PROSPECTIVE MEMORY TRAINING IN HEALTHY OLDER ADULTS: A SYSTEMATIC REVIEW AND AN EXPERIMENT OF MINDFULNESS INDUCTION TO IMPROVE PROSPECTIVE MEMORY

TSANG PAK LIK

PhD

The Hong Kong Polytechnic University

2024

The Hong Kong Polytechnic University

Department of Applied Social Sciences

Prospective memory training in healthy older adults: A systematic review and an experiment of mindfulness induction to improve prospective memory

Tsang Pak Lik

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

June 2023

CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

__________________(Signed)

Tsang Pak Lik, Alex (Name of student)

ABSTRACT

Prospective memory (PM) is the ability to execute a future intention, which includes event-based and time-based PM. Event-based PM (EBPM) is activated by an external cue and is further determined by its cue focality. Focal EBPM is cued by the processing features of an ongoing task, whereas non-focal EBPM shares no common features with the ongoing task. Time-based PM (TBPM) is triggered after a certain amount of time. Previous studies have shown an aging decline in PM, but it is vital for older adults to achieve functional independence. Exploring ways to attenuate an aging decline is crucial to a successful aging experience.

A systematic review was first performed to synthesize existing PM training for older adults (>55 years). This includes strategy-based, process-based, and combined training. Strategy-based training utilizes mnemonics to compensate a PM decline. Process-based training restores the efficiency of cognitive processes that support PM. Combined training uses both approaches to facilitate PM. Eleven studies were identified, including six studies of strategy-based training, two studies of process-based training, and three studies of combined training. Although strategy-based training can facilitate PM in older adults, it often produces limited transfers. Alternatively, process-based training encourages far transfers by targeting its underlying cognitive processes. Considering a lack of evidence of mindfulness as a process-based PM training, two experiments (Experiment I and II) were conducted to evaluate the potential effects of mindfulness on PM.

Mindfulness refers to a state of non-judgmental, present-moment awareness. There are two common styles of mindfulness meditation: focused attention (FA) and open monitoring (OM). Focused attention sustains attention toward an anchor object. Open monitoring involves self-monitoring of present-moment experience using a non-judgmental attitude. To understand how mindfulness facilitates PM, Experiment I and II explore the specific effects of FA and OM on PM. It is hypothesized that FA improves PM by enhancing attentional control while OM facilitates PM by reducing emotional interference.

In Experiment I, 127 healthy older adults (M_{age} = 64.87) were randomized into a FA group or a mind wandering (MW) control group. An experimental paradigm was used to measure PM with commands embedded in an ongoing task. Three types of PM cues were assessed: focal EBPM, non-focal EBPM, and TBPM. Two additional ecological PM tasks (EBPM and TBPM) were included. To explore whether there is a mediation effect of attentional control between FA and PM, two experimental tasks were employed to measure sustained, selective, and executive attention. The results indicated the FA group performed better in experimental focal EBPM ($p < 0.05$) and ecological focal EBPM ($p < 0.05$). While FA improved attentional control, there is only a weak, partial meditation of sustained attention ($p < 0.05$) between FA and experimental focal EBPM.

In Experiment II, 157 healthy older adults (M_{age} = 66.19) were randomized into two between-subject factors: induction types (OM vs. MW) and mood conditions (negative vs. neutral). Three types of PM cue were assessed: focal EBPM, non-focal EBPM, and TBPM. In the negative mood condition, the OM group performed better than the MW group in experimental focal EBPM ($p < 0.01$).

This thesis offers preliminary evidence of mindfulness as a process-based PM training for older adults. Even brief inductions of FA and OM produced measurable benefits in focal EBPM. While FA improved focal EBPM, such improvement was only weakly and partially mediated by better sustained attention. On the other hand, OM primarily facilitated focal EBPM by reducing emotional interference from negative emotions. Therefore, mindfulness may hold the promise to facilitate older adults to achieve functional independence, which ultimately contributes to a successful aging experience.

PUBLICATIONS

Journal Articles

- **Tsang, A. P. L.**, Au, A., & Lo, H. H. M. (2022). Prospective memory training for healthy older adults: A systematic review. *Clinical Gerontologist*, *45*(3), 486-502.
- **Tsang, A. P. L.**, Lu, H., & Lo, H. H. M. (in press). The acute effects of focused attention and open monitoring meditations on prospective memory in older adults. *Mindfulness*.

ACKNOWLEDGEMENTS

Pursuing a PhD is a challenging yet fulfilling journey. Throughout these years, I have learnt to become a persistent person, allowing me to overcome challenges and obstacles. Of course, this is never a lone journey. This endeavor would not have been possible without the support that I have received.

I am extremely grateful to my chief supervisor, Dr. Huijing Lu, for her unwavering support in my learning. She has not only taught me knowledge and skills as a researcher, but also shared invaluable practical insights from her own experience. Her constructive and timely feedback has greatly aided my learning process. I would also like to express my gratitude to my co-supervisor, Dr. Herman Lo. His expert opinions in mindfulness have provided me much guidance in the experiments. I am also deeply indebted to Dr. Alma Au and Dr. Simon Lai, for their initial support. Their help in conceptualizing this project means a lot to me, especially when I was confused at the beginning of this journey.

I would like to extend my sincere thanks to Ms. Aya Kwan, for her generous help in preparing the materials for the experiments. Her passion about mindfulness has been a profound source of motivation for me to persist in this research. I am also thankful to all older participants for their time and efforts to take part in this project.

I am extremely grateful to my girlfriend, Vivien Chan, for her emotional support. I am glad that I have met you during this journey. Also, my journey would not have been possible without the unlimited support and care from my mom and dad.

This thesis is dedicated to my dad. Thank you for always being supportive, especially regarding my decision to pursue a PhD. I am sure that you are proud of me in heaven.

TABLE OF CONTENTS

LIST OF TABLES ... ix

LIST OF FIGURES ... x

CHAPTER I: INTRODUCTION ... 1

Cognitive Processes in Prospective Memory ... 2

Theoretical Frameworks of Prospective Memory ... 3

Retrieval of Event-based Prospective Memory ... 3

Preparatory Attentional and Memory Processes Theory ... 3

Multi-Process Framework ... 4

Retrieval of Time-based Prospective Memory ... 5

Test-Wait-Test-Exit Model ... 5

Development of Prospective Memory in Adulthood ... 9

CHAPTER II: SYSTEMATIC REVIEW OF PROSPECTIVE MEMORY TRAINING FOR HEALTHY OLDER ADULTS ... 11

Strategy-based Training ... 11

Process-based Training ... 12

Combined Training ... 13

Limitations of Prospective Memory Training ... 13

Methods ... 14

Data Sources ... 14

Study Selection ... 15

Data Extraction ... 15

Assessment of Methodological Quality ... 15

Data Analyses ... 16

Results ... 17

Study Selection ... 17

Study Characteristics ... 19

Prospective Memory Training Characteristics ... 24

Strategy-based Training ... 28

Process-based Training ... 28

Outcome Data and Reporting ... 29

Standardized Clinical Measures......29
Laboratory-based Measures......30
Ecological Tasks......30
Evidence of Prospective Memory Training......31
Strategy-based Training......35
Process-based Training......36
Combined Training......37
Methodological Quality......38
Discussion......39
CHAPTER III: LITERATURE REVIEW......44
Mindfulness and Cognitive Functions......47
Mindfulness as Prospective Memory Training......48
Effects of Focused Attention on Prospective Memory......48
Attentional Control in Prospective Memory......50
Development of Attentional Control in Adulthood......51
Evidence of Focused Attention in Training Attentional Control......52
Effects of Open Monitoring on Prospective Memory......54
Emotional Interference in Prospective Memory......56
Development of Emotion Regulation in Adulthood......57
Evidence of Open Monitoring in Reducing Emotional Interference......59
Limitations of Existing Literature......61
Research Questions......62
CHAPTER IV: EXPERIMENT I......65
Methods......65
Participants......65
Materials......66
Screening Assessments......66
Experimental Tasks......67
Sustained Attention.......67
Selective and Executive Attention.......68
Prospective Memory.......69

Ecological Tasks 71
Procedures 72
Data Analyses 74
Results 74
Performance of Attentional Control 76
Prospective Memory Performance 79
Correlational Analyses 80
Mediation Analyses 82
Discussion 84
CHAPTER V: EXPERIMENT II 88
Methods 88
Participants 88
Materials 89
Procedures 90
Data Analyses 93
Results 93
Manipulation Check 96
Prospective Memory Performance 99
Discussion 102
CHAPTER VI: GENERAL DISCUSSION 105
Implications 110
Theoretical Implications 110
Practical Implications 111
Limitations 112
Conclusion 115
ACKNOWLEDGEMENTS 116
REFERENCES 117
APPENDICES 145
Appendix A: Script of Focused Attention 145

Appendix B: Script of Open Monitoring 152

Appendix C: Script of Mind Wandering..159

Appendix D: Descriptions of Mood Induction Materials 164

LIST OF TABLES

Table 1. Theoretical Frameworks of Prospective Memory Retrieval 7

Table 2. Characteristics of the Reviewed Studies 19

Table 3. Prospective Memory Training Characteristics...24

Table 4. Studies' Methodological Quality and Findings 32

Table 5. Socio-demographic Information in Experiment I 75

Table 6. Performance of Screening Assessments in Experiment I 75

Table 7. Ongoing Tasks Performance in Experiment I 76

Table 8. Performance of Attentional Control in Experiment I..77

Table 9. Univariate Tests of Performance Indicator in Attentional Control in Experiment I.78

Table 10. Prospective Memory Performance in Experiment I..79

Table 11. Univariate Tests of Performance Indicator in Prospective Memory in Experiment I 80

Table 12. Correlation Matrix of Outcome Measures in Experiment I 81

Table 13. Mediation Effects of Attentional Control Between Induction Types and Prospective Memory 83

Table 14. Socio-demographic Information in Experiment II..94

Table 15. Performance of Screening Assessments in Experiment II 95

Table 16. Ongoing Tasks Performance in Experiment II...96

Table 17. Mean Valence and Arousal Scores in the Self-Assessment Manikin 97

Table 18. Univariate Tests of the Mean Valence and Arousal Scores in the Self-Assessment Manikin 98

Table 19. Prospective Memory Performance in Experiment II 99

LIST OF FIGURES

Figure 1. PRISMA's Flowchart 17

Figure 2. Percentage of Studies Meeting the PEDro Scale 38

Figure 3. Hypothesized Effects of Focused Attention and Open Monitoring on Prospective Memory 63

Figure 4. Schematic Representation of the Sustained Attention to Response Task 67

Figure 5. Schematic Representation of the Stroop Color-Word Test 68

Figure 6. Flowchart of Procedures in Experiment I 72

Figure 7. Flowchart of Procedures in Experiment II 91

Figure 9. Induction Types × Mood Conditions Interaction in Focal Event-based Prospective Memory 101

CHAPTER I: INTRODUCTION

Prospective memory (PM) describes a set of cognitive processes that enables us to realize a future intention at an appropriate moment; it is classified into event-based PM (EBPM) or time-based PM (TBPM) (Einstein & McDaniel, 1996). EBPM refers to a PM intention that is activated by the occurrence of an external cue, such as remembering to replenish groceries when passing by a specific store. TBPM describes a PM intention that is triggered once a certain amount of time has been elapsed, such as remembering to attend a work meeting after 10 minutes.

Conceivably, PM is ubiquitous in our daily life, and it plays a vital role to maintain our daily functioning. For example, Gardner and Ascoli (2015) investigated the natural frequencies of having thoughts related to PM or retrospective memory (RM). They probed young and older adults intermittently about the nature of their current thoughts using experience sampling. On average, young adults had about 13 RM and 17 PM thoughts per hour. Although the estimated rate of RM in older adults was similar to young adults, they had about 31 PM thoughts per hour. Not only the results have highlighted that PM is more ubiquitous than RM, but it is also of increasing importance as we age.

Given the prevalence of PM tasks in daily lives, there is also a higher chance of encountering PM failures. PM failures could account for up to 80% of everyday memory usages (Crovitz & Daniel, 1984; Kliegel & Martin, 2003). At the same time, PM failures tend to be more frustrating than lapses in RM (Smith et al., 2000). Consider, for example, the dreadful consequences of forgetting to turn off the stove after cooking.

Acknowledging the significance of PM, this thesis explores ways that can facilitate PM in older adults. First, a systematic review will synthesize the current evidence of PM training for older adults. Second, two experiments will be conducted to explore whether mindfulness meditations can increase PM performance in this population.

Cognitive Processes in Prospective Memory

In every PM task, there are always prospective and retrospective components (Einstein & McDaniel, 1990). The prospective component is remembering the intention itself, i.e., something remains to be fulfilled. The retrospective component refers to the contextual factors and intended actions, i.e., what to perform and when to perform the intention. Although a PM task clearly involves a RM component, it also incorporates other cognitive processes that are not shared by RM (Glisky, 1996).

In the Process Model of PM, Kliegel et al. (2002) outlined various cognitive constructs that support a PM intention via four distinct phases: (1) intention formation, (2) intention retention, (3) intention initiation, and (4) intention execution.

A PM intention is first formed in the intention formation phase. Taken from an earlier example of EBPM, this is where you realized the need to replenish groceries and plan accordingly. In this phase, planning is the most important cognitive ability, which enables one to focus on task relevant information. For example, you may plan the most efficient route to replenish your groceries is by choosing a specific store, a place where you can obtain all supplies at once.

The next phase is the intention retention phase, in which the PM intention is maintained in long-term memory. It is often filled with other duties until an appropriate moment to realize the intention. Presumably, this phase is where a PM task involves a RM component, such as remembering what groceries to buy and where to buy them.

Then, the intention initiation phase is the point when the intention should be triggered. Cognitive processes such as monitoring, cognitive flexibility and inhibition are essential in this phase. Monitoring functions to detect an external cue (e.g., passing by the specific store) for one to carry out the PM intention. Cognitive flexibility and inhibition serve to disengage any ongoing activities (e.g., stop texting your friends) and switch to the PM intention.

The last phase is the intention execution phase. This is where the planned intention is being executed. Again, cognitive flexibility is required to switch between different tasks, such as getting off the transit and walking into that store).

Theoretical Frameworks of Prospective Memory

Early PM theorists (e.g., Einstein & McDaniel, 1990) have been particularly interested in how a PM intention is retrieved. In the following section, I will provide a brief overview on major theoretical frameworks in EBPM and TBPM retrieval, which covers some of the key concepts to aid subsequent discussions in this thesis (for a summary, see Table 1).

Retrieval of Event-based Prospective Memory

Preparatory Attentional and Memory Processes Theory

The Preparatory Attentional and Memory Processes (PAM) Theory (Smith, 2003; Smith & Bayen, 2004) posits that limited attentional resources are needed to retrieve a PM intention. Accordingly, a supervisory attention system (SAS; Shallice, 1988) first encodes an association between an external cue and a PM intention, i.e., a PM cue-action pair. Then, it allocates attentional resources from competing tasks to prioritize the PM intention. The SAS constantly monitors the external environment for the occurrence of a PM cue, which signals an appropriateness to carry out the PM intention. Upon encountering the PM cue, a retrospective recognition check determines whether the external cue is associated with the PM intention. Once the correct PM cue is identified, the SAS interrupts ongoing activities for one to perform the PM intention.

The PAM theory has been supported by experimental studies (e.g., Smith, 2003) utilizing the Einstein-McDaniel Paradigm (Einstein & McDaniel, 1990) to measure PM. In this paradigm, a PM intention is embedded in an ongoing task (OT). A common example of OT is the lexical decision task, i.e., to decide whether a string of characters could form a word or not. The PM intention would be an additional command (to press a button) whenever the character string belongs a certain word or in a specific category. Utilizing this paradigm, Smith (2003, Experiment I) compared the performance of those who were either performing the lexical decision task with or without the PM intentions. Interestingly, those who performed the additional PM intentions were approximately 300 ms slower in reaction time (RT). Those who performed more accurately (mean proportion of correct responses > 69%) also required a longer RT. This implies that limited attentional resources are deployed in monitoring the PM cue with fewer resources available for processing the lexical decision task.

However, the PAM theory has been criticized for being maladaptive to our everyday functioning, especially that a heavy attentional cost is associated with constant monitoring in tasks with longer delay intervals, such as several days (Anderson et al., 2017). It is also counterintuitive to our everyday experience, such as seeing a specific store would automatically trigger the thought to replenish groceries (McDaniel & Einstein, 2007).

Multi-Process Framework

Alternatively, the Multi-Process Framework (McDaniel & Einstein, 2000) posits that two distinct processes to support PM retrieval: strategic monitoring and spontaneous retrieval. Strategic monitoring is akin to the process described in the PAM theory, in which limited attentional resources are engaged in top-down monitoring for the presence of a PM cue (Scullin et al., 2010). In contrast, spontaneous retrieval is a bottom-up approach that allows the PM cue to be automatically detected without engaging in constant monitoring. This process is presumably supported by the automatic-associative memory system (McDaniel et al., 1998; Moscovitch, 1994). In the intention formation phase, an associative link is formed between a PM cue-action pair, which remains activated in the automatic-associative memory system to a certain extent. After encountering a PM cue, the system transfers this information into an awareness for one to carry out the PM intention. Note that while spontaneous retrieval is relatively automatic, it still relies on controlled processing, such as initiating a search for the significance of an external cue (Scullin et al., 2010).

Utilizing spontaneous retrieval also depends on a number of contextual factors (McDaniel & Einstein, 2000). One of the most studied factors is PM cue focality (Einstein & McDaniel, 2005). A PM task is considered focal if there are shared processing features with an OT, such as talking to a friend about shopping can stimulate the PM intention of replenishing groceries. On the other hand, a PM task is non-focal if there are no common features between the OT and PM intention, such as scheduling a work meeting is unlikely to stimulate the thought to replenish groceries. Einstein and McDaniel (2005) suggest that focal PM is more likely to activate spontaneous retrieval, whereas non-focal PM is primarily supported by strategic monitoring.

The Multi-Process Framework has been substantiated by experimental studies demonstrating minimal costs associated with spontaneous retrieval. Einstein and McDaniel (2005) manipulated PM cue focality in a category association task (i.e., to decide whether a word belongs to a given category). The focal PM cue was to press a specific button when a PM target word appeared. The non-focal PM cue was to respond when a PM target syllable appeared, which is not required in the category association task. Evidently, OT costs (latency in RT data) were only observed in non-focal PM.

Retrieval of Time-based Prospective Memory

Test-Wait-Test-Exit Model

Thus far, the discussions of PM retrieval have been focused on EBPM. Due to an absence of external cue, TBPM retrieval typically requires a higher degree of self-initiation because of time monitoring (d'Ydewalle et al., 2001). Harris and Wilkins' (1982) Test-Wait-Test-Exit (TWTE) Model offers a detailed account in how a TBPM intention is retrieved. After forming a PM intention, people tend to check the time ("test") and return to their ongoing activities (“wait”) until another clock check is appropriate. The test-wait cycles loop until a clock check (“test”) is made within the PM interval. The loop then closes at this point (“exit”) for the intention to be performed. Importantly, clock checks tend to increase as the PM interval is approaching to ensure that one of the clock checks will fall within this critical period. This type of transient monitoring is more adaptive to our everyday functioning, especially that it mitigates a heavy attentional cost associated with constant time monitoring (Oksanen et al., 2014).

The TWTE model is supported by a functional Magnetic Resonance Imaging (fMRI) study. Oksanen et al. (2014) scanned their participants with fMRI while performing a TBPM task. In the TBPM task, participants pressed a specific button at three-minute intervals (PM targets) while performing a two-back version of the n-back task, i.e., to decide whether a stimulus matches the stimulus presented at 2 trials back. For the sake of time monitoring, participants could access a hidden clock by pressing a button. Consistent with the TWTE Model, there were no sustained activations in any brain regions during the task. Prior to any clock checks, there was a weak activation of the anterior prefrontal cortex (i.e., an area responsible for clock checking decisions) and a strong activation of the pre-supplementary motor area (i.e., an area responsible for pressing the clock check button). Therefore, their findings implicated a pattern of transient time monitoring.

Table 1. *Theoretical Frameworks of Prospective Memory Retrieval*

	Event-based PM		Time-based PM
	Preparatory Attentional and Memory Processes Theory	Multi-Process Framework	Test-Wait-Test-Exit Model
Core Assumptions	• Attentional resources are needed to retrieve a PM intention. • A supervisory attentional system is involved in processes such as: ○ To allocate attentional resources between competing tasks and the PM intention. ○ To monitor the external environment for the presence of a PM cue.	• A PM intention can be retrieved by two processes: strategic monitoring and spontaneous retrieval. 1. Strategic Monitoring • This process is akin to the core assumptions in the PAM theory. 2. Spontaneous Retrieval • This process allows a PM cue to be automatically detected without deploying attentional resources. • An automatic-associative memory system is involved in processes such as: ○ To form an associative link between a PM cue and its associated actions. ○ To transfer this associative link into an awareness after encountering a PM cue.	• A PM intention is retrieved by transient time monitoring. • The “test-wait” cycle of clock checking loops until one of the clock checks (“test”) is made within the PM target interval for one to perform the PM intention (“exit”). • Clock checks will increase as the PM target interval is approaching.
Examples	PM Intention • To replenish groceries when seeing a specific store.	PM Intention • To replenish groceries when seeing a specific store.	PM Intention • To attend a work meeting after 10 minutes.

	PM Retrieval • While engaging in other tasks, you will keep an eye on the external environment to mind for that store.	PM Retrieval in Strategic Monitoring • See example in the PAM theory. PM Retrieval in Spontaneous Monitoring • While engaging in other tasks, the intention will automatically come into mind after encountering the store.	PM Retrieval • You check the clock in a few minutes ("test") and return to other activities ("wait"). As it is approaching 10 minutes, you will likely increase the number of clock checks ("test") until you attend the meeting ("exit").

Note. PM = prospective memory.

Development of Prospective Memory in Adulthood

PM encompasses a broad range of vital daily tasks that sustains functional independence, especially for older adults, such as attending to medical appointments or taking medications on schedule. Woods et al. (2012) reported an association between PM capacity and functional independence in older adults. To measure PM capacity, they utilized the Memory for Intentions Screening Test (MIST; Raskin, 2009), where participants responded to four EBPM and TBPM commands in a standardized word search task. They included additional measures of executive functions and self-perceived functional independence. Not only that there was a positive association between PM and functional independence, but this association was also evident after accounting for executive functions performance, indicating a unique contribution of PM in older adults' functional independence. The capacity to perform PM tasks is also particularly important for one to achieve a successful aging experience. Woods et al. (2015) further observed an association between PM and quality of life in older adults. They utilized the MIST to assess PM capacity with self-reported measures of functional independence and quality of life. They found a positive association between the MIST and quality of life, especially for those who had reported a lower level of functional independence.

Considering the importance of PM for older adults, I will provide a brief overview of related literature in the following section. Presumably, PM should be adversely impacted by aging because it relies on cognitive processes in the prefrontal and medial temporal cortex, which are subjected to an aging decline (Burke & Barnes, 2006). However, there is a rather complex picture in the findings emerged from PM studies that compare the performance between young and older adults, at least compared to those in RM (Grady & Craik, 2000).

Einstein and McDaniel (1990) reported an age invariability in focal EBPM. They compared the performance of young and older adults in a focal EBPM task and a free recall task. In focal EBPM, participants responded to PM target words while performing a short-term memory task, i.e., to recall words presented in each trial. Note that the short-term memory task was adjusted for their respective age group, where older adults have fewer words to recall. In the free recall task, participants learned an unstructured list for later recall. While there was a clear aging decline in RM, both groups performed similarly in the focal EBPM task.

On the contrary, Kidder et al. (1997) found an aging decline in non-focal EBPM. While comparing PM performance between young and older adults, they manipulated the task difficulty. They utilized a working memory (WM) task as an OT, where participants recalled either the last two words (low WM load) or the last three words (high WM load) presented in the screen. The PM component was to respond to one (low PM load) or three specific background patterns (high PM load) where these words were shown. Comparing to young adults, older adults performed worse in non-focal EBPM, especially when there was a higher level of strategic demand.

While these studies (e.g., Einstein & McDaniel, 1990; Kidder et al., 1997) were somewhat inconsistent, it is clear that PM is not immune to an aging decline, at least in experimental PM tasks that require a higher level of strategic demand (Kliegel et al., 2008; Uttl, 2008). In a meta-analysis in 26 studies, Henry et al. (2004) reported that older adults were more impaired in experimental PM tasks that require a higher level of strategic demand ($r = -0.40$). In another meta-analysis in 46 studies, Kliegel et al. (2008) also reported an effect of aging decline ($d = 0.64$) in experimental focal and non-focal EBPM tasks. Another meta-analysis in 60 studies from Uttl (2008) also revealed a similar pattern, with an aging decline observed in experimental focal EBPM ($d = -0.50$) and non-focal EBPM tasks ($d = -0.72$). Note that a reliable aging effect is still evident in focal EBPM, which should require less cognitive resources through the support of spontaneous retrieval.

CHAPTER II: SYSTEMATIC REVIEW OF PROSPECTIVE MEMORY TRAINING FOR HEALTHY OLDER ADULTS

An important endeavor in applied developmental research is to explore ways that can attenuate an aging decline in PM. Generally, there are three approaches in PM training: (1) strategy-based training, (2) process-based training, and (3) combined training (Hering et al., 2014).

Strategy-based Training

Strategy-based training, or compensatory training, utilizes a variety of mnemonics to compensate for a PM aging decline. This approach rests on the premise that learning is mostly intact in older adults (Hering et al., 2014). In a meta-analysis in 67 studies of episodic memory training in older adults, Verhaeghen et al. (1992) reported a weighted effect size of 0.81 in 31 reviewed studies of strategy-based training, suggesting that older adults can make use of mnemonics to compensate for an age-related memory decline. For various mnemonics taught in these programs, Harris (1980) classified them into internal or external strategies.

Internal strategies are self-generated mnemonics, such as mental imagery, which serves to strengthen a PM cue-action pair to increase the likelihood of spontaneous retrieval. For example, Potvin et al. (2011) evaluated the effectiveness of using mental imagery to compensate for a PM decline in patients with acquired brain injury (ABI). Participants learned to create mental images of PM intentions and applied this technique to a variety of simulated everyday tasks. At pre- and post-training, they measured PM by a simulated task (with EBPM and TBPM commands). Comparing to a control group who had only received a brief education session, those who were trained in using mental imagery performed better at post-test.

External strategies manipulate the external environment to facilitate PM, such as using an external memory aid to prompt for task execution. For example, McDonald et al.

(2011) explored the effectiveness of employing different external aids in compensating a PM decline in ABI patients. Specifically, they compared the effectiveness of using a standard diary or Google Calendar. In the standard diary group, participants used a diary to keep track of everyday tasks. In the Google Calendar group, participants were given a step-by-step guide on how to use Google Calendar to remind their everyday tasks. Training gains were quantified by observational reports from patients' family members. Interestingly, there were more PM gains in using Google Calendar, especially with an active reminder that alleviates the needs to monitor a PM intention.

Process-based Training

Process-based training, or restorative training, targets one or multiple underlying cognitive processes to restore a PM aging decline. This approach assumes that repetitive practices of a particular process would enhance its neural connections and therefore increasing the efficiency to perform that task (Kolb et al., 2011; Raskin & Sohlberg, 2009). An example of process-based training could be targeting the RM component of PM using spaced retrieval, i.e., to memorize a PM intention at a progressively longer retention span (Hering et al., 2014). For example, Raskin and Sohlberg (2009) piloted a process-based training of spaced retrieval to restore PM capacity in ABI patients. Participants practiced spaced retrieval at a progressively longer retention span at 1-minutes intervals of their recorded baselines. On the other hand, the control group received an educational session. Training gains were assessed at pre- and post-training with EBPM and TBPM commands embedded in a letter cancellation task and an alphabetizing sentences task. At post-test, only those who had received training in spaced retrieval shown PM gains, and more so, the improvements were maintained at one-year follow-up test.

Combined Training

Combined training uses both strategy-based and process-based approaches to maximize PM gains (Hering et al., 2014). Recently, Raskin et al. (2019) evaluated a combined PM training in facilitating PM in ABI patients. In the training group, participants learned to imagine visual-audio properties, emotions, and thoughts associated with a PM cue and practiced this technique at a progressively longer retention span at 1-minute intervals. In the control group, participants performed tasks analogous to those in a PM training but with no demonstrated benefits on PM, such as recalling a task performed two minutes ago. PM performance was measured by the MIST at pre- and post-training. Importantly, PM gains were only observed in the training group.

Limitations of Prospective Memory Training

While PM training have demonstrated benefits in clinical populations, there have been criticisms on PM training for older adults, regarding its weak evidence base in transferability to everyday PM tasks (e.g., Craik & Rose, 2012; McDaniel & Bugg, 2012; Zelinski, 2012). In a strategy-based training, materials are often highly specific, which limit their generalizability even to other experimental tasks (McDaniel & Bugg, 2012). Some sophisticated mnemonics taught in strategy-based training are too challenging for older adults to apply in everyday scenarios (Hertzog & Dunlosky, 2012). Despite process-based training should encourage far transfer due to its focus on the underlying cognitive processes of PM (Hering et al., 2014), they have also been criticized for limited transfer to untrained tasks, at least in short-term process-based training (Craik & Rose, 2012).

A contributing factor to its weak evidence base could be the small number of PM training for this population. Traditionally, the component of PM was not covered in many large trials of memory training (Waldum et al., 2016). Among the scant evidence of PM training, emphasis have been placed on the rehabilitation settings, such as PM training for

ABI patients (e.g., Raskin & Sohlberg, 2009). In a systematic review in 11 studies of PM training in ABI patients, Mahan et al. (2017) reported benefits of using external strategies to compensate for PM declines, such as a simple reminder system. While there have been studies addressing PM in healthy older adults (e.g., Rose et al., 2015), the current evidence base has yet to be systematically appraised. Therefore, a systematic review is conducted to appraise the effectiveness of PM training for healthy older adults with special considerations given to methodological quality of these studies.

