The Acute Effects of Focused Attention and Open Monitoring Meditations on Prospective Memory in Older Adults

Alex Pak Lik Tsang[1]

Huijing Lu[1]

Herman Hay Ming Lo[1]

[1]Department of Applied Social Sciences, The Hong Kong Polytechnic University

Author Note

Correspondence of this article should be addressed to Alex Pak Lik Tsang (ORCiD: 0000-0003-2919-1587), Department of Applied Social Sciences, The Hong Kong Polytechnic University. Email: pak-lik-alex.tsang@connect.polyu.hk

Abstract

Objectives: This study explores the acute effects of meditation on prospective memory (PM) in older adults. Study 1 evaluates whether focused attention (FA) meditation improves PM, while Study 2 investigates whether open monitoring (OM) meditation can facilitate PM under the influence of a negative mood.

Methods: In Study 1, 127 healthy older adults (M_{age} = 64.87) were randomized into a FA group or a mind wandering (MW) group. Three types of PM were assessed: focal event-based PM (EBPM), non-focal EBPM, and time-based PM (TBPM). Two experimental tasks were employed to measure sustained, selective, and executive attention. In Study 2, 157 healthy older adults (M_{age} = 66.19) were randomized into an OM group or a MW group. Using a mood induction paradigm (neutral vs. negative), three types of PM (focal EBPM, non-focal EBPM, and TBPM) were assessed.

Results: In Study 1, the FA group outperformed the MW group in focal EBPM ($p < 0.05$); however, this improvement was only weakly and partially mediated by enhanced sustained attention ($p < 0.05$). In Study 2, the OM group exhibited better performance than the MW group in focal EBPM under a negative mood induction ($p < 0.01$).

Conclusions: This study offers preliminary evidence that FA and OM meditations are beneficial for PM in older adults. Even brief 25-minute inductions of FA and OM can produce measurable benefits in focal EBPM, which can facilitate older adults to achieve functional independence and contribute to a successful aging experience.

Preregistration: This study is not preregistered.

Keywords: aging, focused attention, meditation, mindfulness induction, older adults, open monitoring, prospective memory.

The Acute Effects of Focused Attention and Open Monitoring Meditations on Prospective Memory in Older Adults

Prospective memory (PM) describes the cognitive processes that allows us to realize a future intention at an appropriate moment; it is broken down into event-based PM (EBPM) and time-based PM (TBPM) (Einstein & McDaniel, 1996). EBPM is activated by the occurrence of a PM cue, for example, to replenish groceries when passing by a specific store. According to the Multi-Process Theory of PM (McDaniel & Einstein, 2000), EBPM is further distinguished by its cue focality. Focal EBPM is cued by the processing features of an ongoing task, which is supported by spontaneous retrieval, a bottom-up approach that allows the automatic capture of attention paid to the PM cue, such as having a conversation about shopping may remind of an intention to replenish groceries. In contrast, non-focal EBPM shares no overlapping features with the ongoing task, which requires strategic monitoring, a top-down attentional process to monitor for the presence of a PM cue, such as scheduling a work meeting is unlikely to stimulate the intention to replenish groceries. On the other hand, TBPM occurs after a certain amount of time has been elapsed, such as taking medications after two hours. PM encompasses a range of vital daily tasks for older adults, such as attending medical appointments and taking medications on schedule, to achieve functional independence (Woods et al., 2012). Yet, PM utilizes cognitive processes in the prefrontal and medial temporal cortex that are subject to an age-related decline (Burke & Barnes, 2006). Several meta-analyses in studies investigating the aging effect of PM consistently reported a decline of PM in older adults (e.g., Kliegel et al., 2008; Uttl, 2008). An important endeavor in gerontological research is therefore to explore ways to attenuate a PM aging decline.

There are two major approaches in PM training in regard to attenuating a PM aging decline in older adults: strategy-based training and process-based training (Hering et al., 2014). Strategy-based training, or compensatory training, utilizes mnemonics to compensate for a PM aging decline. Process-based training, or restorative training, targets one or multiple underlying cognitive processes, such as attentional control, executive functions, episodic memory processes, to restore its efficiency (see Kliegel et al., 2002, for an elaborate discussion on cognitive processes involved in PM). Although PM is important for older adults to achieve functional independence, there is currently a lack of PM training for this population, contributing to a weak evidence base (Tsang et al., 2022). Among the scant evidence of PM training, strategy-based training has been criticized for its lack of transferability to untrained tasks (McDaniel & Bugg, 2012; Zelinski, 2012). Utilizing process-based training should encourage transfers because it can target the underlying cognitive mechanisms (Zelinski, 2009), with potential to be transferable to tasks that also utilize the trained cognitive processes. For example, a process-based training could utilize spaced retrieval to practice PM retention progressively at a longer span, which may transfer into better episodic memory. Thus far, there is positive preliminary evidence in different approaches to process-based PM training for older adults. Rose et al. (2015) reported gains in EBPM and TBPM by training PM with computer simulations of daily PM tasks. Targeting more generic cognitive functions, Pandya (2020) also observed an improvement in EBPM after yoga practice.

An alternative promising approach in process-based PM training could involve the practice of meditation. Lutz et al. (2008) broadly classified different meditative practices into focused attention (FA) and open monitoring (OM) meditations. FA entails sustaining attention toward an anchor object (e.g., the sensation of breathing), maintaining self-awareness when the mind wanders, and directing attention back to the anchor object. OM involves the self-monitoring of all experiences while adopting a non-judgmental attitude. Recently, there has been a growing interest in exploring the acute effects of meditation in experimental settings. Mindfulness induction refers to a single session of brief meditative practices, typically lasting between five to 45 minutes (Heppner & Shirk, 2018). It often involves the utilization of FA meditation (e.g., Bokk & Forster, 2022), OM meditation (e.g., Lin et al., 2019), or a combination of both (e.g., Jankowski & Holas, 2020). Employing mindfulness inductions in a highly controlled experimental setting would permit more robust causal inferences to be drawn about its acute effects (Lin et al., 2022).

The salutary effects of mindfulness induction on episodic memory have been consistently observed. Brown et al. (2016) reported better episodic memory in recognition and free-recall tasks following mindfulness induction. Similarly, Leuke and Leuke (2019) found that mindfulness induction led to enhanced episodic memory encoding. Although the mechanism by which mindfulness induction improves episodic memory is still under investigation (see Levi & Rosenstreich, 2019, for a review), its benefits on episodic memory may extend into PM because successful PM retrieval relies on episodic memory. Further, considering the different natures of FA and OM meditations, they should exert different effects on PM.

FA meditation should facilitate attentional control in older adults. In FA, selective and sustained attention function to direct attentional resources and maintain an alertness toward the anchor object. When a distraction arises, executive attention resolves conflicts between the distraction and the anchor object to guide the participant's attention back to the present moment. This cyclical process of attentional control repeatedly activates associated brain regions, which may strengthen neural connectivity (Tang et al., 2015). In a recent systematic review, Melis et al. (2022) reported an increase functional connectivity between the frontoparietal network and the default mode network in FA, which suggests an enhanced top-down attentional regulation of mind wandering. Consistently, Bokk and Forster (2022) found that 10 minutes of FA induction can prevent a decrease in the P300 event-related potential (a marker of mind wandering) when performing a monotonous counting task, suggesting an improved executive attention.

Compared to episodic memory, the dual-task nature of PM retrieval typically requires a higher level of top-down attentional control. The Preparatory Attentional and Memory Process Theory of PM stresses the importance of attentional control in the retrieval of a PM intention (Smith, 2003; Smith & Bayen, 2004). Attentional resources are necessary to encode and monitor for the presence of a PM cue. Beyond detecting the PM cue, attentional control is involved in processes such as initiating a retrospective recognition check and interrupting ongoing activities to enable an individual to perform the PM task. Previous studies have shown consistent results. For example, Smith (2003) observed that it took 300 ms longer to respond after including a PM command to an ongoing task, which illustrates that limited attentional resources are devoted to the PM command, resulting in an overall slower reaction time (RT). Marsh et al. (2002) found that increasing the attentional load of an ongoing task impaired PM performance. Because insufficient attentional resources would lead to a PM failure, FA should facilitate PM by enhancing the efficiency of attentional control. An enhanced top-down control resulted from FA should further benefit non-focal PM tasks, which require top-down attentional regulation to monitor for the presence of a PM cue.

Contrary to FA, OM involves self-monitoring the present-moment experience, including emotions, while adopting a non-judgmental attitude, which inevitably transforms our affective experience. In OM, attention is directed toward any experience arises in the present moment, which promotes a bottom-up, stimulus-driven response (Tanaka et al., 2014). This process facilitates top-down emotion regulation (ER) to lessen emotional intensity. Adopting a non-judgmental attitude also facilitates disengaging habitual maladaptive emotional responses (Lindsay & Creswell, 2019). Neurological data have shown similar activation patterns, including increased activations of the dorsolateral prefrontal cortex and anterior insula, and decreased activations of the posterior insula and amygdala (Lutz et al., 2014). Similarly, after a brief mindfulness training, Ortner et al. (2007) observed shorter RT in a cognitive task (to indicate the tone pitch) following exposures to negative stimuli. Jankowski and Holas (2020) also reported that a mindfulness induction can attenuate the impact of anxiety on attention switching with faster processing speed. Dunn et al. (2023) further suggested a unique positive association between external sensory observing and positive affectivity in Mindfulness-based Cognitive Therapy, implicating a specific effect of OM in facilitating ER.

According to the Resource Allocation Model (Ellis & Ashbrook, 1988), mood states can interfere with the allocation of cognitive resources. Intense mood states can generate task-irrelevant or intrusive thoughts, which consume cognitive resources. As this model predicts, emotional interference should be particularly pronounced in cognitive tasks that require a high degree of controlled processing, such as PM. Experimental studies concerning the effects of negative affectivity on PM have yielded consistent results with this model, such as impaired PM in clinical depressed individuals in TBPM (Rude et al., 1999) and non-focal EBPM (Altgassen et al., 2009). Utilizing a mood induction paradigm, Kliegel et al. (2005) also observed that a negative mood can impair TBPM, primarily due to less accurate time monitoring, which implies that fewer cognitive resources were available to perform clock checks under a negative mood. Since OM improves ER, it could free up cognitive resources that would otherwise be occupied by mood fluctuations and this in turn facilitates PM. OM may further enhance focal PM by temporarily activating an enhanced stimulus-driven response, which allows a PM cue to be automatically capture in attention.

Thus far, only one recent study has explored the association between mindfulness induction and PM. Girardeau et al. (2020) explored whether FA can improve PM in young adults. In their study, PM was assessed using virtual reality to simulate an urban environment, including three PM cue types: focal EBPM, non-focal EBPM, and TBPM. Participants were told to encode their PM intentions. Then, they went through 15-minute inductions of FA or mind wandering. As a control group, participants in the mind wandering induction were told to daydream without any guidance in terms of attentional control. Participants then retrieved the PM intentions through their navigation in virtual reality. However, this study did not observe any differences between the two groups in regard to any of the PM cue types.

Since Girardeau et al. (2020) sampled on a younger population, its effects on older adults remain unclear. With an aging decline in attentional control, older adults are more prone to PM failures (Craik, 1986). At the same time, a recent longitudinal randomized-controlled trial demonstrated that FA can improve sustained attention in older adults (Isbel et al., 2020). Therefore, FA could still be a useful process-based approach to enhance the efficiency of attentional control for this population.

Another important question also remains unanswered in Girardeau et al. (2020), which concerns the effects of OM meditations on PM. Due to an aging decline in cognitive resources, older adults may recruit more resources to regulate their emotions (Mather & Knight, 2005). Phillips et al. (2002) found that older adults were more impaired than younger adults in planning under a positive or negative mood condition. They also tend to rely on maladaptive ER strategies (Eldesouky & English, 2018). Because maladaptive ER strategies consume a significant amount of cognitive resources, this may leave them with even fewer resources with which to perform PM tasks. Given that everyday PM tasks rarely occur in an emotionally neutral context, OM, which improves ER, could facilitate PM by allowing more cognitive resources to perform PM tasks that would otherwise be occupied by mood fluctuations.

This study explores the acute effects of mindfulness induction on PM in older adults. Two experiments (Study 1 and 2) are conducted to explore the specific effects of FA and OM meditations on PM. Study 1 evaluates whether FA improves PM through an enhanced attentional control. Study 2 investigates whether OM facilitates PM under the influence of a negative mood.

