The Effects of Mindfulness on False Memory Production and the Depression-Focused Attention Link: A Replication and Extension Study

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Abstract

Building upon Ayache et al.'s (2021) original research, replication efforts confirmed no significant recall and recognition differences between the mindfulness and control conditions. However, false memory recognition varied by item type. Extending beyond replication, this study also explores how depression levels interact with various cognitive states—focused attention, mind wandering, and sleepiness—during the experimental mindfulness induction and the controlled storytelling induction. Findings indicate a significant interaction effect between induction conditions (mindfulness vs. storytelling) and depression on focused attention. However, no significant differences were found for the depression-mind wandering correlation or depression-sleepiness correlation among the two induction conditions. This extension offers insights into the complex relationship between depression and cognitive processes, emphasizing the need for further investigation considering potential confounders and other moderators. Future research could employ longitudinal studies, imaging techniques, and more to elucidate underlying mechanisms, informing targeted interventions for individuals with depressive symptoms.

Introduction

Mindfulness is a technique that uses guided meditation, breathing exercises, and various other methods to achieve an awareness of the present moment to accept bodily sensations and thoughts without judgment. It can be defined as "paying attention in a particular way: on purpose, in the present moment, and non-judgmentally" (Kabat-Zinn, 1994). State mindfulness is the quality of awareness being experienced temporarily during or immediately following mindfulness practices. Aside from state mindfulness, dispositional mindfulness can occur. Dispositional mindfulness is a specific mental state that is considered a personality-like trait beyond practice in which individuals naturally possess a disposition to be mindful in everyday situations. It is a stable aspect of personality achieved by practicing mindfulness over time, which can be cultivated by meditation, yoga, or other mindfulness practices. Disposition mindfulness tends to be affected by the consistency of the practice. Some individuals tend to have naturally higher levels of dispositional mindfulness, usually assessed by self-check questionnaires (Baer et al., 2006). With the field of mindfulness gaining tremendous interest in recent years, multiple studies have been conducted to analyze the effects of mindfulness. For instance, mindfulness has been found to have promising effects on cognitive and psychological outcomes for individuals with cognitive impairment, anxiety, or subjective cognitive decline (Tran et al., 2023). Other findings suggest that mindfulness benefits motivation and episodic memory (Brown et al., 2016).

Ayache et al. (2021) investigates how dispositional and state mindfulness were measured in a virtual setting using the Deese-Roediger-McDermott Task to gauge the production of false memories. Deese-Roediger-McDermott Task (DRM) is a widely used false memory paradigm, in which subjects are presented with lists of semantically related words and then asked to recall or recognize these words after a short delay to measure the incidence of false memories in a controlled environment (Delgado et al., 2017). The DRM is applicable to various demographics: it has mainly been used on adults, but additional experiments have tested this paradigm on a wide age range, including children (Sugrue et al., 2006). Ayache et al. (2021) used the DRM to analyze the correlation between state and dispositional mindfulness on false memory incidences when presented in a virtual environment

The replication part of this paper will attempt to replicate the main findings of Ayache et. al (2021). Using the paper's existing database, the extension part of this paper will investigate the relationship between depression levels and various cognitive processes (focused attention, mind wandering, and sleepiness). We will be utilizing the Beck Depression Inventory (BDI) for the assessment of depression levels, and we will use the paper's visual analogical scales to measure these three cognitive variables.

Problems with Replication

This study was done with a relatively small sample size compared to previous studies on this topic: 44 participants were randomly assigned to mindfulness ($N = 22$, 16 females, age 21.20 ± 2.26 years) or a fable storytelling control ($N = 22$, 19 females, age 21.88 ± 3.15 years) (Ayache et al., 2021). Participants in the study underwent individual sessions where they signed participation agreements and engaged in a structured experimental procedure. The protocol involved self-report questionnaires, neuropsychological assessments, virtual training tasks, and an induction phase with mindfulness or story inductions. The study concluded with mood assessments, a virtual environment walk corresponding to an encoding phase, memory tasks, and a debriefing lasting approximately 90 minutes. A replication of this study with a larger sample size is warranted. A small sample size leads to less accuracy and more variability in data, which could be hard to replicate directly. Larger sample sizes more closely approximate the population, while small sample sizes fail to do so. Hence, replicating small sample sizes accurately could be fairly difficult to get the same results: mindfulness did not have any effect on false or correct memories (free recall and recognition) after a short mindfulness practice session compared to a control condition. These results were also contrary to previous studies, suggesting that the small sample size affected this: recent studies reported some unexpected side effects, observing an increase in false memories after mindfulness practice (Rosenstreich, 2016; Wilson et al., 2015). Additionally, the study only employed visual material, which inhibited directly testing the differential impact of mindfulness depending on the studied material on the same participants since only a virtual reality version of the DRM was employed. Ensuring a controlled environment is also key in replication. External factors such as noise, distractions, or participant fatigue can all impact results.

