arousal is the administration of caffeine (Revelle, 1987) or physical exercise (Lambourne & Tomporowski, 2010). The reduction of arousal is expected when someone is practicing mindful meditation. Mindfulness is used for precisely that reason in the regulation of arousal problems in children with ADHD (Zylowska et al., 2008).

Hebb (1955) showed that there is an optimal level of arousal for task performance and that one can be under-aroused or over-aroused. The effect of arousal on task performance has been tested in different studies. The type of Stroop task (high competing vs. low competing) interacts with arousal, high competing versions are facilitated by arousal, and low competing versions are hindered by arousal (Pallak, Pittman, Heller, & Munson, 1975). Anderson and Revelle (1983) performed an arousal experiment with two different versions of the same task. By administering caffeine to increase arousal or placebo, they showed that arousal was beneficial for low short term memory workload tasks, but deterrent for high short term memory workload tasks, which is in line with the research by Pallak et al. (1975). Several other experiments showed that some tasks are indeed facilitated by arousal, and some tasks are hindered by arousal, based on their short term memory workload (Revelle, 1987). Thus, arousal is predicted to have no direct effect on task performance, but an interactive effect with the memory workload of the task.

Current research

The interaction between arousal and short term memory workload is mostly tested with arousal manipulations to increase arousal such as caffeine. Since mindfulness decreases arousal, this research aims to explore its interaction with memory workload as well. The joint effect of the short term memory workload of a task and mindfulness has not been tested before. Furthermore, contradictory to previous research, there are reasons to believe that mindfulness can increase task performance. Mindfulness increases task focus and decreases arousal. Thus it should improve task performance on tasks facilitated by low arousal. This research aims to give insight into the research question *“Is there an interaction effect of mindfulness’ arousal reduction and short term memory workload on task performance, and what role does task focus have?”*

An online experiment was conducted to examine the research question. The experiment had three experimental conditions: a *mindfulness* condition, another, non-mindful low arousal (*mindless*) condition, and a *control* condition. Predicted is that the mindfulness condition lowers arousal; Arousal is predicted to have no direct effect on task performance.

Hypothesis 1a: Mindfulness reduces state arousal.

Hypothesis 1b: Arousal alone does not predict task performance.

Furthermore, due to the detachment of stressors and increasing the focus on the present, the mindfulness condition is expected to increase task focus. This increased focus is predicted to improve task performance.

Hypothesis 2a: Mindfulness increases task focus

Hypothesis 2b: Task focus predicts task performance

This experiment will use two versions of the same task, one with high memory workload and one with low memory workload. Because of the expected interaction effect of arousal and memory workload, the following two predictions are made:

Hypothesis 3a: Arousal facilitates task performance on low short term memory workload tasks.

Hypothesis 3b: Arousal hinders task performance on high short term memory workload tasks.

The hypotheses are schematically depicted in Figure 1.

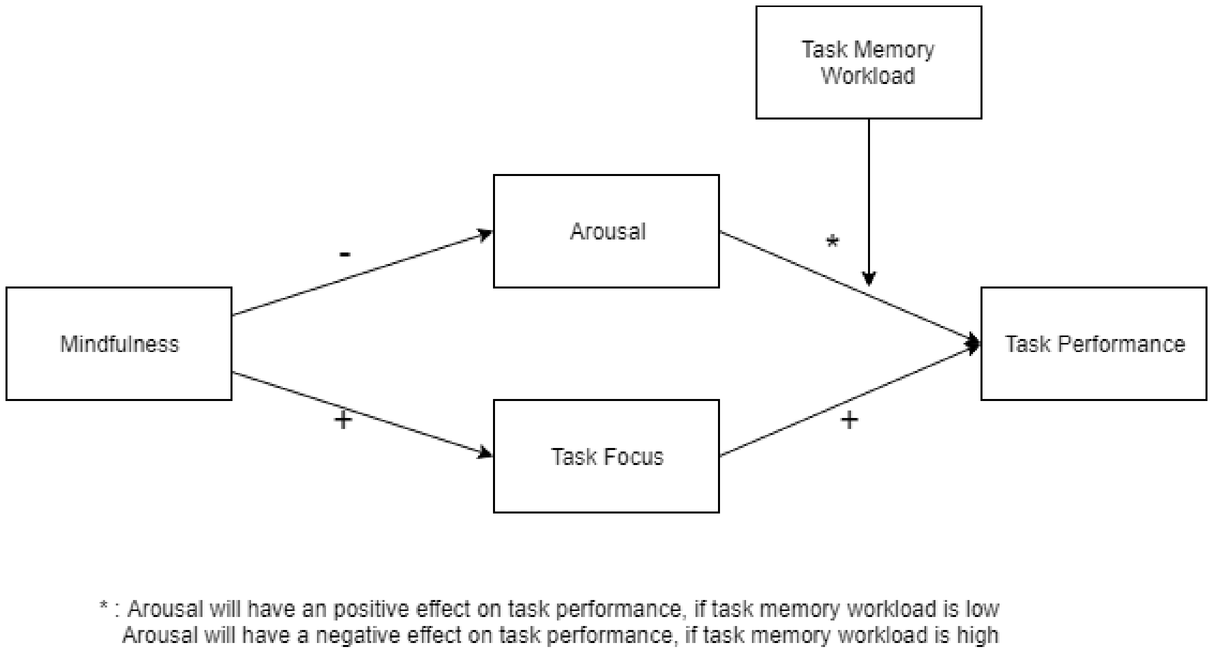

Figure 1. A schematic representation of the expected effects of mindfulness on task performance. The minus signs indicate a negative effect, while the plus signs indicate a positive effect.