Methods

Data Sources

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards (Moher et al., 2009). A comprehensive search was performed on the PubMed/Medline, PsycARTICLES & PsycINFO via ProQuest, the Cochrane Library, and EBSCO databases, using the following groups of terms that appeared in the articles' keywords, titles, or abstracts: (1) prospective memory, prospective remembering, intentional memory, delayed intention, (2) intervention, rehabilitation, training, treatment, (3) older adult, elder. Where appropriate, wildcards (denoted by *) were placed to ensure broad coverage of variations within these terms. The search was conducted by the thesis author between April 2020 and October 2020. The publication records that have been identified range from 1992 (e.g., Rockwood et al., 1992) to 2020 (e.g., Woods et al., 2020). It should be noted that none of the publications prior to 1992 could be identified because PM is a relatively recent concept. Until 1985, there were only 10 publications available in the field of PM (McDaniel & Einstein, 2007). Nonetheless, considering the possibility that not all studies were included in the electronic databases or indexed by the aforementioned keywords, this review also followed the recommendations from the Cochrane handbook (Higgins et al., 2020) to perform a manual journal search on the most prominent journals in geriatrics. That search included: *Journal of Applied Gerontology, American Journal of Physical Medicine & Rehabilitation, Educational Gerontology, Psychology and Aging*, and *Aging & Mental Health*.

Study Selection

There were several inclusion criteria for eligible studies. First, they must be quantitative studies that addressed PM training and were published in a peer-reviewed journal. Second, the target population must be healthy older adults without any cognitive impairments. Third, the mean age of participants must be above 55 years. Fourth, the PM training must also include at least one pre-post outcome measure of objective EBPM or TBPM performance.

Data Extraction

Studies were first screened by their titles and abstracts. Upon removing duplicates, the manuscripts were evaluated on the basis of a priori inclusion and exclusion criteria. A backward citation search was then carried out for the screened publications. To extract data from eligible studies, a coding template was developed that covered: (1) reference (first author, year of publication), (2) type of training, (3) duration of training, (4) number of sessions, (5) total hours of training, (6) strategies/process trained, (7) outcome measures, (8) type(s) of PM assessed, (9) description of the control, (10) main findings, (11) study design, (12) sample size, (13) age (mean), (14) gender (% female), and (15) location. Studies with overlapped samples were considered as a single record, with preference for the study with the larger sample size. The data extraction process was conducted by the thesis author.

Assessment of Methodological Quality

Methodological quality of the individual studies was assessed using the PEDro scale (Verhagen et al., 1998) from the Physiotherapy Evidence Database. This scale is frequently employed by systematic reviews of cognitive interventions (e.g., Mowszowski et al., 2016;

Sprague et al., 2019). The original scale consists of 11 items to assess the methodological quality of a randomized-controlled trial with demonstrated reliability (Maher et al., 2003). In line with other reviews of cognitive interventions (Mowszowski et al., 2016; Sprague et al., 2019), item number 5 and item number 6 were excluded in our review because it is not practical to blind either the therapists or participants in a PM training. Our resulting total score was therefore 9/9.

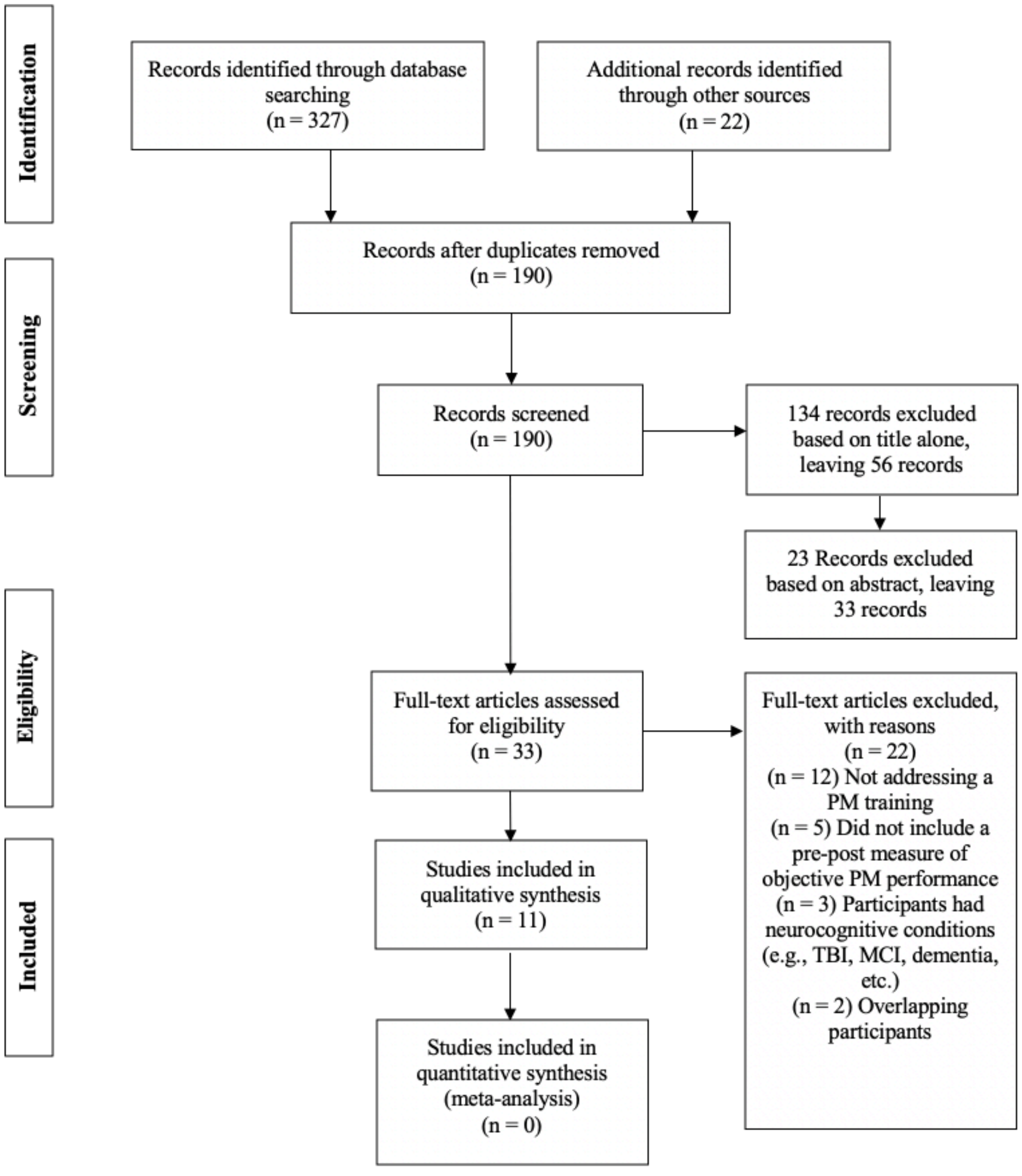
Data Analyses

The primary outcome of interest was objective EBPM and/or TBPM performance. After performing the data search, the results, including the assessment of methodological quality, were shared between the second and third authors of this systematic review to ensure agreement is achieved upon the data interpretation. Due to substantial heterogeneity of PM training in terms of the outcome measures and/or analyses employed, this review followed the recommendations from the Cochrane handbook (Higgins et al., 2020) specifying that a meta-analysis not be carried out because it would be unlikely to reach meaningful conclusions. Therefore, our findings were synthesized qualitatively.

Results

Study Selection

Figure 1. *PRISMA's Flowchart*



Note. MCI = mild cognitive impairment; PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses; *TBI = traumatic brain injury.*

As illustrated in Figure 1, a total of 349 articles were identified during the data search. Upon removing duplicates, we had 190 records. Of those records, 134 articles were excluded on the basis of the title or abstract alone. The remaining 56 studies were screened for eligibility. After reading the full manuscripts, we arrived at 11 studies for inclusion. Half of the excluded studies (50%) did not address a PM training/intervention but instead teased out the effectiveness of a particular strategy or condition that might enhance PM performance in a single session (e.g., Altgassen et al., 2014; Chasteen et al., 2001). Approximately 23% of the excluded studies did not include a pre-post measure of either EBPM or TBPM performance (e.g., Brom & Kliegel, 2014). Fourteen percent of the studies included both healthy older adults and neurocognitive patients in the training group (e.g., McDougall, 2000).

Notably, two studies (18%) were excluded due to overlapping participants. McDaniel et al. (2014) Waldum et al. (2016) recruited the same group of participants. As a result, we gave preference to the study by McDaniel et al. (2014) because it had a larger sample size. Cavallini et al. (2003a) and Cavallini et al. (2003b) also recruited the same group of participants, but with identical sample sizes. After consulting with the first author, we included the group's main study (Cavallini et al., 2003a).

Study Characteristics

Table 2. *Characteristics of the Reviewed Studies*

Reference	Study Design	Location	Sample Size	Age (Mean)	Gender (% Female)
Andrewes et al. (1996)	Randomized controlled study	Australia	T = 40 EG = 20 CG = 20	T = 60-70	T = 50%
Cavallini et al. (2003a)	Uncontrolled study	Italy	T = 60 EG (adult, Loci) = 10 EG (adult, strategic) = 10 EG (younger elderly, Loci) = 10 EG (younger elderly, strategic) = 10 EG (older elderly, Loci) = 10 EG (older elderly, strategic) = 10	EG (adult) = 24.1 EG (younger elderly) = 64.2 EG (older elderly) = 74.4	Not reported
Farzin et al. (2018b)	Randomized controlled study	Malaysia	T = 25 EG (treatment first) = 13 EG (control first) = 12	T = 63.32 EG (treatment first) = 63.69 EG (control first) = 62.92	T = 76% EG (treatment first) = 77% EG (control first) = 75%
Ihle et al. (2018)	Uncontrolled study	Poland	T = 44 EG (imagery) = 21 EG (rehearsal) = 23	T = 67.93 EG (imagery) = 67.62 EG (rehearsal) = 68.22	T = 84% EG (imagery) = 90.5% EG (rehearsal) = 78.3%

Reference	Study Design	Location	Sample Size	Age (Mean)	Gender (% Female)
Mateos et al. (2016)	Retrospective case control study	Spain	T = 145 EG (preserved memory) = 72 EG (impaired memory) = 73	T = 75.06 EG (preserved memory) = 74.80 EG (impaired memory group) = 75.32	T = 68% EG (preserved memory) = 69% EG (impaired memory) = 67%
McDaniel et al. (2014)	Randomized controlled study	United States	T = 78 EG (combined) = 19 EG (cognitive) = 18 EG (exercise) = 22 CG = 19	T = 65, 5.92 EG (combined) = 65 EG (cognitive) = 64 EG (exercise) = 67 CG = 64, 7	T = 64% EG (combined) = 67% EG (cognitive) = 70% EG (exercise) = 71% CG = 60%
Pandya (2020)	Randomized controlled study	India, Singapore, South Africa, Kenya	T = 792 EG = 396 CG = 396	T = 67.12 EG = 67.22 CG = 67.01	T = 50% EG = 49% CG = 51%
Rose et al. (2015)	Quasi-experimental study	Canada	T = 55 EG = 23 CG = 32	T = 67.5 EG = 67.4 CG = 67.6	Not reported
Schmidt et al. (2001)	Randomized controlled study	Netherlands	T = 65 EG = 20 CG = 45	T = 62.09 EG = 61.9 CG = 62.17	T = 63% EG = 65% CG = 62%

Reference	Study Design	Location	Sample Size	Age (Mean)	Gender (% Female)
Troyer (2001)	Quasi-experimental study	Canada	T = 60 EG = 36 CG = 24	T = 72 EG = 72.6 CG = 71.1	T = 77% EG = 81% CG = 71%
Villa and Abeles (2000)	Uncontrolled study	United States	T = 68 EG (ecological stimuli) = 38 EG (laboratory-generated stimuli) = 30	T = 67.37 EG = 67.37	T = 60% EG = 60%

Note. T = total; EG = experimental group; CG = control group.

Overall, the included studies had adopted a variety of research designs: quasi-experimental studies (*n* = 2; Rose et al., 2015; Troyer, 2001), uncontrolled studies (*n* = 3; Cavallini et al., 2003a; Ihle et al., 2018; Villa & Abeles, 2000), a retrospective case-control design (*n* = 1; Mateos et al., 2016), and randomized controlled studies (*n* = 5; Andrewes et al., 1996; Farzin et al., 2018b; McDaniel et al., 2014; Pandya, 2020; Schmidt et al., 2001) (Table 2). The studies also took place in different countries: the United States (*n* = 2), Canada (*n* = 2), Australia (*n* = 1), Spain (*n* = 1), Italy (*n* = 1), Poland (*n* = 1), Netherlands (*n* = 1), Malaysia (*n* = 1). One study (Pandya, 2020) took place across multiple countries: India, Singapore, South Africa and Kenya. Furthermore, the studies included in this review span from 1996 (e.g., Andrewes et al., 1996) to 2020 (e.g., Pandya, 2020).

The total sample size was 1,339 participants. However, it is important to note that individual studies varied in their sample sizes, ranging from 25 (Farzin et al., 2018b) to 792 (Pandya, 2020) participants. The mean age of participants was 67.67 years, with ages ranging from 62.09 (Schmidt et al., 2001) to 75.06 years (Mateos et al., 2016). On average, the total sample consisted of more females (66%) than males, with the studies ranging from 49% (Pandya, 2020) females to 84% (Ihle et al., 2018) females.

The reviewed studies had utilized a variety of screening measures to rule out potential cognitive impairments in their samples. The most commonly used screening measure was the Mini Mental State Examination (MMSE; Folstein et al., 1975), which is a widely used screening tool for generic cognitive functions. Typically, the cutoff points are 24/30 to screen for patients with mild cognitive impairment and 18/30 for patients with severe cognitive impairment (Tombaugh & McIntyre, 1992). Of the included studies (*n* = 3) that used the MMSE, however, only one (Villa & Abeles, 2000) had specified the cutoff point of 24/30 as an exclusion criteria. Instead of specifying the cutoff point, Ihle et al. (2018) reported that all participants had scored above 28/30. Other commonly used screening tools were the Telephone Interview for the Cognitive Status (TICS; Brandt et al., 1988) and its variant, the Telephone Interview for the Cognitive Status - Modified (TICS-M; Welsh et al., 1993). The TICS is similar to the MMSE and also is a widely used measure of global mental functions. Among the reviewed studies, Rose et al. (2015) followed Brandt et al.'s (1988) recommendation, with the cutoff point of 31/41 to screen for cognitive impairment. In contrast, the TICS-M includes additional components of delayed recall and verbal comprehension (Welsh et al., 1993). Of the reviewed studies, Troyer (2001) adopted the cutoff point of 30/50, which corresponds to the TICS at the cutoff point 32/41 (Welsh et al., 1993). Surprisingly, only two of the reviewed studies (Andrewes et al., 1996; Villa & Abeles, 2000) had incorporated a screening measure for depression, despite the possibility that affective impairments have been shown to affect PM functioning (Rude et al., 1999).

Prospective Memory Training Characteristics

Table 3. *Prospective Memory Training Characteristics*

Reference	Type of Training	Duration of Training	Number of Sessions	Total Hours of Training	Strategies	Target Processes
Andrewes et al. (1996)	Strategy-based	1 month	1	.5	Internal strategies: Imagery (internal and external cueing), information organization (peg-word system)	None
Cavallini et al. (2003a)	Strategy-based	3 months	5	7.5	External strategies: External aids (diary alarm method) Internal strategies: Imagery, method of loci	None
Farzin et al. (2018b)	Combined	6 weeks	6	12	Internal strategies: Implementation intention	PM (computer simulation)
Ihle et al. (2018)	Strategy-based	4 weeks	8	Not reported	Internal strategies: Imagery, rehearsal (spaced retrieval)	None
Mateos et al. (2016)	Combined	5 weeks	5	10	Educative component Internal strategies: Imagery, rehearsal (spaced retrieval)	Attention Working memory
McDaniel et al. (2014)	Combined	8 months [EG (combined)]	Not reported	Not reported	External strategies: External aids Educative component	Attention Task-switching

Reference	Type of Training	Duration of Training	Number of Sessions	Total Hours of Training	Strategies	Target Processes
		2 months [EG (cognitive training)] 6 months [EG (exercise training)]			Internal strategies: Active monitoring, implementation intention External strategies: Clock monitoring, external aids	General cognitive functions (aerobic exercise)
Pandya (2020)	Process-based	5 years	Not reported	Not reported	None	General cognitive functions (yoga practice)
Rose et al. (2015)	Process-based	1 month	12	12	None	PM (computer simulation)
Schmidt et al. (2001)	Strategy-based	3 weeks	6	6	Internal strategies: Imagery, convert TBPM to EBPM External strategies: External aids Educative component	None
Troyer (2001)	Strategy-based	5 weeks	5	10	Internal strategies: Active monitoring, information organization, rehearsal (spaced retrieval), imagery External strategies: External aids	None
Villa and Abeles (2000)	Strategy-based	Not reported	7	8.75-10.5	Educative component (discussion of mood-related effects on memory)	None

Reference	Type of Training	Duration of Training	Number of Sessions	Total Hours of Training	Strategies	Target Processes
					Internal strategies: Imagery, method of Loci, Preview-Question-Read-Summarize-Test method (PQRST) External strategies: External aids	

Note. EG = experimental group.

Of the reviewed studies, four did not include any control condition (Cavallini et al., 2003a; Ihle et al., 2018; Mateos et al., 2016; Villa & Abeles, 2000). Three studies had employed only a passive control, which did not receive any active training in PM (Farzin et al., 2018b; Pandya, 2020; Troyer, 2001). Two studies employed only an active control (Andrewes et al., 1996; McDaniel et al., 2014). The remaining two studies included both active and passive control groups (Rose et al., 2015; Schmidt et al., 2001).

The reviewed PM training also varied in duration, ranging from three weeks (Schmidt et al., 2001) to five years (Pandya, 2020) (Table 3). The average number of sessions was six, with the number of sessions ranging from one (Andrewes et al., 1996) to 12 (Rose et al., 2015). Likewise, the average number of hours of training was 7.6, from training totals that ranged from 0.5 hours (Andrewes et al., 1996) to 12 hours (Rose et al., 2015). Perhaps surprisingly, nearly half of the studies (*n* = 5) did not describe whether the training was conducted in a group or individual format. Of the remaining studies, five were delivered in a group format and only one in an individual format (Schmidt et al., 2001).

The majority of the PM training studies (*n* = 8) had incorporated forms of homework for participants to do to practice the training strategies or processes. Three studies also included a diary for participants to use to document their learning progress. Four studies also included an educative component in their training that contained factual information about memory and aging. However, nearly half of the studies (*n* = 6) did not focus exclusively on PM — that is, PM was only one component of their memory training program. Overall, there were six reviewed studies of strategy-based training (Andrewes et al., 1996; Cavallini et al., 2003a; Ihle et al., 2018; Schmidt et al., 2001; Troyer, 2001; Villa & Abeles, 2000) and two of process-based training (Pandya, 2020; Rose et al., 2015). The three remaining reviewed studies had adopted a combination of both approaches (Farzin et al., 2018b; Mateos et al., 2016; McDaniel et al., 2014).

Strategy-based Training

The most common internal strategy of the strategy-based training studies was the use of mental imagery (*n* = 7). Participants were often instructed to generate a mental image of performing the intended action (i.e., internal cueing) or the associated events (i.e., external cueing). In turn, that mental imagery was intended to strengthen the action-cue linkage to better detect the PM cue. Another variant of mental imagery employed in the studies was the method of loci ("loci" is the Latin word for places) (*n* = 2). Participants were trained to generate a visuospatial image of a familiar place that contained all of the target objects to be memorized. In addition, two studies utilized the implementation intention, which could strengthen the action-cue linkage by elaborate planning of an intention, usually in the form of "if X (target), then Y (action)." Another approach employed was to organize the PM target information during the encoding phase (*n* = 2), such as the peg-word system (*n* = 2), in which participants were instructed to associate the target information with ordered systems (numbers, alphabets). Two studies used an active monitoring strategy, in which paying close attention was expected to divert additional attentional resources during the PM cue retrieval phase. Apart from the mental imagery technique, three studies incorporated mental rehearsal. Participants were instructed to mentally rehearse the target information for progressively longer intervals, in order to achieve a longer span in the PM cue retention phase.

In terms of external strategies, the majority of the reviewed studies (*n* = 6) encouraged the use of external aids as an external strategy. Participants were often encouraged to use external aids on a TBPM task, such as monitoring a clock (McDaniel et al., 2014) or using the diary-alarm method (Andrewes et al., 1996).

Process-based Training

Various cognitive processes were targeted, such as attention (*n* = 2), working memory (*n* = 1), and task switching (*n* = 1). Two studies targeted generic cognitive functions through aerobic exercise (McDaniel et al., 2014) or yoga practice (Pandya, 2020). Alternatively, two studies directly targeted the PM underlying processes with computer simulations of everyday PM challenges. Regardless of the different targeted cognitive processes, however, all of the reviewed process-based training regimens progressively increased their task difficulty.

Outcome Data and Reporting

The reviewed studies employed a variety of PM measures. The majority of studies (*n* = 6) assessed both EBPM and TBPM performance, and the remaining studies either measured EBPM (*n* = 4) or TBPM *(n* = 1) exclusively. In addition, more than half of the studies (*n* = 6) utilized multiple PM measures. Such measures generally could be grouped into three categories: (1) standardized clinical measures, (2) lab-based measures, and (3) ecological tasks.

Standardized Clinical Measures

The Rivermead Behavioral Test (RBMT; Wilson et al., 1985) was the most used standardized clinical measure in the studies (*n* = 3). The test comprises various subtasks (spatial memory, PM, face recognition, picture recognition, name recall, text recall) to capture everyday memory capabilities. Three RBMT subtasks address EBPM performance: (1) remembering an appointment at the trigger of an alarm, (2) delivering a message somewhere along a route, and (3) asking for a personal belonging at the trigger of a key phrase. Another standardized PM measure is the Prospective Memory Screening Test (PROMS; Sohlberg & Mateer, 1993), which was only used by one study (Villa & Abeles, 2000). The PROMS test captures EBPM and TBPM at multiple time intervals (1 minute, 2 minutes, 10 minutes, 20 minutes and 24 hours). The PM tasks are one-step commands, such as writing a name after two minutes (TBPM) or drawing a square after the cue of an experimenter (EBPM).

Laboratory-based Measures

The most common lab-based PM task used in the studies was the standardized Einstein-McDaniel paradigm (Marsh et al., 1998) (n = 5). To measure EBPM performance, PM cues are embedded in an ongoing task. Participants are then requested to press a specific key whenever the PM cue appears in the middle of an ongoing task. Another variant also was adopted to assess TBPM performance (n = 1). Participants are instructed to indicate the passing of time (e.g., a 2-minute interval) while engaging in an ongoing task. Typically, a clock can be summoned by a key press.

Ecological Tasks

The most common ecological task used in the reviewed studies was the call-back task (n = 4) to measure TBPM performance. In a call-back task, participants are instructed to call the experimenter at or after a specific time, without the use of any external aids. Another call-back task variant was used to assess EBPM (n = 1) by asking participants to memorize a list of appointments for an upcoming week.

More complex ecological tasks were also used in some of the studies to measure EBPM and TBPM simultaneously, such as the Cooking Breakfast task (n = 2; Craik & Bialystok, 2006) and the Virtual Week (n = 2; VW; Foster et al., 2013). The Cooking Breakfast task is a computer simulation of preparing breakfast. Participants are required to cook food while setting up the table. To successfully carry out the task, participants also need to plan for the order of cooking, because different foods require different times to cook thoroughly. In contrast, the VW is a computer board game. Participants move a token around on a board to simulate different times throughout a day when they will encounter regular PM tasks (those that are repeating daily), irregular PM tasks (those that are changing from days), and time-based PM tasks.

Evidence of Prospective Memory Training

The main findings from the studies we reviewed are presented in Table 4.

Table 4. *Studies' Methodological Quality and Findings*

Reference	Outcome Measure(s)	Type of PM Assessed	Control	Main Findings	Note	PEDro (Total: 9)
Andrewes et al. (1996)	Lab-based EBPM task Naturalistic TBPM task	Both	Active (given a pamphlet about memory strategies without instructions)	Lab-based EBPM (EG = CG) Naturalistic TBPM (EG = CG)		6
Cavallini et al. (2003a)	Naturalistic EBPM task	EBPM	None	EPBM (EG ↑*) EBPM [EG (Loci) = EG (strategic)]		4
Farzin et al. (2018b)	Lab-based EBPM task Lab-based TBPM task	Both	Passive	Lab-based EBPM [EG (treatment first) ↑*] Lab-based EBPM [EG (control first) ↑*] Lab-based TBPM [EG (treatment first) ↑*] Lab-based TBPM [EG (control first) ↑*]		9
Ihle et al. (2018)	Lab-based EBPM task	EBPM	None	Lab-based EBPM [EG (imagery) ↑*] Lab-based EBPM [EG (rehearsal) ↑*] Lab-based EBPM [EG (rehearsal) > EG (imagery)*]		5
Mateos et al.	RBMT (PM	EBPM	None	RBMT (PM subtests) [EG (preserved memory)		5

Reference	Outcome Measure(s)	Type of PM Assessed	Control	Main Findings	Note	PEDro (Total: 9)
(2016)	subtests)			↑*]		
McDaniel et al. (2014)	Cooking Breakfast task VW	Both	Active (low intensity exercise and health education)	VW regular tasks [EG (cognitive training) ↑*] VW regular tasks [EG (cognitive training) > EG (exercise training)*] VW irregular tasks [EG (cognitive training) ↑*] VW irregular tasks [EG (cognitive training) > EG (exercise training)*]		8
Pandya (2020)	RBMT (PM subtests)	EBPM	Passive	RMBT (PM subtests) (EG ↑*) RBMT (PM subtests) (EG > CG*)		7
Rose et al. (2015)	VW Naturalistic TBPM task Lab-based EBPM task Cooking Breakfast task	Both	Active (musical training) & passive	VW regular tasks (EG > CG*) VW irregular tasks (EG > CG*) VW time-based tasks (EG > CG*) Naturalistic TBPM task (EG > CG*) Lab-based EBPM task (EG = CG) Cooking Breakfast task (EG = CG)		3

Reference	Outcome Measure(s)	Type of PM Assessed	Control	Main Findings	Note	PEDro (Total: 9)
Schmidt et al. (2001)	Naturalistic TBPM task Lab-based EBPM task	Both	Active (memory education) & passive	PM (EG ↑*) PM (EG > CG*)	Separate analyses on individual assessments did not reach statistical significance	6
Troyer (2001)	Naturalistic TBPM task	TBPM	Passive	Naturalistic TBPM (EG ↑*) Naturalistic TBPM (EG > CG*)		4
Villa and Abeles (2000)	RBMT (PM subtests) PROMS	Both	None	PM [EG (ecological stimuli) ↑*] PM [EG (laboratory stimuli) ↑*] PM [EG (ecological stimuli) > EG (laboratory stimuli)]		5

Note. PM = prospective memory; EBPM = event-based prospective memory; TBPM = time-based prospective memory; PROMS = Prospective Memory Screening Test; RBMT = Rivermead Behavioral Memory Test. EG ↑ = experimental group improved; EG = CG = no differences between experimental and control group; EG > CG = experimental group had larger gains compared with the control group.

Significant results are denoted by *

Strategy-based Training

Among the six reviewed studies of strategy-based training, only one (Andrewes et al., 1996) had adopted an unguided training approach. While utilizing a variety of internal and/or external strategies, the remaining five studies of strategy-based training with guided training have all reported significant training gains.

As the only unguided strategy-based training, Andrewes et al. (1996) compared the effectiveness of a memory handbook training group with an active control group on PM performance. The training group was given a handbook with detailed instructions on the applications of both internal and external strategies. The active control group was given a pamphlet that described the same set of strategies but gave no further instructions on the daily applications of the strategies. However, that study found no between-group differences in either EBPM or TBPM performance.

Schmidt et al. (2001) explored the differences of a PM training with both active and passive control groups. As a guided approach, the memory training included both internal and external strategies. The active control group received memory education training with factual knowledge on memory and aging. Although the training group improved in overall PM performance compared with an active control group and also a passive control group, individual analyses on EBPM and TBPM did not reach statistical significance.

Troyer (2001) compared the effectiveness of a memory intervention with a passive control group. In addition to both internal and external strategies, the memory intervention also incorporated an educative component to dispel common misunderstandings on aging and memory. As a result, the experimental group performed significantly better on TBPM than the passive control group did.

Cavallini et al. (2003a) compared the effectiveness of two specific internal strategies on PM performance. One experimental group was trained with the method of loci, while the other group received training on mental imagery. Although both groups improved in EBPM performance, there were no between-group differences.

Villa and Abeles (2000) compared the use of different types of stimuli (ecological vs. laboratory-generated stimuli) in their PM training. Although there were no significant between-group differences, those who trained with ecological stimuli seemed to experience a larger PM gain.

Ihle et al. (2018) compared two internal strategies that targeted different phases of PM. One experimental group was trained with implementation intention for the PM encoding phase, while the other group received training on the rehearsal technique for the PM retention phase. Although both experimental groups improved in EBPM performance, the experimental group that had received training for the PM retention phase outperformed the group with training for the PM encoding phase.

Process-based Training

Of the two studies of process-based training that targeted different underlying cognitive mechanisms, both have reported some levels of significant training gains.