Study 1

Method

Participants

A priori power analysis was performed using G*Power 3.1 (Faul et al., 2009), based on effect sizes in literature related to the effects of mindfulness on episodic memory. Since these studies have typically reported medium to large effect sizes (e.g., Brown et al., 2016; Lueke & Lueke, 2019), the power analysis was formulated utilizing a one-tailed t-test to detect a medium effect size with a power of 0.80 at $p = 0.05$, which resulted in a target sample size of 102.

The total sample size of Study 1 was 127. The inclusion criteria were Chinese older adults (aged from 60 to 75 years) living in Hong Kong without any cognitive or affective impairments. Participants were screened using the Hong Kong version of the Montreal Cognitive Assessment (MoCA-HK; Nasreddine et al., 2005; Yeung et al., 2014) (cut-off: 22/30) for cognitive impairments and the Patient Health Questionnaire-9 (PHQ-9; Cheng & Cheng, 2007; Kroenke et al., 2001) (cut-off: 9/27) for affective disorders. One participant was excluded for scoring below the cut-off in the MoCA-HK. Participants were recruited through convenience and snowball sampling. Mass emails were sent to members of the Institute of Active Aging at the Hong Kong Polytechnic University. Those who participated were asked to refer their friends and relatives.

Procedures

Participants were individually tested in the experimental session (see Fig. 1 for a flowchart describing the procedures in Study 1). After completing the screening assessments, participants were randomized sequentially into FA or MW inductions. The inductions were recorded by a local certified mindfulness instructor in an audio-visual format. Both inductions lasted about 25 minutes and were adapted from a randomized-controlled trial that explored the cognitive effects of FA in older adults (Polsinelli et al., 2020).

In FA, the goal is to promote concentrated attention with the sensation of breathing as an anchor of focus. Participants in the FA group were instructed to direct their attention progressively to the breathing sensations of different body parts (e.g., chest, nostril). During the practice, there were probes for participants to notice any distractions or mind wandering and return their attention to breathing in a non-judgmental manner. The practice of FA would tap into some of the core aspects of mindfulness, including concentrated attention, an awareness of mind wandering, and a non-judgmental attitude.

On the other hand, MW has been frequently employed for control groups in experimental studies to minimize the effects of treatment expectancy (e.g., Rosenstreich & Ruderman, 2017). Participants were told that the practice would promote creativity. They were encouraged to engage in mind wandering. The induction of MW consisted of minimal guidance, where participants freely engage in thoughts, daydreams, or fantasies, without exerting any attentional control. Therefore, participants in the MW group did not receive training in these core aspects of FA: concentrated attention, an awareness of mind wandering, and a non-judgmental attitude.

After the inductions of FA or MW, participants encoded two ecological PM tasks (EBPM and TBPM), which they would retrieve during the experimental session after encountering appropriate PM cues. In the experiment venue, three model cars (red, green, and white cars) were placed on the desk. A clock was also placed on the desk for the sake of time monitoring. In ecological EBPM, participants were told to give the red car to an experimenter after receiving the financial incentive. In ecological TBPM, participants were instructed to give the white car to the experimenter after 30 minutes. In both ecological tasks, a total score of two was used to assess whether (1) the intention was triggered appropriately [i.e., EBPM: upon receiving the incentive; TBPM: at 30 minutes (with a time window of ± 5 minutes) after the instruction was given] and (2) the appropriate intention was executed (i.e., give the right car to the experimenter).

Next, participants proceeded to the experimental tasks. There were three counterbalanced experimental blocks corresponding to each PM cue types: focal EBPM, non-focal EBPM, and TBPM. PM was assessed by the standard Einstein-McDaniel paradigm (Einstein & McDaniel, 1990), where participants execute intentions while performing an ongoing task. Within each experimental block, participants first received instructions to perform the ongoing task. The lexical decision task, color matching task, and category association task were used as ongoing tasks for focal EBPM, non-focal EBPM, and TBPM, respectively. These ongoing tasks have been commonly employed in studies utilizing the Einstein-McDaniel paradigm (e.g., Einstein & McDaniel, 2005; Hicks et al., 2005; Smith & Bayen, 2004).

In the lexical decision task, we adopted a Chinese modification (Tsai et al., 2006). A central fixation (“+”) first appeared on a black screen for 500 ms, followed by a two-character string (75 pt. font) for 3000 ms. Participants pressed the buttons “Y” and “N” to indicate whether the two-character string was a real word or a non-word (i.e., the sequence of a two-character string is reversed, such that there is no meaning attached to it), respectively. Once a response was recorded, the screen remained blank for 500 ms. This task consisted of 10 practice trials and 30 actual trials.

In the color matching task, four colored rectangles, each a different color, were presented sequentially in the center of a black screen. Each rectangle remained on screen for 750 ms with an interstimulus interval of 250 ms. After the last rectangle was shown, a two-character string printed in color (75 pt. font) appeared at the center for 3000 ms. Then, participants indicated whether the display color of the two-character string matched the color of any of the rectangles that had just been shown. The buttons “Y” and “N” were pressed for matched and non-matched pairs, respectively. The screen then stayed blank for 500 ms after a response was made. There were six colors (white, red, yellow, blue, green, and purple) used in this task. The color matching task contained 10 practice trials and 20 actual trials.

In the category association task, participants pressed a button to indicate whether a word matched with a given category (“Y”) or not (“N”). A central fixation “+” first appeared on a black screen for 500 ms. Then, a category was displayed for 2500 ms, followed by a word for 2500 ms. After a response was made, the word remained on screen, so that each trial had a fixed duration of 5500 ms. This task was comprised of 10 practice trials and 20 actual trials.

Once they were familiar with the ongoing task, they encoded the PM intention. The focal EBPM command was to press the button “S” whenever the two-character string was an animal word, such that its focality aligns with the lexical decision task, with both tasks requiring semantic processing (Einstein & McDaniel, 2005). The non-focal EBPM intention was to press the button “S” if they saw any word describing a fruit. Therefore, PM cue focality does not align with the color matching task because it requires semantic processing to execute the PM intention (Einstein & McDaniel, 2005). In TBPM, the intention was to press the button “T” at a two-minute interval throughout the task. They could also access a clock to display a time-counter by pressing “C”, which appeared for 3000 ms at the bottom right corner of the screen.

To allow sufficient time to induce PM forgetting, a filler task was placed between PM encoding and retrieval in each experimental block. Thus, the filler tasks for the first, second, and third experimental blocks were the Sustained Attention to Response Task (SART; Robertson et al., 1997), the Stroop-Color Word Test (SCWT; Stroop, 1935), and filling out a self-reported measure of demographic questions, respectively. Each filler task lasted for approximately five minutes.

The SART measures sustained attention. Using a go/no-go paradigm, a numerical digit (random, from 1 to 9) was presented at the center of a black screen for 250 ms, in varying font sizes (random, 72, 94, 100, 120, and 160 pt.). Participants pressed the spacebar when the go stimuli (digits 1–2, 4–9) appeared and withheld their responses to the no-go stimuli (digit 3). Immediately after, a circular mask with a diagonal cross in the middle (~10.5 x 10.5 cm) appeared in the center for 900 ms. Participants could still respond during this period. During the SART, participants were instructed to place equal emphasis on both speed and accuracy. The SART consisted of 10 practice trials and 180 actual trials. The proportion of go stimuli was 0.89 to 0.11 no-go stimuli (Robertson et al., 1997). Three performance indicators were calculated for sustained attention. The reaction time coefficient of variability (RTCV) (SD_{RT}/M_{RT}) reflects an overall temporal stability of response speed. The proportions of commission errors (i.e., inappropriate responses to the no-go stimuli) and omission errors (i.e., incorrect responses to the go stimuli) were also calculated.

The SCWT assesses selective and executive attention. The stimuli consisted of four color names displaying in one of these colors. A central fixation "+" first appeared on a black screen, followed by the color name (75 pt. font) for 3000 ms. Participants indicated the display color with a corresponding color key, irrespective of its semantic meaning. Once a response was recorded, the screen stayed blank for 500 ms. The SCWT consisted of 10 practice trials and 70 actual trials, which lasted for about five minutes in total. About 50% of the trials were congruent (i.e., both color name and display color were compatible; e.g., the word blue printed in the color blue) and 50% were incongruent trials (i.e., the display color was incompatible with the meaning of a color word; e.g., the word blue printed in the color red). We calculated two indices to capture SCWT performance, including the Stroop interference $(Error\ Rate_{Incongruent\ Trials} - Error\ Rate_{Congruent\ Trials})$ and Stroop RT interference $(M_{Incongruent\ Trials\ RT} - M_{Congruent\ Trials\ RT})$.

After completing the corresponding filler task, they retrieved the PM intention for that experimental block. In focal EBPM (see Fig. 2), there were 100 trials, with six PM cues at the sixth, 30^{th}, 42^{nd}, 54^{th}, 72^{nd}, and 92^{nd} trials. The non-focal EBPM (see Fig. 3) consisted of 60 trials with six PM cues embedded at the third, 12^{th}, 21^{st}, 33^{rd}, 48^{th}, and 57^{th} trials. In both tasks, performance was quantified by the proportion of correct responses to PM targets. On the other hand, TBPM (see Fig. 4) comprised of 100 trials with four target PM intervals, which lasted for approximately nine minutes. The proportion of correct responses in TBPM was defined within a time window of ± 2500 ms at each PM target interval (see Jáger & Kliegel, 2008). We also analyzed time monitoring behaviors by quantifying the number of clock checks within 30 seconds before each PM target interval. Previous studies have shown that this timeframe for clock checking is critical to execute an accurate PM response (Einstein et al., 1995).

After completing the corresponding filler task, they retrieved the PM intention for that experimental block. The experimental session ended with the completion of the last experimental block, which lasted for approximately 120 minutes.

Measures

Demographic variables including age, gender (1 = male, 2 = female), education level (1 = primary school, 4 = postgraduate studies), occupation status (1 = unemployed, 2 = full-time, 3 = part-time, 4 = retired), and previous meditative experience (1 = yes, 2 = no) were collected.

Data Analyses

We first inspected trials with unusual RT data. Except for the SART, we removed trials with RT data less than 200 ms (see Boudewyn et al., 2018). This resulted in an overall 0.03% of data loss. Specifically, there was 0.00%, 0.01%, 0.00%, and 0.09% data loss in the SCWT, focal EBPM, non-focal EBPM, and TBPM, respectively. Note that we did not exclude any SART trials, because of its short response window (1150 ms), which aims to induce a rapid and rhythmic response style (see Helton et al., 2011). We excluded two participants in the focal EBPM group because of poor ongoing task performance (< 50% accuracy), indicating the possibility that they misunderstood the task instructions. We also removed six participants for non-focal EBPM and one participant for TBPM for the same reason. Unless otherwise specified, all statistical analyses were based on an alpha level that did not exceed 5%.

Results

Demographic variables were compared between the FA and MW groups (see Table 1). Using t-test or Fisher's exact tests, the results did not indicate any significant between-group differences.

All means and *SD*s for the outcome measures were presented in Table 2. We first evaluated whether FA improves attentional control in older adults. A multivariate analysis of variance (MANOVA) was performed on all performance indicators of the SART and SCWT. There was a main effect of types of induction (FA vs. MW), Wilks' $\Lambda = 0.87$, $F(5,121) = 3.48$, $p < 0.01$, $\eta^2_p = 0.13$. Follow-up univariate tests were computed to explore the group differences in each dependent variable. Except for SART's RTCV, $F(1,125) = 1.66$, $p = 0.20$, the FA group has fewer SART's commission errors, $F(1,125) = 4.91$, $p < 0.05$, $\eta^2_p = 0.04$, and omission errors, $F(1,125) = 6.20$, $p < 0.05$, $\eta^2_p = 0.05$, and less SCWT's Stroop interference, $F(1,125) = 4.54$, $p < 0.05$, $\eta^2_p = 0.04$, and Stroop RT interference, $F(1,125) = 4.00$, $p < 0.05$, $\eta^2_p = 0.03$. This indicated that FA resulted in better sustained, selective, and executive attention.