In Ayache et al. (2021), the manipulation checks were executed after the mindfulness (experimental induction) or storytelling (control induction) sessions and based on the Five Facets Mindfulness Questionnaire. One thing to note about the manipulation checks, similar to the depression scores, is that self-reports could vary based on participant understanding of the question, participant demographics, etc. Baer et al. (2006) also used five mindfulness questionnaires: the Meditation Attention Awareness Scale (MAAS) the Freiburg Mindfulness Inventory (FMI), the Kentucky Inventory of Mindfulness Skills (KIMS), the Cognitive and Affective Mindfulness Scale-Revised (CAMS-R), and the Mindfulness Questionnaire (MQ). They found four factors aligning closely with the KIMS questionnaire and an additional factor capturing a non-reactive stance toward internal experience from items in the FMI and MQ questionnaires. Combining these questionnaires would provide the most accurate representation of mindfulness in future studies.

Original Study Methods

Participants

Participant recruitment took place at the Institute of Psychology at the University of Paris Descartes. All participants were awarded credit for their contribution to the study. Parameters for participants of this study included: (1) being between the ages of 18 and 30 years, (2) absence of neurological or psychiatric history, (3) absence of auditory or visual troubles that would inhibit their virtual reality experience, (4) absence of substance addiction, (5) must not practice meditation, and (6) must be native French speakers. There were 44 participants, either assigned to the mindfulness or control group. During the mindfulness session, participants were prompted to center their attention on their breath, acknowledging any wandering thoughts and gently guiding their focus back to their breathing. Meanwhile, the control group listened to a philosophical story, encouraged to immerse themselves in the storyline. It was ensured that participants had similar levels of dispositional mindfulness.

Procedure

Each participant's session was conducted individually and consent was attained. Each session started with self-reported questionnaires and then multiple neuropsychological assessments, including the Five Facet Mindfulness Questionnaire (FFMQ), Beck's Depression Inventory (BDI), the Trail Making Test (TMT), and the digit span.

Following the questionnaires, the participants were exposed to the virtual environment through several training tasks. They had to perform timed tasks with the gamepad. Then, encoding started followed by an induction period starting with short anamnesis (recollection) regarding basic personal questions (age, sex, education). This was to ensure that participants had no previous meditation experience. Participants were then categorized into mindfulness and story induction groups. This was done randomly by software.

Participants were left alone with a computer and headset during induction, as they listened to the audio. When the audio stopped playing, participants completed manipulation check items. Then, changes in their moods were assessed using a matrix. They were then presented with the virtual environment and briefly reminded of how to navigate around within it. Participants were presented with a free recall and recognition task immediately after interacting with the virtual environment. A final debriefing was conducted with each participant, with the experiment lasting approximately 1.5 hours.

Questionnaires and neuropsychological assessment

The FFMQ was used to evaluate sub-components associated with mindfulness. The purpose of this questionnaire was to examine dispositional mindfulness. The five subcomponents are 1) Observing, 2) Describing, 3) Acting, 4), Non-judging, 5) Non-reactivity. The participants' mood arousal and valence was also evaluated before and after the induction of the mediation and the control conditions using a matrix. The TMT (Lezak et al., 2004) and digit span (Wechsler, 2001) were administered to assess cognitive flexibility and working memory, respectively.

Inductions

Two audio tracks were created (same voice from a male), roughly 15 min, for the experimental conditions. Participants were instructed to focus on their breathing and notice when their mind wandered from the chosen object during a mindfulness class. At this point, they were encouraged to focus their attention on their breathing. The control group consisted of a philosophical tale that was read. The randomization was automatically performed by the Neuropsydia software (Makowski & Dutriaux, 2017).

