Clarifying the relationship between trait mindfulness and objective performance

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Abstract

The present study focused on the relationship between trait mindfulness and the outcome component of performance, evaluated with objective indicators. In particular, four objective performance indicators were studied: accuracy, reaction time, variability in reaction times, and detection of unexpected stimuli. Because attention and awareness have been described as core components of mindfulness, and previous research suggests that mindfulness is associated with improved attention skills, this study predicted that trait mindfulness would be positively related to objective indicators of high performance (accuracy, detection of unexpected stimuli) and negatively related to objective indicators of low performance (reaction time, variability in reaction time), on an attention task. Moreover, the study predicted that the relationship between trait mindfulness and objective performance would be modulated by task complexity. University students (139) completed mindfulness, intelligence, and personality questionnaires and completed an adapted Stroop task (Stroop, 1935) in E-prime 2 software. To test our hypotheses, we performed hierarchical multiple regression analyses in SPSS. Our results revealed that trait mindfulness is not related to objective indicators of performance in an attention task, except for the detection of unexpected stimuli. Going further with our analyses, we also confirmed the important role of intelligence in performance outcomes. Finally, task complexity was not playing a moderator role in the relationship between mindfulness and objective performance. Our research contributes to the literature on mindfulness and objective performance, providing empirical evidence for the relationship between trait mindfulness and the detection of unexpected stimuli. Study limitations and avenues for future research are discussed.

Keywords Trait mindfulness · Objective performance · Attention · Awareness · Accuracy

Introduction and Theoretical Background

Mindfulness has gone from being a practice associated with Buddhism, and only marginally practiced by some Westerners, to becoming increasingly popular. The development of the Mindfulness-Based Stress Reduction program by Kabat-Zinn (1982) was a milestone in the evolution of mindfulness. Its success led to the appearance of other similar clinically oriented mindfulness-based programs that effectively addressed specific conditions such as substance abuse or eating disorders (Appel & Kim-Appel, 2009). In the past fifteen years, the popularity of mindfulness has reached the academia and the workplace (Hyland et al., 2015).

Research into effectiveness of mindfulness in education shows that mindfulness enhanced well-being (Collard et al., 2008), academic success (Meiklejohn et al., 2012), learning and grades (Bakosh et al., 2015; Barbezat & Bush, 2014), empathy (Beddoe & Murphy, 2004), emotion regulation and cognitive control (Bowlin & Baer, 2012), creativity (Zenner et al. 2004), self-efficacy (Keye & Pidgeon, 2013) and increased capacity for emotional intelligence (Snowden et al., 2015). On the contrary, mindfulness decreased anxiety (Beddoe & Murphy, 2004). Therefore, incorporating mindfulness in academic settings reflects its utility in achieving social, emotional and academic benefits.

In the same line, throughout the past two decades, mindfulness in the workplace has been associated with many benefits for health and psychological well-being. For instance, reduced stress (Donald & Atkins, 2016) and emotional

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exhaustion (Hülsheger et al., 2013), increased work engagement (Leroy et al., 2013), job satisfaction (Hülsheger et al., 2013), resilience (Jha et al., 2010), emotional intelligence (Chu, 2010), and the quality of relationships with others (Brown et al., 2007).

Less attention has been paid to the association between mindfulness and individual performance (Dane, 2011). This is a relevant research gap because organizations expect all employees to contribute to achieving organizational goals (e.g., productivity, quality) through their performance. Organizations need high-performing individuals in order to meet their goals, deliver the products and services they specialize in, and ultimately achieve a competitive advantage (Sonnentag & Frese, 2002). Furthermore, work and organizational psychologists and other professionals working in human resources are expected to make individual needs and organizational goals compatible and contribute to employee well-being and organizational productivity (Mohrman et al., 1986). If research reveals that mindfulness contributes to workplace performance (at least in some jobs or for some tasks), organizations should incorporate the evaluation of candidates' trait mindfulness into recruitment and personnel selection processes. Organizations could also implement intervention programs to enhance mindfulness at work (Hülsheger et al., 2015) or create the best conditions (e.g., increase job control) for states of mindfulness in their employees while doing their work (Donald & Atkins, 2016). If mindfulness has successfully reached the workplace because of its many health benefits, demonstrating that it can also contribute to improving performance would be an important step in consolidating it and keeping it from becoming a fad.

The relevant question is whether mindfulness is associated with performance and, if so, when. Correctly addressing this question involves clarifying what kind of mindfulness and performance we are interested in.

Mindfulness has been defined as "a state of consciousness in which attention is focused on present-moment phenomena occurring both externally and internally" (Dane, 2011, p. 1000). Although most definitions of mindfulness refer to a *state* of consciousness, mindfulness can also be understood as a personality trait (Dane, 2011). State mindfulness refers to the extent to which an individual is currently aware of and paying attention to stimuli occurring in the present (Brown & Ryan, 2003), whereas trait mindfulness refers to the duration, frequency, and intensity with which an individual tends to engage in states of mindfulness (Hülsheger et al., 2013). Research indicates that, due to dispositional tendencies, some people may be in a mindful state of consciousness more often than others (Giluk, 2009). Individuals with high trait mindfulness will more frequently experience states of consciousness where their attention is focused on present-moment phenomena occurring both externally and

internally. Although trait and state mindfulness are related, in that individuals with a mindful disposition are more likely to experience momentary mindfulness, their effects are independent (Brown & Ryan, 2003). In the present study, we focus on the relationship between trait mindfulness and performance.

The most extended definition of performance refers to behaviours or actions that are relevant to the goals of the organization and can be measured or scaled (Campbell, 1990). However, authors agree that when conceptualizing performance, it is important to differentiate between the process, action, or behavioural component of performance and the outcome component of performance (Campbell, 1990; Sonnentag & Frese, 2002). The outcome component of performance refers to the consequences or results of the individual's behaviour. In this study, we focus on the outcome component of performance.

The behavioural component of performance is usually measured through scales where the employee or someone else (e.g., the immediate supervisor) reports on the degree to which the employee performs some actions or behaviours that are relevant to organizational goals. In contrast, the outcome component of performance is usually evaluated through objective indicators that reflect the results achieved by the employee (e.g., sales figures).

Research in the educational setting relates mindfulness with academic performance, such as attention (Semple et al., 2010), working memory (Jha et al., 2010), and academic self-efficacy (Hanley et al., 2015), however these studies use self-reported questionnaires; therefore the results are based on students' perceptions and not on objective indicators. Indeed, there are studies that present results obtained with objective indicators, but the results are not conclusive. For instance, Stillman et al. (2014) found a negative relationship between trait mindfulness and sequence learning in two tasks: Alternating Serial Response Time Task (Howard Jr & Howard, 1997) and Brief Test of Adult Cognition by Telephone (BTACT, Tun & Lachman, 2006). However, Bellinger et al. (2015) examined performance in a high-pressure laboratory setting and found that trait mindfulness indirectly improved math performance by reducing anxiety. Through our study, we attempt to obtain additional evidence regarding the relationship between trait mindfulness and objective performance in an undergraduate sample, in an effort to clarify the relationship between these two variables.

Considering the organizational environment, most previous research has focused on the effects of trait mindfulness on the behavioural component of performance, including overall performance (Dane & Brummel, 2014), intra-role or task performance (Reb et al., 2017), extra-role performance or organizational citizenship behaviour (Reb et al., 2013), counterproductive performance or deviant behaviour in the workplace (Reb et al., 2013), and creative performance

(Zheng & Liu, 2017), or very specific types of performance, such as safety performance (Zhang et al., 2013) or sports performance (Röthlin et al., 2016). Thus, all these studies focus on the effects of trait mindfulness on perceptions or subjective judgments about employee's behaviours, and they do not allow us to draw any conclusions about whether trait mindfulness produces differences in performance outcomes evaluated with objective indicators.

In our study, we aim to overcome this limitation by focusing on the relationship between trait mindfulness and the outcome component of performance, evaluated with objective indicators. Most of the studies that have examined the effects of trait mindfulness on objective performance were conducted in a laboratory context (Eichel & Stahl, 2017; Fountain-Zaragoza et al., 2018; Keith et al., 2017; Lin et al., 2018; Moore & Malinowski, 2009; Quickel et al., 2014; Schmertz et al., 2009), although some field studies also exist (Shao & Skarlicki, 2009). In these studies, there is considerable variability not only in the type of task performed by the participants, but also in the performance indicators or objective measures obtained. The most frequent objective performance indicators used in these studies are accuracy (e.g., number of correct answers, number of commission errors, number of omission errors, etc.), reaction time, and variability in reaction time. Fewer studies calculate the speed or time employed to perform the task (Quickel et al., 2014) or use efficiency indicators with scores that take both speed and accuracy into account (Moore & Malinowski, 2009).