To explore whether FA facilitates PM, we conducted a MANOVA on all performance indicators of PM. Of note, the scoring of TBPM (± 2500 ms) revealed a potential floor effect ($M = 0.13$, $SD = 0.26$). Considering the slow responses of elderly participants, we adopted a more lenient scoring of ± 15000 ms in subsequent analyses (see Yang et al., 2013). The results did not indicate a main effect of types of induction, Wilks' $\Lambda = 0.91$, $F(6,111) = 1.75$, p = 0.12, $\eta^2_p = 0.09$. To further pinpoint the effects of FA on specific performance indicators, we conducted follow-up univariate tests. Overall, there is partial support that FA can improve PM. Compared to the MW group, the FA group performed more accurately in terms of ecological EBPM, $F(1,116) = 6.06$, $p < 0.05$, $\eta^2_p = 0.05$, and experimental focal EBPM, $F(1,116) = 6.05$, $p < 0.05$, $\eta^2_p = 0.05$. No significant differences were found in ecological TBPM, $F(1,116) = 0.03$, $p = 0.85$, experimental non-focal EBPM, $F(1,116) = 0.89$, $p = 0.35$, or TBPM (in both accuracy and clock checks), $Fs(1,116) < 1$, $ps \geq 0.52$.

We also computed mediation analyses to explore whether an improvement in PM in the FA group is mediated by more efficient attentional control. Using the PROCESS macro for SPSS (Hayes, 2017), two parallel mediation analyses (conducted separately for ecological EBPM and experimental focal EBPM) were performed based on non-parametric and bootstrapping procedures of 10,000 samples (Model 4). The indirect effects were considered to be significant at $p < 0.05$ if there were no zeros between the bias-corrected and accelerated 95% intervals. There were four mediator variables: SART's commission errors, SART's omission errors, SCWT's Stroop interference, and SCWT's Stroop RT interference.

In terms of ecological EBPM, the overall model was significant, $F(1,125) = 4.45$, $p < 0.05$, accounting for 18.54% of the variance. However, neither the indirect effects of SART's commission errors, $b = -0.01$, $SE = 0.02$, BCa CI_{95} [-0.05, 0.02], SART's omission errors, $b = 0.03$, $SE = 0.02$, BCa CI_{95} [-0.01, 0.08], SCWT's Stroop interference, $b = 0.01$, $SE = 0.02$, BCa CI_{95} [-0.03, 0.05], nor SCWT's Stroop RT interference, $b < 0.01$, $SE = 0.01$, BCa CI_{95} [-0.03, 0.03], were significant. This suggested that none of these performance indicators mediated an improvement in ecological EBPM in the FA group.

In the experimental focal EBPM, there was also a significant overall model, $F(1,123) = 5.93$, $p < 0.05$. This explained 21.45% of the variance. Bootstrapped 95% confidence intervals revealed an indirect effect of SART's omission errors, $b = 0.02$, $SE = 0.01$, BCa CI_{95} [< 0.01, 0.06]. However, there were no indirect effects of SART's commission errors, $b = -0.02$, $SE = 0.01$, BCa CI_{95} [-0.05, < 0.01], SCWT's Stroop interference, $b < 0.01$, $SE = 0.01$, BCa CI_{95} [-0.02, 0.01], nor SCWT's Stroop RT interference, $b < 0.01$, $SE = 0.01$, BCa CI_{95} [-0.01, 0.02]. Since the direct effect on types of induction was also significant at $p < 0.05$, this suggests a partial mediation. Because the indirect effects were not consistently observed in other performance indicators of attentional control, this indicated a weak mediation, in that sustained attention partially mediated an improvement in experimental focal EBPM in the FA group.

Study 2

With the positive findings in Study 1, we explore whether OM, compared to MW, facilitates PM under the influence of a negative mood in Study 2. Utilizing a mood induction paradigm, participants were sequentially randomized into the two between-subject factors: induction types (OM vs. MW) and mood conditions (negative vs. neutral).

Method

Participants

We performed a priori power analysis based on utilizing an ANOVA to detect a medium effect size with a power of 0.80 at $p = 0.05$, resulting in a target sample size of 128. The total sample size of Study 2 was 157. The inclusion criteria were identical to Study 1 (i.e., Chinese older adults aged from 60 to 75 years living in Hong Kong without any cognitive or affective disorders). Participants were recruited through convenience and snowball sampling and screened by the MoCA-HK and PHQ-9 for cognitive and affective disorders, respectively. Two participants scored below the cut-off in the MoCA-HK (22/30) and were therefore excluded from this experiment. No participants scored below the cut-off in the PHQ-9 (9/27).

Procedures

Each participant was individually tested in the experimental session (see Fig. 5). Upon completing the screening measures, participants received either OM or MW inductions. The induction of OM, lasting approximately 25 minutes, was recorded in an audio-visual format by the same mindfulness instructor as in Study 1. The script was adapted from a randomized-controlled trial that compared the cognitive effects of FA and OM (Britton et al., 2018). The induction of MW was identical to Study 1. The goal of OM is to foster a non-judgmental awareness about the present-moment experience without engaging nor disengaging in attentional control toward any object. In OM, participants were instructed to verbally label their experience using the five senses: (1) seeing, (2) hearing, (3) feeling, (4) tasting, and (5) smelling. They were encouraged to use more precise descriptions to label their experience with terms such as warmth vs. coolness, moist vs. dryness, for their body sensations. During the practice, there were instructor’s prompts to balance awareness across the five senses in positive, neutral, and negative valences.

After the inductions of OM or MW, participants proceeded to the experimental tasks. The procedures were identical to Study 1, including three counterbalanced experimental blocks respective to each PM cue type: focal EBPM, non-focal EBPM, and TBPM. Within each experimental block, participants were instructed to perform the ongoing task for the specific PM cue type. Next, they received a mood induction. Mood induction stimuli consisted of video segments selected from commercially available documentaries, films, or drama episodes. A pool of negative mood induction stimuli was piloted on individuals to select six clips out of the higher ratings of negative valence, with a total of six video clips in each mood condition. Participants were told to watch each clip closely to answer a question related to its content. Following each mood induction, participants filled in the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) to evaluate their self-reported emotional state.

After the mood induction, participants encoded the PM intention for that experimental block, followed by another mood induction. This mood induction also served as a filler task to induce PM forgetting, lasting for approximately five minutes. Once they completed the mood induction, they retrieved the PM intention for that experimental block. Mood inductions were administered six times (two times per experimental block) throughout the experiment. Upon completing the last experimental block, participants filled out a self-report questionnaire of demographical questions. The entire experimental session lasted about 120 minutes.

Measures

We collected demographic variables, including age, gender (1 = male, 2 = female), education level (1 = primary school, 4 = postgraduate studies), occupation status (1 = unemployed, 2 = full-time, 3 = part-time, 4 = retired), and previous meditative experience (1 = yes, 2 = no).

The SAM was utilized to measure self-reported emotional state at a specific time point. It consists of three subscales: valence, arousal, and dominance. Only the SAM valence and arousal subscales were used in this study (see Schnitzspahn et al., 2014). The valence subscale ranges from one (happy) to nine (unhappy) and the arousal subscale ranges from one (calm) to nine (excited). The McDonald's ω of SAM valence and arousal subscale were 0.98 and 0.95, respectively.

Data Analyses

Trials with unusual RT data were inspected. We removed trials with RT data faster than 200 ms from further analyses. This resulted in an overall 0.04% of data loss. In particular, there were 0.04%, 0.01%, and 0.04% of data loss in focal EBPM, non-focal EBPM, and TBPM, respectively. We also removed data from three participant in TBPM due to poor ongoing task performance (< 50% accuracy). This indicates the likelihood of misunderstandings, such as mixing up the task instructions with other ongoing tasks. Unless otherwise specified, statistical analyses did not exceed an alpha level of 5%.

Results

Demographic variables were first compared between the two subject factors [induction types (OM vs. MW) and mood conditions (negative vs. neutral)] using ANOVAs or Fisher’s exact tests (see Table 3). Except gender ($p < 0.05$), there were no significant between-group differences in any demographic variables.

Since individuals might react differently to the mood inductions, we analyzed the SAM valence and arousal scores to determine whether the mood inductions were successful (see Table 4). Based on the procedures in Rummel et al. (2012), the mean SAM valence scores in the neutral mood condition were used as the cut-offs to identify mood non-responders. Participants in the negative mood condition who scored higher than the cut-offs were classified as mood non-responders and were excluded from subsequent analyses. The cut-offs of 5.47, 5.46, and 5.41 were adopted for focal EBPM, non-focal EBPM and TBPM, respectively. The analyses revealed three individuals as mood non-responders. This accounted for 2% of the total sample.

Next, we explored whether there were any group differences between the neutral and negative mood conditions. A MANOVA for the SAM valence and arousal scores was computed. As expected, there was a main effect of mood conditions, Wilks' $\Lambda = 0.27$, $F(6,147) = 66.30$, $p < 0.01$, $\eta^2_p = 0.73$. In follow-up univariate analyses, main effects of mood conditions were found across all instances of mood inductions in the SAM valence scores, $Fs(1,152) \geq 287.30$, $ps < 0.01$, $\eta^2_p \geq 0.65$, and arousal scores, $Fs(1, 152) \geq 12.98$, $ps < 0.01$, $\eta^2_p \geq 0.08$. A clear pattern emerged, as those in the negative mood condition were significantly more aroused, with lower valence ratings.

To explore whether OM can facilitate PM under a negative mood, we computed a 2 [between-subject factor, induction types (OM vs. MW)] × 2 [between-subject factor, mood conditions (neutral vs. negative)] MANOVA for measures in PM (see Table 5). The results indicated a significant interaction of induction types × mood conditions, Wilks' $\Lambda = 0.92$, $F(4,144) = 2.95$, $p < 0.05$, $\eta^2_p = 0.08$. Follow-up univariate tests were computed for each dependent variable. Except for focal EBPM, $F(1,147) = 10.23$, $p < 0.01$, $\eta^2_p = 0.07$, there were no significant interactions of induction types × mood conditions in non-focal EBPM, $F(1,147) = 2.01$, $p = 0.16$, or TBPM (in both accuracy and clock checks), $Fs(1,147) < 1$, $ps \geq 0.48$.

Therefore, we carried out a simple effect analysis to further pinpoint the interaction effect in focal EBPM (see Fig. 6 for a visualization). There were no differences in MW (M = 0.92, SE = 0.03) or OM (M = 0.88, SE = 0.03) under the neutral mood condition, $p = 0.28$. The OM group (M = 0.93, SE = 0.03) outperformed the MW group (M = 0.75, SE = 0.03) in the negative mood condition, $p < 0.01$. Within the OM group, there were no differences between the neutral and negative mood conditions, $p = 0.27$. However, those in the MW group performed worse after negative mood induction, $p < 0.01$.

While OM does not improve focal EBPM in an emotionally neutral context, it appears that OM can effectively facilitate focal EBPM under the influence of a negative mood. However, neither a negative mood nor OM has an impact on non-focal EBPM and TBPM. Considering the significant between-group differences in gender, we recomputed the analyses using gender as a controlled variable. The results did not change.

General Discussion

This study explores the acute effects of mindfulness induction on PM in older adults. Study 1 and 2 investigate the specific effects of FA and OM on PM. Collectively, both experiments illustrate the potential benefits of mindfulness induction in enhancing PM for older adults. These positive findings contribute to the scant evidence regarding PM training for older adults. Indeed, a systematic review of PM training for this population was only able to identify 11 studies (Tsang et al., 2022). The lack of PM training is surprising because of its significance for older adults. PM is vital to many daily tasks for older adults to achieve functional independence (Woods et al., 2012). There is also a positive association between quality of life and PM capacity in older adults (e.g., Woods et al., 2015). Acknowledging the significance of PM in this population, the current findings offer preliminary evidence about the potential utility of meditative practice as an alternative form of process-based training for older adults to achieve functional independence.

The current findings are also congruent with the literature that mindfulness induction can produce immediate cognitive benefits (for a review, see Gill et al., 2020). Specifically, FA resulted in improved attention control, which is evident in better performance in the SCWT and SART. Similarly, Bokk and Forster (2022) reported that a brief 10-minute FA induction can lead to better executive attention in healthy adults. Thus, our findings further support the generalizability and feasibility of utilizing FA to enhance attentional control in an older population. Perhaps more importantly, the immediate effects of mindfulness induction can translate into a better PM performance. Because successful PM relies on different cognitive process across multiple phases (Kliegel et al., 2002), our findings provide evidence of the extended benefits of mindfulness induction in terms of facilitating the performance of more complex tasks, such as PM.

Effects of Focused Attention on Prospective Memory

Study 1 lends partial support to the idea that FA improves PM. This is in contrast with the findings in Girardeau et al. (2020), where they did not observe any effects of FA on PM. A possible interpretation of this result could be that the effects of FA were more pronounced in older adults. In Girardeau et al. (2020), their younger sample had performed fairly well in focal EBPM, with a mean proportion of correct responses of 95%. Meanwhile, our older adults exhibited relatively lower performance. Therefore, FA may no longer benefit PM performance as their participants have reached a ceiling performance. This is especially the case in older adults because they are more prone to PM failures due to distractions (Park et al., 1989). It is therefore possible that FA primarily improves PM through better attentional control.