Manipulation checks

After listening to the audio tracks, participants used a series of six visual analog scales (ranging 0 to 100) to evaluate their cognitive state during the induction. They were required to indicate their level sleepiness ("I felt sleepy"), mind wandering ("My thoughts freely wander, without control"), focused attention ("I was concentrated on specific idea, sensation, or perception"), internal absorption ("My attention was captured by events that I imagined or remembered"), body awareness (My attention was directed towards my body sensations, such as breath or heartbeat), and external absorption ("My attention was captured by what was happening around me, like sounds or voices").

Memory task in virtual reality

The FalseMem task (Abichou et al., 2020; Abichou et al., 2021) was employed for the memory test, which enables the observation of both accurate and false memory occurrences in a natural setting, assessed through both free recall and recognition processes. The FalseMem task's encoding phase was executed within a lifelike 3-D environment constructed using Unity 3D software within a controlled laboratory environment.

Using a gamepad, participants maneuvered through a virtual city displayed on a 17-inch Asus Republic of Gamers laptop screen. Prior to the experimental session, participants underwent a series of tasks within a virtual training area to confirm their proficiency in navigating a 3-D environment using the gamepad. During the encoding phase, participants were given specific instructions to focus on the stalls marked by a red signal on the floor. Additionally, participants were informed that a memory test would follow afterward. The stalls were linked to seven categorical DRM lists: animals, fruits, vegetables, musical instruments, furniture, clothes, and tools. Each list contained ten items, with the exception of the "animals" category, which, due to technical constraints, consisted of only nine items. The duration taken by each participant to navigate through the various stalls was noted to regulate their exposure to the environment. Following the encoding phase, a free recall task of the items from the DRM lists was conducted. During this session, participants were given a 10-minute timeframe to remember and recall as many items as they could from the stalls. Following the free recall session, participants engaged in the FalseMem recognition task. This task involved the presentation of 157 items via Neuropsydia software (Makowski & Dutriaux, 2017), comprising 69 target items shown in the virtual environment, with 7 critical items, each representing a distinct DRM list; 28 semantically related items; 28 perceptually associated items; and 25 neutral items. These items were displayed randomly and at the participant's own pace on a computer screen with a black background. For each item, participants had to determine whether it had been presented in the virtual environment or not. If they recognized an item as previously seen, participants were asked to specify the type of consciousness associated with the recognition using the R/K/G paradigm (Gardiner et al., 1998).

Before starting the recognition task, researchers explained to participants how they should respond to the items they were about to see. Researchers asked them to say "I remember" (R) when they could recall specific details about an item along with where they saw it before. If they felt like they recognized something but couldn't remember specific details, they were instructed to say "I know" (K). Lastly, if they weren't very sure about their answer and it was more of a guess, they were instructed to say "I guess" (G). This helped them understand how certain they were about their memories, whether they remembered the items clearly, or if recognition was based more on a feeling of familiarity without clear recollection.

Replication Data Analysis

For our replication data analysis, we extracted the authors' public R script and data from OSF HOME. Using R software, we ran their R script with the downloaded data and carefully examined the output to replicate the authors' reported results. The goal of the replication was to be able to replicate and confirm our the authors' reported results in the chosen subsection to strengthen the validity of this part of the study. The authors' reported results were able to be replicated, and we will hone in on the main results subsections: free-recall and hit and false-recognition rates. Correct free recall rate for each participant was determined by dividing the number of correct recall items by the total number of items presented (n=69). False recall rate for each participant was determined by dividing the number of false recalls by the total number of critical items (n=7). For hit rate, an ANCOVA analysis was employed with the induction (mindfulness and story) as a between-subject factor. For false-recognition rate, we employed a mixed ANCOVA with the induction (mindfulness and story) as a between-subject factor and the type of lure (neutral, semantic, perceptual, and critical) as a within-subject factor.