Rose et al. (2015) compared the effectiveness of computer-based PM training with both an active control group and a passive one. For the training group, all underlying cognitive processes of PM were targeted by using computer simulations of everyday PM tasks. The active control group received training on basic musical concepts including rhythm, pitch, melody and voice. Compared with both of the control groups, the experimental group performed significantly better in EBPM and TBPM performance as measured by VW and the call-back task, but not on a lab-based EBPM task and the Cooking Breakfast task.

Pandya (2020) compared the effectiveness of yoga training with a passive control group on PM performance. After five years of extensive yoga practice, the experimental group performed significantly better on EBPM than the passive control group did.

Combined Training

All three studies of combined training have also reported different degrees of significant training gains.

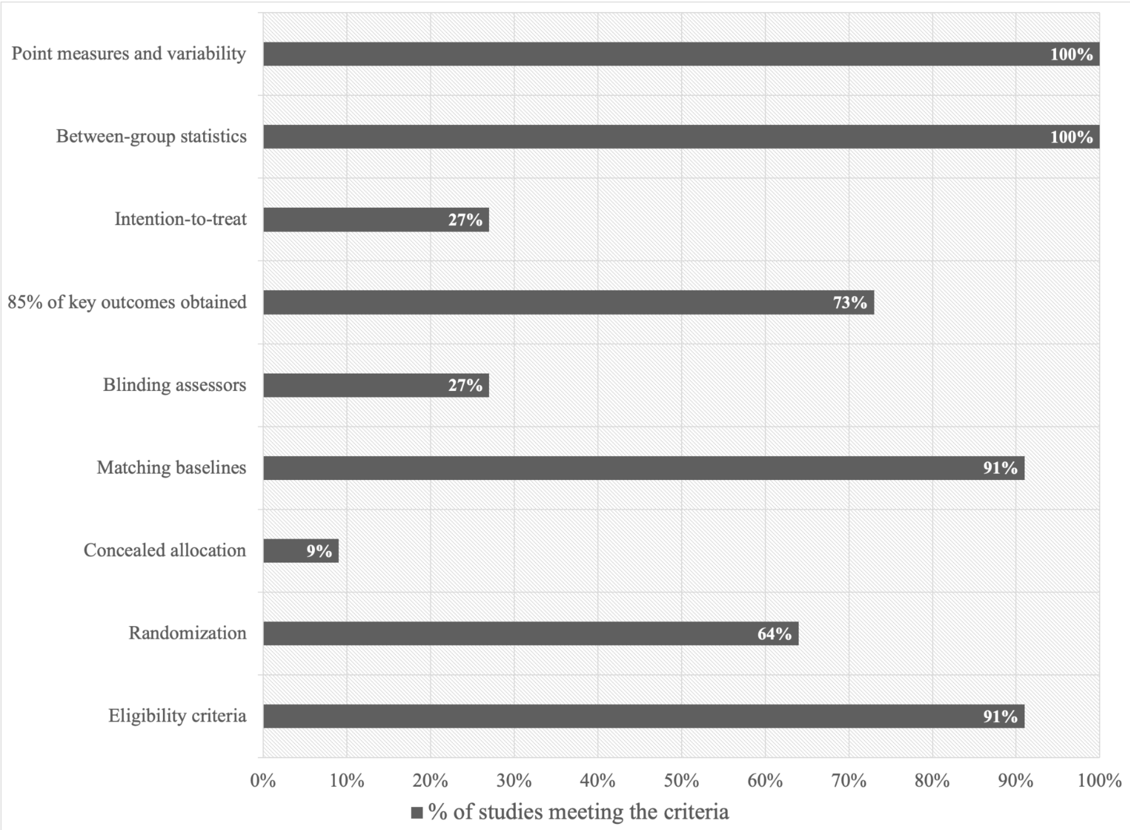
Mateos et al. (2016) compared the effectiveness of a combined training that used both internal and external strategies, as well as attention and working memory training, in older adults with preserved and impaired memory. After the training, the experimental group with preserved memory performed significantly better on EBPM than the group with impaired memory did.

McDaniel et al. (2014) compared the effectiveness of cognitive training and aerobic exercise training on PM performance. The cognitive training incorporated both internal and external strategies with attention and task-switching training. The aerobic exercise training targeted generic cognitive abilities. Overall, the cognitive training group performed significantly better than the aerobic exercise training group did in both VW regular and irregular tasks, but not in VW time-based tasks and the Cooking Breakfast task. No significant improvements were observed for the aerobic exercise training group.

Farzin et al. (2018b) combined an internal strategy approach with the use of computer simulations to train PM in healthy older adults. In a waitlist-controlled trial, both of the experimental groups (the treatment-first group and the control-first group) performed significantly better on both EBPM and TBPM.

Methodological Quality

Figure 2. *Percentage of Studies Meeting the PEDro Scale*



The included studies varied in their methodological quality, as assessed by the PEDro scale (Table 4). The average score for quality was 6/9, with scores ranging from 3/9 (Rose et al., 2015) to 9/9 (Farzin et al., 2018b). As illustrated in Figure 2, the majority of studies had conformed to the standards for reporting between-group statistics (100%), eligibility criteria (91%), baselines between groups (91%), point measures, and variability of PM gains (82%). Relatively fewer studies had randomized their samples (64%) or obtained 85% response rates in at least one key measure (73%). Only 27% of the studies had blinded their outcome assessors or reported using an intention-to-treat analysis. In addition, only one study (9%) reported a concealed allocation of participants. However, it is important to acknowledge that some of the reviewed studies could have incorporated the aforementioned components in their research designs. The ratings were only completed on the basis of what was explicitly reported in the manuscripts.

Discussion

This systematic review sought to synthesize existing evidence of PM training for healthy older adults. In particular, this review identified six studies of strategy-based training and two studies of process-based training. Three other studies utilized a combination of both approaches.

In the reviewed studies that used strategy-based training, both internal and external strategies appeared to promote significant PM gains for older adults. The most common internal strategy was mental imagery, which seeks to promote the distinctiveness of a cue-action pair during the PM encoding phase in EBPM tasks (Potvin et al., 2011). In turn, that mental imagery may encourage a spontaneous retrieval process via the reflective associative memory subsystem, which is largely spared from age-related declines (Cohn et al., 2008; McDaniel & Einstein, 2011). In contrast, the studies' most used external strategy was to encourage the use of external aids for TBPM tasks. Since TBPM tasks are thought to require a larger degree of self-initiated retrieval process (Craik, 1986), external aids are particularly useful to alleviate the attentional resources that would otherwise be spent on time monitoring (Reese & Cherry, 2002).

Interestingly, the majority of reviewed strategies were either targeting the PM encoding phase or the PM retrieval phase. Because PM is a multiphased process, a successful PM cue encoding or retrieval may not guarantee that the intention is being executed. Indeed, Einstein et al. (2000) demonstrated that older adults can fail to maintain an intention for as short a time period as 10 seconds. Similarly, Ihle et al. (2018) suggested a differential PM gain by targeting different PM phases. Specifically, Ihle et al. (2018) found that the rehearsal technique that targets the PM retention phase produced a larger gain than the mental imagery technique that targets the PM encoding phase did. It is therefore important to utilize a variety of strategies that target multiple PM phases simultaneously to ensure better transfers into everyday PM challenges.

In contrast to the strategy-based training, there was no consistent cognitive process to be targeted in process-based training. That may be partly due to the multiphased nature of PM, which requires a host of cognitive functions to successfully carry out a PM task. One intuitive approach was to train all underlying processes by computer simulations of everyday PM tasks –- an approach with which both Rose et al. (2015) and Farzin et al. (2018b) reported varying degrees of success. Rose et al. (2015) reported that PM gains from simulations using VW transferred into naturalistic PM performances. Farzin et al. (2018b) also observed PM gains, in both EBPM and TBPM performance. Because the training approaches were combined, however, the gains were difficult to attribute to the process-based training alone. Considering the preliminary nature of current evidence, this question awaits future studies to further support the effectiveness of this process-based approach.

This review also observed several methodological limitations in the existing PM literature. Despite the relevance of PM in supporting everyday activities, age-related declines of PM among older adults were not sufficiently addressed. Overall, only 11 studies were available, in contrast to another meta-analysis on episodic memory for older adults (Verhaeghen et al., 1992) that identified 67 studies and was produced more than two decades ago. Furthermore, among the scant evidence on PM, nearly half of the included studies had incorporated PM as just one component in a larger memory training program. Because PM wasn't the main focus in these studies, it remains unclear whether there is sufficient coverage of training materials.

It is noteworthy that the findings of these studies were further complicated by substantial heterogeneity in terms of both their research designs and their measurements. The research designs adopted in these studies included quasi-experimental studies (*n* = 2), uncontrolled studies (*n* = 3), a retrospective case-control design (*n* = 1), and randomized controlled studies (*n* = 5). In addition, some studies assessed EBPM exclusively (e.g., Cavallini et al., 2003a), whereas others measured only TBPM (e.g., Troyer, 2001). Altogether, this lack of homogeneity renders their results incompatible for direct comparisons from which to draw conclusions on the effectiveness of various types of PM training for older adults.

Apart from the substantial heterogeneity in measurements, the inherent limitations of some measurements in extant studies are also a matter of concern. Some studies (e.g.,Troyer, 2001) opted for a naturalistic approach to assess PM performances, at the expense of experimental control (Marsh et al., 1998). Although participants were instructed not to use any external aids, participant compliance could still have been an issue. Lab-based paradigms, on the other hand, can lack ecological validity in capturing everyday PM performances (Kliegel et al., 2011). Perhaps more importantly, both approaches have been criticized for their lack of reliability due to the small number of PM items embedded in the tasks (McDaniel & Einstein, 2007). That is also the case in some standardized clinical measures, such as the RBMT, which has only three subtests addressing EBPM (Rendell & Henry, 2009). In turn, more recent methodological advancements, such as VW, could be a viable alternative for capturing the variability of both EBPM and TBPM performances, with demonstrated reliability ranging from 0.84 to 0.94 among nonclinical populations (Rendell & Henry, 2009). Thus, it is important for future studies to adopt more sophisticated approaches, such as VW, to accurately pinpoint their training gains in both EBPM and TBPM performances.

Although the PEDro scale revealed that the reviewed studies were of moderate to high quality, caution should be taken when interpreting their findings. Generally, the included studies had very small sample sizes (82% with $n < 80$), which may risk under-detecting significant training gains. Furthermore, some sophisticated methodological components were often overlooked. Only four of the included studies (36%) had included an active control condition, and that omission may raise concerns about potential overestimates of the training effects. More importantly, critical information about the training protocols was often missing. Nearly half of the studies ($n = 5$) did not specify whether the training was in a group format or an individual one. Similarly, participants' adherence was rarely mentioned in any of the reviewed studies. However, older adults are prone to drop out of studies for a variety of reasons, such as health needs or caregiver roles (Farzin et al., 2018a). The insufficient descriptions of the study protocols will severely hinder future studies in terms of both implementation and replication of their findings. Therefore, to expand the current evidence base of PM training among older adults, future studies should aim for larger-scale randomized controlled trials (RCTs) with greater specificity of their training protocols.

A strength of this review is its focus on PM training, given the relevance of PM on functional independence and successful aging among older adults. As the first attempt to synthesize existing evidence, this review observed methodological concerns for future studies to address. Use of a reliable approach to capture training gains in both EBPM and TBPM performance will be especially important for expanding the current evidence base. Future studies should aim for large-scale RCTs, in an effort to obtain a higher level of evidence. It will also be important to provide sufficient descriptions of the training protocols used, in order to facilitate further implementations and replications of results. At the same time, this review's focus on PM training poses a limitation due to the small number of studies available in the literature. Indeed, the substantial heterogeneity in the scant available evidence precluded this review from drawing direct comparisons of the effectiveness of different types of PM training. In addition, this review did not look into the maintenance of PM gains among older adults over time, due to the surprisingly few studies that had assessed that aspect in their PM training. Nevertheless, the majority of the reviewed studies (64%) were conducted after 2010, which indicates a steady growth in attention addressing PM needs among older adults. With a growing focus on PM training for older adults, perhaps future reviews can address the issue of maintaining treatment gains.

Working from available evidence, mental imagery and the use of external aids can be useful strategy-based approaches to facilitate PM for older adults. Given the multiphased nature of PM, targeting multiple phases may hold significant promise for enhancing transfers from training into everyday PM needs. Due to the limited number of existing studies, however, no definitive conclusions can be drawn currently on the effectiveness of process-based training. Whereas the use of computer simulations may appear to be an intuitive process-based approach, the technique awaits further evidence to support its effectiveness. Although the advantages of both strategy-based and process-based training approaches may make it logical to assume a larger PM gain for combined training (Hering et al., 2014), it is impossible to confirm or reject this notion on the basis of current evidence. Perhaps this unanswered question can be addressed in future reviews, after more PM training has been conducted with process-based or combined approaches.

CHAPTER III: LITERATURE REVIEW

This thesis proposes that mindfulness, as a process-based training, has the potential to facilitate PM in older adults. In this chapter, I will layout the theoretical foundations of this proposal. Before proceeding, it is worth discussing the rationale of using a process-based approach rather than a strategy-based or combined training.

In Chapter II, the systematic review identifies the uses of mental imagery or external aids as potentially useful strategies to improve PM performance in older adults. Meanwhile, it must be cautious that strategy-based training (n = 6) represents the majority of evidence in PM training (n = 11). The interpretability of evidence in process-based (n = 2) or combined training (n = 3) is severely limited due to a small number of available studies.

Strategy-based training has long been criticized for a lack of transferability to everyday PM tasks (McDaniel & Bugg, 2012). This is partly because that most strategies are context dependent. Consider the use of mental imagery as an example, it may work well in EBPM, which promotes the distinctiveness of a PM cue-action pair (Potvin et al., 2011), but it would be relatively useless in TBPM because there is no external cue. Instead, it is more intuitive to use external aids to alleviate the attentional costs in time monitoring (Reese & Cherry, 2002). To accomplish different PM tasks, older adults would require switching back and forth of different strategies, which may post a challenge to them.

A typical strategy often exclusively targets a specific PM phase, which may not be sufficient to facilitate PM remembering. Note that a PM task would undergo four phases: (1) intention formation, (2) intention retention, (3) intention initiation, and (4) intention execution (Kliegel et al., 2002). A failure in each phase would lead to a PM forgetting. For example, the use of mental imagery exclusively targets the intention formation phase. When an intention cannot be immediately retrieved (as is often the case in PM), older adults may fail to maintain the intention for as short as 10 seconds (Einstein et al., 2000). While a strategy-based training can train multiple strategies to target all PM phases, it would be far too complicated for older adults to combine these strategies just to perform a single PM task.

Cognitive resources are also required to perform these strategies, at least to a certain extent. A consistent theme in the literature of PM development in adulthood is that older adults are particularly deficient in PM tasks with a higher level of strategic demand (for meta-analytical reviews, see Henry et al., 2004; Kliegel et al., 2008; Uttl, 2008). According to the Process Resource Framework (Craik, 1986), a PM aging decline is likely the result of having less cognitive resources to perform a self-initiated, strategic memory task. With an aging decline in cognitive resources (Kirasic et al., 1996), they may lack the required cognitive resources to perform these strategies, especially when attention is being divided in a daily context.

Another intuitive approach could be combined training, which utilizes both strategy-based and process-based training approaches to maximize PM gains (Hering et al., 2014). However, this would lead to packed training sessions with fewer opportunities to master a particular strategy or cognitive process (Jones et al., 2021). A recent meta-analysis in 73 studies of PM training (for both healthy and clinical populations) reported that training gains in combined PM training ($g = 0.25$) were smaller than strategy-based ($g = 0.45$) and process-based training ($g = 0.54$) (Jones et al., 2021). Therefore, combining different training approaches do not always translate to better outcomes, at least the context of PM.

Alternatively, a process-based PM training encourages transferability by targeting its underlying cognitive mechanisms (Hering et al., 2014). Because a process-based training exempts older adults from performing strategies, it allows the preservation of cognitive resources for them to perform the PM task. By far, the criticisms of process-based PM training have been centered on its weak evidence base due to a lack of available studies (e.g., Craik & Rose, 2012). Nonetheless, there are preliminary evidence suggesting the potential of process-based PM training to attenuate a PM aging decline. Rose et al. (2015) reported significant gains in EBPM and TBPM utilizing computer simulations to directly train all cognitive processes involved in PM. Pandya (2020) also observed improvements in EBPM after yoga practices to target more generic cognitive functions.

A potential target in process-based PM training could be attentional control. A common theme in theoretical frameworks of retrieval in different PM types suggests that a successful PM requires some levels of attentional control. In EBPM, the PAM Theory (Smith, 2003; Smith & Bayen, 2004) suggests that attentional control is deployed in encoding a PM cue-action pair, prioritizing competing tasks, monitoring a PM cue, performing a retrospective recognition check, and executing a PM task. While the Multi-Process Framework (McDaniel & Einstein, 2000) posits that focal EBPM can be retrieved by spontaneous retrieval, which alleviates the need to monitor the PM cue, attentional resources are still deployed after cue-detection, particularly in performing a retrospective recognition check and task switching (Scullin et al., 2010). The TWTE Model (Harris & Wilkins, 1982) offers an account of transient monitoring in TBPM, which implies that some levels of attentional control are required to perform the clock checks, especially that the numbers of clock check will increase as the PM target is approaching. At the same time, an age-related decline in PM may imply for an inefficient attentional control (Craik, 1986). Therefore, improving attentional control in older adults could be the key to facilitate PM. Because of a close theoretical association between mindfulness and attentional control, as I will further elaborate in the following sections, I proposed utilizing mindfulness as a process-based training for older adults. This may also further contribute to an overall weak evidence based in process-based PM training.

Mindfulness and Cognitive Functions

Mindfulness refers to a unique state of awareness about the present-moment experience without holding any judgments (Kabat-Zinn, 2003). It is typically achieved by practicing mindfulness meditations. The concept of mindfulness has been popularized by standardized treatments such as Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982) and Mindfulness-Based Cognitive Therapy (MBCT; Teasdale et al., 2000). Mindfulness-based interventions (MBI) can alleviate symptoms in a variety of clinical conditions such as chronic pain (Rosenzweig et al., 2010), cancers (Carlson et al., 2003), mood disorders (Greenberg et al., 2017), and substance abuse disorders (Bowen et al., 2006). There are also extended applications of MBIs to reduce stress in non-clinical settings such as workplace (Aikens et al., 2014) and educational settings (Schonert-Reichl et al., 2015; Shapiro et al., 2008).

Mindfulness meditation is often conceptualized as a form of cognitive exercise that is triggered and coordinated by cognitive processes including executive functions and attentional control (Holas & Jankowski, 2013). Therefore, there is a burgeoning interest to explore its salutary effects on cognitive functions. Chiesa et al. (2011), in a systematic review in 23 studies of MBIs, concluded that mindfulness can improve attentional control, particularly in selective, sustained, and executive attention, as well as WM and executive functions such as verbal fluency. Another meta-analysis in 34 studies reported that even a brief, one time mindfulness induction can produce improvements in cognitive functions (g = 0.18) (Gill et al., 2020).

The salutary effects of mindfulness on cognitive functions have led to the proposals of using mindfulness as a process-based approach in attenuating cognitive declines in older adults (see Malinowski & Shalamanova, 2017; Prakash et al., 2014 for reviews). Thus far, there are promising preliminary evidence in this regard. In an RCT, Moynihan et al. (2013)

evaluated whether mindfulness can enhance cognitive functions in older adults (>60 years old). The training group received a standardized MBSR in eight weekly sessions and an all-day intensive retreat. They utilized the Trail Making Test (TMT) to measure executive control, i.e., to draw a line alternating between number and letters in an ascending order. Comparing to a waitlist control group, the training group performed significantly better in the TMT following MBSR ($d = -0.24$). Whitfield et al. (2022), in a meta-analysis in 45 RCTs, also reported that MBIs can improve an overall cognitive function ($g = 0.23$). Their subgroup analysis revealed a larger effect of MBIs on executive functions in older adults ($g = 0.27$).

Mindfulness as Prospective Memory Training

With saturating evidence about the cognitive benefits of mindfulness, more research has begun to explore the mechanisms of how it improves cognitive function (Lindsay & Creswell, 2017). Lutz et al. (2008) proposed two important styles of meditative practice: focused attention (FA) and open monitoring (OM). While both FA and OM share common features, such as an emphasis on a non-judgmental attitude, the two practices are fundamentally different in its style of attentional control. For example, FA sustains attentional control toward an anchor object (typically the sensations of breathing), maintains self-awareness when the mind wanders, and directs attention back to the anchor object in a non-judgmental manner. On the contrary, OM does not involve a focus of attention but maintains self-monitoring of all open experience non-judgmentally. Although MBIs (e.g., MBSR) involve both FA and OM practices (Kabat-Zinn, 1982), such a classification could advance research to explore the specific effects of FA and OM and further our understanding about its mechanisms of change.

Effects of Focused Attention on Prospective Memory

Parallel to mindfulness, attention is not a unidimensional construct. A seminal model of attention proposes three distinct attentional networks: (1) alerting, (2) orienting, and (3) executive attention (Posner & Petersen, 1990). The alerting network, or sustained attention, describes a stable state of alertness toward external stimuli. The orienting network directs attentional resources to an anticipated or salient stimulus, which results in selective attention. The executive attention network, or simply executive attention, monitors and resolves conflicts between competing stimuli.

These attentional networks should heavily involve in FA. In a mindful breathing exercise, the orienting network (selective attention) directs a top-down attentional control toward the sensations of breathing. Then, the alerting network (sustained attention) maintains a stable state of alertness toward these sensations of breathing. When a distractor arises, the executive attention network (executive attention) resolves conflicts between the distractor and sensations of breathing, which guides our attention back to the present moment.

The cyclical process of attentional control in FA also repeatedly activates its associated brain regions, which may strengthen its neural connectivity (Tang et al., 2015). Neuroimaging studies suggested a similar brain activation pattern between FA and attentional control. Fox et al. (2016), in a meta-analysis in 76 neuroimaging studies of MBIs, found that FA is associated with increase activations in the premotor cortex, dorsal anterior cingulate cortex (dACC), and dorsolateral prefrontal cortex (dlPFC). First, the premotor cortex is involved in visual selective attention (Rushworth et al., 2003). Second, the dACC and dlPFC play an important role in executive attention (Kondo et al., 2004). Third, the dlPFC is also involved in the control of sustained attention (Sarter et al., 2001). Besides, FA is associated with deactivations of the ventral posterior cingulate cortex (vPCC) and left inferior parietal lobule (Fox et al., 2016). These areas form an integral part of the default mode network, which is responsible for mind wandering, i.e., spontaneous thoughts of past and future events (Tomasino & Fabbro, 2016). Deactivations in these regions would implicate efforts to suppress mind wandering. Therefore, FA should enhance the efficiency of top-down attentional control.

Attentional Control in Prospective Memory

Attentional control is essential to carry out a PM task. Taken from an earlier example, you planned to replenish groceries when passing by a specific store. Whilst you are texting your friends in the commute, attentional resources are devoted to an external environment. Otherwise, one may fail to notice the store. Beyond detecting the store, attentional control functions to disengage from texting your friend so that the PM intention is executed. Indeed, theoretical frameworks of PM retrieval have acknowledged an importance of attentional control in successful PM executions.

Behavioral studies have shown consistent results regarding the importance of attentional control in PM. When adding a PM command to an OT, Smith (2003, Experiment I) observed that it took 300 ms longer to response, suggesting that limited resources are competing between the two tasks. Marsh et al. (2002, Experiment I, II) also found that increasing the attentional load in an OT disrupted PM performance. In their study, participants either made a single lexical judgment (low attentional load) or alternated between two rules of lexical judgment (high attentional load). The PM command was to press an additional button whenever an animal word appeared. As expected, participants performed poorer (with longer RTs) under the high attentional load condition. Perhaps more importantly, insufficient attentional resources could result in a PM failure.

Neurological data have also illustrated the importance of attentional control in PM. For example, PM consistently activates the anterior PFC (Brodmann's area 10; BA10) (e.g., Burgess et al., 2011; Okuda et al., 1998; Reynolds et al., 2009; Simons et al., 2006). According to the Gateway Hypothesis (Burgess et al., 2007), the BA10 modulates attentional resources between a mental representation of a PM intention and external perceptual processing. The Attention to Delayed Model (Cona et al., 2015) also highlights the importance of attentional control in multiple PM phases (encoding, maintenance, and retrieval). At encoding, the ventral parietal cortex mediates a bottom-up capture of attention of a PM cue. In the maintenance phase, the BA10 modulates attentional resources as described in the Gateway Hypothesis. At retrieval, ACC and BA10 coordinate to resolve attentional conflicts between an OT and the PM intention. Then, PCC and ventral frontoparietal regions direct attentional resources to initiate a retrospective recognition check. These findings have formed compelling evidence about the involvement of brain regions responsible for attentional control when carrying out a PM task.

Development of Attentional Control in Adulthood

It is evident that attentional control is subjected to an age-related decline. An aging brain is typically less efficient in brain regions associated with attentional control. There is a weaker functional connectivity between the parietal attentional network and PFC in older adults (e.g., Bollinger et al., 2011; Madden et al., 2010). Less activations in the right dlPFC were observed, suggesting an age-related decline in sustained attention (Dennis et al., 2007). There is also a weaker connectivity in the default mode network (to suppress task-unrelated thoughts) in an aging brain, particularly when performing a cognitively demanding task (Grady et al., 2016; Lustig et al., 2003; Persson et al., 2007).

Behavioral data suggest a similar pattern of aging decline in sustained, selective and executive attention. Parasuraman and Giambra (1991) reported an aging decline in sustained attention by comparing between three age groups: young (19-27 years old), middle-aged (40-55 years old), and older adults (70-80 years old). Sustained attention was measured by a 30-minute vigilance task, where participants withheld their responses to the nontargets while responding to the targets. Compared to young and middle-aged adults, older adults exhibited a poorer sustained attention, with lower hit rates to the targets and higher false alarm rates to the nontargets.

Madden and Langley (2003, Experiment III) observed a poorer visual selective attention in older adults (60-80 years old) compared to young adults (18-29 years old). In a visual search task, participants responded to the target letter in a circle while ignoring the nontarget letters that were also placed within the circle. There were additional distractor letters outside the circle. As expected, older adults performed poorer in visual selective attention with higher error rates and longer RTs.

Hogan et al. (2006) also found an aging decline in executive attention. Young (M_{age} = 22.06) and older adults (M_{age} = 70.55) performed a lexical judgment task to either: decide the color of a stimulus, judge the semantic category of a stimulus, or decide the color of a stimulus and memorize the word for later recall. These judgments were alternating based on the display location of a stimulus. Then, participants performed a recognition task to decide whether a stimulus has been shown in the lexical judgment task. Not only older adults have recalled fewer words, but they were also more adversely impacted by attention switching (with higher error rates and longer RTs).

Evidence of Focused Attention in Training Attentional Control

There are promising evidence suggesting the potentials of FA to improve top-down attentional control. Wenk-Sormaz (2005, Experiment I) found that a brief 20-minute FA induction improved selective and executive attention in undergraduates (M_{age} = 19.47). Participants were randomized into either: a FA induction group, an active control group (i.e., to learn a mnemonic), or a passive control group. Afterward, participants performed to Stroop task (Stroop, 1935), a measure of selective and executive attention (Josefsson & Broberg, 2011; Wright, 2017). In this task, participants indicated the display color of a color word regardless of its semantic meaning. This resulted in congruent (i.e., color word and displaying color were matched, e.g., blue printed in blue) and incongruent trials (i.e., the display color did not match with the color word, e.g., blue printed in red). As a performance indicator, an interference ratio is typically calculated by subtracting the performance of congruent trials (as baselines of semantic processing) from incongruent trials. Comparing to both control groups, the FA induction group exhibited fewer Stroop interference, indicating that FA resulted in better selective and executive attention.

Ainsworth et al. (2013) found that FA resulted in better executive attention in young adults (M_{age} = 20.30). Participants were randomized into either: a FA group, an OM group, or a passive control group. Over the course of eight days, there were three hourly training sessions of FA or OM with home practices. At pre- and post-training, participants performed the Attentional Network Test (ANT; Fan et al., 2002), which measures the efficiency of three attentional networks in Posner and Petersen's (1990) model. In the ANT, participants indicated the direction of a central arrow (left or right) surrounded by flankers, which can be either in the same direction (congruent trial), opposite direction (incongruent trial), or as straight lines (neutral trial). Preceding each trial, different cues would appear to provide information about an impending stimulus. Center and double cues provide temporal information about the impending stimulus. Spatial cue not only alerts the impending stimulus, but also provides spatial information on where it will appear (above or below the central fixation). There is also a no cue condition, of which participants receive no information about the impending stimulus. Three performance indicators corresponding to the efficiency of each attentional network can obtained by: (1) $Alterting = Double\ Cue - No\ Cue$, (2) $Orienting = Spatial\ Cue - Center\ Cue$, and (3) $Executive\ Attention = Congruent\ Trial - Incongruent\ Trial$. Comparing to the passive control group, the FA and OM groups performed better in the executive attention network.

However, Wenk-Sormaz (2005) and Ainsworth et al. (2013) exclusively recruited young adults. It is difficult to generalize these findings into an older population. Only until recently, Polsinelli et al. (2020) demonstrated that a brief online FA training resulted in better attentional control in older adults (M_{age} = 75.70). Participants were randomized into either a FA group or a mind wandering control group. As a control group, mind wandering was employed to reduce treatment expectancy, which promotes relaxation and creativity without any guidance in attentional control. At pre- and post- training, participants performed an attentional blink (AB; Shapiro et al., 1997) task. Attentional blink refers to a phenomenon where an attentional lapse happened in detecting two target stimuli among distractors in close temporal proximity (< 500 ms). In the AB task, participants reported two target digits among 13-17 letters presented sequentially. After the training, there was an improvement in AB task accuracy (d = 0.70) specific to the FA group, offering preliminary evidence of FA as a process-based training that can facilitate attentional control in older adults.

