REVISTA NEUROCIÊNCIAS

Original

Mindfulness program for cognitive errors of workers: role of consciousness, worry and rumination

Programa de Mindfulness para erros cognitivos dos trabalhadores: papel da consciência, preocupação e ruminação

Programa de Mindfulness para errores cognitivos de los trabajadores: rol de la conciencia, la preocupación y la rumiación

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Resumo

Introdução. O mindfulness foi integrado em vários programas de atenção médica e ambientes de trabalho com resultados promissores. **Objetivo.** Avaliar o impacto de uma intervenção baseada em mindfulness (MBI) nos erros cognitivos relacionados à atenção (ARCEs) de trabalhadores e estudar o papel mediador da atenção plena, da preocupação e da ruminação na redução dos ARCEs. **Método.** A intervenção seguiu o protocolo de Redução do Estresse Baseado em Mindfulness (MBSR), incluindo sessões semanais e uma sessão durante todo o dia. Os participantes foram avaliados por meio das escalas: Attention Related Cognitive Errors Scale (ARCES), Mindfulness Attention Awareness Scale (MASS), Penn State Worry Questionnaire (PSWQ) e Ruminative Response Scale Brooding domain (RRS-B) nas duas condições (pré- teste – pós-teste). Posteriormente, foram realizadas análises de mediação múltipla para examinar se as alterações pré e pós-tratamento nas pontuações ARCES foram mediadas por alterações nas pontuações MASS, PSWQ e RRS-B. **Resultados.** Participaram 74 adultos (idade média: 42,25 anos), sendo 76,3% mulheres. A intervenção gerou alterações significativas nos escores das escalas ARCES e MASS, PSWQ e RRS-B. As análises de mediação mostraram que a atenção plena, a preocupação e a ruminação mediaram melhorias nos erros cognitivos relacionados à atenção. **Conclusão**. A meditação aumenta a atenção plena e reduz a preocupação e a ruminação, diminuindo assim os erros cognitivos relacionados à atenção nos trabalhadores.

Unitermos. Erros cognitivos relacionados à atenção; ambiente de trabalho; atenção plena; preocupar; ruminação

Abstract

Introduction. Mindfulness has been introduced in numerous healthcare programs and in work settings with promising results. **Objective.** To evaluate the impact of a mindfulness-based intervention (MBI) on workers' attention-related cognitive errors (ARCEs) and to study the mediating role of mindfulness, worry, and rumination in decreasing ARCEs. **Method.** The intervention followed the Mindfulness-Based Stress Reduction Program (MBSR) protocol, including weekly sessions and one full-day session. Participants were assessed through the

scales: Attention Related Cognitive Errors Scale (ARCES), Mindfulness Attention Awareness Scale (MASS), Penn State Worry Questionnaire (PSWQ), and Ruminative Response Scale Brooding domain (RRS-B) in the two conditions (pre-test – post-test). Multiple mediation analyses were then conducted to examine whether pre- to posttreatment changes in ARCES scores were mediated by changes in MASS, PSWQ, and RRS-B scores. **Results.** 74 adults (mean age: 42.25 years) participated, 76.3% of whom were women. The intervention resulted in significant changes in ARCES and MASS, PSWQ, and RRS-B scores. Mediation analyses showed that mindfulness, worry, and rumination mediated improvements in attention-related cognitive errors. **Conclusion.** Meditation increases mindfulness and reduces worry and rumination, thereby decreasing attention-related cognitive errors in workers.
Keywords. Attention-related cognitive errors; workplace; mindfulness; worry; rumination

Resumen

Introducción. El mindfulness se ha introducido en numerosos programas de atención médica y en entornos laborales con resultados prometedores. **Objetivo.** Evaluar el impacto de una intervención basada en mindfulness (MBI) en los errores cognitivos relacionados con la atención (ARCEs) de los trabajadores y estudiar el papel mediador de la atención plena, la preocupación y la rumiación en la disminución de los ARCEs. **Método.** La intervención siguió el protocolo del Programa de Reducción de Estrés Basado en Mindfulness (MBSR), incluyendo sesiones semanales y una sesión de todo el día. Los participantes fueron evaluados a través de las escalas: Attention Related Cognitive Errors Scale (ARCES), Mindfulness Attention Awareness Scale (MASS), Penn State Worry Questionnaire (PSWQ) y Ruminative Response Scale Brooding domain (RRS-B) en las dos condiciones (pre-test – pos-test). Posteriormente, se realizaron análisis de mediación múltiple para examinar si los cambios entre el pre y el post-tratamiento de los puntajes ARCES fueron mediados por cambios en los puntajes MASS, PSWQ y RRS-B. **Resultados.** 74 adultos (edad media: 42.25 años) participaron, siendo el 76.3% mujeres. La intervención generó cambios significativos en los puntajes de las escalas ARCES y MASS, PSWQ y RRS-B. Los análisis de mediación mostraron que la atención plena, la preocupación y la rumiación mediaron las mejoras en los errores cognitivos relacionados con la atención. **Conclusión.** La meditación aumenta la atención plena y reduce la preocupación y la rumiación, disminuyendo así los errores cognitivos relacionados con la atención en los trabajadores.
Palabras clave. Errores cognitivos relacionados con la atención; lugar de trabajo; consciencia; preocuparse; rumia