Therefore, this paper aims to study the relationship between trait mindfulness and individual objective performance. Specifically, four objective indicators of performance are studied: accuracy, reaction time, variability in reaction times, and detection of unexpected stimuli. Because of their relevance for work performance, accuracy, reaction time, and variability in reaction times are among the most widely researched objective performance indicators. These are the most applied objective indicators because in the majority of the studies (Eichel & Stahl, 2017; Fountain-Zaragoza et al., 2018; Keith et al., 2017; Larson et al., 2013; Lin et al., 2018; Moore & Malinowski, 2009; Quickel et al., 2014) attention is the performance indicator most related to mindfulness. Therefore, the enumerated indicators are needed to ensure effective performance metrics, and including them in our study makes it possible to compare our findings with those obtained in previous research. Additionally, we include the detection of unexpected stimuli in our study. Today, organizations increasingly face dynamic and uncertain environments. In these environments, managing unexpected stimuli becomes a critical competency. Detection of unexpected stimuli and events is critical in some industries (e.g., nuclear power plants, commercial aviation, air traffic management) in order to react quickly and properly and avoid any negative consequences that could end in catastrophe (Weick &

Sutcliffe, 2015). We intend to contribute to extending previous research by shedding some light on the following research questions: Do mindful individuals (individuals high in trait mindfulness) perform better (considering objective indicators)? If so, in what sense? First, are they more accurate? Second, do they react faster when facing an external stimulus? Third, is their performance more consistent? Lastly, are they better able to detect the appearance of unexpected stimuli? As we argue in the following paragraphs, based on the results of previous literature, these relevant questions remain unanswered.

For Quickel et al. (2014), if mindfulness enhances focused attention, then trait mindfulness should predict individual differences in attentional control. However, in the case of accuracy, the results are far from conclusive. For instance, Keith et al. (2017) found no relationship between trait mindfulness and errors (commission and omission) on a computerized Go/No-Go task (The Test of Variables of Attention, TOVA). Similarly, Quickel et al. (2014) found no relationship between trait mindfulness and the number of correct answers on two different tasks: the Symbol Digit Modalities Test, (Smith, 1982) and the Computer Adaptive Adjustable 2-Back Task. In contrast, Moore and Malinowski (2009) identified a positive relationship between trait mindfulness and precision on two different tasks: the Stroop-test (Stroop, 1935) and the attention test d-2 (Brickenkamp & Zilmer, 1998). Finally, two other studies found mixed evidence of the relationship between these two variables. On the one hand, Fountain-Zaragoza et al. (2018) did not find a relationship between trait mindfulness and precision on a Go/No-Go type task, and they only found a positive association for one of the two precision indicators obtained on a Word-Continuous Performance Task. On the other hand, on the Eriksen flanker task (Eriksen & Eriksen, 1974), Lin et al. (2018) revealed that more mindful individuals made fewer errors in the incongruent stimuli condition; however, these differences were not observed in the case of congruent stimuli.

From a theoretical approach, mindfulness would be expected to lead to shorter reaction times and less variability in reaction times, due to the mindful individual's ability to attend to the present and maintain this attention throughout the task (Brown & Ryan, 2003). However, again the results are far from conclusive. Regarding reaction time, whereas Keith et al. (2017) revealed that trait mindfulness was associated with shorter reaction times, Eichel and Stahl (2017) did not find a relationship between the two variables, despite using two different instruments to measure mindfulness (The Freiburg Mindfulness Inventory FMI, Buchheld & Walach, 2002; and the Mindful Attention and Awareness Scale MAAS, Michalak et al., 2008). Additionally, Lin et al. (2018) found that trait mindfulness was associated with shorter reaction times in the

case of incongruent stimuli, suggesting that individuals with high levels of mindfulness focus their attention on the relevant stimulus, the target, ignoring the rest.

Regarding variability in reaction times, results are again inconsistent. Keith et al. (2017) showed that trait mindfulness was associated with less variability in reaction times. However, Eichel and Stahl (2017) found a relationship between the two variables only when mindfulness was measured with the FMI, but not when it was measured with the MAAS.

The above-mentioned discrepant results on the objective indicators of performance highlight the need for further clarification of the role of trait mindfulness. Additionally, we included detection of unexpected stimuli, which is quite relevant in industries where safety is critical (Zhang et al., 2013; Zhang & Wu, 2014). Mindful individuals are more aware of risks in the system and the potential appearance of unexpected stimuli and events. Therefore, they can preclude automatic information processing and categorical thinking, biased judgements, and "do what you always do" reactions (Bishop et al., 2004; Brown et al., 2007; Zhang et al., 2013).

Furthermore, some authors have suggested that the effects of mindfulness on objective performance could be modulated by task complexity. Task complexity is defined as the set of attentional, memory, reasoning, and other information processing demands imposed by the structure of the task (Robinson, 2001). Although mindfulness may have several positive outcomes, it may also have costs due to its time-consuming nature. Zhang et al. (2013) argued that the benefits of mindfulness could depend on task complexity. On complex tasks, the benefits of being mindful greatly outweigh the time cost because small errors or missing information can seriously undermine the overall performance. However, on simple tasks, the benefits of being mindful may not exceed its time cost. In the context of a nuclear power plant, Zhang et al. (2013) found some evidence for this hypothesis. For high complexity task holders, trait mindfulness was positively associated with task and safety performance (rated by their supervisors), whereas for low complexity task holders, trait mindfulness was negatively associated with task performance and not related to safety performance. However, we did not find any previous studies addressing whether task complexity moderates the relationship between trait mindfulness and objective performance.

Regarding the type of task, with some exceptions (see Pareja et al., 2015 for the incidence of mindfulness on performance on a driving task), most of the studies include cognitive tasks. On these types of tasks, attentional demands are essential in achieving good performance (Eichel & Stahl, 2017; Fountain-Zaragoza et al., 2018; Keith et al., 2017; Lin et al., 2018; Moore & Malinowski, 2009; Quickel et al., 2014).

In this study, we used an adapted Stroop task (Stroop, 1935) to test participants' ability to focus, sustain, and direct their attention and detect unexpected stimuli. The participants were asked to attend to either the colour or the semantics of the words on a computer using E-prime 2 (Schneider et al., 2012). According to MacLeod (1991), the Stroop effect is one of the most reliable phenomena in reaction time research because it forces the individual to check the compatibility of the possible responses cognitively. This task is suitable for mindfulness research because the gradual increase in task complexity requires the ongoing reinvestment of participants' attention to achieve good performance (Moore & Malinowski, 2009).

In sum, the purpose of the present study is to examine the relationship between trait mindfulness and four indicators of individual objective performance, and the moderating role of task complexity. Moreover, we want to find out whether this relationship is maintained or variance is added when we consider intelligence and two personality variables (conscientiousness and neuroticism) that are also associated with performance. To achieve our goal, we conducted a study in a laboratory setting and employed software (E-prime 2.0) to recode the objective indicators of performance on a Stroop task (Stroop, 1935).

Based on the discussion above, we hypothesize the following:

H1. Mindfulness is positively related to accuracy and negatively related to errors of commission and errors of omission. We expect that higher trait mindfulness, the stronger the effect.

H2. Mindfulness is negatively related to reaction time and variability in reaction time.

H3. Mindfulness is positively related to the detection of unexpected stimuli (in high complexity tasks).

H4. The relationship between mindfulness and objective performance is moderated by task complexity, in such a way that this relationship is stronger in tasks with high complexity than in tasks with low complexity.

Method

Participants

This study examined data from 139 participants (21% males and 79% females). The observed imbalance in the distribution by gender can be explained as the sample is representative of the undergraduate students from the Faculty of Psychology and the Faculty of Social Sciences. Concretely, participants recruited were undergraduate students enrolled in Psychology and in Labour Relations and Human Resources courses (59.7% psychology and 40.3%

labour relations and human resources). Their participation was in exchange for course credit. Their ages ranged from 17 to 49 years ($M = 20.9$, $SD = 4.25$). Power analysis using G*Power with three predictors (i.e., independent variable, moderator, and interaction), α-level $= 0.05$, and medium effect size $f^2 = 0.15$, suggests that to attain 95% power we need to recruit at least $N = 119$ participants (Faul et al., 2009). Thus, with the recruited sample size, we ensured to have sufficient statistical power to detect relevant effects.
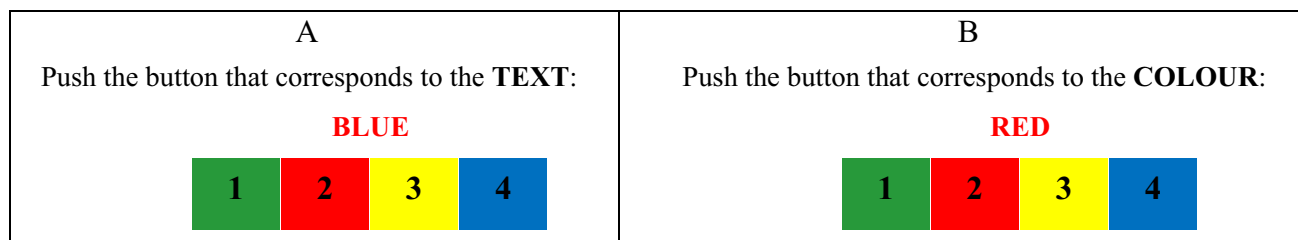
Procedure

The study was carried out in accordance with the Declaration of Helsinki and approved by the local ethics committee. Informal consent was obtained. A pilot study ($n = 4$) was conducted to sort out any possible problems that might lead to the failure of the research procedure. Regarding the study sample, the individuals were contacted via email to establish the planning.