Effects of Open Monitoring on Prospective Memory

In contrast to FA that enhances a top-down attentional control, OM should reduce emotional interference, which allows more cognitive resources when performing daily PM tasks. In daily contexts, emotional stimuli capture our attention and receive priority in its processing (Öhman et al., 2001). With limited cognitive resources, emotional interference occurs when there is a conflict between emotional information and goal-directing behaviors, resulting in a momentary disruption of task performance (Kalanthroff et al., 2013). For example, the presence of negative emotional stimuli can lead to poorer accuracy in a delayed WM response task (Dolcos & McCarthy, 2006). According to the Resource Allocation Model (Ellis & Ashbrook, 1988), mood states can interfere with an allocation of cognitive resources. In particular, intense mood states would lead to an increase of task-irrelevant or intrusive thoughts that consumes cognitive resources. As predicted by this model, emotional interference is particularly pronounced in cognitive tasks where a higher degree of controlled processing is required, such as PM.

Studying the effects of emotional interference in a cognitive task can serve as an indirect performance indicator of emotion regulation (ER). Emotion regulation refers to processes that modulate subjective experiences and behavioral expressions of emotion (Gross, 1998b). Individuals with better ER are less susceptible to emotional interference, which allows them to focus on their cognitive goals (Zhang et al., 2022). The Process Model of ER (Gross, 1998a) further classified ER strategies into antecedent- or response-focused. Antecedent-focused strategies manipulate the input of an emotion generative system before generating an emotion. An example would be cognitive reappraisal. Cognitive reappraisal involves reinterpreting an emotional experience, such that its associated impact is modified, which is often considered as an adaptive ER strategy (Gross, 1998a; Richards & Gross, 2000). On the contrary, response-focused strategies alter the output of the emotion generative system after an emotion is occurred, such as expressive suppression. Expressive suppression involves an inhibition of emotional expression, which is often recognized as a maladaptive ER strategy (Gross & John, 2003; Gross & Levenson, 1997).

There have been proposals of ER as a key psychological mechanism in mindfulness (Khoury et al., 2013). Chambers et al. (2009) conceptualized mindfulness as a variant of cognitive reappraisal. Specifically, OM involves self-monitoring of internal experience (including emotions) in a non-judgmental attitude, which transforms our affective experience. By practicing self-monitoring, OM fosters an emotional awareness, which is a prerequisite of performing adaptive ER (Erisman & Roemer, 2010; Gratz & Roemer, 2004). This allows timely engagement of ER before any intense emotion expressions occur (Teper et al., 2013). Adopting a non-judgmental attitude also facilitates the engagement and disengagement of emotional stimuli and in turn lessening the impact of a negative emotion (Lindsay & Creswell, 2019).

Neurological data have shown similar brain activations between OM and performing ER. In a fMRI study, Lutz et al. (2014) explored a pattern of brain activations associated with OM. Participants (M_{age} = 29.98) were scanned while performing an emotional expectation task, where emotional stimuli were either pre-cued by its valence (positive, neutral, or negative) or masked from its valence. In the experimental group, participants engaged in OM while performing the task. On the other hand, the control group performed the task without engaging in OM. When participants anticipated negative stimuli or stimuli of unknown valence, OM increased activations in the dlPFC and anterior insula. Notably, the dlPFC involves in cognitive controlled processes that coordinate ER (Miller & Cohen, 2001; Ochsner & Gross, 2005), while the anterior insula supports an emotional awareness (Craig, 2009). Upon encountering negative stimuli, OM decreased activations in the posterior insula and amygdala, with both regions responsible for an emotional arousal (Lewis et al., 2007; Morrison & Salzman, 2010). This pattern of brain activations suggests that OM facilitates a timely initiation of cognitive controlled processes to lessen an emotional arousal resulting from a negative emotion.

Emotional Interference in Prospective Memory

Consistent with the Resource Allocation model (Ellis & Ashbrook, 1988), disrupted PM performance was observed in clinically depressed adults (Altgassen et al., 2009; Rude et al., 1999). This model is further substantiated by experimental studies utilizing a mood induction paradigm to explore PM performance under an emotional context. Kliegel et al. (2005) found that a negative mood impaired TBPM. Participants (M_{age} = 25.07) first watched film segments to induce a neutral or negative mood. After the mood induction procedures, participants performed a TBPM task using a two-back version of the n-back task as an OT.

The PM command was to press a key at 1-minute intervals, where they could access a clock for time monitoring. They observed a poorer performance in TBPM after a negative mood induction, primarily due to fewer clock checks, perhaps suggesting that fewer cognitive resources were available to perform clock checks under the influence of a negative mood.

Ballhausen et al. (2015, Experiment II) also reported that positive and negative mood impaired EBPM in older adults (M_{age} = 69.30). Participants performed an EBPM task embedded in a category association task, i.e., deciding whether a word matches with a given category. The PM command was to press a key whenever an animal word appeared. To manipulate mood, they embedded positive (e.g., puppy), neutral (e.g., hen), or negative (e.g., maggot) examples in the task instructions. They found that positive and negative mood impaired EBPM, indicating the mood effects interfere with PM encoding.

Natural mood fluctuations can also affect PM. Pupillo et al. (2022) found that a naturally occurring negative mood impaired EBPM and TBPM. Using experience sampling, young (M_{age} = 21.61) and older adults (M_{age} = 67.22) were sampled on their mood states by SMS notifications nine times per day over a week. To measure PM, they utilized two ecological PM tasks (EBPM and TBPM). In ecological EBPM, participants replied with a specific word after they saw any word written in uppercase in any of the SMS notifications. In ecological TBPM, participants sent an SMS with a specific word at predefined times. Critically, both young and older adults were less likely to execute EBPM and TBPM commands under a negative mood change.

Development of Emotion Regulation in Adulthood

In contrast to an aging decline in cognitive functions, there is generally an enhanced emotional wellbeing in older adults (for a review, see Charles & Carstensen, 2010). Less and shorter durations of negative affectivity were observed in older adults (Carstensen et al., 2000). Based on the Socioemotional Selectivity Theory (Carstensen, 2006), human motivations are driven by time perspectives. As young adults perceive time as expansive, they value novelty, which motivates them to expand their horizons. Because time is finite for older adults, they value emotional meaning. Therefore, older adults tend to monitor and optimize their emotional functioning. Evidently, a positivity effect is typically observed in older adults, where they preferentially recall more positive aspects of past events and avoid situations that may elicit a negative emotion (Kennedy et al., 2004; Wolfe et al., 2022).

A closer examination of the literature in emotional development across adulthood reveals a differential pattern between young and older adults in the utilization of ER strategies. In a cross-sectional study, Brummer et al. (2014) observed that older adults generally favored the uses of expressive suppression over cognitive reappraisal. Interestingly, while expressive suppression is often considered a maladaptive ER strategy (Gross & Levenson, 1997; Harris, 2001), they did not report an association between the use of expressive suppression and psychological distress. In an experimental study, Scheibe et al. (2015) further observed a preference in older adults in using distraction (i.e., directing attention away from emotional stimuli to unrelated thoughts) over cognitive reappraisal after exposures to negative stimuli. Again, the preference of using distraction over cognitive reappraisal predicted a higher level of emotional wellbeing in older adults.

While older adults are more effective in ER and exhibited less psychological costs in engaging maladaptive ER strategies, the choices of ER strategies in older adults may rather reflect a decline in cognitive resources. For example, the use of distraction as an ER strategy is thought to be cognitively less effortful than cognitive reappraisal (Urry & Gross, 2010). When older adults were instructed to use cognitive reappraisal, they were less effective in reducing unpleasant emotions compared to young adults, with decreased activations in the ventrolateral and dlPFC, which play an important role in top-down ER processes (Opitz et al., 2012).

These findings illustrated an importance of cognitive control for older adults to perform top-down ER processes. Evidently, the positivity effect was no longer observed in older adults with low executive functions or when performing a cognitively challenging task (Mather & Knight, 2005). Due to an aging decline in controlled processing, older adults may recruit more cognitive resources to perform ER. For example, an increase in activations of the PFC is generally observed in older adults to dampen emotional arousal in the amygdala (e.g., St Jacques et al., 2009; Urry et al., 2006). Therefore, older adults are still susceptible to emotional interference, especially when cognitive resources are being divided. Phillips et al. (2002), for example, compared the magnitude of emotional interference on planning between young and older adults. They utilized film segments to induce positive, neutral, or negative mood. After the mood induction procedures, participants performed the Tower of London task (ToL; Shallice, 1982), where participants moved discs one at a time to transform a starting arrangement into a desired arrangement. Performance of the ToL is indexed by the number of trials required to achieve a desired arrangement. In particular, older adults performed worse under the positive and negative mood conditions, but no differences were found in the neutral condition. This suggests that older adults have devoted more cognitive resources to perform ER and therefore being left with fewer resources to perform the ToL.

Evidence of Open Monitoring in Reducing Emotional Interference

Given that OM promotes non-judgmental awareness and emotional acceptance, it generally results in a more adaptive form of ER (Brown et al., 2013; Creswell et al., 2007), which require less cognitive resources than other ER strategies. Keng et al. (2013) compared the cognitive costs associated with mindfulness and cognitive reappraisal in the reduction of negative emotions. While mindfulness and cognitive reappraisal both resulted in less unpleasant emotions after a negative mood induction, those who utilized mindfulness had exhibited less interference in a Stroop task, suggesting mindfulness incurs less cognitive resources than cognitive reappraisal. Therefore, OM should facilitate cognitive performance, especially under an emotional context. However, there is a lack of studies exploring whether OM can reduce emotional interference when performing a cognitive task. Thus far, indirect evidence can be found in studies exploring the cognitive effects of mindfulness in an emotional context.

Ortner et al. (2007, Experiment II) found that mindfulness reduced emotional interference in a cognitive task. Participants (M_{age} = 23) were randomized into either: a mindfulness group, a relaxation group, or a waitlist control group. In the mindfulness group, participants were trained in FA and OM in seven weekly 1.5-hour sessions. In the relaxation group, participants practiced exercises such as progressive muscle relaxation and body scans. At pre- and post-training, participants completed the Emotional Interference Task (Buodo et al., 2002), where they viewed images of either positive, neutral, or negative valence. Afterward, they heard a high- or low-pitched tone at either 1 s or 4 s stimulus onset asynchrony (SOA). Then, participants indicated the tone pitch (high vs. low). Emotional interference is indicated by a latency in RT data using the neutral valence as baselines. Initially, all participants were interfered by the negative valence at 1 s SOA. However, only the mindfulness group displayed a reduced interference at 4 s SOA, indicating that it can facilitate a disengagement of negative stimuli.

Jankowski and Holas (2020) observed that mindfulness enhanced processing speed under a state of anxiety. Participants (M_{age} = 22.25) first viewed a film segment to induce state anxiety. Then, they were randomized into either: a mindfulness group, a worry group, or (3) a mind wandering group. In the mindfulness group, participants were trained in FA and OM in a single 10-minute session. In the worry group, participants self-reflected on questions such as their emotional reactions to the film, how others might judge about their reactions, and how they would feel if the film was real. In the mind wandering group, participants freely engaged in mind wandering and daydreaming. Next, participants performed a task-cueing paradigm (Monsell, 2003), which measures attention switching. Participants first completed an experimental block of making lexical judgments (i.e., to decide whether a word is a plant). After the first experimental block, participants performed another block to decide whether the display color of a word is red. Using these two blocks as baselines (with no switching costs involved), participants alternated between the two rules. Latencies in RT data were analyzed to indicate switch costs. While there were no group differences in switch costs, the mindfulness group displayed shorter RTs, suggesting that mindfulness allows more cognitive resources for faster processing speed, especially under the influence of state anxiety.

However, there are several limitations in these studies that require cautious interpretation. Despite mindfulness appears to facilitate ER by reducing emotional interference, it remains unclear whether OM alone can produce a similar effect. Moreover, these studies sampled exclusively on young adults. Because older adults required more cognitive resources to perform ER, it is unclear whether these positive findings can translate into an older population.

Limitations of Existing Literature

While there is a strong theoretical association between mindfulness and PM, only one study has explored such an association. Girardeau et al. (2020) investigated whether FA can enhance PM in young adults (18-30 years old). Participants were randomized into either a FA group or a mind wandering group. They utilized virtual reality to measure PM, where participants navigated in an urban environment. In an encoding phase, participants memorized 15 PM cue-action pairs, with three PM cue types: focal EBPM (e.g., buy crosswords at the kiosk), non-focal EBPM (e.g., eat an ice-cream in front of the church), and TBPM (e.g., phone a friend after 1 minute). After the encoding phase, participants received a

15-minute induction of FA or mind wandering. Then, participants retrieved the encoded PM cue-action pairs through their navigation in virtual reality. However, they did not observe any group differences between FA and mind wandering on any of the PM cue types.

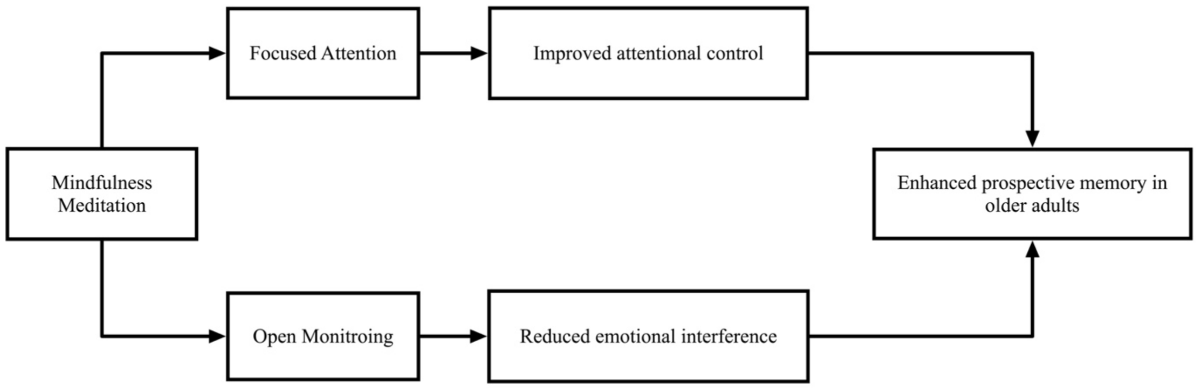
Since the induction of FA in Girardeau et al. (2020) is followed by a PM retrieval phase, its effect on the PM encoding phase remains unclear. An enhanced attentional control resulting from FA could be more pronounced at PM encoding, at least for older adults. Compared to young adults, older adults are more susceptible to distractors in the encoding phase than the retrieval phase (Park et al., 1989). At the same time, a recent RCT demonstrated that FA improved AB accuracy in older adults (Polsinelli et al., 2020). Therefore, FA could be a useful process-based approach to facilitate PM in older adults through enhancing an efficiency of attentional control.

Another important question also remains unanswered in Girardeau et al. (2020), which concerns the effects of OM on PM. Due to an aging decline in cognitive resources, older adults may recruit more resources to regulate their emotions. Phillips et al. (2002) found that older adults were more impaired than younger adults in planning after a positive or negative mood induction. When under the influence of intense emotions, older adults may prioritize ER, which leaves them with fewer resources with which to perform PM tasks. Given that everyday PM tasks rarely occur in an emotionally neutral context, OM, which requires relatively less cognitive resources in reducing emotional interference, should facilitate PM performance.

Research Questions

Considering the distinct features in styles of attentional control between FA and OM, I hypothesized that they would exert different effects on PM (see Figure 3).

Figure 3. *Hypothesized Effects of Focused Attention and Open Monitoring on Prospective Memory*



In FA, top-down attentional processes are emphasized, such as directing attention to a specific anchor object and resolving attentional conflicts when a distractor arises. The cyclical process of a FA practice activates its associated network and therefore increasing an efficiency of attentional control (Tang et al., 2015). At the same time, theoretical frameworks in PM suggest an important role of attentional control in successful PM retrieval (see Chapter I). Further, a PM aging decline is likely the result of a decline in attentional resources among older adults (Craik, 1986). Because top-down attentional processes are required in all PM tasks, FA should primarily facilitate PM in older adults through a more efficient attentional control.

In contrast, OM involves self-monitoring of emotional experience using a non-judgmental attitude. Since OM entails a bottom-up attentional style, it should not improve top-down attentional control. Instead, it promotes an emotional acceptance and facilitates a more adaptive form of ER. According to the Resource Allocation Model (Ellis & Ashbrook, 1988), intense mood states consume cognitive resources and disrupt PM performance. While emotional wellbeing is enhanced in older adults, they are still susceptible to emotional interference, particularly when cognitive resources are being divided. Given that mindfulness requires less cognitive resources than other ER strategies, e.g., cognitive reappraisal (Keng et al., 2013), OM should facilitate PM by reducing emotional interference while preserving cognitive resources to process a PM task that would otherwise be occupied by day-to-day mood fluctuations.

Collectively, this thesis evaluates mindfulness as a process-based training to facilitate PM in older adults. To shed light on how mindfulness facilitates PM, the hypothesized effects of FA and OM on PM were explored in Experiment I and II, respectively. Experiment I evaluates whether FA can facilitate PM in older adults, and an improvement in PM is mediated by a more efficient attentional control. Experiment II investigates whether OM can facilitate PM in older adults under the influence of a negative mood.

CHAPTER IV: EXPERIMENT I

Methods

This thesis was ethically reviewed and approved by the Institutional Review Board at the Hong Kong Polytechnic University (Reference no.: HSEARS20210714006). Prior to data collection, a power analysis was performed using G*Power 3.1 (Faul et al., 2009). Considering the null findings in Girardeau et al. (2020), the only study that explored the effects of mindfulness on PM, I obtained relevant effect sizes in the literature related to the effects of mindfulness on episodic memory. These studies typically reported effect sizes ranging from medium to large (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 80% at $p = 0.05$, which resulted in a target sample size of 102. Conservatively, I aimed to recruit 120 participants. Data collection took place from August 2021 to December 2021.

Participants

The total sample size was 127. The inclusion criteria were Chinese older adults living in Hong Kong (aged from 60 to 75 years) without any cognitive or affective impairments. One participant was excluded from this experiment for scoring below the cut-off of a screening measure of cognitive impairments. All participants provided written consents before taking part in the experiment.

Participants were recruited through convenience and snowball sampling. Mass advertisements were targeted to members of the Institute of Active Aging (IAA) at the Hong Kong Polytechnic University. Those who took part in the experiment were also asked to refer their friends and relatives. Upon completion of the experiment, all participants received a voucher worth HKD $100 from a local chain supermarket.

Materials

Screening Assessments

The Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) was used to screen for cognitive impairments. It is a brief 10-minute tool that assesses various cognitive subdomains including: (1) visuospatial executive functions (e.g., drawing a clock), (2) naming (e.g., naming an animal), (3) verbal memory (e.g., learning an unstructured list), (4) attention (e.g., a forward digit span), (5) language (e.g., a sentence repetition), (6) abstraction (e.g., explaining commonality between two items of the same category), (7) delayed recall (e.g., recalling the unstructured list), and (8) orientation (e.g., stating the current location). The MoCA yields a total score of 30 with a higher score indicating a better cognitive function. Following the procedures in Nasreddine et al. (2005), an additional point is added to the total score if a person has received 12 years of education or less. Nasreddine et al. (2005) reported an internal consistency of 0.83 and a test-reliability of 0.92. The Hong Kong version of MoCA (MoCA-HK; Yeung et al., 2014) measures the exact same cognitive constructs. Using the cut-off of 22, the MoCA-HK had 92.8% sensitivity and 73.5% specificity to differentiate mild cognitive impairment from normal controls. The internal consistency of MoCA-HK was 0.74 in this experiment.

The Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001) was used to detect affective disorders. It is a nine-item assessment of depression severity based on the Fifth Edition of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013). The PHQ-9 consists of items such as "*little interest or pleasure in doing things*" and "*feeling down, depressed, or hopeless*". Responses of the PHQ-9 are based on a two-week recall period and rated on a four-point Likert scale (0 = not at all to 3 = nearly every day). The total score of PHQ-9 is 27 with a higher score suggesting a greater severity of depression symptoms. Based on the cut-off of nine, the Chinese translation of PHQ-9

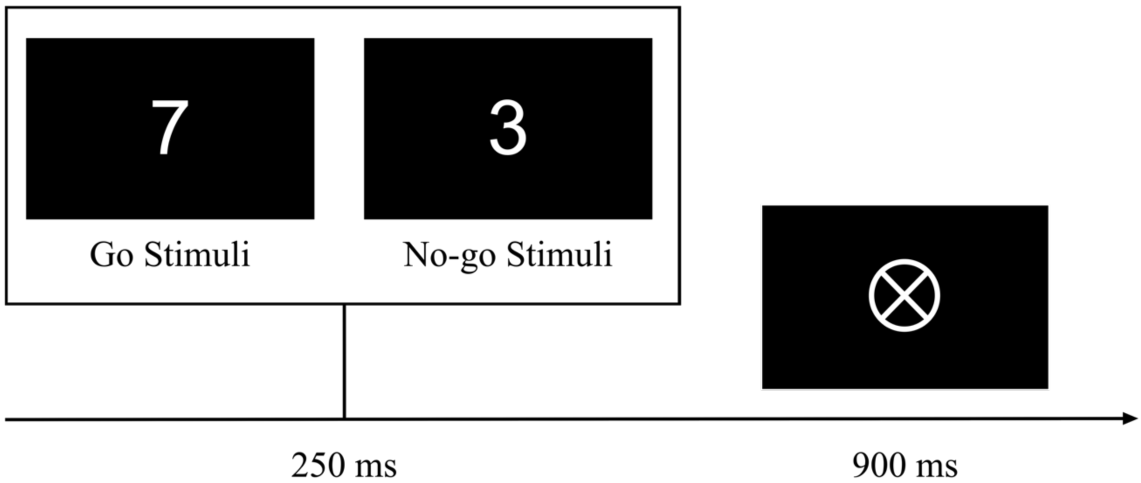
(Cheng & Cheng, 2007) had 80% sensitivity and 92% specificity to detect major depressive disorder. The internal consistency of Chinese PHQ-9 was 0.77 in this experiment.

Experimental Tasks

Experimental stimuli were presented in E-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA) on a 15.6-inch display (screen resolution: 1920 × 1080, 141 pixels per inch). Participants sat at approximately 50 cm in front of the computer screen. Response keys were color-mapped to avoid unnecessary delays in identifying the keys.

Sustained Attention. The Sustained Attention to Response Task (SART; Robertson et al., 1997) was utilized to assess sustained attention (see Figure 4).

Figure 4. *Schematic Representation of the Sustained Attention to Response Task*

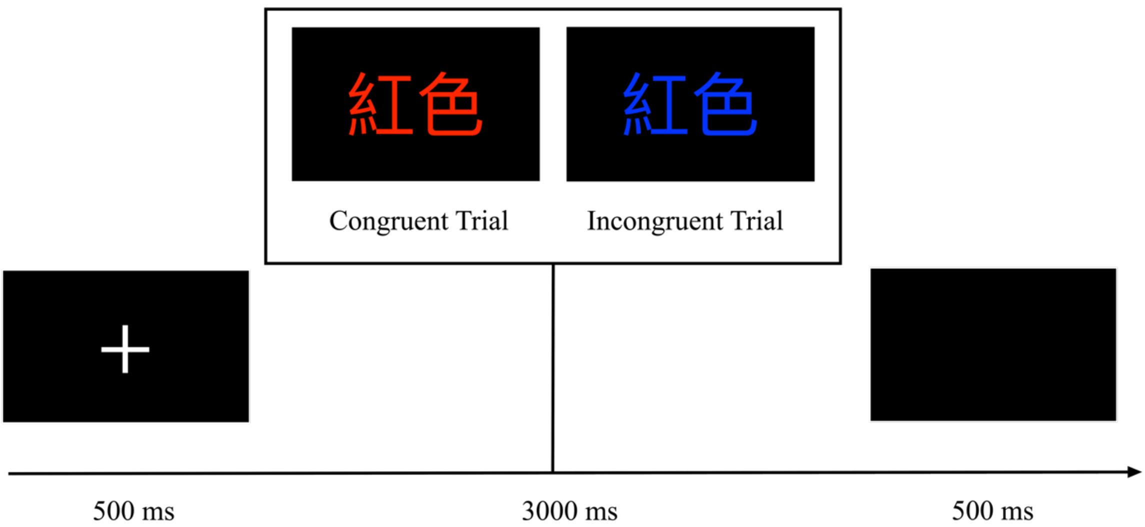


Using a Go/No-go paradigm, a numerical digit (random, from 1-9) was presented at the center of a black screen for 250 ms, in varying font sizes (random, from 72, 94, 100, 120, 160 pt.). In the SART, participant withheld their responses to the No-go stimuli (digit 3) and pressed the spacebar when the Go stimuli (digits 1-2, 4-9) appeared. Immediately after, a circular mask with a diagonal cross in the middle (10.5 × 10.5 cm) appeared at the center for 900 ms. During this period, participants could still make a response. An experimental block of the SART consisted of 180 trials and lasted about five minutes. Following the procedures in Robertson et al. (1997), the proportion of Go stimuli was 0.89 and 0.11 for No-go stimuli.

Because of a disproportionately large number of Go stimuli, the SART induces a rhythmic and inattentive response style (Robertson et al., 1997). Therefore, participants were required to maintain an active, controlled stance to withhold the responses to the No-go stimuli. The SART also offers a rich set of performance indicators, which captures different aspects of sustained attention. Commission errors refer to failures to withhold responses to the Go stimuli, indicating an extent to which the SART is being performed in an automated manner (Robertson et al., 1997). Omission errors describe failures to respond to the No-go stimuli, suggesting a complete inattention and task disengagement (Cheyne et al., 2009). Variability of RT in the Go stimuli captures the fluctuations of response speed, which is also thought to reflect an extent of task disengagement (Cheyne et al., 2009). Prior to the experimental block, there were 10 practice trials provided with feedback. Participants were instructed to place equal emphasis on both speed and accuracy.

Selective and Executive Attention. The Stroop Color-Word Test (SCWT; Stroop, 1935) was used to measure selective and executive attention (see Figure 5).

Figure 5. *Schematic Representation of the Stroop Color-Word Test*



In the SCWT, the stimuli consisted of four color names written in Chinese [紅色 (red), 黃色 (yellow), 藍色 (blue), 綠色 (green)] displaying in one of these colors. A central fixation "+" first appeared on a black screen for 500 ms, followed by the color name (75 pt. font) for 3000 ms. Participants indicated the display color by pressing a corresponding color key, irrespective to its semantic meaning. Once a response is made, the screen remained blank for 500 ms before the next trial begun. An experimental block of the SCWT consisted of 70 trials and lasted about five minutes. About 50% of the trials were congruent (i.e., both color name and display color were compatible, e.g., blue printed in blue) and 50% were incongruent trials (i.e., the display color was incompatible with the meaning of a color word, e.g., blue printed in red). For the incongruent trials, participants were required to maintain attentional efforts to inhibit semantic processing (i.e., the color name) and switch attention to the processing of its visual features (i.e., the display color). Therefore, lower error rates reflect an efficiency of attentional control. Before the actual trials, there were 10 practice trials provided with feedback.

Prospective Memory. PM was assessed by the standard Einstein-McDaniel paradigm (Einstein & McDaniel, 1990). In this paradigm, PM intentions are embedded in an OT, where participants executed intentions at an appropriate moment while performing the OT. Three PM cue types were assessed: focal EBPM, non-focal EBPM, and TBPM.

In focal EBPM, the OT was a lexical decision task (LDT) (see Hicks et al., 2005). Since participants are native Chinese speakers, I adopted a Chinese modification of the LDT (Tsai et al., 2006). In this task, a central fixation "+" first appeared on a black screen for 500 ms, followed by a two-character string (75 pt. font) for 3000 ms. The two-character string could either be a real word [e.g., 蘋果 (apple)] or a non-word [i.e., the sequence of a two-character string is reversed, such that there is no meaning attached to it, e.g., 果蘋]. Participants pressed the button "Y" if it was a real word and the button "N" if it was a non-word. After a response is made, the screen remained blank for 500 ms. Before the actual trials, there were 10 practice trials of the LDT provided with feedback. Next, participants performed 30 trials of the LDT alone. Upon completion, participants encoded a PM intention. They were told to press the button “S” whenever the two-character string belonged to a specific category (animal). Therefore, PM cue focality aligns with the OT, with both tasks require semantic processing (Einstein & McDaniel, 2005). To minimize predictability, the PM cues were unevenly employed in fixed positions to avoid the occurrence of two PM cues in consecutive trials (see Smith & Bayen, 2004). An experimental block of focal EBPM consisted of 100 trials with six PM cues embedded at the sixth, 30th, 42nd, 54th, 72nd and 92nd trials.

In non-focal EBPM, the OT was a color matching task (see Smith & Bayen, 2004). In this task, there were four different color rectangles presented sequentially at the center of a black screen. Each rectangle remained onscreen for 750 ms with an interstimulus interval (ISI) of 250 ms. After the fourth 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 is matched with the color in any of the rectangles that had just been shown. The buttons “Y” and “N” were indicated for matched and non-matched colors, respectively. After a response was collected, the screen stayed blank for 500 ms. A total of six colors (randomly from white, red, yellow, blue, green, and purple) was used in this task. Participants first completed 10 practice trials of the color matching task provided with feedback. Then, participants completed 20 trials of the color matching task alone. After completion, participants encoded a PM intention, where they pressed the button “S” if the two-character string belonged to a specific category (fruit). Therefore, PM cue focality does not align with the OT because it requires semantic processing to successfully execute the PM intention (Einstein & McDaniel, 2005). An experimental block of non-focal EBPM comprised of 60 trials with six PM cues embedded at the third, 12th, 21st, 33rd, 48th and 57th trials.