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INTRODUCTION

Working memory and attention are cognitive functions essential for effective daily life performance. Yet, cognitive failures commonly occur during habitual tasks and routines. These are often called slips of action[1]. Slips of action are different from mistakes, which occur when people's knowledge of a task they are attempting to perform is incorrect or insufficient. Slip errors are hard to avoid and

even happen among highly trained experts. They may simply be frustrating, like failing to recall the reason for entering a room[1], but they are sometimes extremely dangerous, like failing to notice the traffic light has turned red light and causing a fatal auto accident. Such errors in the workplace can result in considerable personal and organizational damage[2].

Work-related stress is a major contributor to human errors of these types[3]. Symptoms of stress have been associated with reduced ability to process information, less job satisfaction and lower performance. At the cognitive level, studies have noted a relationship between levels of stress symptoms and attention-related cognitive errors (ARCEs)[3]. ARCEs and concentration problems, as reported by individuals suffering from stress (e.g., inability to keep one's mind on a complex problem, to concentrate on reading or to focus during a conversation; difficulty in planning actions and generating alternative strategies) indicate that work stress is usually accompanied by difficulties in voluntary or executive control over attention. These may limit people's capacity to work and to handle stressful situations, thus circularly increasing the perception of stress.

Furthermore, earlier research shows that markers of poor psychological health, like worry and rumination, are also associated with greater lapses in performance, mind wandering and off-task thinking while performing attention tasks. Default tendencies for a person's attention to wander may lead to significant errors in organizations. If employers

and employees could be trained to strengthen attention and curb mind wandering, their minds could remain 'at attention' longer in everyday tasks. Mindfulness training is a form of mental training that has proved to be effective at improving attention performance and reducing self-reported mind wandering[4].

Mindfulness is a mental mode in which attention to the present moment experience occurs without judgment, elaboration, or emotional reactivity[5]. Mindfulness-based interventions (MBIs) typically offer content on how to stabilize and focus one's attention on the present moment experience rather than ruminating about the past or worrying about the future[6]. Mindfulness is currently being used in many health care programs, in psychological treatments for coping with various mental disorders[7,8] and even in the workplace[9,10] with favorable results. Organizations like Mayo Clinic, Google and the U.S. Army provide training in mindfulness to improve workplace functioning[6].

There is increasing evidence that MBIs are successful in strengthening attention. The impact of mindfulness training on attention performance failures related to task-unrelated thinking (i.e., mind wandering) has been researched, for example, in military cohorts. They concluded that while long periods of high-demand military training can lead to an increase in attentional performance lapses, MBIs focused on practice can bolster attentional performance[6]. Another recent study researched the alleged benefits of MBIs to

protect against performance lapses in undergraduates over a 7-week interval during the academic semester[11]. Compared to an untrained student group with greater performance lapses and self-reported mind wandering on the Sustained Attention to Response Task (SART), the group that did a 7-hour, 7-week MBI course reduced their performance lapses and remained stable in self-reported mind wandering during the 7-week interval.

Having knowledge of the effects of mindfulness training on cognition, a crucial point in intervention studies of mindfulness is assessing the action mechanisms that explain how and why MBIs affect the events that lead to the outcome. Put differently, one essential point is the study of the causal links between treatment and outcome. Increased understanding of the mechanisms through which MBIs bring about change will make it possible to refine these interventions, thus potentially increasing their potency and providing greater effects at lower cost or risk. In searching for these mechanisms, in the current study we analyze the impact of a mindfulness-based training program on workers' ARCEs and how mindful attention awareness, worry and rumination intervene in these results.