Participants only attended one session, and they were distributed in groups of two; for the first part of the session, they were in the same room completing the questionnaires and for the second part of the session, they were tested individually. The estimated length of a session was around 60 min and comprised two differentiated blocks: paper and pencil questionnaire administration and computer task administration. The session took place in the university's laboratory. Prior to completing the questionnaires and beginning the tasks, the individuals received standard instructions to avoid biases. In the first part of the session, the participants first completed the informed consent and then questionnaires collecting demographic information (age, gender, and specialization), other control variables (conscientiousness, neuroticism, intelligence), and trait mindfulness. In the second part of the session, for task administration, each individual was given a chronometer, taken to a private, sound-attenuated testing room, and seated facing a monitor. The tasks were based on Stroop tasks (Stroop, 1935). These tasks were administered to each participant individually. We divided the Stroop task into 4 tasks with different levels of complexity on a computer, using E-prime 2 software. This software recoded accuracy (ACC), errors (commission errors Ec and omission errors Eo,), and reaction time (RT). Task 1 and Task 2 were composed of 48 stimuli each. Task 3 and Task 4 included 32 stimuli each. Each stimulus was shown on a different screen. Participants had 4 s to answer each stimulus. The computer software moved on to the next screen once the participant had answered or after 4 s had passed. The participants were advised to answer before the time limit (4 s) and avoid making errors. In order to stimulate participants' motivation, they were told that the best participant (with the least amount of errors in the shortest time) would receive a 30-Euro prize. After verbally confirming that they understood the oral instructions and the written instructions on the monitor, the participants began the tasks. On the first and second tasks, they had a short practice session consisting of 4 stimuli. Between the tasks, we introduced a 3-min break. Every time the participants finished the tasks, they received verbal approval to use the chronometers and control the 3-min break; meanwhile, the investigator prepared the following task. At the end of each of the four tasks, within the E-prime 2 environment, the participants had to complete some questions about the perceived difficulty of the task and their subjective performance, and only for Task 4, participants had to answer a set of questions about the presence of distractors. Finally, at the end of the experiment, again in E-prime 2, they had to answer a questionnaire about their previous familiarity with Stroop tasks.

The Task

The Stroop task is a demonstration of interference in the reaction time on a task. The administered tasks were similar to the original version by Stroop (1935). When the name of a colour ("green", "red", "yellow", or "blue") is printed in a colour that is different from the name (e.g., the word "red" printed in blue ink instead of red ink), it takes longer to name the colour of the word, and the participant is more prone to errors than when the colour of the ink matches the name of the colour. As mentioned above, we created four different tasks for our experiment. For each of these tasks, the screen time for each stimulus was 4 s. For the first and the second tasks, we generated three series of 16 stimuli. These 16 stimuli were the result of combining 4 colours (blue, green, red, and yellow) with the text instruction, respectively, for each colour. Specifically, on the first task, participants had to indicate the colour that matched the text of the word, whereas on the second task; they had to indicate the colour that matched the colour of the word. The corresponding instruction was given in written format on the screen at the beginning of each task. After reading it and communicating to the investigator that they understood the instruction, they began the tasks. Participants had to indicate the colour of the word by pressing 1 for green, 2 for red, 3 for yellow, and 4 for blue. The numbers always remained on the screen in the squares with the corresponding colours (see Fig. 1). These numbers with the corresponding colours were the same for all the tasks. Each of these three series of 16 stimuli contained 4 congruent stimuli (the name and colour of the word matched) and 12 incongruent stimuli (the name and the colour of the word did not match). Thus, the test material consisted of 48 stimuli (one per screen). The same word or colour could not appear two times in a row. We used a randomization procedure to determine the order of appearance of the 16 stimuli in each of the 3 series.

A	B
Push the button that corresponds to the **TEXT**:	Push the button that corresponds to the **COLOUR**:
BLUE	RED
1 2 3 4	1 2 3 4

Fig. 1 Example of the tasks (**A**. Task 1- example of the incongruent stimulus; **B**. Task 2 – example of the congruent stimulus)

On the third task, the participants had to indicate either the colour that matched the text of the word or the colour that matched the colour of the word, according to the specific instruction that appeared on each screen for each stimulus. The test material consisted of 32 stimuli (one per screen). The 32 combinations were obtained by combining the 4 words with the 4 colours and the instructions for the text or colour (4x4x2). The same word or colour could not appear two times in a row. We applied a randomization procedure, with a total of 8 congruent stimuli and 24 incongruent stimuli.

For the fourth task, the instructions were the same ones used for the third task. The participants had to indicate either the colour that matched the text of the word or the colour that matched the colour of the word, according to the specific instruction for each stimulus. The difference between Task 4 and Task 3 was the presence of distractors and the randomization procedure. Regarding the presence of distractors, we introduced images of animals (see Fig. 2) in black ink and with no colour as distractors. The distractors appeared in the centre of 4 screens (more precisely on the 3rd, 11th, 19th, and 27th); each distractor appeared twice alternatively. They appeared from the beginning of the stimuli presentation and disappeared in 2 s. Regarding the randomization procedure, the order and combination of the word-colour pairs were different for Task 3.

Measures

Trait Mindfulness

Trait mindfulness was measured using the 15-item Spanish version (Soler et al., 2012) of the Mindfulness Attention Awareness Scale (MAAS, Brown & Ryan, 2003). It is the most widely used instrument for the evaluation of dispositional mindfulness. The MAAS operationalizes mindfulness as a single factor related to attention. A sample item is "*I tend to walk quickly to get where I'm going without paying attention to what I experience along the way*". Items are rated on a six-point Likert scale ranging from 1 (almost never) to 6 (almost always). The total score was obtained after reversing the items (i.e., high scores indicate high trait mindfulness). The MAAS (Brown & Ryan, 2003) is a coherent self-report questionnaire that demonstrated adequate reliability in a number of studies ($\alpha = .82$, Quickel et al., 2014; $\alpha = .80$; Fountain-Zaragoza et al., 2018). The Spanish version (Soler et al., 2012) also demonstrated a good internal consistency ($\alpha = 85$, Muro et al., 2017).

Objective Performance

Several indicators of objective performance were obtained: accuracy was estimated as the number of correct responses on the task, errors of commission, errors of omission, reaction times, variability in reaction times, and detection of unexpected stimuli.

Fig. 2 The distractors
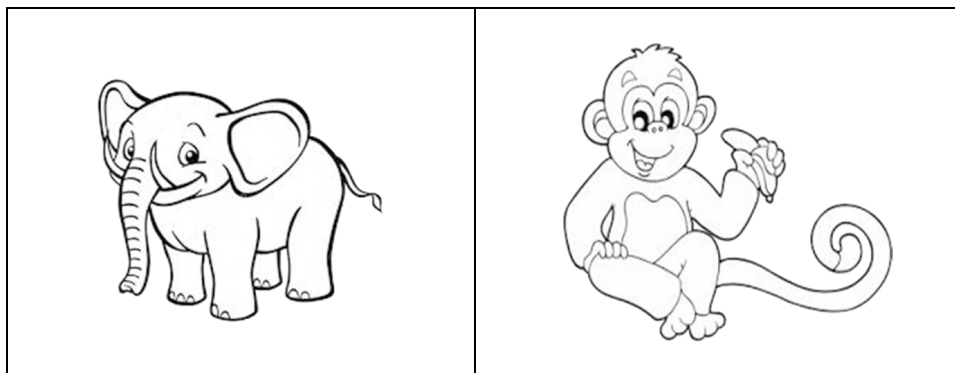
Accuracy (ACC) was estimated as the number of correct responses on the task.

Errors of commission (Ec) were estimated as the number of incorrect responses given by the participant on the task.

Errors of omission (Eo) were estimated as the number of stimuli that were not responded to by the participant (time was up before answering).

Reaction time (RT) was estimated as the mean reaction time values in milliseconds for all the stimuli included in the task.

Variability in reaction time (RTSD) represents the individual stability of information processing speed (Eichel & Stahl, 2017). The RTSD for each task was estimated as the standard deviation for the reaction time values in milliseconds on all the stimuli included in the task.

Detection of Unexpected Stimuli

After finalizing Task 4, the participants answered five questions about the distractors that appeared during the task. Each question had multiple-choice answers. The items were the following: 1) "*Did you see any unexpected stimulus on the screen while doing the task?*" (answer: yes/no); 2) "*Can you remember what it was*?" (answer: a plant/an animal/a transport/domestic utensil/I did not distinguish it/I did not see anything); 3) "*Did you see what it was*?" (answer: whale/rhinoceros/elephant/hippo/I did not distinguish it/I did not see anything); 4) "*Did you see what it was*?" (answer: dog/monkey/cat/koala/I did not distinguish it/I did not see anything); 5) "*What side of the screen did it appear on*?" (answer: lower right/ upper left/ in the centre/ lower left/ upper right/I do not remember/I did not distinguish it/I did not see anything). For each item, there was only one right answer. A total score was obtained by adding up the correct answers on the five items. Thus, this variable ranged from 0 to 5, with a higher score indicating more accuracy in perceiving the distractors.