Despite the observed improvements in attentional control resulted from FA, it did not translate into better non-focal EBPM and TBPM. An enhancement of top-down attentional processes from FA should further benefit these tasks because they require a higher level of top-down control. For example, non-focal EBPM requires strategic monitoring to exert top-down attentional regulation to monitor for the presence of a PM cue. Likewise, TBPM also requires a higher level of self-initiation (for time monitoring because of an absence of PM cues (Craik, 1986). The unexpected null effects of FA on these tasks may indicate an insufficient dosage of FA. Previous studies have demonstrated a dose-response relationship between meditations and attentional control (Chan & Woollacott, 2007; MacLean et al., 2010). Verhaeghen (2021) reported that standardized eight-week Mindfulness-based Stress Reduction can produce improvements in attentional control on par with those seen in expert meditators. Therefore, it is likely that a brief 25-minute FA induction is insufficient to enhance top-down attentional control to an extent that improves cognitive tasks with a higher level of strategic demands.

Study 1 also indicates an indirect effect of sustained attention between FA and focal EBPM, which furthers our understanding of how FA facilitates PM in older adults. At first glance, this finding appears to be inconsistent with the literature regarding the effects of mindfulness induction on episodic memory. Lueke and Lueke (2019) observed better episodic memory encoding after FA, but this improvement was independent of attentional control. Our findings therefore suggest the possibility that an indirect effect of sustained attention led to better PM retrieval. Indeed, Levi and Rosenstreich (2019) proposed that an improvement of attentional control resulted from FA should benefit memory retrieval more than encoding. Compared to episodic memory, PM should pose a greater demand of attentional control at retrieval because of its due task nature. This may partially explain the inconsistent effects observed between PM and episodic memory regarding attentional control. To provide further insights, future studies may isolate the effects of FA on each PM phases.

However, caution is required when interpreting an indirect effect of sustained attention between FA and PM because of a weak, partial mediation. Further, the indirect effects were not consistently observed in measures of attentional control. A plausible explanation for this finding could be that other subsystems of attentional control, which were not captured by the SART and SCWT, are also involved in PM. Given that PM is a dual task, divided attention (the capacity to attend to two sets of stimuli simultaneously) may play a more crucial role in PM than sustained, selective, and executive attention. Evidently, increasing the load of divided attention can impair PM (Marsh & Hicks, 1998). It appears there is a differential engagement of the subsystems of attentional control in PM. Future studies should systematically investigate the engagement of different aspects of attentional control in PM, which can guide attention-based PM training to maximize its benefits.

An improvement in focal EBPM due to FA may indeed suggest that it can improve the efficiency of divided attention. Sumantry and Stewart (2021) theorized that FA utilizes the capacity of divided attention in several ways. In FA, it is necessary to keep track of potential distractions while focusing on when one's attention is being distracted, which is an aspect of divided attention. Listening to verbal instructions while maintaining attentional control may also enhance the efficiency of divided attention. Yu et al. (2021) found that mindfulness can enhance divided attention in older adults with mild cognitive impairment. Therefore, it could be that FA improves divided attention, which mediates the effects of FA on focal EBPM. However, this is only speculative without a direct measure of divided attention. Future studies are needed to investigate the connections between FA, divided attention, and PM, which can provide a further understanding on the mechanisms through which FA may facilitate PM.

Effects of Open Monitoring on Prospective Memory

Study 2 yields partial support for the idea that OM can enhance PM specifically under a negative mood. This finding is consistent with previous studies such as Ortner et al. (2007) and Jankowski and Holas (2020), which has shown that mindfulness induction can reduce emotional interference in cognitive tasks, resulting in faster RTs. However, because both studies combined FA and OM, it would be difficult to delineate the active contributor to the reduction of emotional interference. In contrast, the observable effect of Study 2 can only be attributed to OM, which suggests that OM is sufficient to facilitate ER. This aligns with the notion that external sensory observing had a unique, positive contribution in ER (Dunn et al., 2023). The current finding also demonstrates that improved emotional processing resulted from OM can in turn translate into better cognitive performance.

Considering previous studies (e.g., Ortner et al., 2007, Jankowski and Holas, 2020) exclusively sampled healthy adults, the current findings illustrate the generalizability and feasibility of utilizing OM to facilitate ER in an older population. Older adults often recruit more cognitive resources to perform ER (Mather & Knight, 2005). With an aging decline in cognitive resources, they are prone to emotional interference when performing a cognitive task. Indeed, Phillips et al. (2002) observed poorer performance among older adults after mood induction in a planning task (but not in young adults). Therefore, the current findings suggest that OM can facilitate ER in older adults, which allows more cognitive resources to be diverted to the task at hand.

Our findings suggest ER as a primary mechanism through which OM facilitates PM. This is evident in the absence of main effects of induction types (OM vs. MW) in the neutral mood condition in all PM measures. Further, the null effects of OM on focal PM in the neutral mood condition may indicate a differential involvement of top-down and bottom-up processes in OM. If OM facilitates a cognitive state of enhanced stimulus-driven responses, it should also facilitate spontaneous retrieval in the neutral mood condition. However, we did not observe this pattern, perhaps suggesting a heavier involvement of top-down ER processes in OM. This is consistent with the notion that mindfulness involves a dynamic interplay of top-down and bottom-up processes, where novice meditators tend to rely more on top-down processes (for a review, see Chiesa et al., 2013). However, caution is required for such an interpretation because top-down processes are still involved in focal PM to some extents, such as initiating a search for the significance of a PM cue after its detection (Scullin et al., 2010). Future studies are encouraged to adopt a more sophisticated paradigm to tease out top-down and bottom-up influences in OM, especially between novice and expert meditators, to provide further understandings on the mechanism of how OM facilitates cognitive performance.

There were, however, non-significant effects of OM on other PM measures (non-focal EBPM and TBPM). Despite the successful mood induction procedures, there seems to be an absence of mood effects on these tasks. A plausible explanation for this finding could be that both tasks were too cognitively demanding for our elderly participants. According to the Working Memory Model of Distraction (Van Dillen & Koole, 2007), a cognitively demanding task can disrupt the experience of negative emotion. Specifically, a negative mood activates mood-congruent cognition, which sustains or intensifies an initial mood experience. However, a cognitively demanding task may draw away cognitive resources to an extent that prevents the activation of mood-congruent cognition. Previous studies have shown results largely consistent with this model, where little to no mood effects were found when performing a cognitively demanding task (Erber & Tesser, 1992; van den Hout et al., 2010). Due to the absence of mood effects, this may explain why there is a lack of observable effects of OM on non-focal EBPM and TBPM.

Limitations and Future Research

This study has some limitations. To obtain a naturalistic sample of older adults, we did not select our participants based on previous meditation experience. Therefore, the majority of participants in the FA group (76.9%) in Study 1 possessed some level of previous experience. They might be more readily engaged in our FA induction. However, due to unequal sample sizes, a moderation analysis may not be adequately powered to rule out such an effect. Currently, there are inconsistent findings regarding the effects of previous mindfulness experience on mindfulness induction. Reed (2018) found a positive moderation of previous meditation experience between mindfulness induction and reducing over selectivity, an attentional bias of focusing a narrow range of stimuli. In contrast, Sleimen-

Malkoun et al. (2023) reported that previous meditation experience did not interact with the effects of mindfulness induction on Stroop task. With a dearth of studies to explore this effect, future studies should systematically investigate group differences in terms of previous meditation experience in response to mindfulness induction.

Another limitation could be the inherent brevity of mindfulness inductions. It is important to acknowledge that such brief meditative practices (especially FA or OM alone) may not be sufficient to cultivate mindfulness. Traditional mindfulness interventions, such as Mindfulness-based Stress Reduction, require regular practices and contain other effective components (e.g., psychoeducation) to promote mindfulness. Therefore, it is unclear if the acute effects of FA and OM inductions lead to sustainable improvements in PM among older adults. Nevertheless, employing mindfulness induction in an experimental setting can minimize external factors, such as treatment expectancy, due to longer exposure to an intervention, which may complicate the results (Lin et al., 2022). This in turn allows more robust causal inferences regarding the immediate effects of FA and OM meditations on PM. By separately exploring the effects of these two types of meditation on PM, we can further our understanding of the underlying mechanisms through which meditations may facilitate PM. With the positive preliminary findings that mindfulness inductions can facilitate PM to some extents, it is promising to consider the notion that regular meditative practices may yield further PM gains in older adults and contribute to a successful aging experience. As FA and OM meditations are active components in Mindfulness-based Stress Reduction or Mindfulness-based Cognitive Therapy (Cullen et al., 2021), future studies are encouraged to implement manualized mindfulness-based interventions to further confirm whether mindfulness can result in more sustainable PM improvements in older adults.

Declarations

Conflict of Interest

We have no conflict of interest to disclose. The research received no specific grant from any funding agencies.

Ethics Statement

Ethical approval of this was given by the Institutional Review Board at the Hong Kong Polytechnic University (Reference no.: HSEARS20210714006).

Informed Consent

All participants have provided their written consent before participation.

Author Contributions

Alex Pak Lik Tsang: Conceptualization, Methodology, Data Collection, Data Analyses, Writing- Original Draft Preparation, Writing- Reviewing and Editing. Huijing Lu: Conceptualization, Supervision, Writing- Reviewing and Editing. Herman Hay Ming Lo: Conceptualization, Supervision, Writing- Reviewing and Editing.

Data Availability

Data is available from the corresponding author upon reasonable request. Data is not publicly available due to privacy concerns.

Use of Artificial Intelligence

Artificial intelligence was not used.

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Table 1

Socio-demographic information by induction type for Study 1

	Mind wandering (n = 62)		Focused attention (n = 65)		*t*	*df*	*p*
Age, *M (SD)*	65.13	(3.33)	64.60	(3.64)	0.85	125	0.40[a]
Gender, *n* (%)					-	-	0.34[b]
Male	16	(25.80%)	22	(33.80%)			
Female	46	(74.20%)	43	(66.20%)			
Education, *n* (%)					-	-	0.34[b]
Primary school	6	(9.70%)	2	(3.10%)			
Secondary school	28	(45.20%)	28	(43.10%)			
Tertiary studies	10	(16.10%)	16	(24.60%)			
Postgraduate studies	18	(29.00%)	19	(29.20%)			
Occupation status, *n* (%)					-	-	0.07[b]
Unemployed	3	(4.80%)	0	(0.00%)			
Full-time employment	1	(1.60%)	4	(6.20%)			
Part-time employment	10	(16.10%)	5	(7.70%)			
Retired	48	(77.40%)	56	(86.20%)			
Previous experience in meditative practice, *n* (%)					-	-	0.84[b]
Yes	46	(74.20%)	50	(76.90%)			
No	16	(25.80%)	15	(23.10%)			

Note.

P-values were obtained by [a]t-tests or [b]Fisher's exact tests.

Table 2

Outcome measures by induction type in Study 1

	Mind wandering		Focused attention	
	M	*SD*	*M*	*SD*
SART				
RTCV	0.27	0.07	0.26	0.07
Commission errors	0.35	0.18	0.29	0.14
Omission errors	0.02	0.02	0.01	0.01
SCWT				
Stroop interference	0.04	0.08	0.01	0.06
Stroop RT interference	186.60	146.55	136.30	136.75
Ecological PM tasks				
EBPM	0.64	0.48	0.83	0.37
TBPM	0.74	0.28	0.73	0.28
Experimental PM tasks				
Focal EBPM	0.75	0.29	0.87	0.21
Non-focal EBPM	0.51	0.37	0.57	0.34
TBPM accuracy	0.43	0.40	0.47	0.41
TBPM clock checks	3.23	3.48	2.95	3.95

Note. EBPM = event-based prospective memory; PM = prospective memory; RT = reaction time; RTCV = reaction time coefficient of variability; SART = Sustained Attention to Response Task; SCWT = Stroop Color-Word Test; TBPM = time-based prospective memory.