Method

Participants and research design

The hypotheses were tested in an experimental study. One hundred and twenty-five participants signed up for the study. Participants were recruited via posters at Utrecht University and social media posts. Of all sign-ups 95 participants finished the study (34 male, 60 female, 1 other, M_{age} = 22.52, *SD* = 2.96). Most participants were students (80%) and highly educated (84.2%). Participants could participate in a web-browser at any place. However, a quiet room without distractions was advised. Participants needed to own, or have access to, ear-buds or headphones for the manipulation; there were no further exclusion criteria. Student participants received 0.75 course credit hours for their participation; non-students did not receive any compensation. No ethical approval was needed because participation was voluntary, participants were not deceived or harmed during the experiment, participants could stop at any time, participation was anonymous, and there was no known or theoretical risk involved.

The study involved two between-subjects factors and one within-subject factor. *The experimental condition* and *task order* were between-subject factors. *Memory workload* was the within-subject factor. The primary outcome variables were *arousal*, *task focus*, and *task performance*.

Task

Two versions of the same task were used in this experiment. The task is based on a design by Folkard, Knauth, and Monk (1976) who researched the interactive effects of body temperature and memory workload on task performance. It was also used in workload and arousal research by Anderson and Revelle (1983). Participants had to search for a 2-letter (low memory workload) or a 6-letter target (high memory workload) in a grid of 20-letter strings. The target was visible on the screen. However, participants were encouraged to keep track of found letters in their mind. When the target was absent, the participant had to click on the string, while refraining from clicking when the target was present. This “reverse” clicking was used due to limitations in the survey software. The task was adapted to be feasible in the online survey host Qualtrics. Instead of a long list of trials, the trials were presented in a six-by-four grid. Furthermore, in the original studies, participants had to indicate whether a target was absent or present. In this study, one could only indirectly indicate a target present by not clicking (see Figure 2).

Figure 2. An example of the search task used in this research. The target (the letters [J Z Y E]) must all be present in a string of 20 random letters. If not all letters were present, the participant clicked on the white rectangle, making the rectangle black. Multiple blocks, with the same target, were present on a single page. The 4-letter task was used during the practice round.

Participants completed the high and low-memory workload conditions twice. Because of the possible learning effect of the task, counterbalance groups were created. Participants were distributed equally in either in the low-high-high-low (2662) or high-low-low-high (6226) order. Participants performed all two-minute tasks in a row, with three 15-second breaks in between the four tasks. Task performance was measured by the number of correct black squares in two minutes. Task accuracy was also measured by taking the percentage of correct black squares. To prevent left-skewed results, thus increasing the chance of normally distributed results, the number of trials per task was higher than participants could finish in two minutes.

Manipulations and procedure

To induce state mindfulness, participants listened to a 10-minute English recording of a mindfulness body scan. The body scan guided the participant to focus on all parts of their body in a non-judgmental way and was easy to do without prior experience with mindfulness. An excerpt of this is: *"Notice that you are breathing, breathe deep and fully, and notice your breath flowing in and out of your body. Without trying to control it in any way, focus your attention on your breath for a few moments; you are breathing."* A body scan has been used successfully in several previous studies to induce mindfulness in participants (Cropley, Ussher, & Charitou, 2007; Hafenbrack & Vohs, 2018; Ostafin & Kassman, 2012).

In the low-arousal, non-mindful (from now on *mindless*) condition participants listened to a 10-minute English recording about the natural history of Hampshire, UK. This recording was previously used by Cropley et al. (2007). During the pilot of this study, participants reported that they felt sleepy and low in arousal after listening to the recording. This condition aimed to induce a state of low arousal, but not mindfulness. The control group conducted tasks without manipulation. The manipulations were provided by Mark Cropley and embedded in Qualtrics.

After signing an informed consent form, participants received general instructions, were asked to go to a quiet room, reduce distractions, and test their audio output. Upon continuing, participants were randomly assigned to one of the three experimental conditions (mindful, mindless or control) and one of two task orders (2662 or 6226).

Following the general instructions, participants received task instructions and a two-minute practice round with a 4-letter target. After the practice round the manipulation took place for the mindful and mindless conditions, after which the arousal questionnaire was filled in. The participants in the no-manipulation control condition immediately proceeded to the arousal questionnaire. After the arousal questionnaire, participants performed the search tasks. After finishing the last round of tasks, participants filled in a task focus survey and demographics. Afterward, there was a debriefing.

Measures

State arousal was measured with a five-item survey, asking participants how alert, active, excited, bored, and sleepy they felt. Responses were measured on a five-point Likert scale (1 = very slightly or not at all; 5 = extremely), with the items covering boredom and sleepiness reverse-scored. An example item is *"How alert do you feel?"* The sum of all responses was computed, with a high score indicating a high level of arousal. The internal consistency was relatively low ($\alpha = .67$). However, no items could be deleted to increase this consistency.

Task focus was measured with a six-item survey. Three items covered preoccupation by the task, and three items covered thoughts not related to the task. Responses were measured on a five-point Likert scale (1 = very slightly or not at all; 5 = extremely), with the items covering thoughts not related to the task reverse scored. An example item of preoccupation is: *"To what extent were you fully absorbed by the task?"*; an example item of non-related thoughts is: *"I was daydreaming about something else during the task."* Responses were totaled, with a high score indicating a high level of task focus. Internal consistency was good ($\alpha = .87$). Both measures were taken from the research by Hafenbrack and Vohs (2018)

Data analysis

To test whether the manipulation influenced arousal and task focus (hypotheses 1a and 2a), a factorial MANOVA was conducted. The independent variable was the experimental condition. The dependent variables are task focus and state-arousal. For the MANOVA an alpha of .05 was used.