In TBPM, the OT was a category association task (see Einstein & McDaniel, 2005). In this task, participants indicated whether a word is matched with a given category. A central fixation "+" first appeared on a black screen for 500 ms. Then, a category [e.g., 動物 (animal)] was displayed for 2500 ms, followed by a word [e.g., 獅子 (lion)] for 2500 ms. The buttons "Y" and "N" were pressed for matched and non-matched pairs, respectively. After a response is made, the word remained onscreen, so that each trial has a fixed duration of 5500 ms. Participants completed 10 practice trials of the category association task provided with feedback. After, participants performed 20 trials of the category association task alone. Next, participants encoded a PM intention, which was an extra command to press the button "T" at a two-minute interval throughout the task. Participants could press the button "C" to display a time counter ("00:00"), which appeared for 3000 ms at the bottom right corner of the screen. An experimental block of TBPM consisted of 100 trials with four target PM intervals, which lasted for approximately nine minutes.

Ecological Tasks

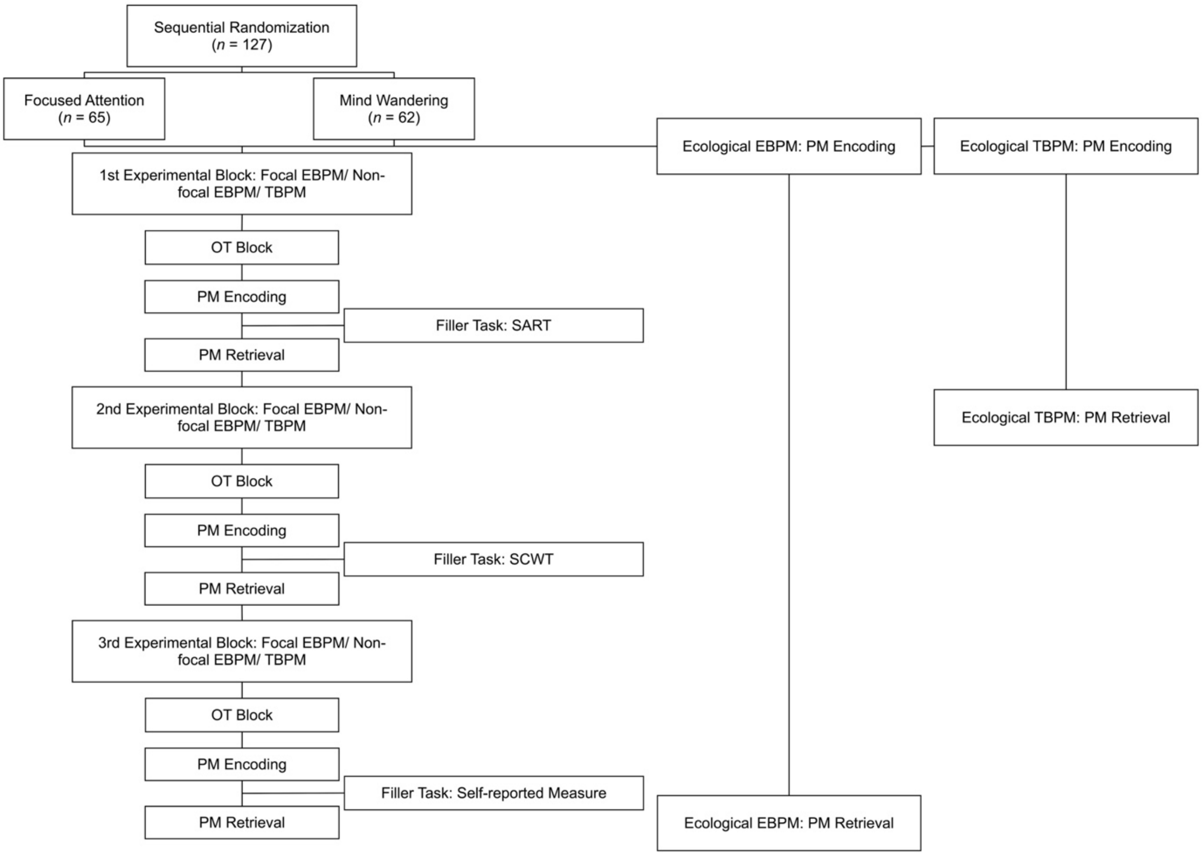
I included two ecological PM tasks (EBPM and TBPM) to provide a more holistic assessment of PM. In the experiment venue, three model cars (red, green, and white car) were placed on the desk. In ecological EBPM, participants were asked to give the red car to an experimenter after receiving the financial incentive. A total score of two is used to assess whether: (1) the intention is triggered appropriately (i.e., remembering something to be fulfilled after receiving the incentive) and (2) the appropriate intention is executed (i.e., giving the right car to the experimenter). In ecological TBPM, participants were instructed to give the white car at a predetermined time (30 minutes after receiving the instruction). A clock is placed on the desk for the sake of time monitoring. Similarly, a total score of two is used to assess whether: (1) the intention is executed at an appropriate time (± 5 minutes) and

(2) the appropriate intention is performed. To facilitate interpretation, the scores in both ecological tasks were transformed into mean proportions of correct responses.

Procedures

Participants were sequentially randomized into either a FA group or a mind wandering (MW) group (see Figure 6).

Figure 6. *Flowchart of Procedures in Experiment I*



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.

The inductions of FA and MW were recorded in an audio-visual format by a local female mindfulness instructor certified in MBCT. Focused attention and MW (see Appendices A and C) were adapted from an RCT that explored the effects of FA on cognitive functions in older adults (Polsinelli et al., 2020). Both inductions were structurally equivalent and lasted about 25 minutes. Mind wandering was employed to minimize the effects of treatment expectancy, which has been frequently employed as a control group in experimental studies that explored the cognitive effects of mindfulness (e.g., Rosenstreich & Ruderman, 2017). Participants in the MW group were told that the practice would promote creativity. They were encouraged to freely engage in mind wandering and daydreaming without providing any guidance of attentional control. The goal of FA is to enhance attentional control using the sensations of breathing as an anchor of focus. Participants in the FA group were encouraged to notice any distractors and return their attention to breathing in a non-judgmental manner. Notably, the utilization of a self-reported measure of state mindfulness as a manipulation check may elicit demand characteristics, potentially influencing subsequent PM performance. To ensure that the FA induction has indeed produced the intended mindfulness state, a pilot study was conducted, which included qualitative interviews to explore participants' experiences following the induction. The focus of these interviews was specifically on any difficulties encountered during the process. The results suggested that the FA induction was effective in achieving the desired state of mindfulness.

After completing FA or MW, participants were given the instructions for two ecological PM tasks (EBPM and TBPM). Then, participants performed three counterbalanced experimental blocks (focal EBPM, non-focal EBPM, and TBPM). Within each block, participants first performed the OT alone provided with instructions and practice trials. After, participants encoded the PM intention. To allow sufficient time to induce PM forgetting, a filler task was placed between PM encoding and retrieval. There were three filler tasks: (1) SART, (2) SCWT, and (3) filling out a self-reported measure of demographical questions. Each filler task lasted for approximately five minutes. The experimental session ended with the completion of the last experimental block and lasted for approximately 120 minutes.

Data Analyses

Statistical analyses were based on the aims to explore whether (1) FA can facilitate PM and (2) an enhancement of PM is mediated by a more efficient attentional control. The only between-subject factor was induction types (FA vs. MW). First, I performed a multivariate analysis of variance (MANOVA) to compare performance indicators of attentional control (SART and SCWT) between the FA and MW groups. Second, I conducted another MANOVA to compare the FA and MW groups in PM performance (focal EBPM, non-focal EBPM, and TBPM). Third, I computed correlations to explore the associations between performance indicators in all outcome measures. Fourth, I performed meditation analyses to explore whether these improvements in PM were due to a better attentional control. Unless otherwise specified, all statistical analyses were based on an alpha level that did not exceed 5%.

I first inspected trials with unusual RT data. Except for the SART, I 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 were 0.00%, 0.01%, 0.00% and 0.09% of data loss in the SCWT, focal EBPM, non-focal EBPM and TBPM, respectively. Note that I did not exclude any SART trials, because of its short response timeframe (1150 ms), which aims to induce a rapid and rhythmic response style (see Helton et al., 2011). Additionally, I excluded two participants in focal EBPM due to poor OT performance (<50% task accuracy), indicating the possibility of misunderstanding the task instructions. I also removed six participants in non-focal EBPM and one participant in TBPM for the same reason.

Results

Before proceeding to the planned statistical analyses, I explored whether there were differences between the FA and MW groups in all socio-demographic variables (see Table 5).

Table 5. *Socio-demographic Information in Experiment I*

	Mind wandering (*n* = 62)		Focused attention (*n* = 65)		*t*	*p*
Age, *M (SD)*	65.13	(3.33)	64.60	(3.64)	0.85	0.40[a]
Gender, *n (%)*					-	0.34[b]
Male	16	(25.80%)	22	(33.80%)		
Female	46	(74.20%)	43	(66.20%)		
Years of education, *M (SD)*	13.81	(3.67)	14.55	(3.03)	-1.25	0.21[a]
Occupation status, *n (%)*					-	0.63[b]
Unemployed	51	(82.30%)	56	(86.20%)		
Employed	11	(17.70%)	9	(13.80%)		
Previous experience in mindfulness practice, *n (%)*					-	0.84[a]
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.

Using t-tests or Fisher's exact tests, the results did not reveal any between-group differences in all socio-demographic variables, including participants' previous experience in mindfulness practice. Next, I computed t-tests to compare the performance of screening assessments (MoCA-HK and PHQ-9) between induction types.

Table 6. *Performance of Screening Assessments in Experiment I*

	Mind wandering		Focused attention		*t*	*df*	*p*
	M	*SD*	*M*	*SD*			
MoCA-HK	27.10	2.20	27.55	2.25	-1.16	125.00	0.25
PHQ-9	1.74	1.76	2.34	2.30	-1.64	119.58	0.10

Note. MoCA-HK = Hong Kong Version of Montreal Cognitive Assessment; PHQ-9 = Patient Health Questionnaire-9.

As can be seen from Table 6, there were no significant between-group differences in the MoCA-HK or PHQ-9.

I also compared OT performance between induction types. To avoid a contamination of PM costs, I excluded trials followed by the PM targets to avoid carryover effects of executing the PM intentions or simply distracted by just having seen the PM targets. This procedure is commonly employed in studies utilizing the Einstein-McDaniel paradigm to assess PM (e.g., Smith & Bayen, 2004; Smith et al., 2014). The total number of OT trials excluded is equal to the number of PM cues employed. Therefore, I conducted a 3 [within-subject factor: OT blocks (focal EBPM vs. non-focal EBPM vs. TBPM)] × 2 [between-subject factor: induction types (FA vs. MW)] mixed analysis of variance (ANOVA). Corresponding mean scores can be found in Table 7.

Table 7. *Ongoing Tasks Performance in Experiment I*

	Mind wandering		Focused attention	
	M	*SD*	*M*	*SD*
Focal EBPM	0.90	0.06	0.90	0.07
Non-focal EBPM	0.80	0.11	0.81	0.12
TBPM	0.91	0.05	0.91	0.06

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

As expected, the results did not suggest an OT blocks × induction types interaction, $F(1.68,194.94) = 0.51$, $p = 0.57$, $\eta^2_p < 0.01$. However, a main effect of OT blocks was found, $F(1.68,194.94) = 86.09$, $p < 0.01$, $\eta^2_p = 0.43$. Comparing to non-focal EBPM ($M = 0.80$, $SE = 0.01$), participants have a higher level of task accuracy in the OTs of focal EBPM ($M = 0.90$, $SE = 0.01$, $p < 0.01$) and TBPM ($M = 0.91$, $SE = 0.01$, $p < 0.01$). Nonetheless, there was no main effect of induction types, $F(1,116) = 0.64$, $p = 0.43$, $\eta^2_p = 0.01$. The intrapersonal variations may indicate that the OT of non-focal EBPM (color matching task) is more difficult than the OTs of focal EBPM (LDT) and TBPM (category association task).

Performance of Attentional Control

Next, I evaluated whether there were any group differences between induction types in the SART and SCWT. In the SART, there were three performance indicators. First, I computed the RT coefficient of variability (RTCV) (SD_{RT}/M_{RT}), which indicates an overall temporal stability of responses in the SART (see Cheyne et al., 2009). Second, I calculated the proportion of commission errors (inappropriate responses to the No-go stimuli, i.e., pressed the spacebar when the No-go stimuli appear) and omission errors (incorrect responses to the Go stimuli, i.e., failed to press the spacebar when the Go stimuli appear). In the SCWT, there were two performance indicators, including the Stroop interference $(Error\ Rate_{Incongruent\ Trials} - Error\ Rate_{Congruent\ Trials})$ and Stroop RT interference $(M_{Incongruent\ Trials\ RT} - M_{Congruent\ Trials\ RT})$. Corresponding mean scores by induction types were presented in Table 8.

Table 8. *Performance of Attentional Control in Experiment I*

	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

Note. RT = reaction time; RTCV = reaction time coefficient of variability; SART = Sustained Attention to Response Task; SCWT = Stroop Color-Word Test.

A MANOVA was computed using all performance indicators in attentional control. There was a main effect of induction types, Wilks' Λ = 0.87, $F(5,121) = 3.48$, $p < 0.01$, η^2_p = 0.13. Follow-up univariate tests were computed to further explore the group differences in each dependent variable (see Table 9).

Table 9. *Univariate Tests of Performance Indicator in Attentional Control in Experiment I*

Source	Dependent variables	*SS*	*df*	*MS*	*F*	*p*	η^2_p
Induction types	SART RTCV	0.01	1	0.01	1.66	0.20	0.01
	SART commission errors	0.12	1	0.12	4.91	<0.05	0.04
	SART omission errors	<0.01	1	<0.01	6.20	<0.05	0.05
	SCWT Stroop interference	0.02	1	0.02	4.54	<0.05	0.04
	SCWT Stroop RT interference	80264.43	1	80264.43	4.00	<0.05	0.03
Error	SART RTCV	0.61	125	0.01			
	SART commission errors	3.15	125	0.03			
	SART omission errors	0.04	125	<0.01			
	SCWT Stroop interference	0.63	125	0.01			
	SCWT Stroop RT interference	2506895.23	125	20055.16			
Total	SART RTCV	9.52	127				
	SART commission errors	16.32	127				
	SART omission errors	0.06	127				
	SCWT Stroop interference	0.75	127				
	SCWT Stroop RT interference	5873292.61	127				

Note. RT = reaction time; RTCV = reaction time coefficient of variability; SART = Sustained Attention to Response Task; SCWT = Stroop Color-Word Test.

Except for RTCV in the SART, the FA group committed fewer SART's commission errors ($p < 0.05$, $\eta^2_p = 0.04$) and omission errors ($p < 0.05$, $\eta^2_p = 0.05$), as well as less

SCWT's Stroop interference ($p < 0.05$, $\eta^2_p = 0.04$) and Stroop RT interference ($p < 0.05$, $\eta^2_p = 0.03$).

Prospective Memory Performance

PM was operationalized by (1) two ecological PM tasks (EBPM and TBPM) and (2) three experimental PM tasks (focal EBPM, non-focal EBPM and TBPM).

In focal and non-focal EBPM, performance was indicated by the proportion of correct responses to PM targets. There were two performance indicators in TBPM. Initially, a proportion of correct responses was defined by pressing the correct button within a time window of ± 2500 ms at each PM target interval (two-minute) (see Jáger & Kliegel, 2008). However, this scoring revealed a potential flooring effect (*M* = 0.13, *SD* = 0.26). Considering the slowness of elderly participants, I adopted a more lenient scoring of ± 15000 ms in the analyses (see Yang et al., 2013). Additionally, I analyzed their 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 of clock checking is critical to execute an accurate PM response (Einstein et al., 1995).

Corresponding mean scores of each PM measure can be found in Table 10.

Table 10. *Prospective Memory Performance in Experiment I*

	Mind wandering		Focused attention	
	M	*SD*	*M*	*SD*
Ecological EBPM	0.64	0.48	0.83	0.37
Ecological TBPM	0.74	0.28	0.73	0.28
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; TBPM = time-based prospective memory.

Next, I performed a MANOVA to compare PM performance between induction types. The results did not suggest a main effect of induction types, Wilks' $\Lambda = 0.91$, $F(6,111) =$

1.75, $p = 0.12$, $\eta^2_p = 0.09$. To further pinpoint the effects of specific PM measure, I computed univariate test in each dependent variable (see Table 11).

Table 11. *Univariate Tests of Performance Indicator in Prospective Memory in Experiment I*

Source	Dependent variables	*SS*	*df*	*MS*	*F*	*p*	η^2_p
Induction types	Ecological EBPM	1.11	1	1.11	6.06	<0.05	0.05
	Ecological TBPM	<0.01	1	<0.01	0.03	0.85	<0.01
	Focal EBPM	0.40	1	0.40	6.05	<0.05	0.05
	Non-focal EBPM	0.11	1	0.11	0.89	0.35	0.01
	TBPM accuracy	0.07	1	0.07	0.41	0.52	<0.01
	TBPM clock checks	2.35	1	2.35	0.17	0.68	<0.01
Error	Ecological EBPM	21.23	116	0.18			
	Ecological TBPM	9.34	116	0.08			
	Focal EBPM	7.63	116	0.07			
	Non-focal EBPM	14.74	116	0.13			
	TBPM accuracy	18.63	116	0.16			
	TBPM clock checks	1597.63	116	13.77			
Total	Ecological EBPM	85.75	118				
	Ecological TBPM	72.75	118				
	Focal EBPM	85.48	118				
	Non-focal EBPM	49.03	118				
	TBPM accuracy	42.50	118				
	TBPM clock checks	2729.00	118				

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

Comparing to the MW group, the FA group performed better in ecological EBPM ($p < 0.05$, $\eta^2_p = 0.05$), but no differences were observed in ecological TBPM. In experimental tasks, the FA group outperformed the MW group in focal EBPM, $p < 0.05$, $\eta^2_p = 0.05$. No differences were found in non-focal EBPM nor TBPM (in both accuracy and clock checks).

Correlational Analyses

Before examining how FA improves ecological EBPM and experimental focal EBPM, I computed a series of correlational analyses to explore the associations between performance indicators in all outcome measures (see Table 12).

Table 12. *Correlation Matrix of Outcome Measures in Experiment I*

	1	2	3	4	5	6	7	8	9	10
1. SART RTCV										
2. SART commission errors	0.36**									
3. SART omission errors	0.39**	0.12								
4. SCWT Stroop interference	0.09	0.15	-0.07							
5. SCWT Stroop RT interference	0.10	0.17	-0.06	0.23**						
6. Ecological EBPM	0.05	0.01	-0.19*	-0.03	0.01					
7. Ecological TBPM	-0.16	-0.07	0.02	-0.05	-0.01	-0.14				
8. Focal EBPM	-0.10	0.16	-0.21*	0.01	-0.02	0.32**	-0.08			
9. Non-focal EBPM	-0.09	-0.16	-0.25**	-0.09	-0.02	0.23*	0.04	0.30**		
10. TBPM accuracy	-0.05	-0.01	-0.15	-0.13	-0.14	0.16	0.03	0.27**	0.22*	
11. TBPM clock checks	-0.06	-0.01	-0.15	0.02	0.09	0.19*	0.16	0.14	0.05	0.33**

Note. *$p < 0.05$, **$p < 0.01$. EBPM = event-based 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.

As can be seen from Table 12, no strong associations were observed between outcome measures. In attentional control, there were weak positive correlations across performance indicators within the same experimental task, but no correlations were observed between the SART and SCWT. Weak positive correlations were also found between experimental PM tasks. Ecological EBPM was positively associated with experimental focal and non-focal EBPM. Interestingly, SART omission error was negatively associated with ecological EBPM, experimental focal and non-focal EBPM.

Mediation Analyses

I performed meditation analyses to explore whether the positive findings in ecological EBPM and experimental focal EBPM could be attributed to a better attentional control resulting from FA. Using the PROCESS macro for SPSS (Hayes, 2017), I computed meditation analyses 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 the bias-corrected and accelerated 95% intervals did not contain any zeros.

With multiple performance indicators in the SART and SCWT, I included only those with significant group differences between induction types. There were four mediators: (1) SART's commission errors, (2) SART's omission errors, (3) SCWT's Stroop interference, and (4) SCWT's Stroop RT interference.

Table 13. *Mediation Effects of Attentional Control Between Induction Types and Prospective Memory*

Relationship	Effect of IV on mediator (*a*)		Unique effect of mediator (*b*)		Direct effect (*c'*)		Indirect effect (*ab*)		BC 95% CI	
	b	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	Lower	Upper
Induction types → SART commission errors → Ecological EBPM	-0.06	(0.03)*	0.14	(0.25)	0.17	(0.08)*	-0.01	(0.02)	-0.04	0.02
Induction types → SART omission errors → Ecological EBPM	-0.01	(<0.01)*	-3.99	(2.29)	0.13	(0.08)	0.03	(0.02)	<0.01	0.07
Induction types → SCWT Stroop interference → Ecological EBPM	-0.03	(0.01)*	0.01	(0.55)	0.16	(0.08)*	<0.01	(0.02)	-0.02	0.03
Induction types → SCWT Stroop RT interference → Ecological EBPM	-50.29	(25.14)*	<0.01	(<0.01)	0.17	(0.08)*	-0.01	(0.01)	-0.03	0.02
Induction types → SART commission errors → Focal EBPM	-0.06	(0.03)*	0.33	(0.14)	0.13	(0.05)**	-0.02	(0.01)	-0.06	0.01
Induction types → SART omission errors → Focal EBPM	-0.01	(<0.01)*	-2.53	(1.33)	0.09	(0.05)*	0.02	(0.01)*	<0.01	0.04
Induction types → SCWT Stroop interference → Focal EBPM	-0.03	(0.01)*	0.17	(0.32)	0.12	(0.05)*	-0.01	(0.01)	-0.02	0.01
Induction types → SCWT Stroop RT interference → Focal EBPM	-54.14	(25.23)*	<0.01	(<0.01)	0.11	(0.05)*	<0.01	(0.01)	-0.02	0.01

Note. *$p < 0.05$, **$p < 0.01$. EBPM = event-based prospective memory; RT = reaction time; SART = Sustained Attention to Response Task;

SCWT = Stroop Color-Word Test.

The results can be found in Table 13. In ecological EBPM, all indirect effects were nonsignificant, suggesting none of the measurement indicators in attentional control have mediated the effects of FA on ecological EBPM. In experimental focal EBPM, the only significant mediator was SART's omission errors. Since the direct effect of induction types was also significant at $p < 0.05$, this suggests a partial mediation, in that the effect of FA on experimental focal EBPM was partially mediated by committing fewer SART's omission errors.

Discussion

The purpose of this experiment is twofold: (1) to investigate whether FA, compared to MW, can facilitate PM in older adults, and (2) to explore whether an enhancement of PM from FA was mediated by a more efficient attentional control.

Overall, FA appears to improve an efficiency of top-down attentional control in older adults, which is evident in better performance of selective and executive attention in the FA group (with fewer Stroop interference in the SCWT). Wenk-Sormaz (2005, Experiment I) also reported fewer Stroop interference in undergraduates after three sessions of FA comparing to an active control (i.e., to learn a mnemonic) and a passive control. Despite aging is associated with a decline in attentional control (Craik, 1986), a single session of 25-minute FA training appears to produce measurable benefits in selective and executive attention. The current finding also demonstrates the generalizability and feasibility of utilizing FA to enhance attentional control in an older population.

Focused attention can also enhance sustained attention in older adults. The FA group committed fewer commission and omission errors in the SART. Consistently, Isbel et al. (2020) found that FA improved sustained attention in older adults with less commission errors and variability in response speed in the SART comparing to a computerized attention-based training. The current finding also extends the findings in Isbel et al. (2020), suggesting that FA resulted in fewer omission errors. This performance indicator is typically overlooked in studies utilizing the SART (for a review, see Turkelson & Mano, 2022). As an important performance indicator, SART's omission errors (i.e., failures to respond to the more frequent Go stimuli) reflect a more extreme form of task disengagement. Therefore, it appears that FA can facilitate task engagement, especially in a monotonous task such as the SART.

However, FA did not improve SART's RTCV, a performance indicator capturing an overall stability of response speed in the SART. This is inconsistent with the findings in Isbel et al. (2020), where they found less variability in SART's RTCV after a FA training. Perhaps this inconsistent finding is due to differences in the number of trials implemented in the SART. Considering the SART is associated with more fluctuations in sustained attention over an extended period (Cheyne et al., 2009), there could be an insufficient number of trials (180 trials) in this experiment to reflect the fluctuations in response speed. Implementing a similar number of trials (240 trials), Bennike et al. (2017) also reported a non-significant finding of SART's RTCV after an app-based mindfulness training. Compared to 540 trials in Isbel et al. (2020), it is likely that more SART's trials are required to capture an overall stability of response speed in sustained attention.

There is also a partial support that FA can facilitate PM in older adults. Participants in the FA group outperformed the MW group in focal EBPM (but not in non-focal EBPM and TBPM). This finding is inconsistent with the null findings in Girardeau et al. (2020), where they did not observe an effect of FA on any PM measures (focal EBPM, non-focal EBPM and TBPM) comparing to a MW control. A potential explanation could be that the effects of FA on PM is more pronounced at PM encoding. Since they employed FA before the PM encoding phase, its effects were only observable at PM retrieval. However, the memory encoding process is also sensitive to attentional control (Levi & Rosenstreich, 2019). This is especially relevant to older adults given that they are more prone to distractions at PM encoding (Park et al., 1989). Therefore, FA could primarily facilitate PM by enhancing attentional control at PM encoding.

Sampling on different target populations could also contribute to the inconsistent findings reported in Girardeau et al. (2020). In their study, young adults performed fairly well in focal EBPM (with a mean proportion of correct responses of 95%). Meanwhile, our older participants performed relatively poorer (with a mean proportion of correct responses of 81%). It is plausible that FA can no longer benefit PM as their participants have reached a ceiling performance.

On the other hand, the null findings in non-focal EBPM and TBPM could indicate an insufficient dosage of FA because both tasks are more demanding than focal EBPM. According to the Multi-Process Framework (McDaniel & Einstein, 2000), non-focal EBPM relies on strategic monitoring, which draws on more attentional resources than focal EBPM that is supported by spontaneous retrieval. TBPM also requires a higher degree of self-initiation in time monitoring because of an absence of PM cue (Craik, 1986). Due to a higher level of strategic demands, older adults should be particularly deficient in both tasks (Henry et al., 2004). The analysis of OT performance also revealed a main effect of OT blocks, in that the OT of non-focal EBPM (color matching task) could be more demanding than the OTs of focal EBPM (LDT) and TBPM (category association task). A demanding OT may disrupt PM because it further competes with the limited attentional resources to perform task switching between the OT and PM intention (d'Ydewalle et al., 2001). Meanwhile, mindfulness requires longer practice to consolidate its benefits (Williams, 2010). Previous studies of mindfulness training in attentional control have demonstrated a dose-response relationship (Chan & Woollacott, 2007; MacLean et al., 2010). While studies of MBI have varied in their training durations (ranging from few weeks to several months), Verhaeghen (2021), in a review of mindfulness training in attentional control, suggested that a standardized eight-week MBSR can produce improvements of attentional control on par with those that have been seen in more experienced meditators. Therefore, it is likely that a brief 25-minutes FA training is insufficient to enhance attentional control to an extent that improves cognitive tasks that require a higher level of strategic demands.

Nonetheless, the current finding indicates an indirect effect of sustained attention, in that FA led to fewer SART's omission errors, which partially mediated its effect on experimental focal EBPM. However, it requires caution to interpret this finding because indirect effects were not consistently observed in other performance indicators in the SART. Furthermore, no indirect effects were found in the SCWT. This weakens the conclusion that the effect of FA on focal EBPM was because of a better sustained attention.

CHAPTER V: EXPERIMENT II

Besides FA, OM is also another important style of meditative practice. Given the positive results in Experiment I about the effects of FA on OM, I explored the effects of OM on PM in Experiment II to provide a more comprehensive understanding about the effects of mindfulness on PM. Because OM is hypothesized to reduce emotional interference from negative emotions, I utilized a mood induction paradigm to investigate the effects of OM on PM in an emotional context.

Methods

According to previous studies in the effects of mindfulness on episodic memory (e.g., Brown et al., 2016; Lueke & Lueke, 2019), a power analysis was formulated utilizing an ANOVA to detect a medium effect size at a power of 80% at $p = 0.05$, which resulted in a target sample size of 128. Therefore, I conservatively aimed to recruit 150 participants. Data collection took place between June 2022 and October 2022.

Participants

The total sample size was 157. The inclusion criteria were Chinese older adults living in Hong Kong aged between 60 and 75 years without any cognitive or affective impairments. Participants were recruited by means of convenient and snowball sampling. Recruitment emails were sent to members of the IAA at the Hong Kong Polytechnic University. Those who took part were invited to refer their friends and relatives. All participants provided written consents and received a voucher of $100 HKD from a local chain supermarket.

Participants were screened by the MoCA-HK (cutoff: 22/30) for cognitive impairments and the PHQ-9 (cutoff: 9/27) for affective disorders. The Cronbach's alphas of MoCA-HK and PHQ-9 were 0.71 and 0.75, respectively. Note that two participants scored below the cut-off of MoCA-HK and were therefore excluded from this experiment. No participants were excluded from scoring below the cut-off of PHQ-9.

Materials

I did not include any ecological PM tasks because it is impractical to use a mood induction paradigm for tasks that requires a longer retention interval.

Experimental stimuli were presented in a 15.6-inch display (screen resolution: 1920 × 1080, 141 pixels per inch) using E-Prime 3.0, with color-mapped response keys. Participants sat at approximately 50 cm in front of the computer screen.