Table 3

Socio-demographical information by induction type and mood condition for Study 2

	Mind wandering + Neutral mood ($n = 39$)	Mind wandering + Negative mood ($n = 39$)	Open monitoring + Neutral mood ($n = 39$)	Open monitoring + Negative mood ($n = 40$)	*F*	*df*	*p*
Age, *M* (*SD*)	65.54 (4.04)	66.79 (4.15)	66.46 (3.70)	65.95 (3.70)	0.79	153	0.50[a]
Gender, *n (%)*					-	-	< 0.05[b]
Male	20 (51.30%)	12 (30.80%)	15 (38.50%)	8 (20.00%)			
Female	19 (48.70%)	27 (69.20%)	24 (61.50%)	32 (80.00%)			
Education, *n (%)*					-	-	0.48[b]
Primary school	0 (0.00%)	0 (0.00%)	1 (2.60%)	0 (0.00%)			
Secondary school	26 (66.70%)	27 (69.20%)	21 (53.80%)	22 (55.00%)			
Tertiary studies	5 (12.80%)	7 (17.90%)	8 (20.50%)	12 (30.00%)			
Postgraduate studies	8 (20.50%)	5 (12.80%)	9 (23.10%)	6 (15.00%)			
Occupation status, *n (%)*					-	-	0.93[b]
Unemployed	1 (2.60%)	1 (2.60%)	1 (2.60%)	0 (0.00%)			
Full-time employment	1 (2.60%)	2 (5.10%)	0 (0.00%)	0 (0.00%)			
Part-time employment	5 (12.80%)	6 (15.40%)	6 (15.40%)	6 (15.00%)			
Retired	32 (82.10%)	30 (76.90%)	32 (82.10%)	34 (85.00%)			
Previous experience in meditative practice, *n (%)*					-	-	0.84[b]
Yes	8 (20.50%)	8 (20.50%)	11 (28.20%)	10 (25.00%)			
No	31 (79.50%)	31 (79.50%)	28 (71.80%)	30 (75.00%)			

Note.

P-values were obtained by [a]ANOVAs or [b]Fisher's exact tests.

Table 4

Mean valence and arousal scores in the Self-Assessment Manikin

		Neutral mood (*n* = 78)		Negative mood (*n* = 76)	
		M	*SD*	*M*	*SD*
Valence					
	Focal EBPM	5.47	1.31	2.33	0.93
	Non-focal EBPM	5.46	1.36	2.28	0.93
	TBPM	5.41	1.28	2.35	0.92
Arousal					
	Focal EBPM	3.03	1.64	4.09	1.65
	Non-focal EBPM	3.04	1.63	4.13	1.79
	TBPM	2.95	1.60	3.95	1.84

Note. EBPM = event-based prospective memory; TBPM = time-based prospective memory.

Table 5

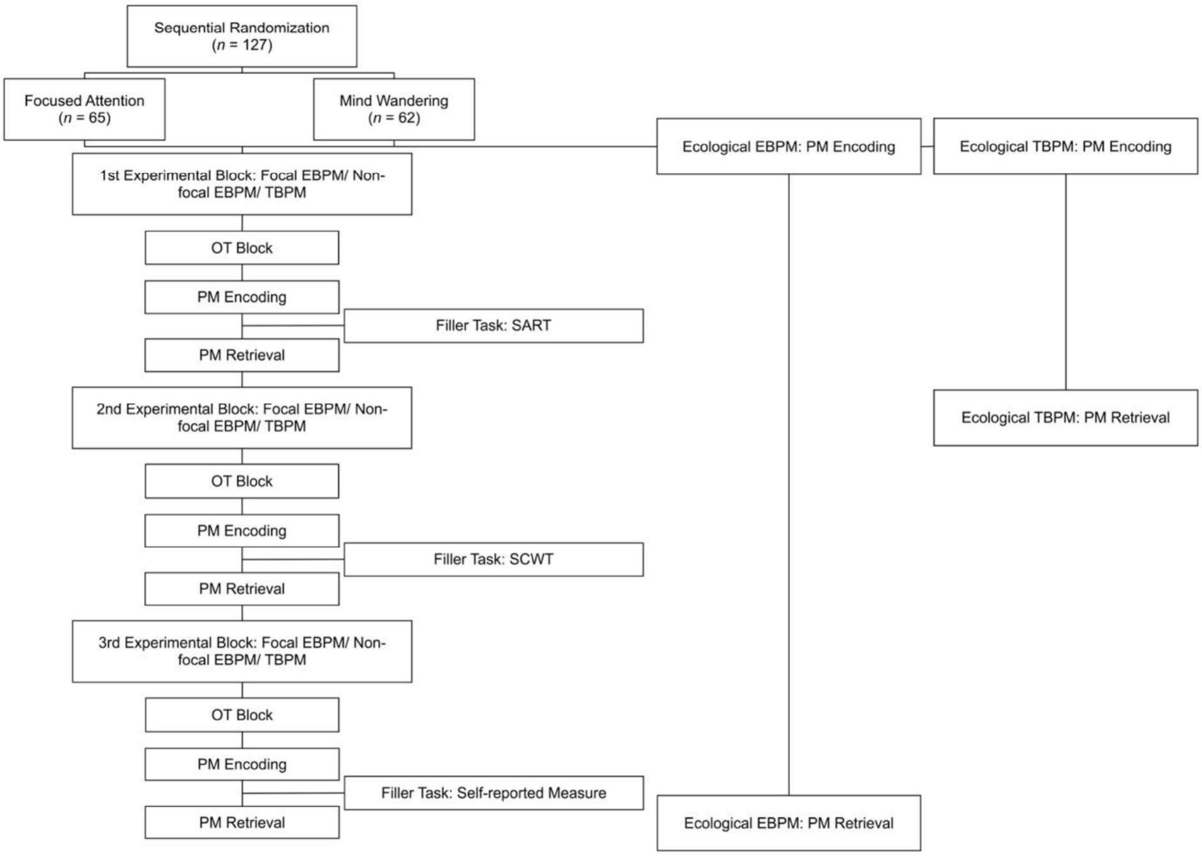
Prospective memory performance by induction type and mood condition in Study 2

	Mind wandering + Neutral mood		Mind wandering + Negative mood		Open monitoring + Neutral mood		Open monitoring + Negative mood	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Focal EBPM	0.92	0.13	0.75	0.33	0.88	0.19	0.93	0.12
Non-focal EBPM	0.68	0.30	0.63	0.34	0.66	0.31	0.75	0.28
TBPM accuracy	0.58	0.39	0.55	0.39	0.57	0.44	0.63	0.40
TBPM clock checks	4.21	3.11	4.30	3.25	4.92	5.76	4.55	2.52

Note. EBPM = event-based prospective memory; TBPM = time-based prospective memory.

Fig. 1

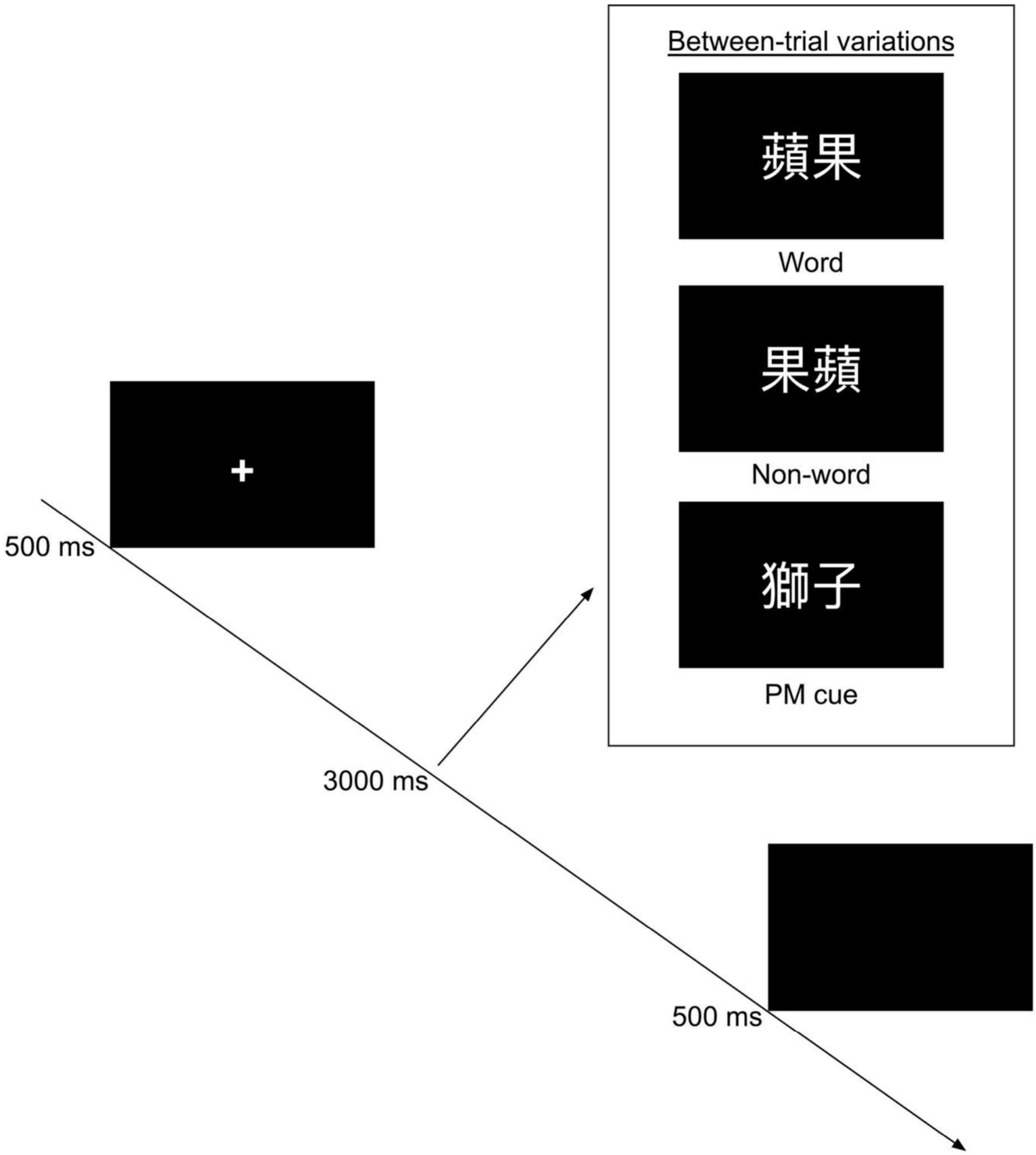
Flowchart of Procedures in Study 1



Note. EBPM = event-based prospective memory; OT = ongoing task; PM = prospective memory; SART = Sustained Attention to Response Task; SCWT = Stroop Color-Word Test; TBPM = time-based prospective memory.

Fig. 2

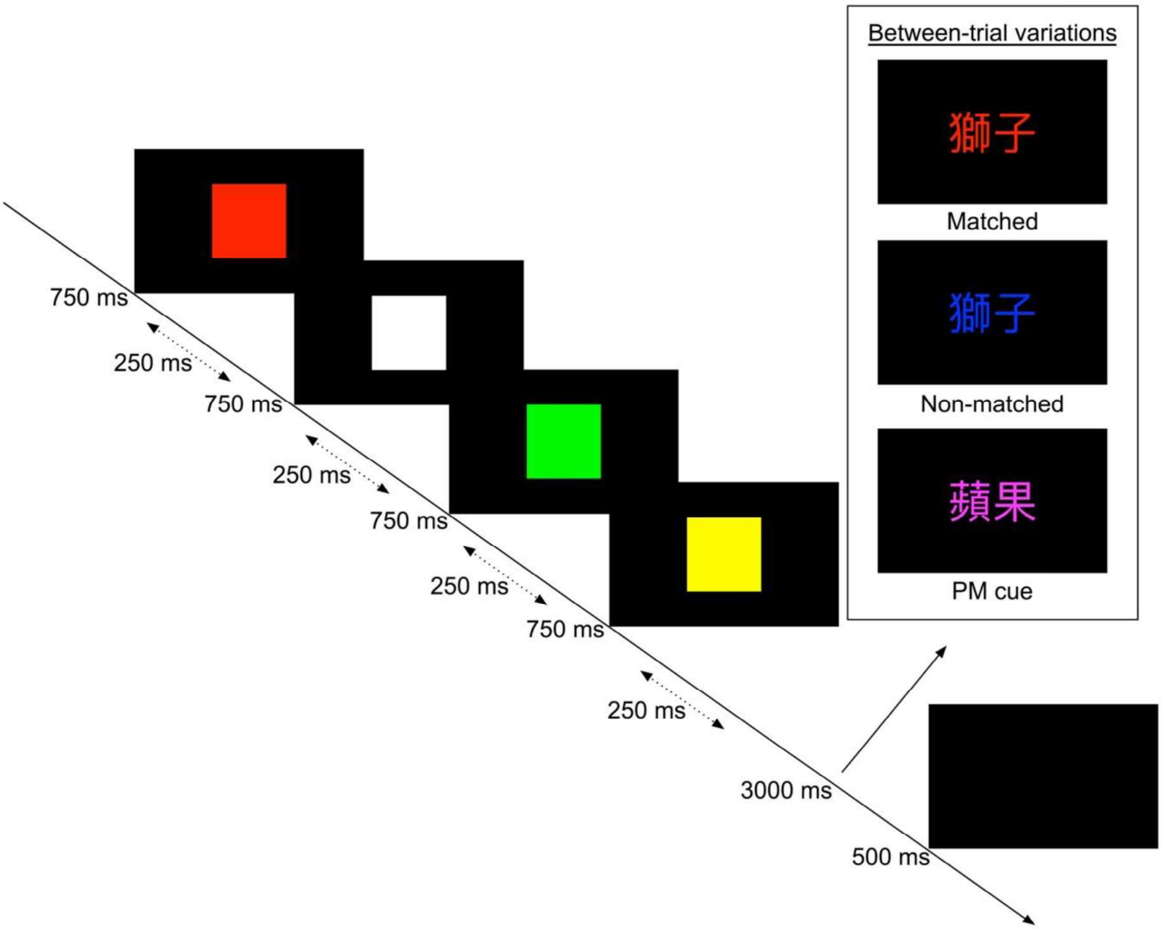
Procedures in the experimental focal event-based prospective memory task



Note. 蘋果 = apple; 果蘋 = the reversed sequence of “apple” ; 獅子 = lion.