METHOD

Sample

Participants were recruited from mindfulness stress reduction program offered by Universidad Siglo 21. Seventy-four adults between 23 and 64 years of age participated in

the study. Adults who met the criteria for a neurocognitive or neuropsychiatric disorder, who had a psychological, neurological or psychiatric history or with unstable medication were excluded from the study. Participants were assessed at baseline (pre-treatment) and post-treatment. All participants gave informed consent, and the study was approved by the Regional Ethical Review Board of Córdoba, Argentina. The protocol and the future utilization of the data for statistical purposes were explained to them to obtain oral informed consent and adherence. Emphasis was placed on the voluntary nature of participation and the potential publication of results in scientific meetings or medical journals. Anonymous data processing was ensured in accordance with Law 25.326 of the National Legislative Power (Personal Data Processing), with all interventions based on the principles of the Helsinki Declaration.

Procedure

The intervention was primarily based on the Mindfulness Based Stress Reduction protocol (MBSR)[5]. The MBSR is an eight-week program in mindfulness training. The standard program has weekly sessions of 2 or 2 1/2 hours and one all-day session after six to seven weeks. The weekly sessions have standardized core elements consisting of different mental and physical mindfulness exercises: 1) Body-scan exercises, 2) Mental exercises focusing on breathing, 3) Physical exercises focusing on developing awareness of bodily sensations and personal limits, 4) Using

breathing as an anchor for attention during everyday activities. In addition to the exercises there is information (and discussion) on stress, stress management, and how to apply mindfulness to interpersonal communication[5].

Measures

The project included a sociodemographic questionnaire and measures that assess mindful attention awareness, attention related errors, worry and rumination, as described below.

Mindful Attention Awareness Scale (MAAS)[12]: The MAAS is a 15-item self-report measure of mindfulness. It is rated on a 6-point Likert scale from 1 to 6, to evaluate the degree of awareness and attention regarding what is occurring in the present moment. Score 1 for each item indicates absence of attention or awareness, while score 6 indicates the greater level of attention or awareness. Thus, higher mean scores on MAAS indicate greater mindlessness.

Attention Related Cognitive Errors Scale (ARCES)[13]: The ARCES is a 12- item scale describing everyday performance failures arising directly or primarily from brief failures of sustained attention' e.g., "I have absent-mindedly placed things in unintended locations (e.g., putting milk in the pantry or sugar in the fridge)" or "I have gone to the fridge to get one thing (e.g., milk) and taken something else (e.g., juice)."Responses are made using a five-point Likert scale, with responses ranging from (1) never to (5) very often, with

greater scores reflecting greater frequencies of cognitive failures.

The Penn State Worry Questionnaire (PSWQ)[14] has a total of 16 items that measure the presence of worries. In the present study we used the brief version PSWQ-A[15], which consists of 8 self-applied items about excessive and uncontrollable worries that individuals could experience. The questionnaire, with 4 Likert-type response options from 1 (not at all typical of me) to 5 (very typical of me), higher scores represented more uncontrollable worries. For these items, the internal consistency obtained was adequate (α= 0.90).

Ruminative Response Scale Brooding domain (RRS-B)[16] was used to evaluate ruminative and intrusive thoughts. The original self-reported questionnaire consists of 10 items, but in the present study we used the RRS-B short-form of 5 items[15]. Each participant had to self-report the frequency of recurrent thoughts from 1 (almost never) to 4 (almost always), and higher scores represented more rumination and intrusive thoughts. For these items, the internal consistency obtained was adequate (α=0.79).

Data analysis

Descriptive statistics for the proposed mediators and outcome measures were produced. Mediation analyses investigate the effect of the independent variable (X) on the dependent variable (Y) through a possible mediator (M)[17]. To carry out the analysis, we followed the logical process

recommended by Judd, Kenny and McClelland[18], with the methodological modifications[19–21].

Judd *et al*.'s[18] approach is like the Baron and Kenny causal steps procedure in its logic. It is required to first establish whether there is a statistically significant difference in Y between the two conditions. That is, is there an effect of condition that can be mediated? The next step is to examine whether there is a difference in the mediator. The third stage of the causal steps approach asks whether there is evidence that the difference in M affects the difference in Y.

In the present research, in the first place, we carried out one effectiveness study using a dependent means t test comparing the means of ARCES, MAAS, worry and rumination scores in the two conditions (pretest – posttest). Subsequently, the mediation analysis was performed. Within-subjects effect sizes (pre-to-post-treatment) were calculated using the formula described by Dunlap *et al*.[22]. Effect sizes (Cohen's d) were interpreted as small (.2), medium (.5), and large (.8). Using a bootstrapping method (23), we conducted multiple mediation analyses to examine whether the change between pre- and post-treatment of ARCES scores was mediated by changes in mindfulness, attention awareness, worry and rumination. As applied to the current study, X represents the effect of time in treatment (pre-treatment to post-treatment), with change scores on the mediators (M) and outcome variables (Y) assumed to be influenced by the treatment program. The evidence produced from such approaches is not as definitive as that

from studies with control groups but can still deepen our understanding of these processes of change[17]. If significant indirect effects were obtained, evidence was obtained in favor of the potential mediating effect of mindfulness attention awareness, worry and rumination[19]. On the contrary, if no significant results are obtained, mindfulness attention awareness, worry and rumination can be discarded as potential mediators.