Replication Results

Free-recall

As in the original paper, no significant difference was found between the mindfulness induction (0.32 ± 0.14) and story (0.28 ± 0.11) conditions for the ratio of correct recalled items with $F(1,41) = 0.03$, $p = 0.86$, $\eta2 < 0.01$. This was neither the ratio of false recall with $F(1,41) = 0.04$, $p = 0.84$, $\eta2 < 0.01$ or mindfulness induction (0.09 ± 0.12) and story (0.09 ± 0.10).

Hit and false-recognition rates

In regards to correct recognition rate ("hits"), we did not see a significant difference between the mindfulness induction (0.54 ± 0.16) and story (0.51 ± 0.14) with $F(1,41) =.34$ $p = 0.56$, $\eta2 < 0.0082$. For the false-recognition rate, we found a significant main effect of the type of items on false recognition with $F(3,167) = 35.51$, $p < 0.001$, $\eta 2 = 0.37$ (Fig 1). The post hoc analyses showcased that the false-recognition rate of critical items (0.342 ± 0.197) was significantly higher than semantic (0.185 ± 0.128, $p < 0.001$ $p < 0.0037$), perceptual (0.215 ± 0.118, $p < 0.001$ $p < 0.537$) and neutral items (0.056 ± 0.063, $p < 0.001$). False-recognition rates of neutral items were significantly lower (all $p < 0.001$) than perceptual and semantic items. The difference between perceptual and semantic items was not significant ($p = 0.3$). The main effect of the induction was insignificant with mindfulness induction (0.19 ± 0.16) and story (0.21 ± 0.18) with $F(1,167) = 1.79$, $p = 0.18$, $\eta 2 < 0.01$. The interaction between the induction and the type of items was insignificant with $F(3,167) = 0.29$ $p = 0.83$, $\eta 2 < 0.01$.

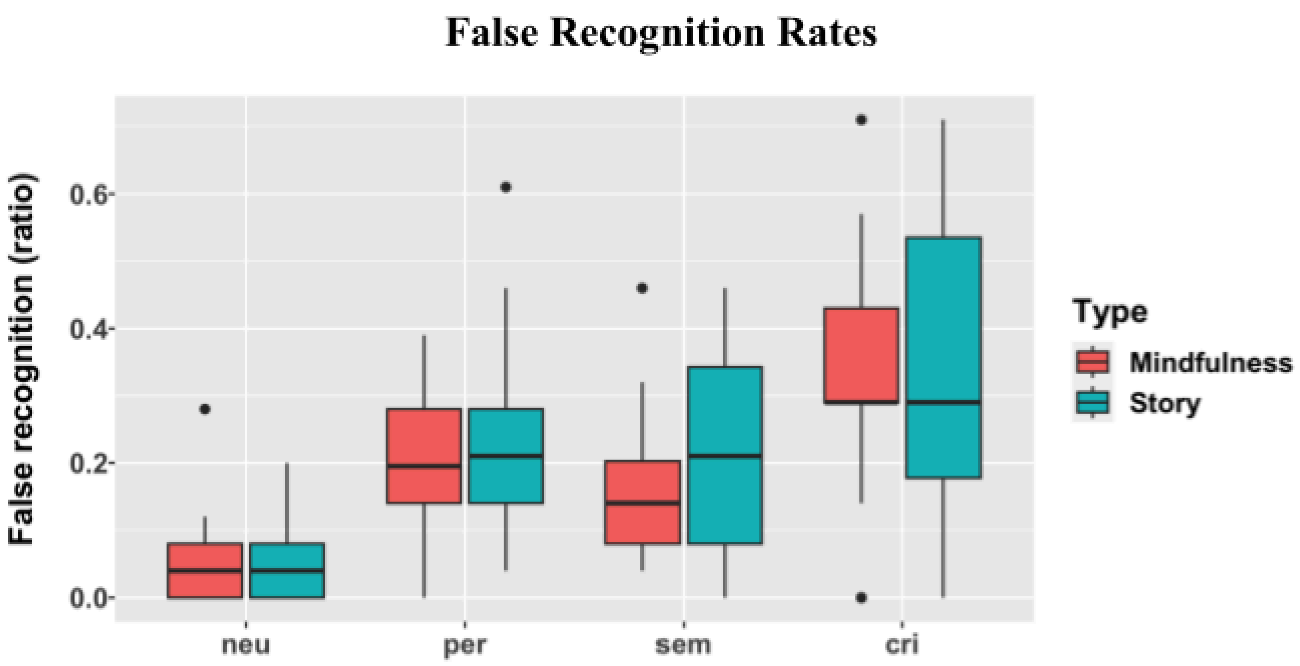

Fig 1. Box plot of memory performances by types of lures and type of induction for false recognition rate.