Task Difficulty

Participants had to indicate the level of difficulty of the task they had just performed on a 10-point Likert scale ranging from 0 (very easy) to 9 (very difficult).

Task Complexity

It was measured according to the levels of complexity of the four tasks, which were presented from lower to higher levels of complexity. On Task 1, participants had to indicate the colour that matched the text of the word. On Task 2, they had to indicate the colour that matched the colour of the word. On Task 3, they had to indicate the colour that matched the text of the word or indicate the colour that matched the colour of the word, according to the specific instruction presented with the stimulus. Finally, Task 4 was similar to Task 3, but we included four distractors. The tasks were assumed to have an increasing level of complexity because of the differences in cognitive processing demands (Robinson, 2001).

Manipulation of the Complexity Levels

A one-way within-subjects ANOVA was conducted to compare the participants' perception of the difficulty of each of the four tasks. This analysis aimed to check whether the participants perceived the level of complexity of the different tasks. Results of the ANOVA [F (3,414) = 107.53, $p < .001$, $\eta^2 = 0.44$] indicated significant differences. The pairwise comparison results indicated no statistically significant differences in the perceived difficulty level between Task 1 and Task 2 ($p = .07$) or Task 3 and Task 4 ($p = .24$). However, statistically significant differences were found in the perceived difficulty level of Tasks 1 and 2 in comparison with Tasks 3 and 4, with the latter showing a higher level of perceived difficulty. Thus, we decided to categorize the tasks according to two complexity levels: low complexity tasks (1 and 2) and high complexity tasks (3 and 4).

Control Variables

We tested the potential influence of seven control variables: age, gender, specialization, familiarity with the tasks, conscientiousness, neuroticism, and intelligence. According to the literature, there are age and gender differences in mindfulness (Sturgess, 2012), and so we controlled for these demographic variables. Moreover, given that mindfulness may be especially beneficial for domain experts (Dane, 2011), we asked participants to report their specialization and familiarity with the tasks. Additionally, in order to observe whether the effect of mindfulness can be differentiated from other trait-like variables, we controlled for conscientiousness and neuroticism (Giluk, 2009). Finally, because intelligence is a predictor of performance on some cognitive tasks (Shakeel & Goghari, 2017), we also controlled this construct. We treated gender (1 = male, 2 = female) and specialization (1 = psychology, 2 = labour relations and human resources) as dummy variables, and age and intelligence were used as continuous variables.

Familiarity Scale

We measured familiarity with the tasks on a 3-item scale. The sample items for this scale were: "*I heard about this task in one of my courses, during my college years*"; "*I previously did tasks like this*;" and "*I am familiar with the type of task I just did*". The participants rated each statement

on a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree).

Conscientiousness and Neuroticism

To assess personality dimensions (conscientiousness and neuroticism), the two selected facets from the Spanish version (Cordero et al., 2008) of the Five-Factor Reduced Personality Inventory (NEO-FFI, Costa & McCrae, 1992) were administered, with 12 items per dimension. A sample item for conscientiousness is "*I never seem to be able to get organized*", and for neuroticism "*I rarely feel scared or anxious*" (reverse-coded). The participants rated each statement on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). NEO-FFI showed good reliability in previous studies ($\alpha = 0.79$ for conscientiousness and $\alpha = 0.80$ for neuroticism; Giluk, 2009) as well as the Spanish version, with values of the Cronbach's α fluctuating between .71 and .82 (Poch, 2009). Moreover, the validity of this instrument has been demonstrated in different studies (Magalhães et al., 2014; McCrae & Costa, 2004).

Intelligence

To measure intelligence, we used the Spanish version (Cruz et al., 1988) of the *Domino Test D-70* (Kowrousky & Rennes, 1988). The material that forms the D-70 is nonverbal, represented by dominoes ordered according to a law the participant must discover in order to continue the series started and find the solution required. The test has 44 elements, preceded by 4 examples. Individuals had limited time to complete the test (25 min).

Data Analyses

According to the guidelines for publication, data are not publicly available at the point of this submission, but an active link would be included in the manuscript if this were accepted for publication in the journal.

All the variables were screened for missing data and distributional assumptions prior to analysis. Confirmatory factor analyses (CFA) were carried out to test the factorial structure of the mindfulness scale and the two personality dimensions using Mplus version 8 (Muthén and Muthén 1998–2012) and WLSMV estimation. A single-factor model was tested for mindfulness and a two-factor model for the two personality scales (conscientiousness and neuroticism). Model fit for the CFA was evaluated using commonly recommended fit indices: Chi-Square Test of Model Fit (χ^2), Root Mean Square of Approximation (RMSEA), Tucker-Lewis Fit index (TLI), the Comparative Fit Index (CFI) and the Weighted Root Mean Square Residual (WRMR). These indicators must provide results close to the acceptable scores

provided by Hu and Bentler (1999). Therefore, for a model to demonstrate satisfactory fit, it must obtain the χ^2 values closer to zero RMSEA <0.08 (closer to zero); CFI ≥ 0.90; TLI ≥ 0.95 and WRMR <1.0.

Descriptive statistics (mean, standard deviation) and reliability were estimated for all continuous variables, and the Pearson correlation coefficient was estimated among the study variables. To test our hypotheses, we performed hierarchical multiple regression analyses in SPSS (version 24), first entering the demographic control variables (age, gender, specialization, and familiarity with the tasks), and then entering the two personality variables (conscientiousness and neuroticism), intelligence, and, finally, trait mindfulness. To evaluate the statistical significance of the parameter estimates, we used one-tailed tests, which are suitable for directional hypotheses (Erickson & Nosanchuk, 1977; Wonnacott & Wonnacott, 1984).

Results

The CFA conducted to test a one-factor model for the mindfulness scale demonstrated satisfactory fit ($\chi^2(90) = 167.82$, $p < .001$; RMSEA $= 0.079$, CFI $= .924$, TLI $= .911$, WRMR $= .842$). However, the fit of the two-factor model for the two personality dimensions (conscientiousness and neuroticism) was not satisfactory ($\chi^2(251) = 629.746$, $p < .001$; RMSEA $= 0.104$; CFI $= .791$; TLI $= .770$; WRMR $= 1.451$). The values on the modification indices suggested correlating the residuals of the items ("*Before doing an action, I always consider its consequences*" and "*Sometimes I act first and think later*") (MI $= 24.38$), and the residuals of the item ("*I have clear objectives and I strive to achieve them in an orderly manner*") and the item ("*I work hard to achieve my goals*") (MI $= 25.98$), all of them from the conscientiousness scale. Considering the similarities in the wording and the content of each pair of items, we introduced the suggested modifications, which resulted in a better fit of the model, but without reaching satisfactory values ($\chi^2(249) = 584.21$, $p < .001$; RMSEA $= 0.098$; CFI $= .815$; TLI $= .795$; WRMR $= 1.376$). The results of the modification indices suggested the elimination of the item "*Sometimes I do things impulsively and then I regret it*" from the neuroticism scale because it showed a relevant weight on the conscientiousness scale (MI $= 88.50$). Applying this modification, along with the correlated residuals, the two-factor model exhibited adequate goodness of fit indices ($\chi^2(227) = 359.982$, $p < .001$; RMSEA $= 0.065$; CFI $= .921$; TLI $= .912$; WRMR $= 1.031$). Hence, the score on the neuroticism scale was obtained with only 11 items. We also checked the subscale reliabilities with omega coefficients (McDonald, 1999; McNeish, 2018). The value

obtained for McDonald's omega in the case of NEO-FFI was .86 for neuroticism and .87 for conscientiousness, while for the MAAS was .86.

As indicate above, hierarchical multiple regression analyses were applied to test our hypotheses. For all regression models, the assumptions (no collinearity; independence, normality and homoscedasticity of residuals) were met in this data set. The descriptive statistics, correlations, and scale reliabilities for mindfulness, control variables, and the dependent variables (performance indicators) for low and high complexity tasks are reported in Table 1. As expected, mindfulness was positively correlated with conscientiousness and negatively with neuroticism, but it was not significantly related to age, gender, or intelligence. Intelligence was the only variable that correlated with all the indicators of objective performance for low complexity tasks. Meanwhile, for high complexity tasks, intelligence was positively correlated with accuracy and detection of unexpected stimuli, and negatively with errors of commission, errors of omission, reaction time, and variability in reaction time. Nevertheless, for low complexity tasks, neuroticism only correlated (positively) with errors of omission, and conscientiousness and mindfulness did not correlate with any variable. Instead, in the case of high complexity tasks,

neuroticism, conscientiousness, and mindfulness did not correlate with any of the performance indicators.

To test our hypotheses, we performed multiple hierarchical regression analyses, as described above. The results of these analyses for low and high complexity tasks can be seen in Table 2 and Table 3.