Using the standard Einstein-McDaniel paradigm (Einstein & McDaniel, 1990), three PM cue types were assessed: (1) focal EBPM, (2) non-focal EBPM, and (3) TBPM. Given the possibility of recruiting a few overlapping participants from Experiment I, the lists of stimuli and PM targets were slightly modified to minimize any potential practice effects.

In focal EBPM, the OT was a Chinese modification of the LDT. 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 button "Y" if the two-character string was a real word or the button "N" if it was a non-word. Once a response is recorded, the screen stayed blank for 500 ms. An OT block of the LDT consisted of 10 practice trials with feedback and 20 actual trials. Upon completion, participants encoded a PM intention. The PM intention was to press the button "S" if the two-charactering belonged to a specific category (transportation). There was a total of 100 trials with six PM targets embedded at the fifth, 31st, 42nd, 55th, 71st and 90th trials.

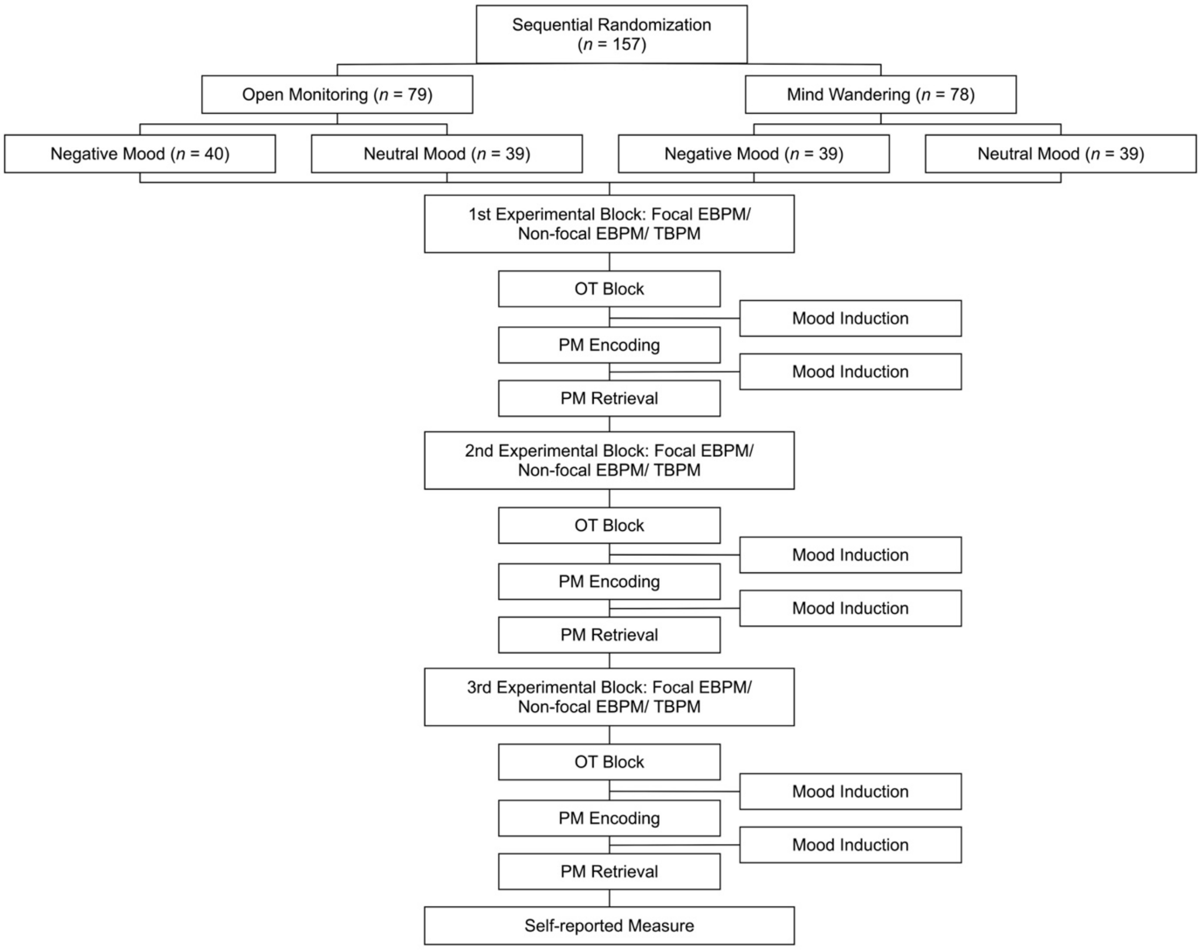
In non-focal EBPM, the OT was a color matching task. Four rectangles (18.5 × 13.2 cm), each with a different color, were sequentially presented at the center of a black screen. Each color rectangle remained onscreen for 750 ms with an ISI of 250 ms. After the last color rectangle was shown, a two-character string printed in color (75 pt. font) was displayed at the center of the screen for 3000 ms. Participants decided whether the display color of the two-character string had been shown in any of the four color rectangles back in the series. The buttons “Y” and “N” were pressed for matched and non-matched colors, respectively. Once a response was made, the screen remained blank for 500 ms. An OT block of the color matching task comprised of 10 practice trials with feedback and 20 actual trials. After completion, participants encoded a PM intention, where they pressed the button “S” if the two-character string belonged to a specific category (occupation). This task consisted of 60 trials with six PM cues embedded at the second, 13th, 22nd, 34th, 49th and 58th trials.

In TBPM, the OT was a category association task. In this task, a central fixation “+” first displayed on a black screen for 500 ms. A category then displayed for 2500 ms, followed by a word for 2500 ms. Participants decided whether the word is belonged to the given category. The buttons “Y” and “N” were pressed for matched and non-matched pairs, respectively. An OT block of the category association task consisted of 10 practice trials provided with feedback and 20 actual trials. After, participants encoded a PM intention, where they press the button “T” at 2-minute intervals throughout the task. They could press the button “C” to summon a time counter (“00:00”) at the bottom-right of the screen for 3000 ms. There was a total of 100 trials with four PM intervals.

Procedures

Participants were sequentially randomized into two between-subject factors: (1) induction types (OM vs. MW) and (2) mood conditions (negative vs. neutral) (see Figure 7).

Figure 7. *Flowchart of Procedures in Experiment II*



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

The inductions of OM and MW utilized an audio-visual format and were recorded by the same mindfulness instructor in Experiment I. Open monitoring (see Appendix B) was adapted from an RCT that explored the cognitive effects of FA and OM (Britton et al., 2018). The induction of MW (see Appendix C) was identical to Experiment I. Both inductions were structurally equivalent and lasted for approximately 25 minutes. The goal of OM is to promote a state of non-judgmental awareness about the present-moment experience. Participants were encouraged to label their experiences using the six senses: (1) seeing, (2) hearing, (3) feeling, (4) tasting, (5) smelling, and (6) thinking. Mind wandering promotes relaxation and creativity without emphasizing an awareness nor a non-judgmental attitude about the present moment experience. To investigate whether the OM induction successfully induced the desired state of mindfulness, a pilot study was conducted by interviewing a small group of older participants about their experience after the OM induction. These interviews focused on any challenges encountered during the process. The results indicated that the participants did not encounter any significant difficulties in practicing the OM induction.

Mood induction stimuli were video segments selected from commercially available documentaries, films, or drama episodes. A pool of negative mood induction stimuli was piloted on five individuals to select six clips out of the highest ratings of negative valence. There were six videos in each mood condition. The content descriptions of each video can be found in Appendix D. Before the mood induction procedures, participants were instructed to watch the clip closely to answer a question related to its content.

The Self-Assessment Manikin (SAM; Bradley & Lang, 1994) was employed to evaluate whether the mood inductions were successful. It is a pictorial nine-point Likert scale to measure self-reported emotional state at a specific time point. It consists of three subscales: (1) valence, (2) arousal, and (3) dominance. For the current purpose, only the SAM valence and arousal subscales were used (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 (excite). The Cronbach's alphas of SAM valence and arousal subscale were 0.98 and 0.95, respectively. The SAM was administered six times throughout the experiment.

After the completion of OM or MW, participants immediately proceeded to three counterbalanced experimental blocks (focal EBPM, non-focal EBPM, and TBPM). Within each block, participants first performed an OT block. A mood induction was placed after the OT block, followed by an administration of SAM. Afterward, participants encoded the PM intention. Before they retrieved the PM intention, another mood induction took place with the administration of SAM. The mood induction would serve as a filler task to induce PM forgetting, which lasted for approximately five minutes. The SAM valence and arousal scores were averaged for each experimental block. Upon completing the last experimental block, participants filled out a self-reported questionnaire of demographical questions. The entire experimental session lasted about 120 minutes.

Data Analyses

Statistical analyses were based on the aim to explore whether OM can facilitate PM under the influence of a negative mood. With a 2 × 2 factorial design, there were two between-subject factors: (1) induction types (OM vs. MW) and (2) mood conditions (negative vs. neutral). Unless otherwise specified, statistical analyses did not exceed an alpha level of 5%.

Before proceeding to the statistical analyses, I inspected trials with unusual RT data. Trials with RT data faster than 200 ms were removed 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. I also removed data from three participant in TBPM due to poor OT performance (<50% accuracy), indicating the likelihood of misunderstanding the task instructions.

Results

First, socio-demographic variables were compared against the two between-subject factors (induction types and mood conditions) (see Table 14).

Table 14. *Socio-demographic Information in Experiment II*

	Induction types				Mood conditions				*F*	*B*	*SE*	*p*
	Mind wandering (*n* = 78)		Open monitoring (*n* = 79)		Neutral (*n* = 78)		Negative (*n* = 79)					
Age, *M* (*SD*)	66.17	(4.12)	66.20	(3.67)	66.00	(3.88)	66.37	(3.92)	2.02	-	-	0.16[a]
Gender, *n(%)*									-	0.05	0.70	0.94[b]
Male	32	(41.00%)	23	(29.10%)	35	(44.90%)	20	(25.30%)				
Female	46	(59.00%)	56	(70.90%)	43	(55.10%)	59	(74.70%)				
Years of education, *n(%)*	13.62	(2.43)	14.08	(2.67)	13.90	(2.73)	13.80	(2.39)	0.14	-	-	0.71[a]
Occupation, *n(%)*									-	-0.38	0.86	0.66[b]
Unemployed	64	(82.10%)	67	(84.80%)	66	(84.60%)	65	(82.30%)				
Employed	14	(17.90%)	12	(15.20%)	12	(15.40%)	14	(17.70%)				
Previous experience in mindfulness practice, *n(%)*									-	-0.16	0.76	0.83[b]
Yes	16	(20.50%)	21	(26.60%)	19	(24.40%)	18	(22.80%)				
No	62	(79.50%)	58	(73.40%)	59	(75.60%)	61	(77.20%)				

Note.

P-values were obtained by [a]two-way ANOVAs or [b]binary logistic regressions.

Using two-way ANOVAs or binary logistic regressions, the results did not suggest any significant induction types × mood conditions interactions in all socio-demographic variables, including participants' previous experience in mindfulness practice.

I also investigated whether there were any differences in the MoCA-HK and PHQ-9. Corresponding mean scores were presented in Table 15.

Table 15. *Performance of Screening Assessments in Experiment II*

	Induction types				Mood conditions			
	Mind wandering		Open monitoring		Neutral		Negative	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
MoCA-HK	27.28	1.98	27.53	2.06	27.45	1.97	27.37	2.01
PHQ-9	2.63	2.51	2.94	2.50	2.59	2.54	2.97	2.46

Note. MoCA-HK = Hong Kong version of Montreal Cognitive Assessment; PHQ-9 = Patient Health Questionnaire-9.

I computed two 2 [between-subject factor: induction types (MW vs. OM)] × 2 [between-subject factor: mood conditions (neutral vs. negative)] ANOVAs separately on the mean scores of MoCA-HK and PHQ-9. As expected, there were no significant induction types × mood conditions interaction in the MoCA-HK, $F(3,153) = 0.48, p = 0.49, \eta^2_p < 0.01$, and PHQ-9, $F(3,153) = 1.05$, p = 0.31, $\eta^2_p = 0.01$.

Then, I evaluated whether there were any differences in OT performance (proportion of correct responses). The calculation of OT performance was identical to Experiment I, i.e., excluding the trials followed by a PM target. A 3 [within-subject factor: OT blocks (focal EBPM vs. non-focal EBPM vs. TBPM)] × 2 [between-subject factor: induction types (MW vs. OM)] × 2 [between-subject factor: mood conditions (neutral vs. negative)] mixed ANOVA was computed (see Table 16).

Table 16. *Ongoing Tasks Performance in Experiment II*

	Induction types				Mood conditions			
	Mind wandering		Open monitoring		Neutral		Negative	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Focal EBPM	0.90	0.07	0.91	0.05	0.90	0.06	0.90	0.06
Non-focal EBPM	0.83	0.11	0.86	0.10	0.84	0.11	0.86	0.10
TBPM	0.91	0.07	0.92	0.07	0.92	0.07	0.92	0.07

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

The results did not suggest a significant OT blocks × induction types × mood conditions interaction, $F(1.67,245.34) = 0.68$, $p = 0.48$, $\eta^2_p = 0.01$. Neither the interaction effects of OT blocks × induction types, $F(1.67,245.34) = 0.16$, $p = 0.81$, $\eta^2_p < 0.01$, nor OT blocks × mood conditions, $F(1.67,245.34) = 1.30$, $p = 0.27$, $\eta^2_p = 0.01$, were significant. However, a main effect of OT blocks was observed, $F(1.67,245.34) = 40.08$, $p < 0.01$, $\eta^2_p = 0.21$. Comparing to the OT in non-focal EBPM ($M = 0.85$, $SE = 0.01$), there was a higher accuracy in the OTs in focal EBPM ($M = 0.90$, $SE = 0.01$, $p < 0.01$) and TBPM ($M = 0.92$, $SE = 0.01$, $p < 0.01$). A higher level of task accuracy was found in the OT in focal EBPM compared to the OT in TBPM, $p < 0.01$. Although the OT in non-focal EBPM (color matching task) was more difficult than the OTs in focal EBPM (LDT) and TBPM (category association task), there were no between-group interactions between induction types and mood conditions.

Manipulation Check

Acknowledging that individuals might react differently to the mood induction stimuli, I analyzed the SAM valence and arousal scores to determine whether the mood induction procedures were successful (see Table 17).

Table 17. *Mean Valence and Arousal Scores in the Self-Assessment Manikin*

	Induction types				Mood conditions			
	Mind wandering		Open monitoring		Neutral		Negative	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Valence								
Focal EBPM	3.91	1.96	3.94	1.93	5.47	1.31	2.33	0.93
Non-focal EBPM	3.88	1.99	3.90	1.96	5.46	1.36	2.28	0.93
TBPM	3.87	1.85	3.93	1.95	5.41	1.28	2.35	0.92
Arousal								
Focal EBPM	3.61	1.65	3.49	1.80	3.03	1.64	4.09	1.65
Non-focal EBPM	3.71	1.75	3.44	1.83	3.04	1.63	4.13	1.79
TBPM	3.44	1.73	3.45	1.86	2.95	1.60	3.95	1.84

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

Based on the procedures in Rummel et al. (2012), the SAM valence scores in the neutral mood condition were used as cut-off points to identify mood non-responders. Participants in the negative mood condition who scored higher above the cut-offs were identified as mood non-responders and therefore excluded from subsequent analyses. Of note, the SAM valence and arousal scores were averaged in each experimental block. Therefore, the cut-offs of 5.47, 5.46 and 5.41 were adopted for focal EBPM, non-focal EBPM and TBPM, respectively. Three individuals were identified as mood non-responders. This accounted for 2% of the total sample.

To explore whether there were induction types × mood conditions interaction in SAM valence and arousal scores, I computed a 2 [between-subject factor: induction types (MW vs. OM)] × 2 [between-subject factor: mood conditions (neutral vs. negative)] MANOVA. The results did not indicate a significant induction types × mood conditions interaction, Wilks' $\Lambda = 0.98$, $F(6,145) = 0.44$, $p = 0.85$, $\eta^2_p = 0.02$. There was no main effect of induction types, Wilks' $\Lambda = 0.96$, $F(6,145) = 0.62$, $p = 0.71$, $\eta^2_p = 0.03$. As expected, a main effect of mood conditions was observed, Wilks' $\Lambda = 0.27$, $F(6,145) = 65.50$, $p < 0.01$, $\eta^2_p = 0.73$. Follow-up univariate tests were presented in Table 18.

Table 18. *Univariate Tests of the Mean Valence and Arousal Scores in the Self-Assessment Manikin*

Source	Dependence variables	*SS*	*df*	*MS*	*F*	*p*	η^2_p
Induction types	Valence						
	Focal EBPM	0.03	1	0.03	0.02	0.89	<0.01
	Non-focal EBPM	0.02	1	0.02	0.01	0.92	<0.01
	TBPM	0.13	1	0.13	0.10	0.75	<0.01
	Arousal						
	Focal EBPM	0.51	1	0.51	0.19	0.67	<0.01
	Non-focal EBPM	3.00	1	3.00	1.02	0.32	0.01
	TBPM	0.01	1	0.01	<0.01	0.96	<0.01
Mood conditions	Valence						
	Focal EBPM	380.84	1	380.84	290.58	<0.01	0.66
	Non-focal EBPM	388.93	1	388.93	283.26	<0.01	0.65
	TBPM	360.81	1	360.81	283.75	<0.01	0.65
	Arousal					<0.01	
	Focal EBPM	42.72	1	42.72	15.65	<0.01	0.09
	Non-focal EBPM	45.44	1	45.44	15.41	<0.01	0.09
	TBPM	38.39	1	38.39	12.81	<0.01	0.08
Induction types × Mood conditions	Valence						
	Focal EBPM	0.11	1	0.11	0.08	0.78	<0.01
	Non-focal EBPM	0.08	1	0.08	0.06	0.81	<0.01
	TBPM	0.01	1	0.01	0.01	0.92	<0.01
	Arousal						
	Focal EBPM	0.92	1	0.92	0.34	0.56	<0.01
	Non-focal EBPM	<0.01	1	0.00	<0.01	0.99	<0.01
	TBPM	0.06	1	0.06	0.02	0.89	<0.01
Error	Valence						
	Focal EBPM	196.59	150	1.31			
	Non-focal EBPM	205.96	150	1.37			
	TBPM	190.74	150	1.27			
	Arousal						
	Focal EBPM	409.42	150	2.73			
	Non-focal EBPM	442.45	150	2.95			
	TBPM	449.52	150	3.00			
Total	Valence						
	Focal EBPM	2946.50	154				
	Non-focal EBPM	2928.75	154				
	TBPM	2893.25	154				

Arousal		
Focal EBPM	2396.50	154
Non-focal EBPM	2458.75	154
TBPM	2312.00	154

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

Main effects of mood conditions were found in the SAM valence and arousal scores in all instances of mood induction, *ps* < 0.01. A clear pattern emerged, as those in the negative mood condition were significantly more aroused, with lower valence ratings.

Prospective Memory Performance

PM was operationalized by three experimental PM tasks: (1) focal EBPM, (2) non-focal EBPM, and (3) TBPM. The calculations were identical to Experiment I. In focal EBPM and non-focal EBPM, performance was quantified by the proportion of correct responses to PM targets. In TBPM, the proportion of correct responses was defined by an appropriate response within a time window of ± 15000 ms at each PM target interval (two-minute). I also quantified the number of clock checks at 30 seconds prior to each PM target interval. Corresponding mean scores were presented in Table 19.

Table 19. *Prospective Memory Performance in Experiment II*

	Induction types				Mood conditions			
	Mind wandering		Open monitoring		Neutral		Negative	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Focal EBPM	0.84	0.26	0.90	0.16	0.90	0.16	0.84	0.26
Non-focal EBPM	0.66	0.32	0.70	0.29	0.67	0.30	0.69	0.31
TBPM accuracy	0.61	0.37	0.65	0.41	0.63	0.39	0.63	0.39
TBPM clock checks	4.25	3.16	4.73	4.40	4.55	4.58	4.43	2.89

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

To explore whether there was an interaction between induction types and mood conditions, I computed a 2 [between-subject factor: induction types (OM vs. MW)] × 2 [between-subject factor: mood conditions (negative vs. neutral)] MANOVA in all performance indicators of PM. 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 (see Table 20).

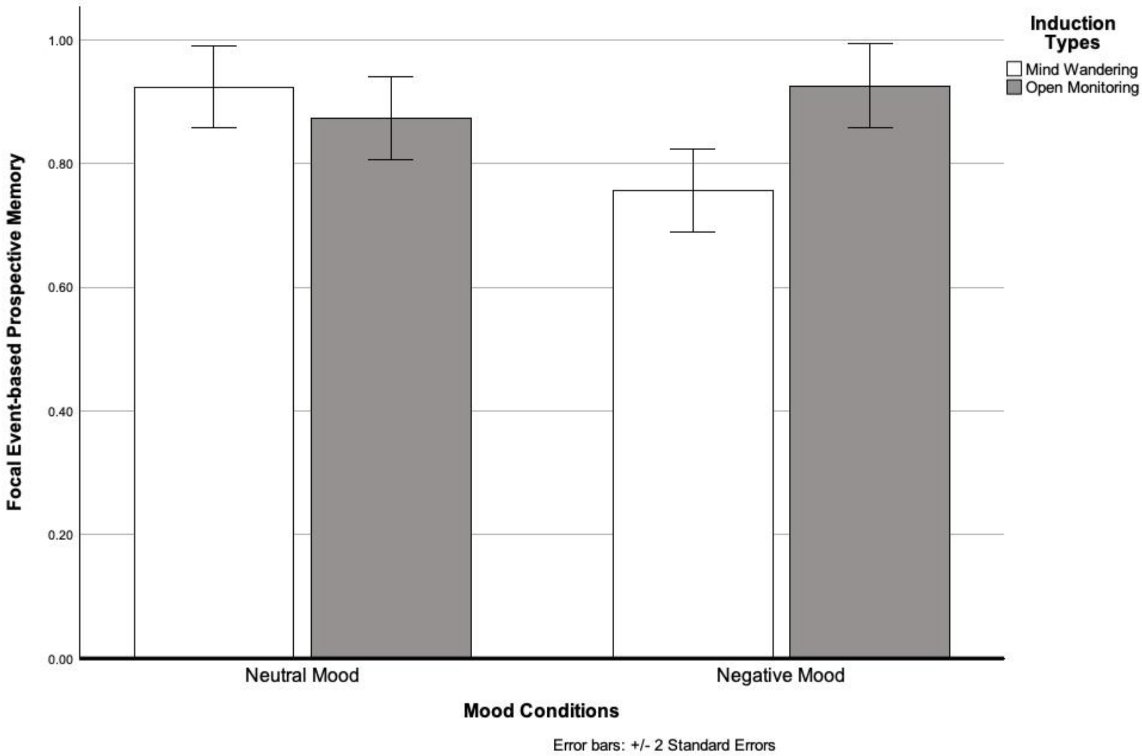
Table 20. *Univariate Tests of Performance Indicator in Prospective Memory in Experiment II*

Source	Dependent variables	*SS*	*df*	*MS*	*F*	*p*	η^2_p
Induction types	Focal EBPM	0.15	1	0.15	3.42	0.07	0.02
	Non-focal EBPM	0.09	1	0.09	0.96	0.33	0.01
	TBPM accuracy	0.05	1	0.05	0.33	0.57	<0.01
	TBPM clock checks	8.86	1	8.86	0.60	0.44	<0.01
Mood conditions	Focal EBPM	0.14	1	0.14	3.24	0.07	0.02
	Non-focal EBPM	0.01	1	0.01	0.07	0.80	<0.01
	TBPM accuracy	<0.01	1	<0.01	0.03	0.87	<0.01
	TBPM clock checks	0.71	1	0.71	0.05	0.83	<0.01
Induction types × Mood conditions	Focal EBPM	0.45	1	0.45	10.23	<0.01	0.07
	Non-focal EBPM	0.19	1	0.19	2.01	0.16	0.01
	TBPM accuracy	0.08	1	0.08	0.51	0.48	<0.01
	TBPM clock checks	1.98	1	1.98	0.13	0.72	<0.01
Error	Focal EBPM	6.46	147	0.04			
	Non-focal EBPM	13.75	147	0.09			
	TBPM accuracy	23.85	147	0.16			
	TBPM clock checks	2176.24	147	14.80			
Total	Focal EBPM	121.73	151				
	Non-focal EBPM	83.78	151				
	TBPM accuracy	75.56	151				
	TBPM clock checks	5232.00	151				

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

Except for focal EBPM ($p < 0.01$, $\eta^2_p = 0.07$), there were no significant interactions of induction types × mood conditions in all dependent variables. I carried out a simple effect analysis to further explore the interaction effect in focal EBPM (see Figure 9 for a visualization of the result).

Figure 8. *Induction Types × Mood Conditions Interaction in Focal Event-based Prospective Memory*



There were no differences between MW ($M = 0.92$, $SE = 0.03$) and OM ($M = 0.88$, $SE = 0.03$) in the neutral mood condition, $p = 0.28$. In the negative mood condition, the OM group ($M = 0.93$, $SE = 0.03$) outperformed the MW group ($M = 0.75$, $SE = 0.03$), $p < 0.01$. Within the OM group, no differences were observed between the neutral and negative mood conditions, $p = 0.27$. However, those in the MW group performed worse in the negative mood condition, $p < 0.01$. Therefore, the result indicated that OM facilitated focal EBPM under the influence of a negative mood. However, neither a negative mood nor OM has an effect on non-focal EBPM and TBPM.

Discussion

This experiment explores whether OM, compared to MW, can facilitate PM in older adults by reducing emotional interference from negative emotions. Overall, there is a partial support to this aim, which is substantiated by a significant interaction between induction types (OM vs. MW) and mood conditions (negative vs. neutral) in focal EBPM (but not in non-focal EBPM and TBPM). Further, an absence of induction types × mood conditions interaction in the SAM valence and arousal scores indicated that OM and MW did not result in different levels of emotional reactivity to negative stimuli. Therefore, an improved focal EBPM in the OM group in the negative mood condition supports the notion that OM reduces emotional interference. This is consistent with experimental studies about the effects of mindfulness in emotional contexts. Utilizing a mood induction paradigm, Ortner et al. (2007, Experiment II) also reported that mindfulness reduced emotional interference in a cognitive task in young adults, comparing to an active control (i.e., to practice relaxation exercises) and a passive control.

This experiment also extends the findings in Ortner et al. (2007) in several important ways. Because Ortner et al. (2007) combined FA and OM as a package of mindfulness practice, it would be difficult to delineate whether FA or OM as an active contributor to the reduced emotional interference. On the other hand, the observable effect of this experiment can only be attributed to OM, which suggests that OM alone may be sufficient to reduce emotional interference, suggesting its potentials to improve cognitive performance under an emotional context.

Considering Ortner et al. (2007) exclusively sampled on healthy adults, the current findings further illustrate the generalizability and feasibility of utilizing OM to reduce emotional interference in an older population. Although emotional wellbeing is generally improved in older adults (Carstensen et al., 2000), they are still susceptible to emotional interference, especially in performing a cognitive challenging task. Evidently, Phillips et al. (2002) observed a poorer performance in older adults after a mood induction in a planning task (but not in young adults). Because OM requires relatively less cognitive resources to reduce emotional interference, it should allow the preservation of cognitive control for the task at hand.

OM also appears to facilitate cognitive control in tasks that require a higher level of strategic demand. Based on the Resources Allocation Model (Ellis & Ashbrook, 1988), emotional interference should be especially pronounced in these tasks because they require more cognitive resources to perform. Whereas Ortner et al. (2007) had employed a cognitive task with relatively low strategic demands (i.e., to decide the pitch of a tone after viewing images of emotional valence), this experiment utilized a considerably more demanding task with a dual-task paradigm to assess PM. Therefore, it appears the OM is sufficient to reduce emotional interference while preserving cognitive resources to an extent that it can translate into a better performance for cognitive tasks where a higher level of strategic demands is required.

There were, however, non-significant effects of OM on other PM measures (non-focal EBPM and TBPM). Despite the successful mood induction procedures (as indicated in the lower SAM valence and higher SAM arousal scores in the negative mood condition), there seems to be an absence of mood effects on these tasks, which is evident in the non-significant main effects of mood conditions (negative vs. neutral). A plausible explanation could be that both tasks were too cognitively demanding for our elderly participants. As discussed in Experiment I, non-focal EBPM and TBPM are more demanding than focal EBPM (Craik, 1986; McDaniel & Einstein, 2000). According to the Working Memory Model of Distraction (Van Dillen & Koole, 2007), a cognitively demanding task can disrupt a negative emotional experience. Typically, a negative mood activates a 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 consistent with this model, with little or no mood effects observed in performing a cognitively demanding task (Erber & Tesser, 1992; van den Hout et al., 2010). Because OM primarily reduces emotional interference, it may serve little to enhance cognitive performance under an emotionally neutral context, which is evident in the absence of main effects of induction types (OM vs. MW) in the neutral mood conditions in all PM measures. Due to the absence of mood effects, perhaps this may explain why there is a lack of observable effects of OM in non-focal EBPM and TBPM.

CHAPTER VI: GENERAL DISCUSSION

This thesis explores ways to facilitate PM in older adults. A systematic review (Chapter II) is performed to synthesize the existing evidence of PM training for this population. Based upon these findings, two experiments (Chapter IV and V) were conducted to explore the potential benefits of mindfulness on PM. Note that there are two common styles of meditative practice: (1) FA and (2) OM (Lutz et al., 2008). To shed light on how mindfulness facilitates PM, Experiment I (Chapter IV) and Experiment II (Chapter V) explore the specific effects of FA and OM on PM. Experiment I explores whether FA can facilitate PM through a more efficient attentional control in older adults. Experiment II investigates whether OM can enhance PM in this population under the influence of a negative mood.