To test whether arousal and task focus influence task performance (hypotheses 1b and 2b) and to test the interactive effect of arousal and workload (hypotheses 3a and 3b) hierarchical multiple regression was conducted. The predictors were workload, arousal, arousal and workload interaction, and task focus. The dependent variable was task performance. An alpha of .01 was used for the multiple regression.

Data pre-processing

The survey and tasks were created in Qualtrics. For data processing and analysis, SPSS version 25 and Microsoft Excel were used. Participants that did not finish the experiment were removed from the data. For task performance, scores and accuracy were measured. Outliers were removed and counterbalanced groups compared, this is further explained in the preliminary analysis. All assumptions were checked, showing that these were met for both analyses.

To be able to conduct the multiple regression, a data restructure was performed after conducting the MANOVA. Every participant provided two entries to the data set, i.e., an entry for the low memory workload condition and one for the high memory workload condition. This doubled the data for the multiple regression only. Note that this implies that the data were no longer statistically independent since all participants contributed two records to the data set. Since the number of records per participant was very small, we refrained from using multilevel analysis.

Instead, since statistical dependence of observations tends to lead to inflated alpha levels, we decided to test at $p < .01$ rather than $p < .05$.

Results

Effect of the group on arousal and task focus

Preliminary analyses

To see whether multivariate tests could be performed, the correlation between the dependent variables: arousal, and task focus, was calculated. The Mahalanobis distance of every participant based on arousal and focus was calculated. Based on the critical chi-squared ($\chi^2 = 5.99$, $df = 2$, $\alpha = .05$), seven outliers were removed. Arousal and task focus had a small, but significant, correlation, $r = .22$, $p = .044$.

Hypothesis testing

A MANOVA was calculated to see whether the experimental condition influenced arousal and task focus. The results of the multivariate analysis showed an effect of the experimental condition on the levels of state arousal and task focus. Pillai's trace indicated that there was a significant effect of group on arousal and focus, $V = .486$, $F_{(4,170)} = 13.64$, $p < .001$. The follow-up univariate analysis showed no significance for task focus, $F_{(2,85)} = 2.82$, $p = .065$. A medium effect of groups on arousal, $F_{(2,85)} = 35.44$, $p < .001$, $\eta^2 = .46$, was found. A Games-Howell post hoc analysis revealed that the control group ($M = 16.63$, $SD = 1.83$) had significant higher arousal than the mindful ($M = 12.79$, $SD = 2.61$, $p < .001$) and mindless ($M = 11.62$, $SD = 2.68$, $p < .001$) conditions. There was no significant difference ($p = .22$) between the mindful and mindless condition. For all outcomes, see Table 1. Thus, mindfulness decreased arousal (Hypothesis 1a is supported); however, mindfulness did not reduce arousal more than the mindless condition (Hypothesis 2a is rejected; mindfulness did not increase task focus). A post hoc power analysis was conducted using GPower (Faul & Erdfelder, 1992). A sample size of 87 instead of 88 was used, as power analysis requires the sample size to be equal for all groups. With a sample size of 87, three groups, and two response variables, calculations showed high power at an alpha of .05 with *Pillai's value* = .486, $f_2 = 0.32$, power $(1 - \beta) > .99$.

Table 1

Means and standard deviations of arousal and task focus of the experimental conditions.

Group	*n*	$M_{Arousal}$[A]	$SD_{arousal}$	M_{Focus}[B]	SD_{Focus}
Mindful	29	12.79	2.61	26.14	2.57
Mindless	29	11.62	2.68	24.72	3.37
Control	30	16.63	1.82	26.27	2.21

Note: [A] The *control* condition had significantly higher arousal than the *mindful* and *mindless* condition at $p < .001$. [B] There was no significant difference between the three groups on task focus.

Effect of arousal, workload and task focus on task performance

Preliminary analysis

In previous research, the accuracy of all participants on the search task was high (Anderson & Revelle, 1983; Folkard et al., 1976). The accuracy of all participants was calculated to see whether participants were accurate on this digital version of the task. Accuracy was consistently high for all participants (M = 97.81%, SD = 3.01%). One of the participants had an accuracy of more than 7*SD* lower (74.30%) than the mean accuracy. This was interpreted as highly unlikely and was attributed to other variables such as holding a conversation while performing the task. Subsequently, this participant was removed from the data.

To see if task order affected task performance, a one-way ANOVA was performed on total task performance. There was no significance difference between the 6226 order (*M* = 115.84, *SD* = 38.53) and the 2662 order (*M* = 118.43, *SD* = 39.16), $F_{(1,85)} = .10$, $p = .76$. The orders were therefore treated as equal, and no control for task order was included in further analyses.

Hypothesis testing

Hierarchical multiple linear regression was used to predict task performance from workload, arousal, the interaction between workload and arousal, and task focus. The hierarchical multiple regression showed a significant regression model for the predictor workload on task performance ($F_{(1,172)} = 71.79$, $p < .001$, $R^2 = .294$). Univariate analysis showed that on low workload tasks (*M* = 71.86, *SD* = 23.86) participants scored better than on high workload tasks (*M* = 45.29, *SD* = 16.93), $F_{(1,172)} = 71.79$, $p = <.001$, $\eta^2 = .294$.