Results indicated that there were no relationships between mindfulness and accuracy, errors of commission, and errors of omission for low or high task complexity ($p > .05$). Moreover, we did not find a significant relationship between mindfulness and reaction time and variability in reaction time for low or high complexity tasks ($p > .05$). Therefore, Hypotheses 1 and 2 were not supported. However, the analysis revealed that mindfulness was positively related to the detection of unexpected stimuli ($\beta = .18$, $p = .04$). Thus, Hypothesis 3 was supported.

Finally, because the results were similar for low and high task complexity, we could conclude that task complexity did not play a moderating role in the relationship between mindfulness and objective performance. Thus, Hypothesis 4 was not supported.

These results indicate that mindfulness did not affect the performance indicators (except for the detection of unexpected stimuli). Thus, we decided to perform additional

Table 1 Means, standard deviations, correlations, and reliabilities for mindfulness, control variables, and for performance indicators

	M	SD	1	2	3	4	5	6	7	8
1. Mindfulness	4.21	0.77	(.85)							
2. Age	20.91	4.25	−.03							
3. Gender	–	–	−.16	.06						
4. Specialization	–	–	−.09	−.22**	−.05					
5. Familiarity	3.41	1.47	.02	.00	.01	−.56**	(.71)			
6. Conscientiousness	3.42	0.66	.43**	.16	.09	−.32**	.27**	(.84)		
7. Neuroticism	2.86	0.73	−.45**	−.14	−.01	.12	−.07	−.33**	(.84)	
8. Intelligence	29.33	4.68	−.01	.04	.03	−.36**	.15	.12	−.13	
9. ACC_L	89.94	8.28	.01	−.28**	−.16	−.15	−.01	−.06	.03	.30**
10. Ec_L	5.60	7.90	.01	.29**	.15	.13	.02	.05	−.06	−.27**
11. Eo_L	.47	1.20	−.12	.03	.14	.17*	−.07	.10	.22**	−.30**
12. RT_L	1225.53	260.40	−.03	.18*	.18*	.33**	−.25**	.00	.09	−.53**
13. RTSD_L	419.59	140.11	.01	.05	.11	.32**	−.21*	.01	.07	−.46**
14. ACC_H	55.78	6.34	.09	−.05	−.07	−.30**	.04	.04	−.10	.47**
15. Ec_H	5.99	5.11	−.10	.08	.07	.27**	−.01	.03	.10	−.35**
16. Eo_H	2.23	2.64	−.02	−.04	.03	.19*	−.07	−.13	.04	−.45**
17. RT_H	1964.81	275.985	.09	.21*	.11	.18*	−.15	−.00	−.03	−.48**
18. RTSD_H	716.60	147.212	−.01	−.11	.04	.14	.02	−.09	.10	−.44**
19. Det. of unexp. st	.88	0.223	.07	−.24**	−.02	−.07	.08	−.05	.09	.27**

* $p < .05$, ** $p < .01$; Reliabilities are measured with Cronbach's alpha and displayed on the diagonal in brackets.; Gender (1 = male, 2 = female); Specialization (1 = psychology, 2 = labour relations and human resources);; ACC_L = accuracy for low complexity tasks; Ec_L = errors of commission for low complexity tasks; Eo_L = errors of omission for low complexity tasks; RT_L = reaction time for low complexity tasks; RTSD_L = variability in reaction time for low complexity tasks; ACC_H = accuracy for high complexity tasks; Ec_H = errors of commission for high complexity tasks; Eo_H = errors of omission for high complexity tasks; RT_H = reaction time for high complexity tasks; RTSD = variability in reaction time for high complexity tasks; Det. of unexp. st = detection of unexpected stimuli

Table 2 Multiple regression for low complexity tasks

Predictor Variable	Dependent	Variable								
	ACC_L		Ec_L		Eo_L		RT_L		RTSD_L	
	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1	.173**		.168**		.057*		.216**		.130**	
Age		−.35**		.35**		.07		.25**		.11
Gender		−.15*		.14*		.15*		.18*		.12
Specialization		−.34**		.32**		.22*		.37**		.33**
Familiarity		−.20*		.20*		.06		−.05		−.03
Step 2	.062*		.051*		.143**		.207**		.153**	
Conscientiousness		−.05		.02		.24**		.12		.13
Neuroticism		.01		−.05		.26**		.07		.05
Intelligence		.26**		−.24**		−.24**		−.47**		−.40**
Step 3	.000		.001		.007		.000		.000	
Mindfulness		−.02		.03		−.11		.01		.01
Total R^2	.236		.219		.208		.423		.283	

*$p < .05$, ** $p < .01$; ACC_L = accuracy for low complexity tasks; Ec_L = errors of commission for low complexity tasks; Eo_L = errors of omission for low complexity tasks; RT_L = reaction time for low complexity tasks; RTSD_L = variability in reaction time for low complexity tasks

Table 3 Multiple regression for high complexity tasks

Predictor Variable	Dependent	Variable										
	ACC_H		Ec_H		Eo_H		RT_H		RTSD_H		Det of. unexp. st	
	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1	.136**		.134**		.040		.108**		.039		.075*	.075*
Age		−.14*		.17*		.01		.25**		−.06		−.27**
Gender		−.08		.08		.04		.11		.05		−.01
Spec.		−.45**		.44**		.23*		.22*		.20*		−.13
Fam.		−.21*		.23*		.06		−.03		.13		.01
Step 2	.146**		.080**		.177**		.200**		.179**		.076*	
Consc.		−.05		.12		−.10		.02		−.05		−.03
N.		−.06		.10		−.06		−.06		.02		.09
Int.		.40**		−.27**		−.45**		−.48**		−.45**		.29**
Step3	.003		.005		.000		.008		.000		.021*	.
Mindf.		.07		−.09		.01		.11		.03		.18*
Total R^2	.285		.220		.217		.316		.218		.172*	

* $p < .05$, ** $p < .01$; Mindf. = Mindfulness; Spec. = Specialization; Fam = Familiarity; Consc = Conscientiousness; N = Neuroticism; Int. = Intelligence; ACC_H = accuracy for high complexity tasks; Ec_H = errors of commission for high complexity tasks; Eo_H = errors of omission for high complexity tasks; RT_H = reaction time for high complexity tasks; RTSD = variability in reaction time for high complexity tasks; Det. of unexp. st = detection of unexpected stimuli

analyses to explore the relevance of personality variables and intelligence beyond the effect of mindfulness. Our correlational and regression analyses seemed to indicate that intelligence was the most relevant variable, and so we decided to check the same hypotheses by introducing the variables in a different order: step 1: age, gender, specialization, and familiarity; step 2: mindfulness; step 3: the two

personality variables (conscientiousness and neuroticism); step 4: intelligence.

Results of the additional analyses (see Table 4) indicated that, after controlling for mindfulness and personality variables, intelligence had a positive relationship with accuracy and negative relationships with errors of commission, errors of omission, reaction time, and variability in reaction times

Table 4 Multiple regression for low and high complexity tasks

Dependent Variables (Low Complexity Tasks)

Predictor Variable	ACC_L		Ec_L		Eo_L		RT_L		RTSD_L	
	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1	.173**		.168**		.057*		.216**		.130**	
Age		−.35**		.35**		.07		.25**		.11
Gender		−.15*		.14*		.15*		.18*		.12
Specialization		−.34**		.32**		.22*		.37**		.33**
Familiarity		−.20*		.20*		.06		−.05		−.03
Step 2	.003		.004		.006		.002		.003	
Mindfulness		−.05		.07		−.08		.05		.06
Step 3	.002		.000		.091**		.021		.016	
Consc.		−.04		.00		.27**		.10		.11
Neuroticism		−.03		−.00		.26**		.15*		.11
Step 4	.058**		.047**		.054**		.184**		.133**	
Intelligence		.26**		−.24**		−.25**		−.47**		−.40**
Total R²	.236**		.219**		.208**		.423**		.283**	

Dependent Variables (High Complexity Tasks)

Predictor Variable	ACC_H		EC_H		EO_H		RT_H		RTSD_H		Det of unexp. st	
	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1	.136**		.134**		.040		.108**		.039		.075*	
Age		−.14*		.17*		.01		.25**		−.06		−.27**
Gender		−.08		.08		.04		.11		.05		−.01
Specialization		−.45**		.44**		.23*		.22*		.20*		−.13
Familiarity		−.21*		.23*		.06		−.03		.13		.01
Step 2	.001		.002		.000		.018*		.000		.002	
Mindfulness		.03		−.05		.01		.14		.01		.05
Step 3	.009		.020		.011		.003		.011		.016	
Consc.		.06		.14		−.12		−.04		−.07		−.08
Neuroticism		−.10		.11		.02		.05		.09		.11
Step 4	.139**		.064**		.166**		.186**		.168**		.079**	
Intelligence		.41**		−.28**		−.44**		−.47**		−.45**		.31**
Total R²	.285**		.220**		.217**		.316**		.218**		.172**	

* $p < .05$, ** $p < .01$; Consc = Conscientiousness; ACC_L = accuracy for low complexity tasks; Ec_L = errors of commission for low complexity tasks; Eo_L = errors of omission for low complexity tasks; RT_L = reaction time for low complexity tasks; RTSD_L = variability in reaction time for low complexity tasks; Consc = Conscientiousness; ACC_H = accuracy for high complexity tasks; Ec_H = errors of commission for high complexity tasks; Eo_H = errors of omission for high complexity tasks; RT_H = reaction time for high complexity tasks; RTSD_H = variability in reaction time for high complexity tasks; Det. of unexp. st = detection of unexpected stimuli

($p < .01$). The pattern of relationships was the same for low and high complexity tasks. Additionally, intelligence showed positive relationships with detection of unexpected stimuli in high complexity tasks ($p < .01$).