With the scant evidence of process-based PM training, Chapter II identified the uses of mental imagery and external aids as useful strategy-based approaches to facilitate PM in older adults. However, there are some major limitations in using these approaches. A strategy typically confines its target to a single PM phase, which is often insufficient to facilitate PM remembering. An example could be the use of mental imagery, which targets the intention formation phase exclusively to strengthen an activation of PM cue-action pair (Potvin et al., 2011). Likewise, external aids only target the intention initiation phase to prompt for timely task execution (Reese & Cherry, 2002). Note, however, a successful PM remembering would undergo four phases: (1) intention formation, (2) intention retention, (3) intention initiation, and (4) intention execution (Kliegel et al., 2002). A failure of each phase would inadvertently result in a PM forgetting. Perhaps more critically, strategy-based approaches often lack transferability to untrained tasks (see McDaniel & Bugg, 2012). This is partly because of these strategies are being context dependent. Whereas the use of mental imagery is useful in EBPM, it would be relatively less effective in TBPM due to the absence of an external cue.

This creates additional challenges for older adults to identify and apply the best strategy in different scenarios to meet with their PM needs.

Utilizing a process-based approach may overcome these limitations. It encourages transferability to untrained tasks by targeting the underlying cognitive processes in PM (Zelinski, 2009), with the potentials to benefit tasks that also utilize the trained cognitive processes. Since there is currently a lack of process-based PM training, it remains unclear on which cognitive process could potentially be an efficient target. Thus far, two vastly different process-based PM approaches have both yielded some levels of success. Rose et al. (2015) reported gains in utilizing a computer simulation training to directly target all cognitive processes of PM. Targeting more generic cognitive functions, Pandya (2020) also observed an improvement in PM after a yoga practice.

Besides these approaches, attentional control could be a potential target in process-based PM training. Literature in PM development across adulthood suggests that older adults are particularly deficient in PM tasks that require a higher level of strategic demand, primarily due to an insufficient attentional control (Craik, 1986). Theoretical frameworks of PM retrieval also highlight an important role of attentional control. In EBPM, the PAM Theory (Smith, 2003; Smith & Bayen, 2004) suggests that attentional control is at least required in encoding a PM cue, resolving attentional conflicts between tasks, monitoring the PM cue, performing a recognition check for the PM cue, and switching between tasks to execute the PM intention. In TBPM, the TWTE Model (Harris & Wilkins, 1982) also implies that attentional control is required in performing clock checks, especially that clock checks tend to increase when the PM target time interval is approaching. Considering a close theoretical association between attentional control and mindfulness, it has the potentials to facilitate PM performance in older adults.

Overall, Experiment I and II demonstrated that mindfulness can improve PM in older adults. In Experiment I, the FA group outperformed the MW group in focal EBPM. The OM group in Experiment II also performed better than the MW group in focal EBPM under the influence of a negative mood. These positive results have contributed to the scant evidence of PM training in older adults. Over the last two decades, there were only 11 studies of PM training for this population. Yet, a systematic review conducted in two decades ago was able to locate 67 studies of training in episodic memory for older adults (Verhaeghen et al., 1992). The lack of PM training is surprising because of its significance for older adults. PM is vital to many daily tasks for them to sustain 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 for this population, this thesis offers preliminary evidence about the potential utility of mindfulness to assist older adults in achieving functional independence.

The findings in Experiment I and II also align with the notion that mindfulness improves cognitive performance in older adults (Malinowski & Shalamanova, 2017; Prakash et al., 2014). As a cognitive exercise, mindfulness is triggered and coordinated by cognitive processes such as executive functions and attentional control (Holas & Jankowski, 2013). Engaging in these cognitive processes during a mindfulness meditation can enhance its efficiency (Tang et al., 2015). Perhaps more importantly, this enhanced efficiency can translate into PM. Because successful PM requires different cognitive processes at multiple phases (Kliegel et al., 2002), this provides evidence of the extended benefits of mindfulness in terms of facilitating the cognitive performance in more complex tasks, such as PM.

Experiment I also indicated an indirect effect of sustained attention (SART's omission errors) between FA and focal EBPM, which furthers our understanding on the mechanism of how FA facilitates PM. A partial mediation of sustained attention between FA and focal

EBPM also aligns with the PAM Theory, suggestion attentional control has a unique contribution in PM. However, it requires caution to interpret this finding because of a weak partial mediation. Critically, the indirect effects were not consistently observed in other performance indicators in measures of attentional control. This finding was unexpected because these measures should tap into the three attentional networks proposed by Posner and Petersen (1990). The SART requires the alerting network (sustained attention) to maintain vigilant when attending a disproportionately large amount of Go stimuli while withholding responses to the No-go stimuli. The SCWT requires the executive attention and orienting (selective attention) networks to resolve attentional conflicts between semantic and visual processing so one can attend to its visual feature. Due to a heavy involvement of attentional control in PM, these performance indicators of attentional control should also mediate the effects of FA on PM.

A possible interpretation about the weak, partial mediation of sustained attention between FA and focal EBPM could be that other subsystems of attentional control are involved in PM. Given that PM is dual task in nature, divided attention, the capacity to attend two sets of stimuli simultaneously, could play a larger role in PM than sustained, selective and executive attention. Evidently, increasing the load of divided attention can impair PM performance (Marsh & Hicks, 1998). In the intention formation phase, an insufficient allocation of resources in divided attention reduces the specificity of PM encoding (Einstein et al., 1997). A failure of divided attention can also disrupt the monitoring of a PM cue, causing a miss of the PM target (Smith, 2003; Smith & Bayen, 2004). Even in focal EBPM, which requires minimal attentional resources because of spontaneous retrieval, divided attention is at least involved in initiating a controlled memory search about the meaning of a PM cue (Harrison et al., 2014). Therefore, it appears that there is a differential engagement of subsystems of attentional control in PM. Perhaps future studies can systematically investigate the engagement of different aspects of attentional control in PM, which can guide future attention-based PM training to maximize its benefits.

An improvement in focal EBPM in Experiment I may suggest that FA can enhance divided attention. Sumantry and Stewart (2021) theorized that FA utilizes the capacity of divided attention in several ways. During FA meditation, it is necessary to keep track of potential distractors 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 might investigate the relationships between mindfulness, divided attention, and PM to provide further insights on how FA facilitates PM.

Experiment II also offered a novel understanding that OM primarily facilitates PM by reducing emotional interference from negative emotions. First, OM has a unique, positive effect on PM in emotional contexts, given that it did not result in better PM in a neutral context, suggesting that a bottom-up attentional style may not facilitate PM through more efficient attentional control. Second, OM and MW did not result in different levels of emotional reactivity under the influence of a negative mood, suggesting that an improved PM is likely the result of a reduced emotional interference. This is consistent with literature related to the mechanisms of OM. Particularly, OM encourages an awareness of one's emotional experience through self-monitoring the present-moment experience (Erisman & Roemer, 2010; Gratz & Roemer, 2004). This enables one to perform ER in a timely fashion before an emotion became intense (Teper et al., 2013). Perhaps more importantly, the current finding demonstrates the generalizability about the benefits of OM to an older population.

Despite an enhanced emotional wellbeing is often observed in an older population, they can be prone to emotional interference, partly because of an aging decline in cognitive resources. Since OM requires fewer cognitive resources to reduce emotional interference, it should facilitate a broad range of cognitive tasks, promoting far transfers of its benefits.

Implications

Theoretical Implications

Theoretically, this thesis contributes to an understanding that mindfulness can facilitate PM in older adults, which holds the promise to assist older adults to achieve functional independence. The current findings also contribute to a novel understanding of the underlying mechanisms through which FA and OM, two common styles of mindfulness meditations, facilitate PM in older adults. Notably, FA and OM appear to facilitate PM through distinct mechanisms. For example, FA improved focal EBPM in emotionally neutral contexts, and this effect was partially mediated by better sustained attention. In contrast, OM did not lead to better focal EBPM in emotionally neutral contexts. However, when older adults were under the influence of a negative mood, an improvement in focal EBPM was observed. This indicates that OM enhanced focal EBPM by reducing emotional interference, thereby allowing for more cognitive resources to be allocated to the task. The findings align with existing literature, which supports the notion that PM requires top-down attentional processes (Smith, 2003; Smith & Bayen, 2004). Consequently, FA, which enhances top-down control of attention, would likely benefit PM in emotionally neutral contexts. On the other hand, OM involves a bottom-up, stimulus driven response, which may be not as effective in facilitating PM in emotionally neutral contexts. Therefore, different types of meditative practices may have varying effects on PM, depending on the context and the specific cognitive processes involved.

As a process-based training, mindfulness improves PM by targeting attentional and emotional processes, where these enhanced processes can be employed in a wide range of untrained tasks. In contrast to a strategy-based training that relies older adults to identify the most relevant strategy for a PM task, which consumes cognitive resources, mindfulness does not require the uses of mnemonics to realize its benefits.

The preliminary positive effects of FA and OM on PM in this thesis also lay foundations for a larger scale mindfulness-based PM intervention for older adults. As mindfulness requires longer practice to maximize its benefits, future study can utilize a standardized eight-week MBSR or MBCT to explore whether it can facilitate PM tasks with a higher level of strategic demand, such as non-focal EBPM and TBPM. Utilizing standardized MBIs with a manualized protocol can further encourage replications to achieve a higher level of evidence base. In addition, employing a large scale MBI with homework assignments can encourage older adults to continue engage in regular mindfulness practices beyond the intervention, which may prevent a cognitive decline given its protective effects on biological markers of Alzheimer's disease, such as decreases in hippocampus volume and telomerase activity (Schutte & Malouff, 2014; Sevinc et al., 2021). Besides its cognitive gains, mindfulness can enhance psychological wellbeing in older adults. In a systematic review of 15 studies of MBI, Geiger et al. (2016) concluded that mindfulness can reduce feelings of loneliness, depression, anxiety and stress, as well as increase positive mood in older adults. Therefore, mindfulness should facilitate better cognitive and psychological wellbeing, which further contributes to a successful aging experience.

Practical Implications

The utilization of mindfulness as a PM training can also save costs in healthcare. If PM needs of older adults are left unattended, it could lead to subjective memory complaints, which increase their utilization of healthcare by about 60% in the next three years (Waldorff et al., 2009). Meanwhile, a mindfulness-based PM training can be flexibly implemented with minimal costs. In contrast to the traditional delivery of a memory trial (e.g., Farzin et al., 2018b), which requires participants to physically attend multiple training sessions, mindfulness training can take place at home. For example, Polsinelli et al. (2020) demonstrated the feasibility of an online FA training to improve attentional control in older adults. Therefore, older adults are likely motivated to join the training as it saves them time and costs of traveling. Mindfulness may also be particularly appealing to an older population. Anecdotal reports from our participants suggest that older adults are receptive to mindfulness. Perhaps due to the popularization of MBIs, most older adults are aware of its associated benefits. Similarly, Parra et al. (2019) also found that older adults have perceived mindfulness as helpful to improve their physical, psychological, and social domains.

Limitations

This thesis has some limitations. First, the hypothesized effects of FA and OM on PM were tested in isolation, which remains difficult to rule out a potential interaction effect between the potential mechanisms of FA and OM on PM. Because FA and OM are both integral components of mindfulness (Lutz et al., 2008), there could be some overlapping effects between the two. For example, Dolcos et al. (2020) found that FA resulted in more efficient down-regulation of negative emotions because of better attentional control. Indeed, there is an intimate linkage between attentional control and ER. Difficulties in attentional control can result in maladaptive ER and mood disorders (Hu et al., 2017). Morillas-Romero et al. (2015) also reported a positive association between self-reported capacity of attention control and objective performance in ER following exposures to negative stimuli. Nevertheless, the results of Experiment II demonstrate that OM did not lead to a more efficient top-down attentional control for older adults, at least for emotionally neutral contexts. Without testing an interaction between the possible effects of FA and OM, however, it would be difficult to delineate whether FA can improve PM by reducing interference in an emotional context. Due to the constraints in sample size feasibility, a 3 [between-subject factor: induction types (FA vs. OM vs. MW)] × 2 [between-subject factor: mood conditions (negative vs. neutral)] factorial design was not conducted to tease out a potential interaction between the associated effects of FA and OM on PM performance. However, future studies should incorporate such a design to obtain further insights on how mindfulness can facilitate PM.

In addition, emotional interference from positive emotions was not explored in Experiment II. Based on the Resource Allocation Model (Ellis & Ashbrook, 1988), intense mood states should impact cognitive performance irrespective to their emotional valence. While the disruptive effect from negative emotions on PM is consistently reported (e.g., Kliegel et al., 2005; Pupillo et al., 2022), emotional interference from positive emotions on PM is rather ambiguous. Ballhausen et al. (2015) found that a positive mood induction resulted in worse EBPM performance in older adults. However, Rendell et al. (2011) found the opposite, in that a positive mood induction enhanced EBPM performance in older adults. At the same time, it remains unclear on whether OM is sufficient to reduce an emotional interference from positive emotions. Brown et al. (2022) reported that OM increased self-reported pleasantness in response to positive stimuli. Therefore, OM may amplify an emotional interference from positive emotions and further impair cognitive performance. Future studies should incorporate a positive mood induction to explore its effects on PM, which can shed light on whether a positive mood would impair PM, and whether OM can facilitate PM by minimizing an emotional interference from positive emotions.

To obtain a naturalistic sample of older adults, the selection of participants was not based on previous meditation experience. Therefore, the majority of participants in the FA group (76.9%) in Experiment I possessed some level of previous experience. They might be more readily engaged in the FA induction. While the results of Experiment I and II did not reveal significant differences between groups regarding previous meditation experience, conducting a moderation analysis would be more appropriate to explore whether there is a positive moderating effect of meditation experience on the effects of FA and OM on PM. However, due to unequal sample sizes (between those with and without meditation experience), such analyses 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.

Moreover, this thesis did not utilize follow-up tests in both experiments. It remains difficult to draw conclusions on whether the effects of mindfulness on PM can be sustained beyond the experimental session. Also, the brevity of mindfulness inductions could pose a limitation. Both experiments utilized one-time, brief mindfulness inductions (25-minute) to establish preliminary evidence of the effects of mindfulness on PM. However, mindfulness typically requires repeated practices to consolidate its associated benefits (Williams, 2010). There is evidence suggesting a dose-response relationship in training attentional control with mindfulness (Chan & Woollacott, 2007; MacLean et al., 2010). Perhaps an insufficient dosage of FA also partly explains the null effects of FA on more demanding tasks such as non-focal EBPM and TBPM. Nonetheless, utilizing a brief laboratory manipulation of mindfulness can effectively minimize external factors such as treatment expectancy due to longer exposure to an intervention, which may complicate the results (Lin et al., 2022). By dismantling mindfulness to its bare components (FA and OM), this can advance our understanding on how mindfulness facilitates PM. With the positive preliminary findings that mindfulness can facilitate PM, future studies may implement a larger scale MBI with multiple training sessions and homework practices, as well as follow-up tests to further explore its training gains.

Conclusion

This thesis for the first time offers preliminary evidence of mindfulness as an alternative process-based training that can facilitate PM in older adults. It appears that even brief inductions of FA and OM can produce measurable benefits in focal EBPM (but not in non-focal EBPM and TBPM). While FA enhanced focal EBPM, such improvement was only weakly and partially mediated by better sustained attention. Nonetheless, this thesis also offers a novel understanding that OM reduced emotional interference from negative emotions and improved focal EBPM. Therefore, mindfulness may hold the promise to facilitate older adults to achieve functional independence, which ultimately contributes to a successful aging experience.

ACKNOWLEDGEMENTS

Chapter II contains materials from "*Prospective Memory Training for Healthy Older Adults*" by Tsang et al. (2022), published in Clinical Gerontologist. The thesis author was responsible for study conceptualization, literature review, data extraction, data analysis, and drafting the manuscript.

Chapters III, IV, V, and VI contain materials from "*The Acute Effects of Focused Attention and Open Monitoring Meditations on Prospective Memory in Older Adults*" by Tsang, Lu, and Lo (in press), published in Mindfulness. The thesis author was responsible for study conceptualization, literature review, data extraction, data analysis, and drafting the manuscript.

REFERENCES

Aikens, K. A., Astin, J., Pelletier, K. R., Levanovich, K., Baase, C. M., Park, Y. Y., & Bodnar, C. M. (2014). Mindfulness goes to work: Impact of an online workplace intervention. *Journal of Occupational and Environmental Medicine*, *56*(7), 721-731.

Ainsworth, B., Eddershaw, R., Meron, D., Baldwin, D. S., & Garner, M. (2013). The effect of focused attention and open monitoring meditation on attention network function in healthy volunteers. *Psychiatry Research*, *210*(3), 1226–1231.

Altgassen, M., Kliegel, M., & Martin, M. (2009). Event-based prospective memory in depression: The impact of cue focality. *Cognition and Emotion*, *23*(6), 1041–1055.

Altgassen, M., Rendell, P., Bernhard, A., Henry, J., Bailey, P., Phillips, L., & Kliegel, M. (2014). Future thinking improves prospective memory performance and plan enactment in older adults. *Quarterly Journal of Experimental Psychology*, *68*(1), 192-204.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. American Psychiatric Association.

Anderson, F. T., McDaniel, M. A., & Einstein, G. O. (2017). Remembering to remember: An examination of the cognitive processes underlying prospective memory. In J. H. Byrne (Ed.), *Learning and memory: A comprehensive reference 2E* (pp. 451-463). Elsevier.

Andrewes, D. G., Kinsella, G., & Murphy, M. (1996). Using a memory handbook to improve everyday memory in community-dwelling older adults with memory complaints. *Experimental Aging Research*, *22*(3), 305-322.

Ballhausen, N., Rendell, P. G., Henry, J. D., Joeffry, S., & Kliegel, M. (2015). Emotional valence differentially affects encoding and retrieval of prospective memory in older adults. *Neuropsychology, Development, and Cognition: Section B*, *22*(5), 544–559.

Bennike, I. H., Wieghorst, A., & Kirk, U. (2017). Online-based mindfulness training reduces behavioral markers of mind wandering. *Journal of Cognitive Enhancement*, *1*, 172-181.

Bollinger, J., Rubens, M. T., Masangkay, E., Kalkstein, J., & Gazzaley, A. (2011). An expectation-based memory deficit in aging. *Neuropsychologia*, *49*(6), 1466-1475.

Boudewyn, M. A., Luck, S. J., Farrens, J. L., & Kappenman, E. S. (2018). How many trials does it take to get a significant ERP effect? It depends. *Psychophysiology*, *55*(6), e13049.

Bowen, S., Witkiewitz, K., Dillworth, T. M., Chawla, N., Simpson, T. L., Ostafin, B. D., Larimer, M. E., Blume, A. W., Parks, G. A., & Marlatt, G. A. (2006). Mindfulness meditation and substance use in an incarcerated population. *Psychology of Addictive Behaviors*, *20*(3), 343-347.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The Self-Assessment Manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*(1), 49-59.

Brandt, J., Spencer, M., & Folstein, M. F. (1988). The Telephone Interview for Cognitive Status. *Neuropsychiatry, Neuropsychology, & Behavioral Neurology*, *1*(2), 111-117.

Britton, W. B., Davis, J. H., Loucks, E. B., Peterson, B., Cullen, B. H., Reuter, L., Rando, A., Rahrig, H., Lipsky, J., & Lindahl, J. R. (2018). Dismantling Mindfulness-Based Cognitive Therapy: Creation and validation of 8-week focused attention and open monitoring interventions within a 3-armed randomized controlled trial. *Behaviour Research and Therapy*, *101*, 92-107.

Brom, S., & Kliegel, M. (2014). Improving everyday prospective memory performance in older adults: Comparing cognitive process and strategy training. *Psychology and Aging*, *29*(3), 744-755.

Brown, K. W., Berry, D., Eichel, K., Beloborodova, P., Rahrig, H., & Britton, W. B. (2022). Comparing impacts of meditation training in focused attention, open monitoring, and mindfulness-based cognitive therapy on emotion reactivity and regulation: Neural and subjective evidence from a dismantling study. *Psychophysiology*, *59*(7), e14024.

Brown, K. W., Goodman, R. J., & Inzlicht, M. (2013). Dispositional mindfulness and the attenuation of neural responses to emotional stimuli. *Social Cognitive and Affective Neuroscience*, *8*(1), 93–99.

Brown, K. W., Goodman, R. J., Ryan, R. M., & Anālayo, B. (2016). Mindfulness enhances episodic memory performance: Evidence from a multimethod investigation. *PLoS One*, *11*(4), e0153309.

Brummer, L., Stopa, L., & Bucks, R. (2014). The influence of age on emotion regulation strategies and psychological distress. *Behavioural and Cognitive Psychotherapy*, *42*(6), 668–681.

Buodo, G., Sarlo, M., & Palomba, D. (2002). Attentional resources measured by reaction times highlight differences within pleasant and unpleasant, high arousing stimuli. *Motivation and Emotion*, *26*(2), 123–138.

Burgess, P. W., Dumontheil, I., & Gilbert, S. J. (2007). The gateway hypothesis of rostral prefrontal cortex (area 10) function. *Trends in Cognitive Sciences*, *11*(7), 290-298.

Burgess, P. W., Gonen-Yaacovi, G., & Volle, E. (2011). Functional neuroimaging studies of prospective memory: What have we learnt so far? *Neuropsychologia*, *49*(8), 2246-2257.

Burke, S. N., & Barnes, C. A. (2006). Neural plasticity in the ageing brain. *Nature Reviews Neuroscience*, *7*(1), 30-40.

Carlson, L. E., Speca, M., Patel, K. D., & Goodey, E. (2003). Mindfulness-based stress reduction in relation to quality of life, mood, symptoms of stress, and immune parameters in breast and prostate cancer outpatients. *Psychosomatic Medicine*, *65*(4), 571-581.

Carstensen, L. L. (2006). The influence of a sense of time on human development. *Science*, *5782*(5782), 1913–1915.

Carstensen, L. L., Pasupathi, M., Mayr, U., & Nesselroade, J. R. (2000). Emotional experience in everyday life across the adult life span. *Journal of Personality and Social Psychology*, *79*(4), 644-655.

Cavallini, E., Pagnin, A., & Vecchi, T. (2003a). Aging and everyday memory: The beneficial effect of memory training. *Archives of Gerontology and Geriatrics*, *37*(3), 241-257.

Cavallini, E., Pagnin, A., & Vecchi, T. (2003b). The rehabilitation of memory in old age: effects of mnemonics and metacognition in strategic training. *Clinical Gerontologist*, *26*(1-2), 125-141.

Chambers, R., Gullone, E., & Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clinical Psychology Review*, *29*(6), 560–572.

Chan, D., & Woollacott, M. (2007). Effects of level of meditation experience on attentional focus: Is the efficiency of executive or orientation networks improved? *Journal of Alternative and Complementary Medicine*, *13*, 651–658.

Charles, S. T., & Carstensen, L. L. (2010). Social and emotional aging. *Annual Review of Psychology*, *61*, 383–409.

Chasteen, A., Park, D., & Schwarz, N. (2001). Implementation intentions and facilitation of prospective memory. *Psychological Science*, *12*(6), 457-461.

Cheng, C., & Cheng, M. (2007). To validate the Chinese version of the 2Q and PHQ-9 questionnaires in Hong Kong Chinese patients. *The Hong Kong Practitioner*, *29*, 381-390.

Cheyne, J. A., Solman, G. J., Carriere, J. S., & Smilek, D. (2009). Anatomy of an error: A bidirectional state model of task engagement/disengagement and attention-related errors. *Cognition*, *111*(1), 98-113.

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review*, *31*(3), 449-464.

Cohn, M., Emrich, S. M., & Moscovitch, M. (2008). Age-related deficits in associative memory: The influence of impaired strategic retrieval. *Psychology and Aging*, *23*, 93–103.

Cona, G., Scarpazza, C., Sartori, G., Moscovitch, M., & Bisiacchi, P. S. (2015). Neural bases of prospective memory: A meta-analysis and the "Attention to Delayed Intention" (AtoDI) model. *Neuroscience and Biobehavioral Reviews*, *52*.

Craig, A. D. (2009). How do you feel—now? The anterior insula and human awareness. *Nature Reviews Neuroscience*, *10*(1), 59-70.

Craik, F. I. M. (1986). A functional account of age differences in memory. In F. I. M. Craik (Ed.), *Memory, attention, and aging* (1st ed., pp. 11-16). Routledge.

Craik, F. I. M., & Bialystok, E. (2006). Planning and task management in older adults: Cooking breakfast. *Memory & Cognition*, *34*, 1236-1249.

Craik, F. I. M., & Rose, N. S. (2012). Training cognition: Parallels with physical fitness? *Journal of Applied Research in Memory and Cognition*, *1*(1), 51-52.

Creswell, J. D., Way, B. M., Eisenberger, N. I., & Lieberman, M. D. (2007). Neural correlates of dispositional mindfulness during affect labeling. *Psychosomatic Medicine*, *69*(6), 560–565.

Crovitz, H. F., & Daniel, W. F. (1984). Measurements of everyday memory: Toward the prevention of forgetting. *Bulletin of the Psychonomic Society*, *22*(5), 413-414.

d'Ydewalle, G., Bouckaert, D., & Brunfaut, E. (2001). Age-related differences and complexity of ongoing activities in time- and event-based prospective memory. *The American Journal of Psychology*, *114*(3), 411-423.

Dennis, N. A., Daselaar, S., & Cabeza, R. (2007). Effects of aging on transient and sustained successful memory encoding activity. *Neurobiology of Aging*, *28*(11), 1749-1758.

Dolcos, F., & McCarthy, G. (2006). Brain systems mediating cognitive interference by emotional distraction. *The Journal of Neuroscience*, *26*(7), 2072-2079.

Dolcos, F., Katsumi, Y., Shen, C., Bogdan, P. C., Jun, S., Larsen, R., Heller, W., Bost, K. F., & Dolcos, S. (2020). The impact of focused attention on emotional experience: A functional MRI investigation. *Cognitive, Affective, & Behavioral Neuroscience*, *20*(5), 1011-1026.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*(4), 717-726.

Einstein, G. O., & McDaniel, M. A. (1996). Retrieval processes in prospective memory: Theoretical approaches and some new empirical findings. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 115–141). Lawrence Erlbaum Associates, Inc.

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science*, *14*(6), 286-290.

Einstein, G. O., McDaniel, M. A., Manzi, M., Cochran, B., & Baker, M. (2000). Prospective memory and aging: Forgetting intentions over short delays. *Psychology and Aging*, *15*, 671-683.

Einstein, G. O., McDaniel, M. A., Richardson, S. L., Guynn, M. J., & Cunfer, A. R. (1995). Aging and prospective memory: Examining the influences of self-initiated retrieval processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 996–1007.

Einstein, G. O., Smith, R. E., McDaniel, M. A., & Shaw, P. (1997). Aging and prospective memory: The influence of increased task demands at encoding and retrieval. *Psychology and Aging*, *12*(3), 479–488.

Ellis, H. C., & Ashbrook, P. W. (1988). Resource Allocation Model of the effects of depressed mood states on memory. In K. Fiedler & J. Forgas (Eds.), *Affect, cognition and social behavior* (pp. 25-43). Hogrefe.

Erber, R., & Tesser, A. (1992). Task effort and the regulation of mood: The absorption hypothesis. *Journal of Experimental Social Psychology*, *28*(4), 339-359.

Erisman, S. M., & Roemer, L. (2010). A preliminary investigation of the effects of experimentally induced mindfulness on emotional responding to film clips. *Emotion*, *10*(1), 72–82.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, *14*(3), 340-347.

Farzin, A., Ibrahim, R., Madon, Z., & Basri, H. (2018a). Challenges faced and lessons learned a multi-component prospective memory training program for Malaysian older adults. *Dementia & Neuropsychologia*, *12*(2), 189-195.

Farzin, A., Ibrahim, R., Madon, Z., & Basri, H. (2018b). The efficiency of a multicomponent training for prospective memory among healthy older adults: A single-blind, randomized controlled within-participants cross-over trial. *American Journal of Physical Medicine & Rehabilitation*, *97*(9), 628-635.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149-1160.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189-198.

Foster, E. R., Rose, N. S., McDaniel, M. A., & Rendell, P. G. (2013). Prospective memory in Parkinson disease during a virtual week: Effects of both prospective and retrospective demands. *Neuropsychology*, *27*(2), 170-181.

Fox, K. C., Dixon, M. L., Nijeboer, S., Girn, M., Floman, J. L., Lifshitz, M., Ellamil, M., Sedlmeier, P., & Christoff, K. (2016). Functional neuroanatomy of meditation: A review and meta-analysis of 78 functional neuroimaging investigations. *Neuroscience and Biobehavioral Reviews*, *65*, 208-228.

Gardner, R. S., & Ascoli, G. A. (2015). The natural frequency of human prospective memory increases with age. *Psychology and Aging*, *30*(2), 209-219.

Geiger, P. J., Boggero, I. A., Brake, C. A., Caldera, C. A., Combs, H. L., Peters, J. R., & Baer, R. A. (2016). Mindfulness-based interventions for older adults: A review of the effects on physical and emotional well-being. *Mindfulness*, *7*(2), 296–307.

Gill, L. N., Renault, R., Campbell, E., Rainville, P., & Khoury, B. (2020). Mindfulness induction and cognition: A systematic review and meta-analysis. *Consciousness and Cognition*, *84*, 102991.

Girardeau, J. C., Blondé, P., Makowski, D., Abram, M., Piolino, P., & Sperduti, M. (2020). The impact of state and dispositional mindfulness on prospective memory: A virtual reality study. *Consciousness and Cognition*, *81*, 102920.