As expected, adding arousal did not improve the regression model ($F_{(1,171)} = 2.38$, $p = .125$, $\Delta R^2 = .01$; hypothesis 1b supported). Contrary to the expectation, workload interaction and task focus did not improve the regression model (see Table 2). Hypothesis 2b, 3a, and 3b were rejected; there was no interactive effect between arousal and workload, and task focus did not predict task performance. All steps of the regression are given in Table 3.

A post hoc power calculation was conducted using GPower. Using a sample size of 174, with 4 predictors and an effect size of $R^2 = .304$ the calculations showed high achieved power at an alpha of .01, power $(1 - \beta) > .99$. Because of the data restructuring, another power calculation was done with the original sample size of 87. Using a sample size of 87, with 4 predictors and an effect size of $R^2 = .304$ the calculations showed high achieved power at an alpha of .01, power $(1 - \beta) > .99$. This indicates that if there was an effect of the predictors on task performance, there is a high statistical chance that the analysis would have found it.

Table 2

Task performance, as predicted by the models of the hierarchical multiple regression. Workload alone is a significant predictor of task performance. Adding the other variables did not significantly improve the regression model.

	Models											
	Model 1			Model 2			Model 3			Model 4		
Predictors	B	β	*p*	B	β	*p*	B	β	*p*	B	β	*p*
Workload	-26.57	-.54	<.001*	-26.57	-.54	<.001*	-26.57	-.54	<.001*	-26.57	-.54	<.001*
Arousal				-.76	-.10	.125	-.90	-.12	.563	-.92	-.12	.555
Workload*Arousal							.10	.02	.922	.10	.02	.922
Task Focus										.12	.01	.835
ΔR^2	.294, $p<.001$			.01, $p = .125$			.00, $p = .922$			.00, $p = .835$		
Total R^2	.294, $p<.001$			.304, $p<.001$			.304, $p<.001$			.304, $p<.001$		

Note: * *is significant at* $\alpha = 0.01$

Table 3

The linear model of hypothesized predictors of task performance, with 95% confidence intervals reported in parentheses. Workload is defined with dummy variables (1 = Low Memory Workload, 2 = High Memory Workload).

		B	SE B	β	ΔR^2	*p*
Step 1						
	Workload	-26.57 (-32.77, -20.38)	3.14	-.54	.294	<.001*
Step 2						
	Workload	-26.57 (-32.74, -20.41)	3.12	-.54		<.001*
	Arousal	-.76 (-1.73, .21)	.49	-.10	.01	.125
Step 3						
	Workload	-26.57 (-32.76, -20.39)	3.13	-.54		<.001*
	Arousal	-.90 (-3.97, -2.17)	1.56	-.12		.563
	Workload*Arousal	.10 (-1.85, 2.04)	.98	.02	.00	.922
Step 4						
	Workload	-26.57 (-32.78, -20.37)	3.14	-.54		<.001*
	Arousal	-.92 (-4.01, 2.16)	1.56	-.12		.555
	Workload*Arousal	.10 (-1.85, 2.04)	.99	.02		.922
	Task focus	.12 (-1.01, 1.25)	.57	.01	.00	.835

Note: * is significant at α = 0.01

Discussion

This research set out to examine the relationship between mindfulness and task performance. We expected that mindfulness would increase task focus, and that task focus would increase task performance. Unexpectedly, the results of this study showed that mindfulness did not improve task focus, and that task focus did not increase task performance. Furthermore, we expected mindfulness to reduce arousal. This was expected to have no main effect on task performance, but to be moderated by the memory workload of the task. Arousal was expected to facilitate performance in high memory workload tasks, but to hinder performance in low memory workload tasks. The findings show that mindfulness did indeed decrease arousal, but not more than the mindless condition. As expected, arousal alone did not directly influence task performance. However, contrary to the expectations, no interactive effect between arousal and memory workload was found. Moreover, an unexpected positive relationship was found between arousal and task focus.

Mindfulness, task focus, and task performance

We expected that by focusing on the present, mindfulness would increase task focus in participants. Contrary to the expectations, mindfulness did not increase task focus in our study; both compared to the control group and the mindless group. However, it is up for debate, whether a direct effect of mindfulness on task focus can be observed. Instead, our findings might be explained by the absence of a mediating factor, such as internal interference. In the experiments by Hafenbrack and Vohs (2018), the relationship between mindfulness and task focus was mediated by detachment from interfering stressors; there was no direct effect of the mindfulness condition on task focus.

Mrazek, Franklin, Phillips, Baird, and Schooler (2013) also concluded that mindfulness increased task focus by decreasing mind wandering. This effect was especially visible in participants who reported high levels of mind wandering in the pre-test. Furthermore, Ortner, Kilner, and Zelazo (2007) showed that mindfulness increased task focus when reducing emotional interference. These findings suggest that mindfulness is effective in reducing interruptions from internal interference, such as mind wandering, stressors, or emotional interference. However, this does not necessarily mean that a direct effect on task focus can also be observed. Thus, it seems that mindfulness can indirectly increase task focus in individuals with high levels of internal interference, but not in individuals without these interruptions.

Hafenbrack and Vohs (2018) found increased task focus, following a reduction in stressors, to be a predictor for task performance. Off-task stressors were also found to be a deterrent of task performance by Mikulincer (1989). Furthermore, mind wandering was found to be a predictor of error in several tasks by Smallwood and Schooler (2015). Therefore, we hypothesized that task focus would predict task performance. Unexpectedly, we found no effect of task focus on task performance.