Discussion

The present study sought to clarify the relationship between trait mindfulness and objective performance. Our findings reveal that trait mindfulness was positively related to detection of unexpected stimuli. However, trait mindfulness was not related to accuracy, reaction time, or variability in reaction time. Moreover, task complexity did not moderate the hypothesized relationship between trait mindfulness and objective performance.

We suggest three possible explanations for these unexpected findings that should be explored in future studies. The first explanation draws on the distinction between trait and state mindfulness. When predicting performance, the important thing might not be how mindful one is (trait mindfulness), but rather how mindful one is in a specific situation (state mindfulness). In our study, we evaluated trait mindfulness before performing the Stroop task. However, we

did not evaluate state mindfulness at any time. We assumed that individuals with high trait mindfulness would be in a mindful state of consciousness throughout the Stroop task, but this might not be the case. In future studies, to evaluate participants´ trait mindfulness, we could induce a state of mindfulness in the experimental group (e.g., through a meditation exercise), but not in the control group, before performing the experimental task. In this way, we could find out whether trait mindfulness or state mindfulness plays a more important role in predicting objective performance, and their interaction effects (e.g., both may be necessary in order to find individual differences in objective performance).

The second explanation refers to the operationalization of trait mindfulness. In the literature, we can find several instruments for the operationalization of trait mindfulness. These instruments differ in aspects such as the conceptualization of mindfulness, the mindfulness components they evaluate, or the greater or lesser weight they give to each of these components. In our case, we employed MAAS (Brown & Ryan, 2003), which is the most commonly used instrument for the evaluation of trait mindfulness. Future studies that compare different mindfulness operationalizations can be of great interest, as in the studies by Schmertz et al. (2009) and Quickel et al. (2014). For example, Schmertz et al. (2009) applied three mindfulness scales (MAAS, Brown & Ryan, 2003; Cognitive and Affective Mindfulness Scale-Revised, CAMS-R, Feldman et al., 2007; Kentucky Inventory of Mindfulness Skills, KIMS, Baer et al., 2006) to examine the relationship between trait mindfulness and performance on two sustained attention tasks: Conners' Continuous Performance Test II (CPT-II, Conners, 2000) and the Paced Auditory Serial Addition Test (PASAT, Gronwall & Sampson, 1974). They found mixed evidence because CPT-II target omissions were correlated with MAAS and CAMS-R, but reaction time on the CPT-II and PASAT performance was not related to any mindfulness scale. Furthermore, several studies (Grossman, 2008; Grossman & Van Dam, 2011) indicate the need for new approaches to discover whether self-ratings of mindfulness reflect how mindful individuals truly are.

The third explanation is related to the nature of the tasks. It is possible that mindfulness improves objective performance on some tasks, but not on others. Future studies should determine to what degree mindfulness can be important for objective performance on some kinds of tasks and not on others. In our paper, we build on previous studies suggesting that mindfulness could be important in high complexity tasks, but not in low complexity tasks (Zhang et al., 2013). We expected that task complexity would moderate the relationship between trait mindfulness and objective performance. However, our hypothesis was not supported. One possible explanation is that we were not able to create enough range variability. Although we created four tasks that

supposedly differed in complexity, the fact that the participants had a time limit to answer (i.e., 4 s) could make all the tasks somewhat complex. Our data provide some evidence supporting a range restriction argumentation. Means on task difficulty perceived by the participants ranged from 4.24 (task 1) to 7.01 (task 4) on a scale from 0 to 9, which means that perceived difficulty ranged from "not easy/not difficult" to "quite difficult". Furthermore, tasks with an imposed time limit and quick answer can cause everyone to increase their level of attention and concentration to achieve good performance, thus reducing individual differences between individuals with high and low trait mindfulness. There is considerable evidence that individual differences and personality traits become less relevant when the intensity of the situation is very high (i.e., when situational clues are very strong; Mischel, 1973). Future studies should include different types of tasks. Along with the level of complexity, we think it is quite relevant to explore how trait mindfulness is associated with objective performance on tasks without a time limit. The lack of a time limit should increase the likelihood of mind-wandering (i.e., the mind travelling from present to past and future during task performance) in individuals with low trait mindfulness, which would negatively affect their objective performance. This kind of research will allow us to explore how mindfulness affects performance on different types of tasks and identify those tasks where differences in mindfulness can explain differences in performance.

Our study contributes to previous research in two ways. First, we have provided new empirical evidence about the relationship between trait mindfulness and objective performance. Despite the relevance of having productive employees, research on the relationship between trait mindfulness and objective performance is scarce. Most of this research has focused on three indicators (accuracy, reaction time, and variability in reaction time), and the results are far from conclusive, indicating the need for more research. In line with some previous work, in our study, we also found no relationship between trait mindfulness and accuracy (Keith et al., 2017; Quickel et al., 2014), reaction time (Eichel & Stahl, 2017), or variability in reaction time (Schmertz et al., 2009). However, the existence of other studies that have found significant associations indicates the need for further research that includes moderating variables to try to clarify the circumstances in which trait mindfulness predicts objective performance. In this vein, we suggested some avenues for future research above.

Second, we introduced a performance variable that had hardly been studied before but could be highly relevant in many organizational environments: the detection of unexpected stimuli. Our findings indicate that trait mindfulness is positively related to the detection of unexpected stimuli. Awareness of the present moment is actually the defining characteristic of mindfulness (Brown & Ryan, 2003). This

allows individuals to enhance their self-regulation and, therefore, decrease automatic behaviors, information processing, categorical thinking, biased judgements, and "do what you always do" reactions (Bishop et al., 2004; Brown et al., 2007; Zhang et al., 2013). These self-regulatory processes would be responsible for the greater capacity of mindful individuals to detect unexpected stimuli.

This finding has relevant practical implications. Today, management of unexpected stimuli and events is a core competency in the dynamic and uncertain environments faced by most organizations, especially in industries where safety is a priority (Zhang et al., 2013; Zhang & Wu, 2014). In high-risk industries and high reliability organizations and teams, detection of unexpected stimuli and management of unexpected events and uncertainty are especially critical, in order to react quickly and properly. This readiness to react would help to avoid any negative consequences that might end in a catastrophe that could cause environmental, social, and human harm and high economic costs (Weick & Sutcliffe, 2015). Our findings reveal that individuals with high trait mindfulness are better at detecting unexpected events than individuals with low trait mindfulness. Therefore, at least in those industries, organizations, and teams where detecting and managing unexpected events is critical to safe and reliable performance, managers and HR experts should incorporate the evaluation of candidates' trait mindfulness into the personnel recruitment and selection process. Trait mindfulness can be extremely important for selection in a high-risk environment, where it would be desirable to have an employee with a high level of risk-awareness who can detect unexpected stimuli quickly and alert the organization to act swiftly in response to the unexpected event.

Some limitations of the present study have been mentioned throughout the discussion. First, we only used one instrument to evaluate mindfulness (MAAS, Brown & Ryan, 2003). We chose this two-construct scale because it treats mindfulness as the two components of consciousness (attention and awareness), but for more accurate results, future studies should use other scales (e.g., FFMQ, Baer et al., 2006; CAMS-R, Feldman et al., 2007).

Another limitation is that the sample only included undergraduate students. This points to a need for further research to determine whether this relationship (trait mindfulness with detection of unexpected stimuli) is also found in samples from high-risk environments (pilots, air traffic controllers, doctors etc.). Nevertheless, the current study represents a first step in gaining empirical support for this relationship.

Conclusions

In summary, our research contributes to the literature on mindfulness and objective performance by providing empirical evidence for the relationship between trait mindfulness

and the detection of unexpected stimuli. The present study adds fuel to the complex issue of mindfulness and objective indicators of performance. It also highlights the relevance of trait mindfulness, not only as a personal benefit, but also as a benefit in the work environment. Further studies are needed that take these aspects into consideration and explore this relationship using other samples in work environments (e.g., high-risk organizations).