We assessed one model with ARCES score post treatment as outcome and gain scores of mindfulness attention awareness as mediator. We replicate the same analyses but considering ARCES subscales score post treatment as outcome and each subscale gain scores of the worry and rumination scales as mediators. To run these models, we employed SPSS PROCESS macro that uses ordinary least squares regression to estimate the indirect effects[23]. More specifically, bootstrapping produces an approximation of the sampling distribution of the indirect effects. This is achieved through empirically generating a sample (with 5,000 replacements) from the full data set and calculating the indirect effects in the resamples. Statistical significance of the mediator was determined at p=.05 if the 95% bias-corrected percentile bootstrapped confidence interval of the indirect effect point estimated did not contain 0[23]. Bias-corrected bootstraps seem to be more suitable for very small samples and more feasible in terms of programs and steps that are needed to conduct the analyses.

RESULTS

Exploratory and descriptive analysis

Seventy-four adults between 23 and 64 years of age participated in the study. The mean age of the sample was 42.25±10.11. All the participants successfully completed secondary education (49%) or higher education (51%). 76.3% of the sample was female and 23.7% was male. Descriptive statistics for the proposed mediators and outcome measures are presented in Table 1.

Outlier analyses were conducted to identify cases that might mask trends in the dataset. An outlier was defined as any case having a leverage score four times the value of the mean leverage value. No meaningful outliers were found. Missingness was tested by creating a dummy variable for each case, which was then correlated with sociodemographic data and scores on the variables of interest. Less than 2% of the data was missing and the missingness was not significantly correlated with any of the variables.

Effectiveness analysis

Following the recommendations of Judd *et al*.[18], before conducting the mediation analysis, the effectiveness of the intervention and the occurrence of statistically significant changes were examined between the two conditions. Using a dependent means t test, we compared the means of ARCES scores in the two conditions. The results obtained (Table 1) indicate that the intervention generates statistically significant changes in the ARCES scores. Regarding potential

mediators, statistically significant changes are observed in MAAS, PSWQ and RRS-B scores.

Table 1. Mean (SD) and t Test results between pretest and posttest in variables of attention related errors, mindfulness attention awareness, worry and rumination.

	Pre-test		Post-test		95% interval of confidence				
Outcome	**Mean**	**SD**	**Mean**	**SD**	**Lower**	**Upper**	**t**	**gl**	**p**
ARCES	26.34	5.35	23.34	6.19	1.38	4.61	3.74	44	.001
Potential Mediators	Mean	SD	Mean	SD	Lower	Upper	t	gl	p
RRS-B (Rumination)	13.40	4.95	11.32	3.17	.71	3.44	3.10	45	.004
PSWQ (Worry)	24.02	6.95	18.97	6.51	3.36	6.74	6.08	45	.000
MASS	12.67	2.45	14.44	3.08	-3.034	-.748	-3.333	45	.002

Mediation analysis

The results of the univariate mediation analyses are presented in Table 2. Results showed the mediational role of MASS, PSWQ and RRS-B in the improvements in ARCES scores.

Table 2. Change in Worry, Rumination and MASS mediators of the effect of mindfulness training on ARCES change.

Mediator	Indirect Effect (SE)	t	p	95% CI
PSWQ (Worry)	.35 (.11)	3.12	.00	[.12; .58]
RRS-B (Rumination)	.30 (.24)	1.23	.22	[-.19; .81]
MASS	.41 (.06)	6.82	.00	[.29; .53]

DISCUSSION

The present research aimed to contribute to the study of mindfulness in the workplace and assess the impact of an MBI on the attention related cognitive errors of workers. The second objective was to study the mediation role of mindful attention awareness, worry and rumination on the decrease of ARCEs after the MBI.

On the first hand, as we expected, the attention lapses reported by the participants decreased after the MBI. We went into greater depth and our findings confirm that the decrease of ARCEs after MBIs, were mediated by less worry and rumination and more mindful attention awareness. This means that the impact of the MBIs on emotional regulation is crucial to cognition improvements after the program. To the best of our knowledge, this is one of the first studies to analyze this set of variables in this manner.