However, task focus might not be as important to task performance as expected. Mansi and Levy (2013) found that interruptions of focus by instant messaging only produced a significant decrease in task performance on spatial tasks. Bailey (2001) found that interruptions affected some, but not all tasks in user-interface research. However, interruptions did annoy participants and increased anxiety. Furthermore, Zijlstra, Roe, Leonora, and Krediet (1999) found that in real-life tasks, interruptions might be beneficial for task performance on specific tasks, by increasing task speed and keeping task accuracy high. However, this was at the expenditure of more psychological costs. This indicates that task focus does not necessarily increase task performance, but does reduce the emotional and psychological costs associated with interruptions.

In summary, mindfulness does not directly increase task focus, but might sometimes indirectly increase task focus by decreasing internal interference. However, internal interference and disruption of focus is not necessarily a hindrance to task performance. These interruptions are more likely linked to lower emotional and psychological well-being. Concluding, this suggests that mindfulness does not increase task performance via task focus, but can improve well-being in specific individuals.

Mindfulness, arousal, workload, and task performance

Our results show that mindfulness can decrease arousal, which is in line with what Hafenbrack and Vohs (2018) and Zylowska et al. (2008) have found. However, the participants in the mindless condition reported similar arousal reduction. This could indicate that mindfulness as a practice was not responsible for the arousal reduction effect. After all, participants in both conditions listened to two different audio tapes in a ten-minute window. This is in line with the findings of Droit-Volet, Fanget, and Dambrun, (2015) who found that relaxation and mindfulness exercises had equal levels of arousal reduction in two experiments, with both groups listening to equal-length audio-tapes. While this study did not have a relaxation exercise per se, i.e., participants listened to an audio tape described as relaxing, the findings are not entirely surprising: participants in the mindless condition also experienced relaxation effects. Thus, if reducing arousal is the goal, mindfulness is not the only option.

Arousal by itself did not predict task performance, which is in line with Hebb (1955) who showed that an optimal level of arousal for an individual is more important than the actual level of arousal. Contrary to Anderson and Revelle (1983); Pallak et al. (1975); Revelle (1987), we found no interactive effect between arousal and memory workload. Part of this might be explained because, in related research, researchers often use the psychoactive stimulant caffeine to increase arousal (as seen in Revelle, 1987), while we used mindfulness meditation to decrease arousal. Administration of caffeine has several effects besides arousal enhancement, such as directly affecting attention and short term memory. Compared to other substances that increase arousal, such as glucose and taurine, caffeine had different effects on short term memory workload tasks (Giles, Mahoney, Brunyé, Gardony, Taylor & Kanarek, 2012). When researching an interactive effect of memory workload and arousal, these effects might distort the results of the arousal-workload link. Thus, it seems that the interactive effects found in caffeine research might not be explained by arousal increase, but other variables affected by this stimulant.

Because caffeine increases physiological arousal, but mindfulness decreases psychological arousal, the effects of caffeine can be stronger in research. This is because typically, physiological changes in arousal follow psychological changes in arousal (Riediger, Wrzus, Klipker, Müller, Schmiedek & Wagner, 2014). By bypassing the psychological step with direct caffeine administration, the effects of the arousal manipulation can be much stronger in caffeine experiments when compared to mindfulness research. This is another reason why we think that the results of the caffeine experiments might not be directly comparable to this mindfulness experiment, and why interactive effects are found in those studies, but not in this study.

Furthermore, increasing the cognitive load of a task might increase arousal. Research by Mehler, Reimer, Coughlin, and Dusek (2009) showed that increasing cognitive workload had an effect on physiological arousal, measured by heart rate monitors. Increased arousal by cognitive workload, might also explain why no interactive effects were found. Since the task that was presumably facilitated by low arousal might have increased arousal in participants, negating the possible effect. Thus it seems likely that the interaction between memory workload and arousal does not exist.

The relationship between task motivation and state arousal could also shed more light on the current findings, as motivation is known predictor for task performance (Locke & Latham, 2002; Locke & Latham, 2006). Furthermore, Hafenbrack and Vohs (2018) showed that a decrease in arousal also predicted a decrease in motivation. This reduction in motivation negated the task focus benefits of mindfulness in their studies. However, one thing to consider is that not just arousal has a curve-linear relationship with task performance (Hebb, 1955). Motivation could very well have a curve-linear relationship with arousal, as predicted by Yerkes-Dodson's Law (Yerkes & Dodson, 1908). Berridge and Arnsten (2013) showed that low arousal impaired motivation and executive functions, while high levels of arousal impaired the top-down regulation of motivational behavior. This inverted U-shape is similar to the link between arousal and task performance as suggested by Hebb (1955), meaning that for both task performance and task motivation, an optimal level between over-aroused and under-aroused must be attained. This suggests that mindfulness would only be beneficial in over-aroused individuals, to increase task performance both directly, and indirectly through task motivation, instead of being tied to memory workload. As mindfulness is not more effective in reducing arousal than relaxation exercises, these benefits are not tied to mindfulness alone.

Summarizing, we conclude that arousal can be reduced by mindfulness, but not more than relaxation exercises. We believe that arousal has no interactive effect with memory workload in real-life situations and that the effect found in caffeine research might be artificial or distorted by other effects of this stimulant. Instead, we support the findings of Hebb (1955), who said that arousal is curvilinear related to task performance. Thus, mindfulness can only be beneficial for task performance in over aroused individuals, but not more than other arousal reducing methods.

Focus and arousal

We predicted that the mindfulness condition would increase task focus and decrease arousal. Thus a negative correlation between those concepts was expected. Surprisingly, we found a small *positive* correlation of .22, $p < .05$, between arousal and task focus. This relationship between arousal and task focus might partly explain why task focus did not increase in the mindfulness condition, while arousal did decrease. However, this relationship is not well-documented in the current body of literature.