Declarations

References

Appel, J., & Kim-Appel, D. (2009). Mindfulness: Implications for substance abuse and addiction. *International Journal of Mental Health and Addiction, 7*(4), 506–512. https://doi.org/10.1007/s11469-009-9199-z

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of

mindfulness. *Assessment, 13*(1), 27–45. https://doi.org/10.1177/1073191105283504

Bakosh, L. S., Snow, R. M., Tobias, J. M., Houlihan, J. L., & Barbosa-Leiker, C. (2015). Maximizing mindful learning: Mindful awareness intervention improves elementary school students' quarterly grades. *Mindfulness, 7*(1), 59–67. https://doi.org/10.1037/e574802013-317

Barbezat, D.P., Bush, M., (2014). *Contemplative practices in higher education: Powerful methods to transform teaching and learning.* Jossey-bass, San Francisco, CA. Doi: 10.1177%2F1521025115611404.

Beddoe, A. E., & Murphy, S. O. (2004). Does mindfulness decrease stress and foster empathy among nursing students? *The Journal of Nursing Education, 43*(7), 305–312. https://doi.org/10.3928/01484834-20040701-07

Bellinger, D. B., DeCaro, M. S., & Ralston, P. A. S. (2015). Mindfulness, anxiety, and high-stakes mathematics performance in the laboratory and classroom. *Consciousness and Cognition, 37*, 123–132. https://doi.org/10.1016/j.concog.2015.09.001

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11*(3), 230–241. https://doi.org/10.1093/clipsy/bph077

Bowlin, S. L., & Baer, R. A. (2012). Relationships between mindfulness, self-control, and psychological functioning. *Personality and Individual Differences, 52*(3), 411–415. https://doi.org/10.1016/j.paid.2011.10.050

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*(4), 211–237. https://doi.org/10.1080/10478400701598298

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. https://doi.org/10.1037/0022-3514.84.4.822

Brickenkamp, R., & Zilmer, E. (1998). *D2 test of attention*: Manual. Oxford: Hogrefe & Huber.

Buchheld, N., & Walach, H. (2002). Achtsamkeit in Vipassana- meditation und Psychotherapie. Die Entwicklung des BFreiburger Fragebogens zur Achtsamkeit^ [mindfulness in Vipassana- meditation and psychotherapy: The development of the Freiburg mindfulness inventory]. *Zeitschrift für Klinische Psychologie, Psychiatrie und Psychotherapie, 50*(2), 153–172.

Campbell, J. P. (1990). Modeling the performance prediction problem in industrial and organizational psychology. In M. D. Dunnette & L. M. Hough (Eds.), Handbook of industrial and organizational psychology (Vol. 1, pp. 687–732). Palo Alto.

Chu, L. C. (2010). The benefits of meditation Vis-à-Vis emotional intelligence, perceived stress and negative mental health. *Stress and Health, 26*(2), 169–180. https://doi.org/10.1002/smi.1289

Conners, C. K., & MHS Staff (Eds.). (2000). *Conners' continuous performance test II: Computer program for windows technical guide and software manual*. Mutli-Health Systems.

Collard, P., Avny, N., & Boniwell, I. (2008). Teaching mindfulness based cognitive therapy (MBCT) to students: The effects of MBCT on the levels of mindfulness and subjective well-being. *Counselling Psychology Quarterly, 21*(4), 323–333. https://doi.org/10.1080/09515070802602112

Cordero, A., Pamos, A., & Seisdedos, N. (2008). *NE0 PI-R, Inventario de Personalidad NEO Revisado. (revised neo personality inventory)*. TEA Ediciones.

Costa, P. T., & McCrae, R. R. (1992). *Revised NEO personality inventory (NEO-PI-R) and NEO five-factor inventory (NEO-FFI) professional manual*. Psychological Assessment Resources.

Cruz, de la M. V., Cordero A., Seisdedos, N., & González, M. (1988). Dominó 70: D-70. Adaptación española. TEA Ediciones, SA.

Dane, E., & Brummel, B. J. (2014). Examining workplace mindfulness and its relations to job performance and turnover intention. *Human Relations, 67*, 105–128. https://doi.org/10.1177/0018726713487753

Dane, E. (2011). Paying attention to mindfulness and its effects on task performance in the workplace. *Journal of Management, 37*(4), 997–1018. https://doi.org/10.1177/0149206310367948

Donald, J. N., & Atkins, P. W. B. (2016). Mindfulness and coping with stress: Do levels of perceived stress matter? *Mindfulness, 7*(6), 1423–1436. https://doi.org/10.1007/s12671-016-0584-y

Eichel, K., & Stahl, J. (2017). The role of mindfulness and emotional stability in error detection. *Mindfulness, 8*(2), 311–324. https://doi.org/10.1007/s12671-016-0601-1

Erickson, B. H., & Nosanchuk, T. A. (1977). *Understanding data*. McGraw- Hill Ryerson.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a non-search task. *Perception & Psychophysics, 16*, 143–149. https://doi.org/10.3758/BF03203267

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Feldman, G., Hayes, A., Kumar, S., Greeson, J., & Laurenceau, J. (2007). Mindfulness and emotion regulation: The development and initial validation of the cognitive and affective mindfulness scale-revised (CMS-R). *Journal of Psychopathology and Behavioral Assessment, 29*, 177–190. https://doi.org/10.1007/s10862-006-9035-8

Fountain-Zaragoza, S., Puccetti, N. A., Whitmoyer, P., & Prakash, R. S. (2018). Aging and attentional control: Examining the roles of mind-wandering propensity and dispositional mindfulness. *Journal of the International Neuropsychological Society, 24*(08), 876–888. https://doi.org/10.1017/s1355617718000553

Giluk, T. L. (2009). Mindfulness, big five personality, and affect: A meta-analysis. *Personality and Individual Differences, 47*(8), 805–811. https://doi.org/10.1016/j.paid.2009.06.026

Gronwall, D., & Sampson, H. (1974). *The psychological effects of concussion*. Auckland University Press.

Grossman, P., & Van Dam, N. T. (2011). Mindfulness, by any other name . . . : Trials and tribulations of sati in western psychology and science. *Contemporary Buddhism, 12*, 219–239. https://doi.org/10.1080/14639947.2011.564841

Grossman, P. (2008). On measuring mindfulness in psychosomatic and psychological research. *Journal of Psychosomatic Research, 64*, 405–408. https://doi.org/10.1016/j.jpsychores.2008.02.001

Hanley, A. W., Palejwala, M. H., Hanley, R. T., Canto, A. I., & Garland, E. L. (2015). A failure in mind: Dispositional mindfulness and positive reappraisal as predictors of academic self-efficacy following failure. *Personality and Individual Differences, 86*, 332–337. https://doi.org/10.1016/j.paid.2015.06.033

Hülsheger, U. R., Feinholdt, A., & Nübold, A. (2015). A low-dose mindfulness intervention and recovery from work: Effects on psychological detachment, sleep quality, and sleep duration. *Journal of Occupational and Organizational Psychology, 88*(3), 464–489. https://doi.org/10.1111/joop.12115

Hülsheger, U. R., Alberts, H. J. E. M., Feinholdt, A., & Lang, J. W. B. (2013). Benefits of mindfulness at work: The role of mindfulness in emotion regulation, emotional exhaustion, and job satisfaction. *Journal of Applied Psychology, 98*(2), 310–325. https://doi.org/10.1037/a0031313

Hyland, P. K., Lee, R. A., & Mills, M. J. (2015). Mindfulness at work: A new approach to improving individual and organizational performance. *Industrial and Organizational Psychology, 8*(04), 576–602. https://doi.org/10.1017/iop.2015.41

Howard, J. H., Jr, & Howard, D. V. (1997). Age differences in implicit learning of higher order dependencies in serial patterns. Psychology and Aging, 12, 634–656. https://psycnet.apa.org/doi/10.1037/0882-7974.12.4.634

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118

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. https://doi.org/10.1037/a0018438

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry, 4*, 33–47. https://doi.org/10.1016/0163-8343(82)90026-3

Keith, J. R., Blackwood, M. E., Mathew, R. T., & Lecci, L. B. (2017). Self-reported mindful attention and awareness, go/no-go response-time variability, and attention-deficit hyperactivity disorder. *Mindfulness, 8*(3), 765–774. https://doi.org/10.1007/s12671-016-0655-0

Keye, M. D., & Pidgeon, A. M. (2013). Investigation of the relationship between resilience, mindfulness, and academic self-efficacy. *Open Journal of Social Sciences, 01*(06), 1–4. https://doi.org/10.4236/jss.2013.16001

Kowrousky, F., & Rennes, P. (1988). Dominó D-70. TEA Ediciones S.A.