Fig. 3

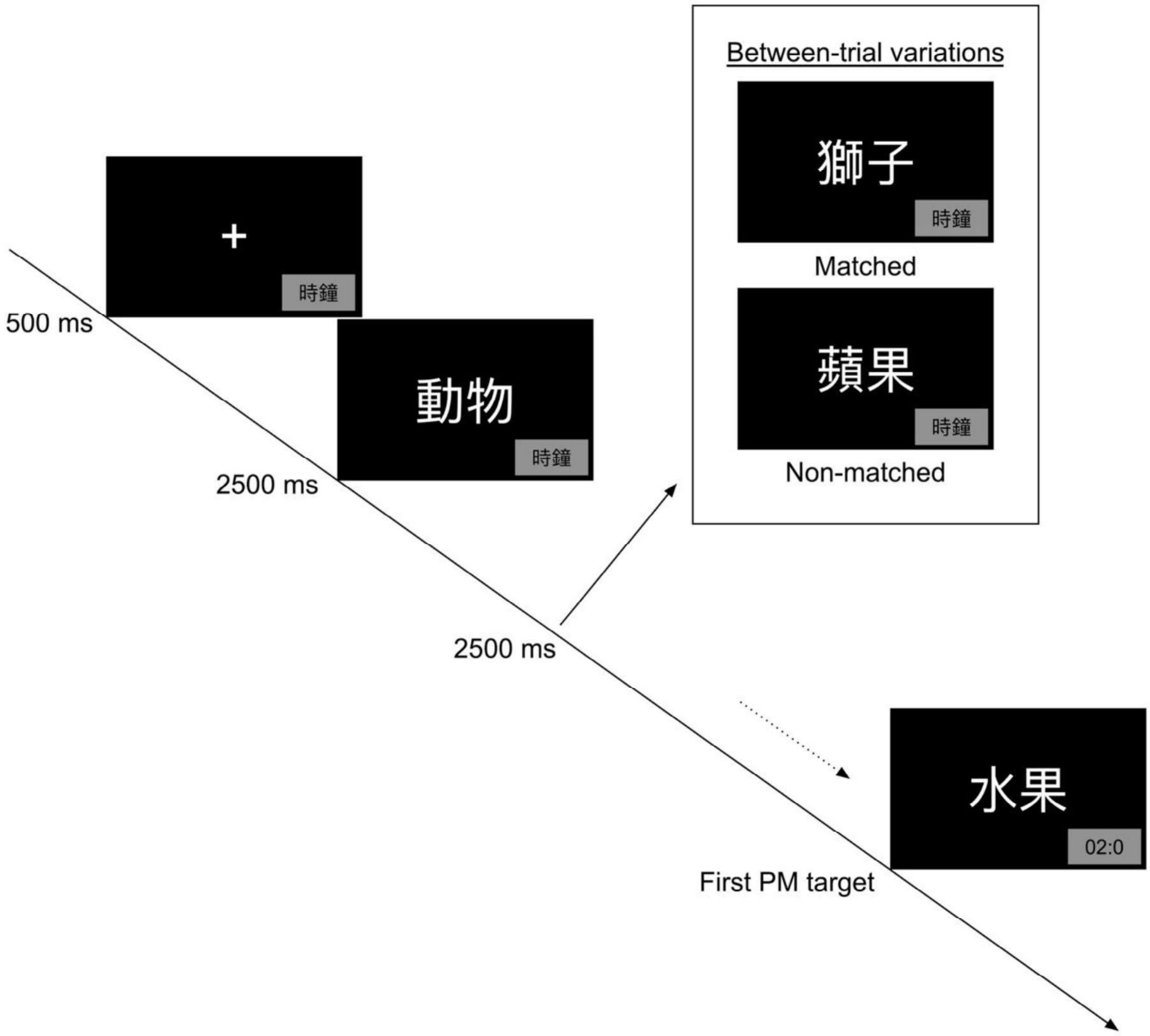
Procedures in the experimental non-focal event-based prospective memory task



Note. 獅子 = lion; 蘋果 = apple.

Fig. 4

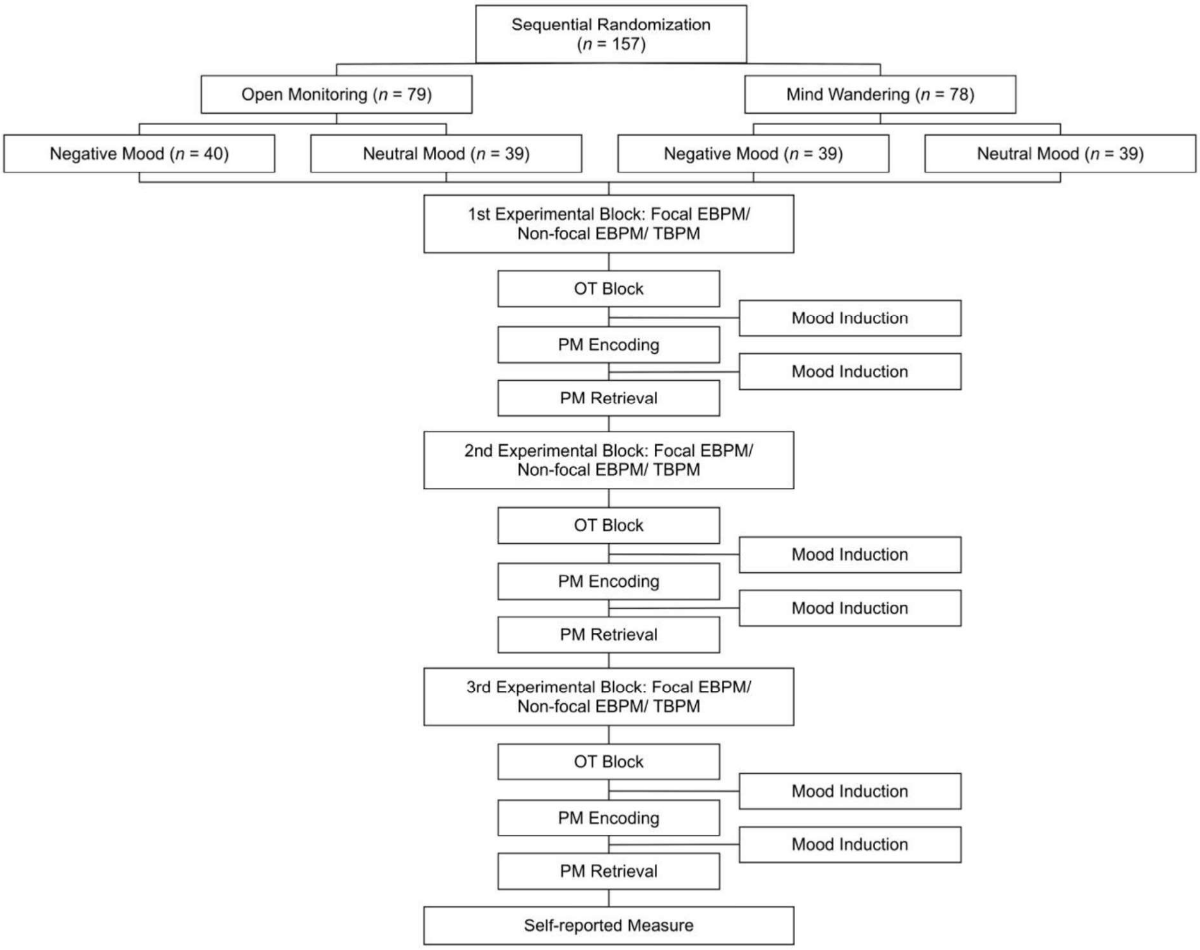
Procedures in the experimental time-based prospective memory task



Note. 時鐘 = clock; 動物 = animal; 獅子 = lion; 蘋果 = apple; 水果 = fruit.

Fig. 5

Flowchart of Procedures in Study 2



Note. EBPM = event-based prospective memory; OT = ongoing task; PM = prospective memory; TBPM = time-based prospective memory.

Fig. 6

Induction types × mood conditions interaction in focal event-based prospective memory