Type-A personalities can hold task focus longer under high arousal states compared to type-B personalities (Rygh, 1992). Type A personality types were also found to have higher arousal compared to type-B when involved with “win-like” experiences (Griffiths & Dancaster, 1995). As the search task of the current study can be seen as a win-like experience, i.e., you could try to finish all trials or do better than your previous round, this might explain why a positive correlation between arousal and task focus was found. Thus, for future research into arousal and task focus, it might be interesting to use A and B personality types as a discriminating factor.

Limitations and strengths

One of the strengths of the current research is that for both analyses, high power of >.99 was observed. Therefore, our chances of false negative results were minimal. This further strengthens our findings that mindfulness does not increase task focus, task focus does not increase task performance and that no interaction effect between mindfulness' arousal reduction and memory workload, as explained in the discussion.

Furthermore, we have shown that the visual search task used is also useable in digital environments. The accuracy on all tasks was high, and participants reported that they knew what to do. By using three experimental conditions, the effects of mindfulness on task focus and arousal could be explained better in terms of differences between groups. By having task performance on two different workloads as a within-subject factor, the predictive value of task focus and arousal could be assessed better, because we could see whether it can predict performance within subjects.

Despite these strengths, some limitations of current research are also worth discussing. As an online experiment, we had no control over the environmental variables of participants. Thus, the conditions were probably not the same for all participants. Especially in a study about being in a conscious state of mind, the environmental factors such as noise, light, and interruptions might have had an impact on that state of mind. By having non-optimal conditions, more statistical noise is created, which can lead to less clear-cut results than desired.

Further, we did not measure participants on their prior experience of mindfulness. Experience in mindfulness might improve work memory capacity (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010). This, in turn, can affect how well you are equipped to deal with high memory workload tasks. Furthermore, experience in mindfulness might increase the effectiveness of mindfulness meditation (Hafenbrack & Vohs, 2018). Therefore, we did not take a seemingly vital covariate into account.

Last, as discussed, the baseline internal interference might be the best predictor whether mindfulness increases task focus and subsequently improves task performance. Especially in participants with high internal interference, mindfulness might be useful. We did however not assess these baselines, which might have given us more insight into the link between mindfulness, task focus, and task performance

Scientific implications

Both the increase of task focus by mindfulness, as well as the presumed increase in task performance, carry an aspect of reducing internal interference, such as emotional interference, stressors, or mind wandering. Maybe mindfulness can predict task performance in individuals that experience high levels of internal interferences. Literature suggests that mindfulness predicts task focus when internal interference is present (Hafenbrack & Vohs, 2018; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013; Ortner, Kilner, & Zelazo, 2007), and that internal interference reduces task performance (Mikulincer, 1989; Smallwood & Schooler, 2005). Thus, it seems that if there is a link between mindfulness, task focus, and task performance, this link can be explained by the reduction of mind wandering, stressors, or emotional interference. Thus, future research should take into account the baseline interference when researching task focus and task performance.

As arousal possibly has a curvilinear relationship with both motivation (Berridge & Arnsten, 2013; Yerkes & Dodson, 1908) and task performance (Hebb, 1955), new research should focus on optimal levels of arousal, instead of an interactive effect with short term memory workload. By assessing the baselines of arousal, motivation, and task performance in subjects before manipulating arousal, more insights can be gained in when to administer mindfulness as arousal reducing manipulation. Furthermore, this should be offset against relaxation exercises, to find whether mindfulness can have added benefits on task performance, besides arousal reduction.

In the current research, we compared mindfulness' arousal reducing effect directly to research that used caffeine as means to increase arousal (Anderson & Revelle, 1983; Revelle, 1987), to show an interactive effect with memory workload. However, it seems that more than just arousal might be at play when administering caffeine. The neurotoxin (Giles, Mahoney, Brunyé, Gardony, Taylor & Kanarek, 2012) and physiological effects of caffeine might explain a different effect than the psychological effects of mindfulness (Riediger, Wrzus, Klipker, Müller, Schmiedek & Wagner, 2014). The interactive effect between workload and arousal might be too broad in current literature, as it seems that other variables play a role as well. Therefore we carefully conclude that *arousal reduction* by *mindfulness* does not interact with memory workload. Furthermore, as arousal increases when cognitive load increases (Mehler, Reimer, Coughlin, & Dusek, 2009), it is questionable whether such an interaction can even exist, as the memory workload will influence arousal in participants. Thus, new research should measure arousal during linear increasing or decreasing cognitive load when trying to find whether this interaction exists.

A positive relationship between arousal and task focus was observed in current research. If mindfulness can predict both an increase in task focus and a decrease in arousal, this is a peculiar relationship. However, type A and type B personality theories might explain this relationship. New research into mindfulness and task performance should take into account these personality types, to see whether a difference between can be observed.

Practical implications

Mindfulness did not predict task focus but might do so in individuals that experience high levels of internal interference. It is questionable, however, whether this increase is necessary for increasing task performance. An increase in task focus at most decreases the psychological and emotional costs associated with interruptions. Thus, an increase in task focus would still be favorable to increase well-being. This is in line with the primary goal of mindfulness. Therefore, mindfulness might be beneficial in participants with high internal interference, but mainly to increase well-being.

We support the idea that an optimal level of arousal should be pursued for optimal motivation and task performance. Mindfulness reduces arousal, however, not more than relaxation exercises. Thus, if someone is over-aroused, mindfulness can be useful but is not the only option. The reduction in arousal does, however, not influence someone's task performance, even when memory workload is taken into account. Thus, we see no harm in individuals practicing mindfulness meditation in work situations.