Larson, M. J., Steffen, P. R., & Primosch, M. (2013). The impact of a brief mindfulness meditation intervention on cognitive control and error-related performance monitoring. *Frontiers in Human Neuroscience, 7*(July), 1–12. https://doi.org/10.3389/fnhum.2013.00308

Leroy, H., Anseel, F., Dimitrova, N. G., & Sels, L. (2013). Mindfulness, authentic functioning, and work engagement: A growth modeling approach. *Journal of Vocational Behavior, 82*(3), 238–247. https://doi.org/10.1016/j.jvb.2013.01.012

Lin, Y., Fisher, M. E., & Moser, J. S. (2018). Clarifying the relationship between mindfulness and executive attention: A combined behavioral and neurophysiological study. Social Cognitive and Affective Neuroscience, December, 205–215. doi: 10.1093/scan/nsy113.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109*(2), 163–120. https://doi.org/10.1037/0033-2909.109.2.163

Magalhães, E., Salgueira, A., Gonzalez, A.J., Costa, J.J., Costa, M.J., Costa, P. & Pedroso de Lim, M. (2014). NEO-FFI: Propriedades psicométricas de um inventário reduzido de personalidade no contexto portugués. Psychological Assessment; *Psicol. Reflex. Crit.* 27 (4). Oct-Dec 2014. doi: https://doi.org/10.1590/1678-7153.201427405

McCrae, R., & Costa, P. (2004). A contemplated revision of the NEO five-factor inventory. *Personality and Individual Differences, 36*(3), 587–596. https://doi.org/10.1016/S0191-8869(03)00118-1

McDonald, R. P. (1999). *Test theory: A unified treatment*. Lawrence Erlbaum Associates, Inc..

McNeish, D. (2018). Thanks coefficient alpha, we'll take it from here. *Psychological Methods, 23*(3), 412–433. https://doi.org/10.1037/met0000144

Meiklejohn, J., Phillips, C., Freedman, M. L., Griffin, M. L., Biegel, G., Roach, A., Frank, J., Burke, C., Pinger, L., Soloway, G., Isberg, R., Sibinga, E., Grossman, L., & Saltzman, A. (2012). Integrating mindfulness training into K-12 education: Fostering the resilience of teachers and students. *Mindfulness, 3*(4), 291–307. https://doi.org/10.1007/s12671-012-0094-5

Michalak, J., Heidenreich, T., Ströhle, G., & Nachtigall, C. (2008). Die deutsche version der mindful attention and awareness scale (MAAS): Psychometrisc he Befund e z u e inem Achtsamkeitsfragebogen [the German version of the mindful attention and awareness scale (MAAS): Psychometric findings of a mindfulness questionnaire]. *Zeitschrift für Klinische Psychologie und Psychotherapie, 37*(3), 200–208. https://doi.org/10.1026/1616-3443.37.3.200

Mischel, W. (1973). Toward a cognitive social learning reconceptualization of personality. *Psychological Review, 80*(4), 252–283. https://doi.org/10.1037/h0035002

Mohrman, S., Lawler, E., Mohrman, A., & Ledford, G. (1986). Quality of work life: Implications for industrial psychology. In C. L. Cooper & I. T. Robertson (Eds.), *Review of industrial/organizational psychology*. John Wiley & Sons.

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*(1), 176–186. https://doi.org/10.1016/j.concog.2008.12.008

Muthén, L. K., & Muthén, B. O. (1998-2012). *Mplus User's guide: Statistical analysis with latent variables* (7th ed.). Muthén & Muthén.

Muro, A., Felin-Soler, A., Castellà, J., Devi, J., & Soler, J. (2017). Does time perspective predict life satisfaction? A study including mindfulness as a measure of time experience in a sample of Catalan students. *Mindfulness, 8*, 655–663. https://doi.org/10.1007/s12671-016-0644-3

Pareja, I., Montes, S. A., Valero-Mora, P., Sánchez, M., Ledesma, R. D., & Pons, D. (2015). Mindfulness, inattention and performance in a driving simulator. *IET Intelligent Transport Systems, 9*(7), 690–693. https://doi.org/10.1049/iet-its.2014.0172

Poch, F. V. (2009). Uso autoinformado de Internet en adolescentes: Perfil psicológico de un uso elevado de la red. *International Journal of Psychology and Psychological Therapy, 9*(1), 109–122.

Quickel, E. J. W., Johnson, S. K., & David, Z. L. (2014). Trait mindfulness and cognitive task performance. *SAGE Open, 4*(4), 215824401456055. https://doi.org/10.1177/2158244014560557

Reb, J., Narayanan, J., Chaturvedi, S., & Ekkirala, S. (2017). The mediating role of emotional exhaustion in the relationship of mindfulness with turnover intentions and job performance. *Mindfulness, 8*(3), 707–716. https://doi.org/10.1007/s12671-016-0648-z

Reb, J., Narayanan, J., & Ho, Z. W. (2013). Mindfulness at work: Antecedents and consequences of employee awareness and absent-mindedness. *Mindfulness, 6*(1), 111–122. https://doi.org/10.1007/s12671-013-0236-4

Robinson, P. (2001). Task complexity, task difficulty and task production: Exploring interactions in a componential framework. *Applied Linguistics, 22*(1), 27–57. https://doi.org/10.1093/applin/22.1.27

Röthlin, P., Birrer, D., Horvath, S., & Grosse Holtforth, M. (2016). Psychological skills training and a mindfulness-based intervention to enhance functional athletic performance: Design of a randomized controlled trial using ambulatory assessment. *BMC psychology, 4,* article 39. doi: 10.1007/s12671-016-0512-1.

Semple, R. J., Lee, J., Rosa, D., & Miller, L. F. (2010). A randomized trial of mindfulness-based cognitive therapy for children: Promoting mindful attention to enhance social-emotional resiliency in children. *Journal of Child and Family Studies, 19*(2), 218–229. https://doi.org/10.1007/s10826-009-9301-y

Schmertz, S. K., Anderson, P. L., & Robins, D. L. (2009). The relation between self-report mindfulness and performance on tasks of sustained attention. *Journal of Psychopathology and Behavioral Assessment, 31*(1), 60–66. https://doi.org/10.1007/s10862-008-9086-0

Schneider, W., Eschman, A., & Zuccolotto, A. (2012). E-Prime 2.0 Reference Guide Manual. Sharpsburg: Psychology Software Tools, Inc.

Shakeel, M. K., & Goghari, V. M. (2017). Measuring fluid intelligence in healthy older adults. *Journal of Aging Res.* https://doi.org/10.1155/2017/8514582

Shao, R., & Skarlicki, D. P. (2009). The role of mindfulness in predicting individual performance. *Canadian Journal of Behavioural Science, 41*(4), 195–201. https://doi.org/10.1037/a0015166

Smith, A. (1982). *Symbol-digit modalities test (SDMT) manual-revised*. Western Psychological Services.

Snowden, A., Stenhouse, R., Young, J., Carver, H., Carver, F., & Brown, N. (2015). The relationship between emotional intelligence, previous caring experience and mindfulness in student nurses and midwives: A cross sectional analysis. *Nurse Education Today, 35*(1), 152–158. https://doi.org/10.1016/j.nedt.2014.09.004

Soler, J., Tejedor, R., Feliu, A., Pascual, J., Cebolla, A., Soriano, J., Alvarez, E., & Perez, V. (2012). Propiedades psicométricas de la versión española de la escala Mindful Attention Awareness Scale (MAAS). *Actas Esp Psiquiatria, 40*(1), 19–26 http://hdl.handle.net/10234/67740

Sonnentag, S., & Frese, M. (2002). *Performance concepts and performance theory.* IN S. Sonnentag (Ed). Psychological Management of Individual Performance. Chichester, UK: John Wiley & Sons, ltd;

Stillman, C. M., Feldman, H., Wambach, C. G., Howard Jr., J. H., & Howard, D. V. (2014). Dispositional mindfulness is associated with reduced implicit learning. *Consciousness and Cognition, 28*, 141–150. https://doi.org/10.1016/j.concog.2014.07.002

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–666. https://doi.org/10.1037/h0054651

Sturgess, M. A. (2012). Psychometric validation and demographic differences in two recently developed trait mindfulness measures (Unpublished master's thesis, Victoria University of Wellington, Wellington, New Zealand).

Tun, P. A., & Lachman, M. E. (2006). Telephone assessment of cognitive function in adulthood: The brief test of adult cognition by telephone. *Age and Ageing, 35*(6), 692–632. https://doi.org/10.1093/ageing/afl095

Weick, K. E., & Sutcliffe, K. M. (2015). *Managing the unexpected: Sustained performance in a complex world* (3rd ed.). Jossey-Bass.

Wonnacott, T. H., & Wonnacott, R. J. (1984). *Introductory statistics for business and economics*. Wiley.

Zenner, C., Hermleben-Kurz, S., & Walach, H. (2014). Mindfulness-based interventions in schools: A systematic review and meta-analysis. *Frontiers in Psychology, 5*(603), 1–20. https://doi.org/10.3389/fpsyg.2014.00603

Zhang, J., & Wu, C. (2014). The influence of dispositional mindfulness on safety behaviors: A dual process perspective. *Accident Analysis and Prevention, 70*, 24–32. https://doi.org/10.1016/j.aap.2014.03.006

Zhang, J., Ding, W., Li, Y., & Wu, C. (2013). Task complexity matters: The influence of trait mindfulness on task and safety performance of nuclear power plant operators. *Personality and Individual Differences, 55*(4), 433–439. https://doi.org/10.1016/j.paid.2013.04.004

Zheng, X., & Liu, X. (2017). The buffering effect of mindfulness on abusive supervision and creative performance: A social cognitive framework. *Frontiers in Psychology*, *8*(SEP), 1–12. doi: 10.3389/fpsyg.2017.01588.