Neu = neutral items
Per = perceptually associated items
Sem = semantically related items
Cri = critical items (one for each DRM list)

Replication Discussion

The replicated results for the replicated measures - free recall and recognition rates - all match up with the original study's. Future directions for replication specifically include replicating the other findings to validate the entire study.

Comparison to the literature

A study by Wilson et al. (2015) demonstrated that mindfulness meditation reduces the ability to distinguish between externally presented and internally generated information, thereby increasing susceptibility to false memories. Some related studies have come up with similar results. In a five-week experiment with a positive mindfulness training group and a control group, a brief positive mindfulness group and a mind wandering control group, positive mindfulness increased recognition of true memories and had no effect on spontaneous false memories but increased the odds of triggering false memories (Rosenstreich, 2016). In a different study of two mindfulness categories, single-session focused attention and open monitoring, it was found that both pre-meditation and post-meditation recall tests demonstrated a significant increase in false memory recall, but there were no differences between these groups in true and false memory recall and recognition (Bitton et al., 2023). Another study, focusing on sleep aspects, suggests that insomnia affects the production of false memories (Malloggi et al., 2022).

However, some related studies have come up with different results. In a study of 2022 undergraduate students using the DRM paradigm, mindfulness induction did not lead to more false memories, nor did warnings interact with induction (Baranski & Was, 2017). Furthermore, a study conducted in a virtual reality environment revealed no statistically significant effects of

VR cognitive training on delayed memory, immediate memory, attention, and instrumental activities of daily living (Zhong et al., 2021). The studies align with the conclusions of Ayache et al. (2021), who found no discernible impact of positive thinking on false or accurate memory (free recall and recognition) following a brief positive thinking session compared to a control group.

Extension

Methods for Extension

We analyzed each variable using linear regression models with interaction effects in R Studio. We replicated data from the original literature using the existing open dataset provided by the Ayache et al. (2021) and looked at four variables in isolation. Our research objective was to investigate how the induction condition (experimental condition of mindfulness vs. controlled condition of storytelling) affected the relationship between depression (BDI, scale 0-18) and various cognitive states. The three cognitive states are focused attention, sleepiness, and mind wandering. These manipulation checks occurred after listening to the experimental mindfulness induction audio tracks.

Six visual analogical scales were used during the manipulation checks to assess current cognitive states. Focused attention, sleepiness, and mind wandering were all self-reported on a continuous scale of 0-100. Participants have to report how much they agreed with the following statements: “I was focused on a specific idea, sensation or perception” (focused attention), “I felt sleepy” (sleepiness), and “I was focused on a specific idea, sensation or perception” (mind wandering).

Hypotheses:

H_1: The condition significantly affects the relationship between reported depression scores and focused attention levels.

H_O: The condition had no significant effect on the relationship between reported depression scores and focused attention levels.

H_2: The condition significantly affects the relationship between reported depression scores and sleepiness levels.

H_O: The condition had no significant effect on the relationship between reported depression scores and sleepiness levels.

H_3: The condition significantly affects the relationship between reported depression scores and mind wandering levels.

H_O: The condition had no significant effect on the relationship between reported depression scores and mind wandering levels.

Results

Focused Attention

We analyzed the data through linear regression in R, which outputted story condition types on focused attention when other variables were constant. Model values were as follows for TypeStory induction (-51.94 ± 11.57). The focused attention scores tend to decrease as story condition type values increase, which is a change between Mindfulness (1) to Story (2). When the TypeStory score increased by 1, the focused attention score decreased by 51.94. This association was found to be statistically significant with our p-value ($t(42) = -4.489$, $p < 0.001$).

When compared to the relationship with the BDI model (-1.795 ± 1.034), depression scores showed a small negative effect on focused attention ($t(42) = -1.736$, $p = 0.0902$), which were found not to be statistically significant. This model explains ~ 35% of the variability between the degree of depression and the degree of focused attention on patients, with $r^2 = 0.3524$, which indicates possible confounding factors in this extension portion.