Conclusion

The present research does not support the idea that mindfulness can directly improve task performance, but has also shown that it does not impair task performance. Mindfulness can decrease arousal and might be beneficial for task performance in over-aroused workers, but relaxation is probably just as useful to combat over-arousal. An interactive effect between mindfulness' arousal reduction and short term memory workload was also not found, and we believe that this effect does not exist. To improve task focus mindfulness is not sufficient, but it might be useful in reducing internal interference, which can improve task focus. However, the benefits of improved task focus are well-being related and do not extend to improved task performance.

All in all, we see no reason to implement mindfulness meditation programs to improve task performance in organizations. For specific individuals, especially those experiencing high levels of internal interference, mindfulness can be considered as a tool to improve well-being. If offered as a choice to those individuals, we see no harm in mindfulness meditation. However, companies should center their attention on preventing stress and interruptions, instead of symptom control such as mindfulness programs.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. doi:10.1016/0749-5978(91)90020-T

Anderson, K. J., & Revelle, W. (1983). The interactive effects of caffeine, impulsivity and task demands on a visual search task. *Personality and Individual Differences, 4*(2), 127-134. doi:10.1016/0191-8869(83)90011-9

Bailey, B. P., Konstan, J. A., & Carlis, J. V. (2001). The effects of interruptions on task performance, annoyance, and anxiety in the user interface. In *Interact*, 593-601.

Berridge, C. W., & Arnsten, A. F. (2013). Psychostimulants and motivated behavior: arousal and cognition. *Neuroscience & Biobehavioral Reviews, 37*(9), 1976-1984. doi:10.1016/j.neubiorev.2012.11.005

Bertera, R. L. (1990). The effects of workplace health promotion on absenteeism and employment costs in a large industrial population. *American Journal of Public Health, 80*(9), 1101-1105. doi:10.2105/AJPH.80.9.1101

Black, L. I., Clarke, T. C., Barnes, P. M., Stussman, B. J., & Nahin, R. L. (2015). Use of complementary health approaches among children aged 4-17 years in the United States: National Health Interview Survey, 2007-2012. *National Health Statistics Reports* (78), 1–19.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822-848. doi:10.1037/0022-3514.84.4.822

Chaykowski, K. (2017). Meet Headspace, the app that made meditation a $250 million business. Retrieved from https://www.forbes.com/sites/kathleenchaykowski/2017/01/08/meet-headspace-the-app-that-made-meditation-a-250-million-business/#3f75d9db1f1b

Clarke, T. C., Black, L. I., Stussman, B. J., Barnes, P. M., & Nahin, R. L. (2015). Trends in the use of complementary health approaches among adults: United States, 2002-2012. *National Health Statistics Reports*, (79), 1–16.

Cropanzano, R., & Wright, T. A. (2001). When a "happy" worker is really a "productive" worker: A review and further refinement of the happy-productive worker thesis. *Consulting Psychology Journal: Practice and Research, 53*(3), 182-199. doi:10.1037/1061-4087.53.3.182

Cropley, M., Ussher, M., & Charitou, E. (2007). Acute effects of a guided relaxation routine (body scan) on tobacco withdrawal symptoms and cravings in abstinent smokers. *Addiction, 102*(6), 989-993. doi:10.1111/j.1360-0443.2007.01832.x

Davis, K., Collins, S. R., Doty, M., Ho, A., & Holmgren, A. L. (2005). Health and productivity among U.S. workers. *The Commonwealth Fund, 856*, 1-12.

Droit-Volet, S., Fanget, M., & Dambrun, M. (2015). Mindfulness meditation and relaxation training increases time sensitivity. *Consciousness and Cognition*, *31*, 86-97. doi:10.1016/j.concog.2014.10.007

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191. doi:10.3758/BF03193146

Folkard, S., Knauth, P., & Monk, T. H. (1976). The effect of memory load on the circadian variation in performance efficiency under a rapidly rotating shift system. *Ergonomics*, *19*(4), 479-488. doi:10.1080/00140137608931559

Friedman, M. (1970, September 13). The social responsibility of business is to increase its profits. *The New York Times Magazine*.

Germer, C. (2004). What is mindfulness. *Insight Journal*, *22(3)*, 24-29.

Giles, G. E., Mahoney, C. R., Brunyé, T. T., Gardony, A. L., Taylor, H. A., & Kanarek, R. B. (2012). Differential cognitive effects of energy drink ingredients: caffeine, taurine, and glucose. *Pharmacology Biochemistry and Behavior*, *102*(4), 569-577. doi:10.1016/j.pbb.2012.07.004

Griffiths, M. D., & Dancaster, I. (1995). The effect of type A personality on physiological arousal while playing computer games. *Addictive Behaviors*, *20*(4), 543-548. doi:10.1016/0306-4603(95)00001-S

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits. A meta-analysis. *Journal of Psychosomatic Research*, *57*(1), 35-43. doi:10.1016/S0022-3999(03)00573-7

Hafenbrack, A. C., & Vohs, K. D. (2018). Mindfulness meditation impairs task motivation but not performance. *Organizational Behavior and Human Decision Processes*, *147*, 1-15. doi:10.1016/j.obhdp.2018.05.001

Hebb, D. O. (1955). Drives and the C.N.S. (conceptual nervous system). *Psychological Review, 62*(4), 243-254. doi:10.1037/h0041823

Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion, 10*(1), 54-64. doi:10.1037/a0018438