Worry and rumination, two basic responses to emotional events, are crucial for maintaining negative emotion and have been associated in the etiology and maintenance of anxiety and depressive disorders. Previous studies evidenced that anxious individuals show impoverished recruitment of frontal cortical regions implicated in attentional control[24]. This is observed when attentional competition is created by threat-related stimuli or in the absence of emotional stimuli[25]. These studies proposes that anxiety may involve a deficit in augmenting attentional control to enable processing of task-relevant

stimuli when competition from salient distractors is present[25].

Our results suggest that mindfulness training may be an effective technique for reducing these two forms of repetitive negative thinking and that this may influence cognitive processing, reducing ARCEs. Certain authors claim that awareness without judgment – typical of mindfulness practices – can facilitate a healthy relationship with emotions, thus helping people to really experience and express their emotions and reducing mechanisms such us avoidance, suppression or over identification with emotions, the sources of worry or rumination[26].

On the second hand, a fundamental point we believe should be mentioned is the complementary theoretical stance recommended by the mind-wandering literature, due to its manifest relationship with attention lapses. In fact, growing evidence indicates that mind-wandering, described as off-task (vs. on-task) stimulus-independent thinking during ongoing task performance, results in lapses in attentional performance[6]. Despite clear theoretical connections, this literature has been isolated from that worry. Mind-wandering results from both impoverished attention control and increased interference from automatically elicited personal concern-related thoughts[27]. It is argued that worry-related cognition is a subclass of personal concern-related thought processes. Therefore, a logical extension to this position is that worry might entail the spontaneous generation of, and occupation with,

negative self-referent thoughts while also being orthogonal to individual differences in attentional control. Where individuals lie on this latter control dimension may have an impact on the ease with which worry-related thoughts are dismissed at will when concentration needs to focus on task performance. This could in turn account for the observation that worry is perceived as less controllable and more disruptive to everyday life when it occurs in connection with anxiety, because of its increased co-occurrence with impoverished attention control.

On the third hand, results on attention awareness (MASS) mediating improvement on ARCEs correlates with novel findings, such as the ones of the recent attention schema theory (AST). AST posits a specific relationship between awareness and attention, in which awareness is the control model that the brain uses to aid in the endogenous control of attention Awareness of the cue would correspond to a state in which the brain is modeling the attention that has been drawn to the cue[28]. Although this is a very recent theory, our findings seem to correlate with this preceding line of research. By improving the understanding of this kind of mechanism of action and seeking to better understand the coherence (and lack thereof) between variables, it may be possible to broaden our understanding of the benefits of mindfulness.

This study is subject to several potential limitations. Firstly, all the measures used were self-reported and therefore limited by the reliability of the method and subject

to error. Secondly, the sample was relatively small and may have restricted the findings, despite the participation of a reasonable cross-section of 74 workplace individuals. Thirdly, unfortunately, we have been unable to include neuropsychological tests in this study to assess attention processes, such as sustained attention or selective attention tests. This would be interesting for further studies, since viewed from a neurocognitive stance, mindfulness may be one type of cognitive training strategy. Such as exercises focusing on attention (FA) during meditation, may respond to strengthening by engaging repeatedly in that activity with an improvement of attention capacities[29]. For further studies we are interested in broadening our line of research and including a neuropsychological test of attention to understand the possible influence in the current findings. Lastly, recruitment of this sample from just one program in a single organization, added to the lack of a control group, may limit the generalizability of these results. Further research is needed on MBI programs in other workplaces.

To sum up, the impact of MBIs on reducing cognitive errors is key within the context of organizations. The effects of attention lapses can be particularly deleterious when experienced by people whose jobs require situational awareness, assessing environmental input to detect low-probability events or rapidly changing circumstances. Moreover, when attention is derailed in this way, the ability to monitor and adjust behavior or take corrective action based on real-time feedback may become compromised.

Attention lapses can therefore result in dire consequences for a variety of professions where present moment attention to immediate environmental input is essential, from air traffic controllers to pilots, fire fighters, police officers and troops on patrol.

Our findings support the literature that suggests that mindfulness interventions are a useful resource to facilitate a variety of aspects of the employee's health. Also, the current pattern of results on the mediation effects of mindfulness awareness, worry and rumination on attention lapses indicates the importance of studying the active processes underlying mindfulness intervention. By improving the understanding of the mechanisms of action of mindfulness and seeking to better understand the coherence (and lack thereof) between variables, it may be possible to broaden our understanding of the benefits of MBI resulting in significant benefits for organizations[30].

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