However, with the interaction of the TypeStory induction and the relationship with the BDI model the focused attention score increases by 4.067 with every change of 1 (4.067 ± 1.517). This indicates a statistically significant interaction effect between story condition type and depression, both interacting on focused attention with ($p = 0.0106$).

The Link Between Depression Scores and Focused Attention Levels under the Mindfulness conditions and Story condition

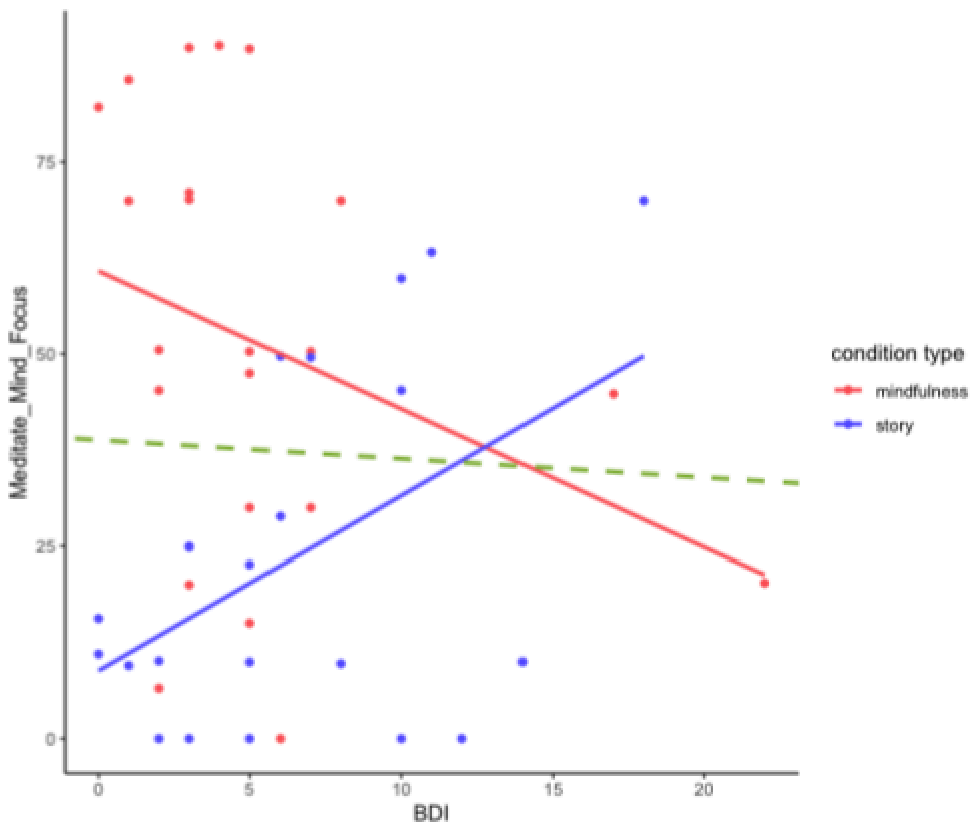

Fig 2:

Mediate_Mind_Focous = focused attention levels assessed by the self-reported measure of “I was concentrated on specific idea, sensation, or perception”

BDI = depression score assessed by the self-reported measure of Beck’s Depression Inventory

Sleepiness

We noted a TypeStory estimate of -18.8445 for sleepiness, which indicates a decrease in sleepiness. Similarly, the TypeStory has shown that the observed sleepiness decrease is not statistically significant($t(24) = 8.112$, $p = 0.108$) . For TypeStory alone, there is an evident negative correlation. With Beck's Depression Inventory (BDI) values, we find an overall increase in sleepiness, with a given estimate of 0.6889. However, this p-value is just over 0.5 at 0.506, unlike our TypeStory value, indicating little statistical significance within the BDI results.

However, our results are much less significant when we compare TypeStory to BDI (represented as TypeStory: BDI). The TypeStory: BDI coefficient value is -0.8543, which indicates a slight decrease in TypeStory: BDI. However, the p-value for this coefficient is 0.573. Therefore, this value is not statistically significant. Also, $F(3) = 3.666$, and an F-statistic greater than 3.95 is needed to reject our null hypothesis, which is not true for these values.