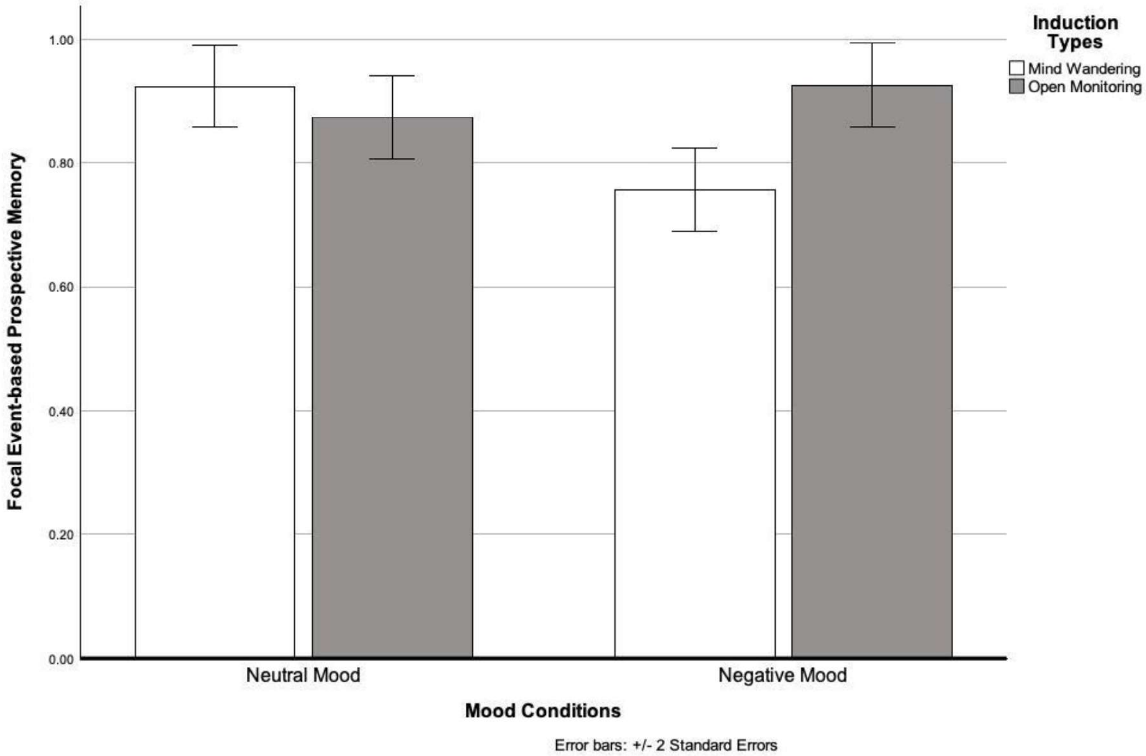


Fig.1

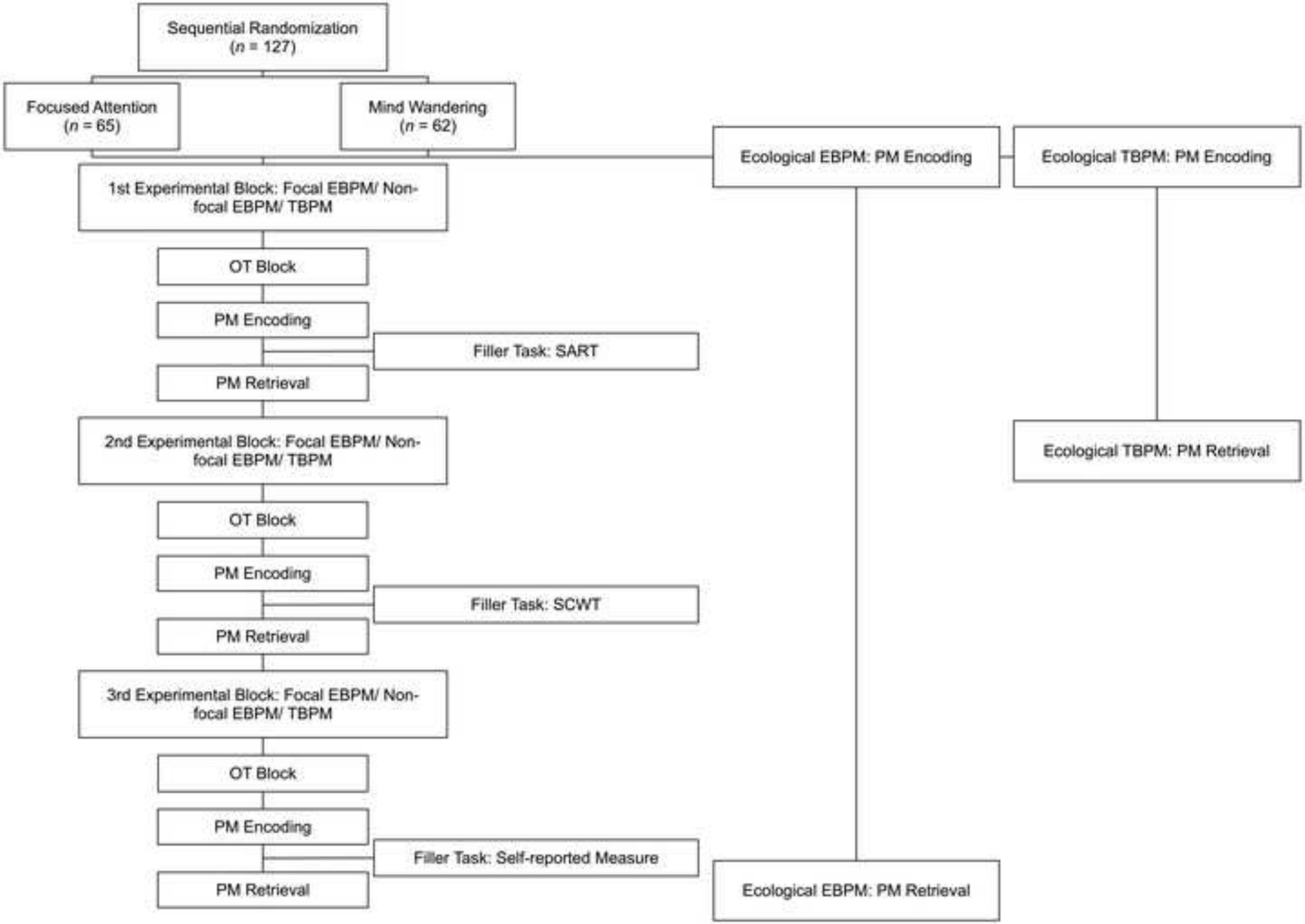

Sequential Randomization
(*n* = 127)
Focused Attention
(*n* = 65)
Mind Wandering
(*n* = 62)
1st Experimental Block: Focal EBPM/ Non-focal EBPM/ TBPM
OT Block
PM Encoding
Filler Task: SART
PM Retrieval
2nd Experimental Block: Focal EBPM/ Non-focal EBPM/ TBPM
OT Block
PM Encoding
Filler Task: SCWT
PM Retrieval
3rd Experimental Block: Focal EBPM/ Non-focal EBPM/ TBPM
OT Block
PM Encoding
Filler Task: Self-reported Measure
PM Retrieval
Ecological EBPM: PM Encoding
Ecological TBPM: PM Encoding
Ecological TBPM: PM Retrieval
Ecological EBPM: PM Retrieval

Fig.2

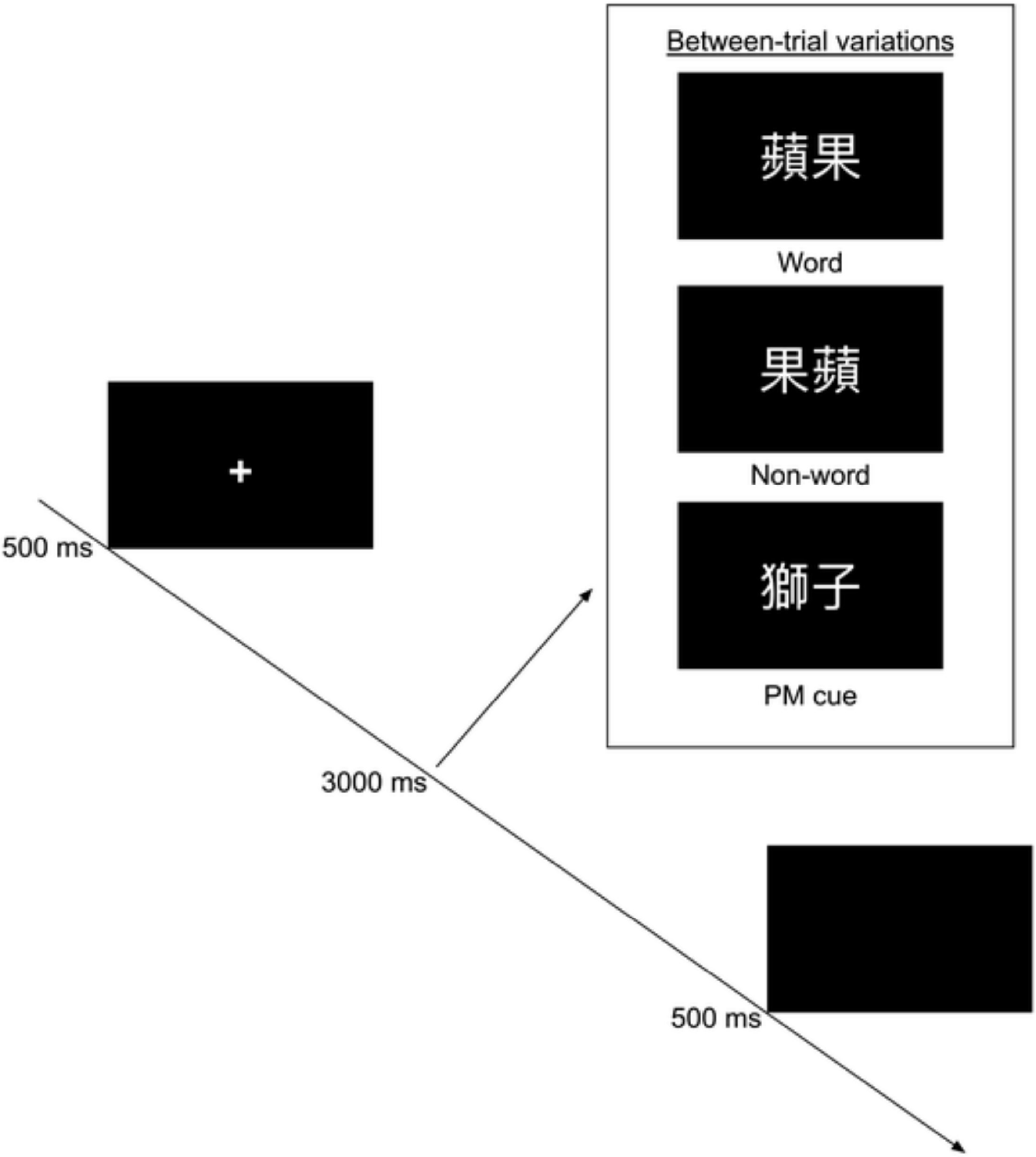
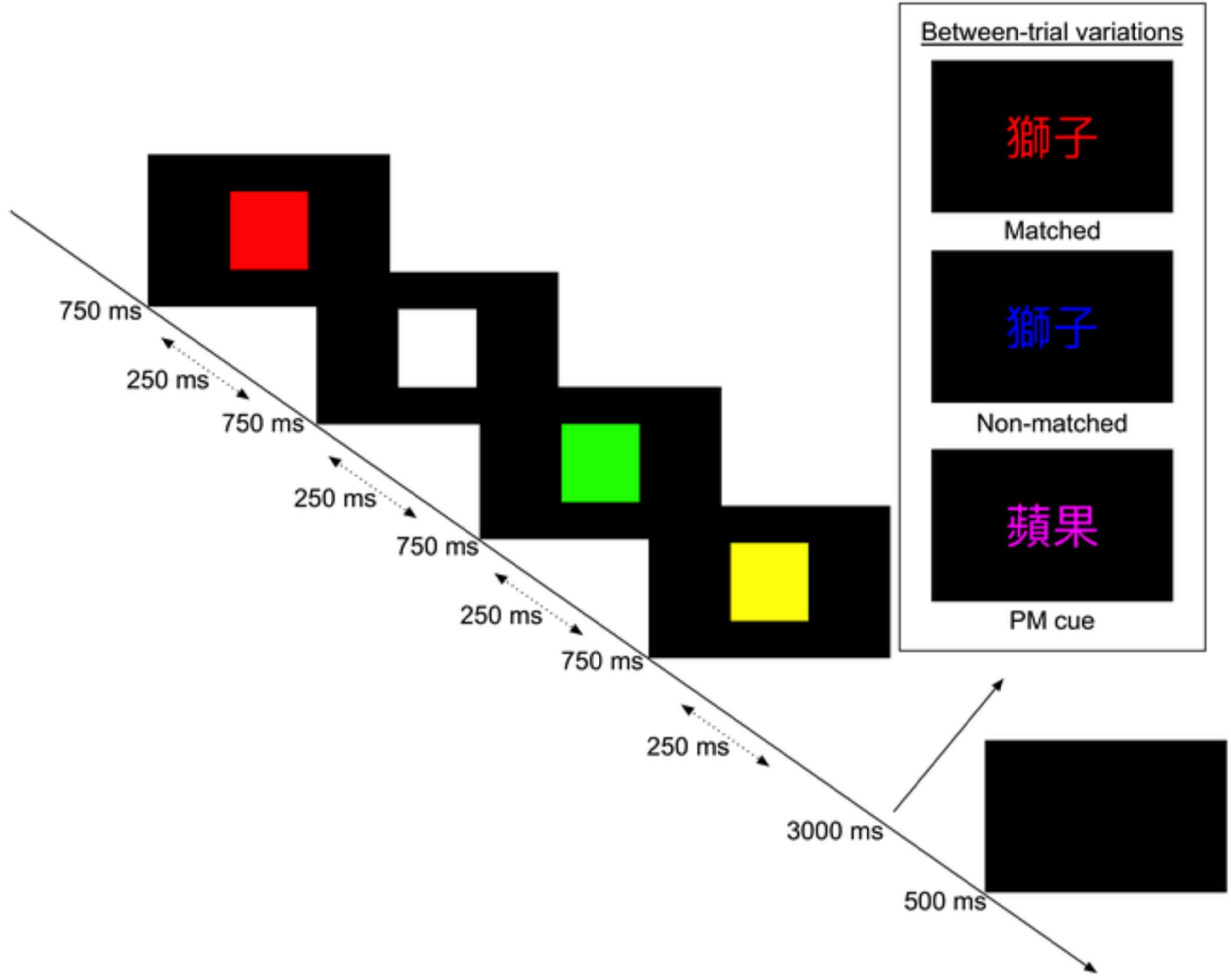
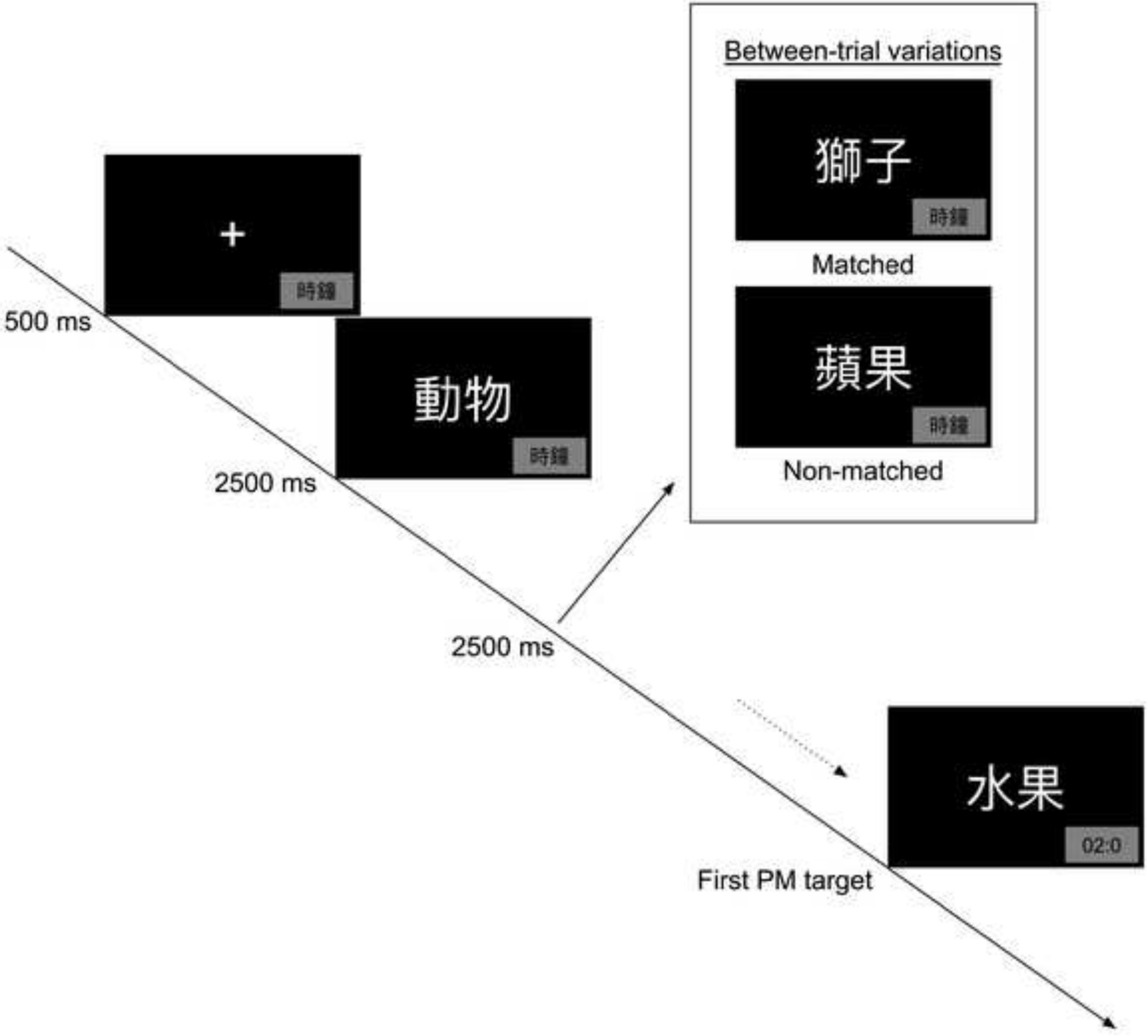