Kachan, D., Olano, H., Tannenbaum, S. L., Annane, D. W., Mehta, A., Arheart, K. L., . . . Lee, D. J. (2017). Prevalence of mindfulness practices in the US workforce: National Health Interview Survey. *Preventing Chronic Disease, 14*, E01. doi:10.5888/pcd14.160034

Khoury, B., Lecomte, T., Fortin, G., Masse, M., Therien, P., Bouchard, V., . . . Hofmann, S. G. (2013). Mindfulness-based therapy: a comprehensive meta-analysis. *Clinical Psychology Review, 33*(6), 763-771. doi:10.1016/j.cpr.2013.05.005

Khoury, B., Sharma, M., Rush, S. E., & Fournier, C. (2015). Mindfulness-based stress reduction for healthy individuals: A meta-analysis. *Journal of Psychosomatic Research, 78*(6), 519-528. doi:10.1016/j.jpsychores.2015.03.009

Lambourne, K., & Tomporowski, P. (2010). The effect of exercise-induced arousal on cognitive task performance: a meta-regression analysis. *Brain Research*, *1341*, 12-24. doi:10.1016/j.brainres.2010.03.091

Ledesma, D., & Kumano, H. (2009). Mindfulness-based stress reduction and cancer: a meta-analysis. *Psycho-Oncology: Journal of the Psychological, Social and Behavioral Dimensions of Cancer*, *18*(6), 571-579. doi:10.1002/pon.1400

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*(9), 705-717. doi:10.1037/0003-066x.57.9.705

Locke, E. A., & Latham, G. P. (2006). New directions in goal-setting theory. *Current Directions in Psychological Science*, *15*(5), 265-268. doi:10.1111/j.1467-8721.2006.00449.x

Mansi, G., & Levy, Y. (2013). Do instant messaging interruptions help or hinder knowledge workers' task performance? *International Journal of Information Management*, *33*(3), 591-596. doi:10.1016/j.ijinfomgt.2013.01.011

Mehler, B., Reimer, B., Coughlin, J. F., & Dusek, J. A. (2009). Impact of incremental increases in cognitive workload on physiological arousal and performance in young adult drivers. *Transportation Research Record, 2138*(2138), 6-12. doi:10.3141/2138-02

Mikulincer, M. (1989). Cognitive interference and learned helplessness: The effects of off-task cognitions on performance following unsolvable problems. *Journal of Personality and Social Psychology,* 57(1), 129. doi:10.1037/0022-3514.57.1.129

Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychological Science, 24*(5), 776-781. doi:10.1177/0956797612459659

Ortner, C. N. M., Kilner, S. J., & Zelazo, P. D. (2007). Mindfulness meditation and reduced emotional interference on a cognitive task. *Motivation and Emotion*, *31*(4), 271-283. doi:10.1007/s11031-007-9076-7

Ostafin, B. D., & Kassman, K. T. (2012). Stepping out of history: mindfulness improves insight problem solving. *Consciousness and Cognition*, *21*(2), 1031-1036. doi:10.1016/j.concog.2012.02.014

Pallak, M. S., Pittman, T. S., Heller, J. F., & Munson, P. (1975). The effect of arousal on Stroop color-word task performance. *Bulletin of the Psychonomic Society*, *6*(3), 248-250. doi:10.3758/BF03336652

Reb, J., & Choi, E. (2014). Mindfulness in organizations. *The Psychology of Meditation,* 1-31.

Reid, D. (2011). Mindfulness and flow in occupational engagement: presence in doing. *Canadian Journal of Occupational Therapy*, *78*(1), 50-56. doi:10.2182/cjot.2011.78.1.7

Revelle, W. (1987). Personality and motivation - sources of inefficiency in cognitive performance. *Journal of Research in Personality, 21*(4), 436-452. doi:10.1016/0092-6566(87)90031-6

Riediger, M., Wrzus, C., Klipker, K., Müller, V., Schmiedek, F., & Wagner, G. G. (2014). Outside of the laboratory: Associations of working-memory performance with psychological and physiological arousal vary with age. *Psychology and Aging*, *29*(1), 103. doi:10.1037/2Fa0035766

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39*(6), 1161-1178. doi: 10.1037/h0077714

Rygh, J. L. (1992). An empirical investigation of an emotion theory of anxiety disorders.

Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: empirically navigating the stream of consciousness. *Annual review of psychology*, *66*, 487-518. doi:10.1146/annurev-psych-010814-015331

Taris, T. W., & Schreurs, P. J. (2009). Well-being and organizational performance: An organizational-level test of the happy-productive worker hypothesis. *Work & Stress*, 23(2), 120-136. doi:10.1080/02678370903072555

Tuckey, M. R., Sonnentag, S., & Bryan, J. (2018). Are state mindfulness and state work engagement related during the workday? *Work & Stress, 32*(1), 33-48. doi:10.1080/02678373.2017.1420707

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology*, *18*(5), 459-482. doi:10.1002/cne.920180503

Zijlstra, F. R., Roe, R. A., Leonora, A. B., & Krediet, I. (1999). Temporal factors in mental work: Effects of interrupted activities. *Journal of Occupational and Organizational Psychology*(72), 163-185. doi:10.1348/096317999166581

Zylowska, L., Ackerman, D. L., Yang, M. H., Futrell, J. L., Horton, N. L., Hale, T. S., . . . Smalley, S. L. (2008). Mindfulness meditation training in adults and adolescents with ADHD: a feasibility study. *Journal of Attention Disorders*, *11*(6), 737-746. doi:10.1177/1087054707308502