Mind Wandering

Participants in the story condition type revealed a coefficient (estimated change in the response variable) of -6.3165, indicating a decrease in mind wandering. However, the associated $p=0.680$ indicates that this observed effect is not statistically significant. Participants in the Beck Depression Inventory (BDI) condition type revealed a coefficient of 1.4407, indicating a potential increase in mind wandering with higher BDI scores. However, the associated $p=0.295$ suggests this observed effect is not statistically significant. The negative coefficient of -0.9073, indicating the presence of both condition types is associated with a decrease in mind wandering. The associated $p=0.651$ suggests that the interaction is not statistically significant. The findings from these analyses do not provide sufficient evidence to support the statistical significance of the relationships between story condition, BDI condition, and their interaction with mind wandering.

Extension Discussion

We concluded that the induction condition moderates the depression-focused attention correlation. On the contrary, the results reveal no differences for the depression-mind wandering correlation or depression-sleepiness correlation among the two induction conditions (mindfulness vs. storytelling). The depression-sleepiness relationship result is particularly surprising, given that indicated EDS (excessive daytime sleepiness) is strongly linked to depression (Chellappa et al., 2009). However, considering that depression is intertwined with circadian rhythms on a wide array of dimensions, a chronobiological approach may shed new light on the interaction between sleep and depression. The depression-mind wandering relationship result is not surprising, given that there was no unambiguous evidence for increased propensity to mind wander in depression (Chaieb et al., 2022). However, rumination is commonly seen as the cognitive key symptom of depression (Spinhoven et al., 2018); and it remains unclear whether the emergence of rumination is an isolated symptom or whether broader distortions in the amount and characteristics of mind wandering occur in depression (Chaieb et al., 2022).

Looking at the results for focused attention, it is quite interesting to see a complete reversal in slopes (**Fig 2**). Particularly, we see an average slope of higher depression scores reporting lower focused attention levels. Mindfulness's impact on focused attention in individuals with high depression levels may be diminished, as previous research suggests that major depressive disorder often presents challenges in maintaining concentration (Keller et al., 2019; Liu et al., 2023). Future studies are required to validate this observation since most participants in Ayache et. al (2021) did not have high depression levels to begin with.

Limitations from extension

This extension used previous data sourced from the replications. Of the prior replication, there were missing variables integral for this portion, such as gender and age. These variables may have confounding effects on levels of depression and the disposition for mind wandering, focused attention, and sleepiness. Excluding crucial self-identifying variables may exclude portions of populations more prone to varying cognitive states and depression, as cultural and social paradigms might be in effect by the time the study was initiated. The original data set did not contain these variables and was therefore not utilized by the extension as a part of our measures. Additionally, much of the collected data in the original study consisted of self-reports. These ratings can vary due to differing understandings of the question, motivation, and other confounding variables.

Future Directions

The current study presents novel insights into the understanding of the complex relationship between depression and cognitive states, particularly focused attention, mind wandering, and sleepiness. While the analysis did not yield statistically significant correlations between depression levels and these cognitive processes directly, the induction moderation finding for focused attention stresses the need for further investigation in this field of study.

Future research efforts should prioritize longitudinal studies and potentially utilize imaging techniques to explore the underlying mechanisms linking depression and cognitive states. Furthermore, investigating potential moderating variables, such as age, gender, or cultural factors, could improve our understanding of the nuanced relationship between depression and cognitive processes. Future researchers should also consider utilizing more diverse cognitive state and BDI assessments to clarify the mechanisms underlying the link between depression and mental states.

Conclusion

The replication of the main results of Ayache et al. (2021) yielded all of the same findings. There were no significant differences between the mindfulness and story conditions for the correct free recall of items, the false free recall of items, the correct recognition of items, or the false recognition of items. However, there was a significant difference between the types of items that were falsely recognized.

Through the extension, we evaluated correlations between depression and three cognitive states: focused attention, sleepiness, and mind wandering. We wanted to delve further into the role of depression from the replication paper and how certain cognitive factors would be impacted by the BDI score. Only the correlation between depression scores and focused attention levels were significantly impacted by the induction condition, suggesting that the induction condition (mindfulness vs. storytelling) was a moderator for this relationship.

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