Between-trial variations
蘋果
Word
果蘋
Non-word
獅子
PM cue
+
500 ms
3000 ms
500 ms

Fig.3



Between-trial variations
獅子
Matched
獅子
Non-matched
蘋果
PM cue
750 ms
250 ms
750 ms
250 ms
750 ms
250 ms
750 ms
250 ms
3000 ms
500 ms

Fig.4



500 ms
+
時鐘
2500 ms
動物
時鐘
2500 ms
Between-trial variations
獅子
時鐘
Matched
蘋果
時鐘
Non-matched
水果
02:0
First PM target

Fig.5

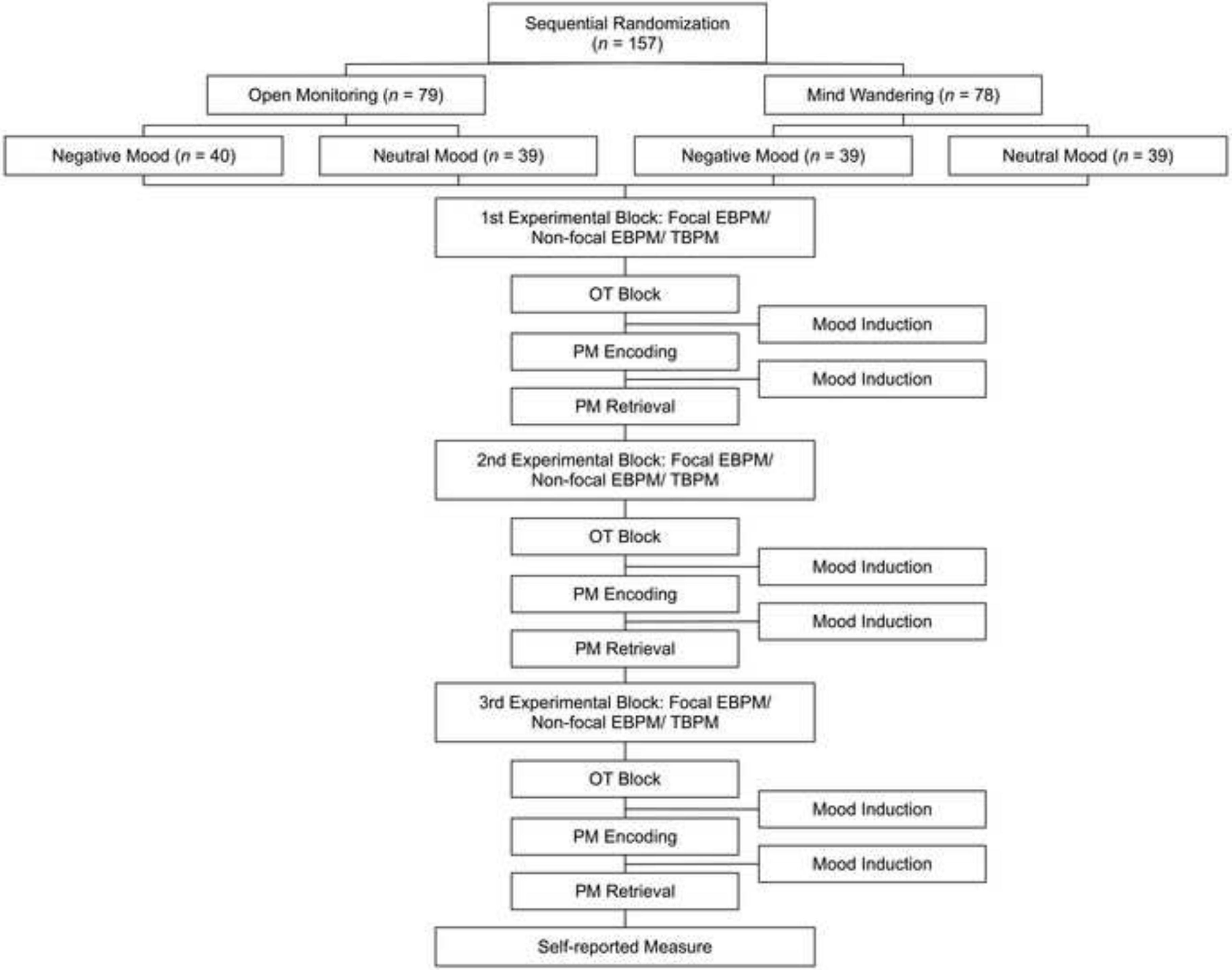
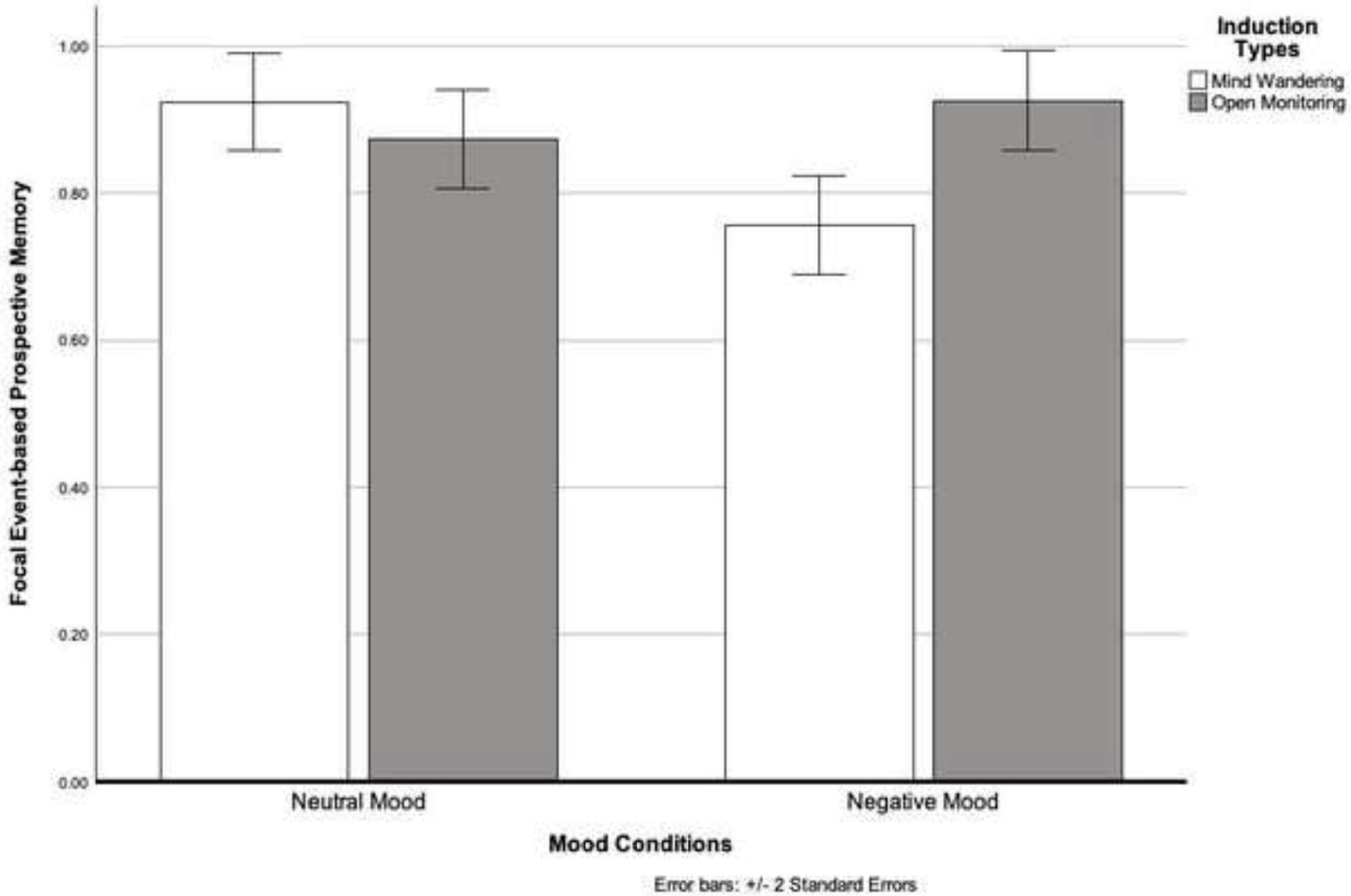

Sequential Randomization (n = 157)
Open Monitoring (n = 79)
Mind Wandering (n = 78)
Negative Mood (n = 40)
Neutral Mood (n = 39)
Negative Mood (n = 39)
Neutral Mood (n = 39)
1st Experimental Block: Focal EBPM/ Non-focal EBPM/ TBPM
OT Block
Mood Induction
PM Encoding
Mood Induction
PM Retrieval
2nd Experimental Block: Focal EBPM/ Non-focal EBPM/ TBPM
OT Block
Mood Induction
PM Encoding
Mood Induction
PM Retrieval
3rd Experimental Block: Focal EBPM/ Non-focal EBPM/ TBPM
OT Block
Mood Induction
PM Encoding
Mood Induction
PM Retrieval
Self-reported Measure

Fig.6


Focal Event-based Prospective Memory
1.00
0.80
0.60
0.40
0.20
0.00
Induction Types
Mind Wandering
Open Monitoring
Neutral Mood
Negative Mood
Mood Conditions
Error bars: +/- 2 Standard Errors