Glisky, E. L. (1996). Prospective memory and the frontal lobes. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 249–266). Lawrence Erlbaum Associates, INC.

Grady, C. L., & Craik, F. I. M. (2000). Changes in memory processing with age. *Current Opinion in Neurobiology*, *10*(2), 224-231.

Grady, C. L., Sarraf, S., Saverino, C., & Campbell, K. (2016). Age differences in the functional interactions among the default, frontoparietal control, and dorsal attention networks. *Neurobiology of Aging*, *41*, 159-172.

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54.

Greenberg, J., Shapero, B. G., Mischoulon, D., & Lazar, S. W. (2017). Mindfulness-based cognitive therapy for depressed individuals improves suppression of irrelevant mental-sets. *European Archives of Psychiatry and Clinical Neuroscience*, *267*(3), 277-282.

Gross, J. J. (1998a). Antecedent- and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology*, *74*(1), 224–237.

Gross, J. J. (1998b). The emerging field of emotion regulation: An integrative review. *Review of General Psychology*, *2*(3), 271–299.

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348–362.

Gross, J. J., & Levenson, R. W. (1997). Hiding feelings: The acute effects of inhibiting negative and positive emotion. *Journal of Abnormal Psychology*, *106*(1), 95–103.

Harris, C. R. (2001). Cardiovascular responses of embarrassment and effects of emotional suppression in a social setting. *Journal of Personality and Social Psychology*, *81*(5), 886–897.

Harris, J. E. (1980). Memory aids people use: Two interview studies. *Memory and Cognition*, *8*, 31-38.

Harris, J. E., & Wilkins, A. J. (1982). Remembering to do things: A theoretical framework and an illustrative experiment. *Human Learning*, *1*, 123-136.

Harrison, T. L., Mullet, H. G., Whiffen, K. N., Ousterhout, H., & Einstein, G. O. (2014). Prospective memory: Effects of divided attention on spontaneous retrieval. *Memory & Cognition*, *42*(2), 212-224.

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford Press.

Helton, W. S., Head, J., & Russell, P. N. (2011). Reliable- and unreliable-warning cues in the Sustained Attention to Response Task. *Experimental Brain Research*, *209*(3), 401–407.

Henry, J. D., MacLeod, M. S., Phillips, L. H., & Crawford, J. R. (2004). A meta-analytic review of prospective memory and aging. *Psychology and Aging*, *19*(1), 27-39.

Hering, A., Rendell, P. G., Rose, N. S., Schnitzspahn, K. M., & Kliegel, M. (2014). Prospective memory training in older adults and its relevance for successful aging. *Psychological Research*, *78*, 892-904.

Hertzog, C., & Dunlosky, J. (2012). Metacognitive approaches can promote transfer of training: Comment on McDaniel and Bugg. *Journal of Applied Research in Memory and Cognition*, *1*(1), 61-63.

Hicks, J. L., Marsh, R. L., & Cook, G. I. (2005). Task interference in time-based, event-based, and dual intention prospective memory conditions. *Journal of Memory and Language*, *53*, 430-444.

Higgins, J. P. T., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (2020). *Cochrane handbook for systematic reviews of interventions (version 6.1)*. Cochrane. www.training.cochrane.org/handbook

Hogan, M. J., Kelly, C. A., & Craik, F. I. M. (2006). The effects of attention switching on encoding and retrieval of words in younger and older adults. *Experimental Aging Research*, *32*(2), 153-183.

Holas, P., & Jankowski, T. (2013). A cognitive perspective on mindfulness. *International Journal of Psychology*, *48*(3), 232-243.

Hu, B., Rao, J., Li, X., Cao, T., Li, J., Majoe, D., & Gutknecht, J. (2017). Emotion regulating attentional control abnormalities in major depressive disorder: An event-related potential study. *Scientific Reports*, *7*(1), 13530.

Ihle, A., Albiński, R., Gurynowicz, K., & Kliegel, M. (2018). Four-week strategy-based training to enhance prospective memory in older adults: Targeting intention retention is more beneficial than targeting intention formation. *Gerontology*, *64*(3), 257-265.

Isbel, B., Weber, J., Lagopoulos, J., Stefanidis, K., Anderson, H., & Summers, M. J. (2020). Neural changes in early visual processing after 6 months of mindfulness training in older adults. *Scientific Reports*, *10*(1), 21163.

Jáger, T., & Kliegel, M. (2008). Time-Based and event-based prospective memory across adulthood: Underlying mechanisms and differential costs on the ongoing task. *The Journal of General Psychology*, *135*, 4-22.

Jankowski, T., & Holas, P. (2020). Effects of brief mindfulness meditation on attention switching. *Mindfulness*, *11*(5), 1150–1158.

Jones, W. E., Benge, J. F., & Scullin, M. K. (2021). Preserving prospective memory in daily life: A systematic review and meta-analysis of mnemonic strategy, cognitive training, external memory aid, and combination interventions. *Neuropsychology*, *35*(1), 123-140.

Josefsson, T., & Broberg, A. (2011). Meditators and non-meditators on sustained and executive attentional performance. *Mental Health, Religion & Culture*, *14*(3), 291-309.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, *4*(1), 33-47.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice*, *10*(2), 144-156.

Kalanthroff, E., Cohen, N., & Henik, A. (2013). Stop feeling: Inhibition of emotional interference following stop-signal trials. *Frontiers in Human Neuroscience*, *7*, 78.

Keng, S. L., Robins, C. J., Smoski, M. J., Dagenbach, J., & Leary, M. R. (2013). Reappraisal and mindfulness: A comparison of subjective effects and cognitive costs. *Behaviour Research and Therapy*, *51*(12), 899-904.

Kennedy, Q., Mather, M., & Carstensen, L. L. (2004). The role of motivation in the age-related positivity effect in autobiographical memory. *Psychological Science*, *15*(3), 208–214.

Khoury, B., Lecomte, T., Fortin, G., Masse, M., Therien, P., Bouchard, V., Chapleau, M. A., Paquin, K., & Hofmann, S. G. (2013). Mindfulness-based therapy: A comprehensive meta-analysis. *Clinical Psychology Review*, *33*(6), 763–771.

Kidder, D. P., Park, D. C., Hertzog, C., & Morrell, R. W. (1997). Prospective memory and aging: The effects of working memory and prospective memory task load. *Aging, Neuropsychology, and Cognition*, *4*(2), 93-112.

Kirasic, K. C., Allen, G. L., Dobson, S. H., & Binder, K. S. (1996). Aging, cognitive resources, and declarative learning. *Psychology and Aging*, *11*(4), 658-670.

Kliegel, M., & Martin, M. (2003). Prospective memory research: Why is it relevant? *International Journal of Psychology*, *38*(4), 193-194.

Kliegel, M., Altgassen, M., Hering, A., & Rose, N. S. (2011). A process-model based approach to prospective memory impairment in Parkinson's disease. *Neuropsychologia*, *49*(8), 2166-2177.

Kliegel, M., Jäger, T., & Phillips, L. H. (2008). Adult age differences in event-based prospective memory: A meta-analysis on the role of focal versus nonfocal cues. *Psychology and Aging*, *23*(1), 203-208.

Kliegel, M., Jáger, T., Phillips, L., Federspiel, E., Imfeld, A., Keller, M., & Zimprich, D. (2005). Effects of sad mood on time-based prospective memory. *Cognition & Emotion*, *19*(8), 1199-1213.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2002). Complex prospective memory and executive control of working memory: A process model. *Psychologische Bettrage*, *44*, S303-S318.

Kolb, B., Mychasiuk, R., Williams, P., & Gibb, R. (2011). Brain plasticity and recovery from early cortical injury. *Developmental Medicine and Child Neurology*, *53*(4), 4-8.

Kondo, H., Osaka, N., & Osaka, M. (2004). Cooperation of the anterior cingulate cortex and dorsolateral prefrontal cortex for attention shifting. *Neuroimage*, *23*(2), 670–679.

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*, 606-613.

Levi, U., & Rosenstreich, E. (2019). Mindfulness and memory: A review of findings and a potential model. *Journal of Cognitive Enhancement*, *3*, 302-314.

Lewis, P. A., Critchley, H. D., Rotshtein, P., & Dolan, R. J. (2007). Neural correlates of processing valence and arousal in affective words. *Cerebral Cortex*, *17*(3), 742–748.

Lin, Y., Tang, R., & Braver, T. S. (2022). Investigating mindfulness influences on cognitive function: On the promise and potential of converging research strategies. *Psychonomic Bulletin & Review*, *29*(4), 1198-1222.

Lindsay, E. K., & Creswell, J. D. (2017). Mechanisms of mindfulness training: Monitor and Acceptance Theory (MAT). *Clinical Psychology Review*, *51*, 48–59.

Lindsay, E. K., & Creswell, J. D. (2019). Mindfulness, acceptance, and emotion regulation: Perspectives from Monitor and Acceptance Theory (MAT). *Current Opinion in Psychology*, *28*, 120–125.

Lueke, A., & Lueke, N. (2019). Mindfulness improves verbal learning and memory through enhanced encoding. *Memory & Cognition*, *47*(8), 1531-1545.

Lustig, C., Snyder, A. Z., Bhakta, M., O'Brien, K. C., McAvoy, M., Raichle, M. E., Morris, J. C., & Buckner, R. L. (2003). Functional deactivations: Change with age and dementia of the Alzheimer type. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(24), 14504–14509.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163–169.

Lutz, J., Herwig, U., Opialla, S., Hittmeyer, A., Jäncke, L., Rufer, M., Grosse Holtforth, M., & Brühl, A. B. (2014). Mindfulness and emotion regulation—An fMRI study. *Social Cognitive and Affective Neuroscience*, *9*(6), 776–785.

MacLean, K. A., Ferrer, E., Aichele, S. R., Bridwell, D. A., Zanesco, A. P., Jacobs, T. L., King, B. G., Rosenberg, E. L., Sahdra, B. K., Shaver, P. R., Wallace, B. A., Mangun,

G. R., & Saron, C. D. (2010). Intensive meditation training improves perceptual discrimination and sustained attention. *Psychological Science*, *21*(6), 829-839.

Madden, D. J., & Langley, L. K. (2003). Age-related changes in selective attention and perceptual load during visual search. *Psychology and Aging*, *18*(1), 54–67.

Madden, D. J., Costello, M. C., Dennis, N. A., Davis, S. W., Shepler, A. M., Spaniol, J., Bucur, B., & Cabeza, R. (2010). Adult age differences in functional connectivity during executive control. *Neuroimage*, *52*(2), 643–657.

Mahan, S., Rous, R., & Adlam, A. (2017). Systematic review of neuropsychological rehabilitation for prospective memory deficits as a consequence of acquired brain injury. *Journal of the International Neuropsychological Society*, *23*(3), 254-256.

Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro Scale for rating quality of randomized controlled trials. *Physical Therapy*, *83*(8), 713-721.

Malinowski, P., & Shalamanova, L. (2017). Meditation and cognitive ageing: The role of mindfulness meditation in building cognitive reserve. *Journal of Cognitive Enhancement*, *1*, 96–106.

Marsh, R. L., & Hicks, J. L. (1998). Event-based prospective memory and executive control of working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*(2), 336–349.

Marsh, R. L., Hancock, T. W., & Hicks, J. L. (2002). The demands of an ongoing activity influence the success of event-based prospective memory. *Psychonomic Bulletin & Review*, *9*(3), 604–610.

Marsh, R. L., Hicks, J., & Landau, J. (1998). An investigation of everyday prospective memory. *Memory & Cognition*, *26*(4), 633-643.

Mateos, P. M., Valentin, A., González-Tablas, M. D. M., Espadas, V., Vera, J. L., & Jorge, I. G. (2016). Effects of a memory training program in older people with severe memory loss. *Educational Gerontology*, *42*(11), 740-748.

Mather, M., & Knight, M. (2005). Goal-directed memory: The role of cognitive control in older adults' emotional memory. *Psychology and Aging*, *20*(4), 554–570.

McDaniel, M. A., & Bugg, J. M. (2012). Memory training interventions: What has been forgotten? *Journal of Applied Research in Memory and Cognition*, *1*(1), 58-60.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology*, *14*, S127-S144.

McDaniel, M. A., & Einstein, G. O. (2007). *Prospective memory: An overview and synthesis of an emerging field*. Sage Publications, Inc.

McDaniel, M. A., & Einstein, G. O. (2011). The neuropsychology of prospective memory in normal aging: A componential approach. *Neuropsychologia*, *49*(8), 2147-2155.

McDaniel, M. A., Binder, E. F., Bugg, J. M., Waldum, E. R., Dufault, C., Meyer, A., Johanning, J., Zheng, J., Schechtman, K. B., & Kudelka, C. (2014). Effects of cognitive training with and without aerobic exercise on cognitively demanding everyday activities. *Psychology and Aging*, *29*(3), 717-730.

McDaniel, M. A., Robinson-Riegler, B., & Einstein, G. O. (1998). Prospective remembering: Perceptually driven or conceptually driven processes? *Memory & Cognition*, *26*(1), 121-134.

McDonald, A., Haslam, C., Yates, P., Gurr, B., Leeder, G., & Sayers, A. (2011). Google Calendar: A new memory aid to compensate for prospective memory deficits following acquired brain injury. *Neuropsychological Rehabilitation*, *21*(6), 784-807.

McDougall, G. (2000). Memory improvement in assisted living elders. *Issues in Mental Health Nursing*, *21*(2), 217-233.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*, 167–202.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, *6*(7), e1000097.

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences*, *7*(3), 134–140.

Morillas-Romero, A., Tortella-Feliu, M., Balle, M., & Bornas, X. (2015). Spontaneous emotion regulation and attentional control. *Emotion*, *15*(2), 162-175.

Morrison, S. E., & Salzman, C. D. (2010). Re-valuing the amygdala. *Current Opinion in Neurobiology*, *20*(2), 221–230.

Moscovitch, M. (1994). Memory and working with memory: Evaluation of a component process model and comparisons with other models. In D. L. Schacter & E. Tulving (Eds.), *Memory systems* (pp. 269-310). The MIT Press.

Mowszowski, L., Lampit, A., Walton, C., & Naismith, S. (2016). Strategy-based cognitive training for improving executive functions in older adults: A systematic review. *Neuropsychology Review*, *26*(3), 252-270.

Moynihan, J. A., Chapman, B. P., Klorman, R., Krasner, M. S., Duberstein, P. R., Brown, K. W., & Talbot, N. L. (2013). Mindfulness-based stress reduction for older adults: Effects on executive function, frontal alpha asymmetry and immune function. *Neuropsychobiology*, *68*(1), 34–43.

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, *53*(4), 695-699.

Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, *9*(5), 242–249.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology*, *130*(3), 466-478.

Oksanen, K. M., Waldum, E. R., McDaniel, M. A., & Braver, T. S. (2014). Neural mechanisms of time-based prospective memory: Evidence for transient monitoring. *PLoS One*, *9*(3), e92123.

Okuda, J., Fujii, T., Yamadori, A., Kawashima, R., Tsukiura, T., Fukatsu, R., Suzuki, K., Ito, M., & Fukuda, H. (1998). Participation of the prefrontal cortices in prospective memory: Evidence from a PET study in humans. *Neuroscience Letters*, *253*(2), 127–130.

Opitz, P. C., Rauch, L. C., Terry, D. P., & Urry, H. L. (2012). Prefrontal mediation of age differences in cognitive reappraisal. *Neurobiology of Aging*, *33*(4), 644-655.

Ortner, C. N. M., Kilner, S. J., & Zelazo, P. D. (2007). Mindfulness meditation and reduced emotional interference on a cognitive task. *Motivation and Emotion*, *31*(4), 271–283.

Pandya, S. P. (2020). Yoga education program for improving memory in older adults: A multicity 5-year follow-up study. *Journal of Applied Gerontology*, *39*(6), 576-587.

Parasuraman, R., & Giambra, L. (1991). Skill development in vigilance: Effects of event rate and age. *Psychology and Aging*, *6*(2), 155–169.

Park, D. C., Smith, A. D., Dudley, W. N., & Lafronza, V. N. (1989). Effects of age and a divided attention task presented during encoding and retrieval on memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(6), 1185-1191.

Parra, D. C., Wetherell, J. L., Van Zandt, A., Brownson, R. C., Abhishek, J., & Lenze, E. J. (2019). A qualitative study of older adults' perspectives on initiating exercise and mindfulness practice. *BMC Geriatrics*, *19*(1), 354.

Persson, J., Lustig, C., Nelson, J. K., & Reuter-Lorenz, P. A. (2007). Age differences in deactivation: A link to cognitive control? *Journal of Cognitive Neuroscience*, *19*(6), 1021–1032.

Phillips, L. H., Smith, L., & Gilhooly, K. J. (2002). The effects of adult aging and induced positive and negative mood on planning. *Emotion*, *2*(3), 263–272.

Polsinelli, A. J., Kaszniak, A. W., Glisky, E. L., & Ashish, D. (2020). Effects of a brief, online, focused attention mindfulness training on cognition in older adults: A randomized controlled trial. *Mindfulness*, *11*, 1182-1193.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*, 25–42.

Potvin, M., Rouleau, I., Sénéchal, G., & Giguère, J. (2011). Prospective memory rehabilitation based on visual imagery techniques. *Neuropsychological Rehabilitation*, *21*(6), 899-924.

Prakash, R. S., De Leon, A. A., Patterson, B., Schirda, B. L., & Janssen, A. L. (2014). Mindfulness and the aging brain: A proposed paradigm shift. *Frontiers in Aging Neuroscience*, *6*, 120.

Pupillo, F., Powell, D., Phillips, L. H., & Schnitzspahn, K. (2022). Remember to stay positive: Affect and prospective memory in everyday life. *Applied Cognitive Psychology*, *36*(1), 179-190.

Raskin, S. A. (2009). Memory for Intentions Screening Test: Psychometric properties and clinical evidence. *Brain Impairment*, *10*(1), 23-33.

Raskin, S. A., & Sohlberg, M. M. (2009). Prospective memory intervention: A review and evaluation of a pilot restorative intervention. *Brain Impairment*, *10*(1), 76-86.

Raskin, S. A., Smith, M. P., Mills, G., Pedro, C., & Zamroziewicz, M. (2019). Prospective memory intervention using visual imagery in individuals with brain injury. *Neuropsychological Rehabilitation*, *29*(2), 289-304.

Reed, P. (2018). Previous mindfulness experience interacts with brief mindfulness induction when reducing stimulus overselectivity. *Applied Cognitive Psychology, 33*(2), 265-271.

Reese, C. M., & Cherry, K. E. (2002). The effects of age, ability, and memory monitoring on prospective memory task performance. *Aging, Neuropsychology, and Cognition*, *9*(2), 98-113.

Rendell, P. G., Phillips, L. H., Henry, J. D., Brumby-Rendell, T., de la Piedad Garcia, X., Altgassen, M., & Kliegel, M. (2011). Prospective memory, emotional valence and ageing. *Cognition & Emotion*, *25*(5), 916-925.

Rendell, P., & Henry, J. (2009). A review of Virtual Week for prospective memory assessment: Clinical implications. *Brain Impairment*, *10*(1), 14-22.

Reynolds, J. R., West, R., & Braver, T. S. (2009). Distinct neural circuits support transient and sustained processes in prospective memory and working memory. *Cerebral Cortex*, *19*(5), 1208–1221.

Richards, J. M., & Gross, J. J. (2000). Emotion regulation and memory: The cognitive costs of keeping one's cool. *Journal of Personality and Social Psychology*, *79*(3), 410–424.

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). 'Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, *35*(6), 747–758.

Rockwood, K., Dobbs, A. R., Rule, B. G., Howlett, S. E., & Black, W. R. (1992). The impact of pacemaker implantation on cognitive functioning in elderly patients. *Journal of the American Geriatrics Society, 40*, 142-146. https://www.cochranelibrary.com/central/doi/10.1002/central/CN-00296211/full

Rose, N. S., Rendell, P. G., Hering, A., Kliegel, M., Bidelman, G. M., & Craik, F. I. M. (2015). Cognitive and neural plasticity in older adults' prospective memory following training with the Virtual Week computer game. *Frontiers in Human Neuroscience*, *9*(592), 1-13.

Rosenstreich, E., & Ruderman, L. (2017). A dual-process perspective on mindfulness, memory, and consciousness. *Mindfulness*, *8*, 505-516.

Rosenzweig, S., Greeson, J. M., Reibel, D. K., Green, J. S., Jasser, S. A., & Beasley, D. (2010). Mindfulness-based stress reduction for chronic pain conditions: Variation in treatment outcomes and role of home meditation practice. *Journal of Psychosomatic Research*, *68*(1), 29–36.

Rude, S. S., Hertel, P. T., Jarrold, W., Covich, J., & Hedlund, S. (1999). Depression-related impairments in prospective memory. *Cognition & Emotion*, *13*(3), 267-276.

Rummel, J., Hepp, J., Klein, S. A., & Silberleitner, N. (2012). Affective state and event-based prospective memory. *Cognition and Emotion*, *26*(2), 351-361.

Rushworth, M. F., Johansen-Berg, H., Göbel, S. M., & Devlin, J. T. (2003). The left parietal and premotor cortices: Motor attention and selection. *Neuroimage*, *20*, S89–S100.

Sarter, M., Givens, B., & Bruno, J. P. (2001). The cognitive neuroscience of sustained attention: Where top-down meets bottom-up. *Brain Research Reviews*, *35*(2), 146–160.

Scheibe, S., Sheppes, G., & Staudinger, U. M. (2015). Distract or reappraise? Age-related differences in emotion-regulation choice. *Emotion*, *15*(6), 677-681.

Schmidt, I. W., Berg, I. J., & Deelman, B. G. (2001). Prospective memory training in older adults. *Educational Gerontology*, *27*(6), 455-478.

Schnitzspahn, K. M., Thorley, C., Phillips, L., Voigt, B., Threadgold, E., Hammond, E. R., Mustafa, B., & Kliegel, M. (2014). Mood impairs time-based prospective memory in young but not older adults: The mediating role of attentional control. *Psychology and Aging*, *29*(2), 264-270.

Schonert-Reichl, K. A., Oberle, E., Lawlor, M. S., Abbott, D., Thomson, K., Oberlander, T. F., & Diamond, A. (2015). Enhancing cognitive and social-emotional development through a simple-to-administer mindfulness-based school program for elementary school children: A randomized controlled trial. *Developmental Psychology*, *51*(1), 52–66.

Schutte, N. S., & Malouff, J. M. (2014). A meta-analytic review of the effects of mindfulness meditation on telomerase activity. *Psychoneuroendocrinology*, *42*, 45-48.

Scullin, M. K., McDaniel, M. A., Shelton, J. T., & Lee, J. H. (2010). Focal/nonfocal cue effects in prospective memory: Monitoring difficulty or different retrieval processes? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *36*(3), 736-749.

Sevinc, G., Rusche, J., Wong, B., Datta, T., Kaufman, R., Gutz, S. E., Schneider, M., Todorova, N., Gaser, C., Thomalla, G., Rentz, D., Dickerson, B. D., & Lazar, S. W. (2021). Mindfulness training improves cognition and strengthens intrinsic connectivity between the hippocampus and posteromedial cortex in healthy older adults. *Frontiers in Aging Neuroscience*, *13*, 702796.

Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London: Series B*, *298*(1089), 199–209.

Shallice, T. (1988). *From neuropsychology to mental structure*. Cambridge University Press.

Shapiro, K. L., Raymond, J. E., & Arnell, K. M. (1997). The attentional blink. *Trends in Cognitive Sciences*, *1*(8), 291–296.

Shapiro, S. L., Oman, D., Thoresen, C. E., Plante, T. G., & Flinders, T. (2008). Cultivating mindfulness: Effects on well-being. *Journal of Clinical Psychology*, *64*(7), 840–862.

Simons, J. S., Schölvinck, M. L., Gilbert, S. J., Frith, C. D., & Burgess, P. W. (2006). Differential components of prospective memory? Evidence from fMRI. *Neuropsychologia*, *44*(8), 1388–1397.

Sleimen-Malkoun, R., Devillers-Réolon, L., & Temprado, J. J. (2023). A single session of mindfulness meditation may acutely enhance cognitive performance regardless of meditation experience. *PLoS One, 18*(3), e0282188.

Smith, G., Della Sala, S., Logie, R. H., & Maylor, E. A. (2000). Prospective and retrospective memory in normal ageing and dementia: A questionnaire study. *Memory*, *8*(5), 311-321.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(3), 347-361.

Smith, R. E., & Bayen, U. J. (2004). A multinomial model of event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*(4), 756-777.

Smith, R. E., Rogers, M. D. M., McVay, J. C., Lopez, J. A., & Loft, S. (2014). Investigating how implementation intentions improve non-focal prospective memory tasks. *Consciousness and Cognition*, *27*, 213-230.

Sohlberg, M. M., & Mateer, C. A. (1993). *Assessing and training prospective memory using the prospective memory screening and prospective memory training: Manual*. Association for Neuropsychological Research and Development.

Sprague, B., Freed, S., Webb, C., Phillips, C., Hyun, J., & Ross, L. (2019). The impact of behavioral interventions on cognitive function in healthy older adults: A systematic review. *Ageing Research Reviews*, *52*, 32-52.

St Jacques, P. L., Dolcos, F., & Cabeza, R. (2009). Effects of aging on functional connectivity of the amygdala for subsequent memory of negative pictures: A network analysis of functional magnetic resonance imaging data. *Psychological Science*, *20*(1), 74–84.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*, 643-662.

Sumantry, D., & Stewart, K. E. (2021). Meditation, mindfulness, and attention: A meta-analysis. *Mindfulness*, *12*(6), 1332–1349.

Tang, Y. Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213–225.

Teasdale, J. D., Segal, Z. V., Williams, J. M. G., Ridgeway, V. A., Soulsby, J. M., & Lau, M. A. (2000). Prevention of relapse/recurrence in major depression by Mindfulness-Based Cognitive Therapy. *Journal of Consulting and Clinical Psychology*, *68*, 615-623.

Teper, R., Segal, Z. V., & Inzlicht, M. (2013). Inside the mindful mind: How mindfulness enhances emotion regulation through improvements in executive control. *Current Directions in Psychological Science*, *22*(6), 449–454.

Tomasino, B., & Fabbro, F. (2016). Increases in the right dorsolateral prefrontal cortex and decreases the rostral prefrontal cortex activation after-8 weeks of focused attention based mindfulness meditation. *Brain and Cognition*, *102*, 46–54.

Tombaugh, T. N., & McIntyre, N. J. (1992). The Mini-Mental State Examination: A comprehensive review. *Journal of the American Geriatrics Society*, *40*(9), 922-935.

Troyer, A. K. (2001). Improving memory knowledge, satisfaction, and functioning via an education and intervention program for older adults. *Aging, Neuropsychology, and Cognition*, *8*(4), 256-268.

Tsai, J. L., Lee, C. Y., Lin, Y. C., Tzeng, O. J., & Hung, D. L. (2006). Neighborhood size effects of Chinese words in lexical decision and reading. *Language and Linguistics*, *7*(3), 659-675.

Tsang, A. P. L., Au, A., & Lo, H. H. M. (2022). Prospective memory training for healthy older adults: A systematic review. *Clinical Gerontologist*, *45*(3), 486-502.

Tsang, A. P. L., Lu, H., & Lo, H. H. M. (in press). The acute effects of focused attention and open monitoring meditations on prospective memory in older adults. *Mindfulness*.

Turkelson, L., & Mano, Q. (2022). The current state of mind: A systematic review of the relationship between mindfulness and mind-wandering. *Journal of Cognitive Enhancement*, *6*, 272-294.

Urry, H. L., & Gross, J. J. (2010). Emotion regulation in older age. *Current Directions in Psychological Science*, *19*(6), 352-357.

Urry, H. L., van Reekum, C. M., Johnstone, T., Kalin, N. H., Thurow, M. E., Schaefer, H. S., Jackson, C. A., Frye, C. J., Greischar, L. L., Alexander, A. L., & Davidson, R. J. (2006). Amygdala and ventromedial prefrontal cortex are inversely coupled during regulation of negative affect and predict the diurnal pattern of cortisol secretion among older adults. *The Journal of Neuroscience*, *26*(16), 4415–4425.

Uttl, B. (2008). Transparent meta-analysis of prospective memory and aging. *PLoS One*, *3*(2), e1568.

van den Hout, M. A., Engelhard, I. M., Smeets, M. A. M., Hornsveld, H., Hoogeveen, E., de Heer, E., Toffolo, M. B. J., & Rijkeboer, M. (2010). Counting during recall: Taxing of working memory and reduced vividness and emotionality of negative memories. *Applied Cognitive Psychology*, *24*(3), 303-311.

Van Dillen, L. F., & Koole, S. L. (2007). Clearing the mind: A working memory model of distraction from negative mood. *Emotion*, *7*(4), 715-723.

Verhaeghen, P. (2021). Mindfulness and meditation training. In T. Strobach & J. Karbach (Eds.), *Cognitive training* (2 ed., pp. 243-253). Springer, Cham.

Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging*, *7*(2), 242-251.

Verhagen, A. P., de Vet, H. C., de Bie, R. A., Kessels, A. G., Boers, M., Bouter, L. M., & Knipschild, P. G. (1998). The Delphi list: A criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. *Journal of Clinical Epidemiology*, *51*, 1235-1241.

Villa, K. K., & Abeles, N. (2000). Broad spectrum intervention and the remediation of prospective memory declines in the able elderly. *Aging & Mental Health*, *4*(1), 21-29.

Waldorff, F. B., Siersma, V., & Waldemar, G. (2009). Association between subjective memory complaints and health care utilisation: A three-year follow up. *BMC Geriatrics*, *9*, 43.

Waldum, E., Dufault, C., & McDaniel, M. A. (2016). Prospective memory training: Outlining a new approach. *Journal of Applied Gerontology*, *35*(11), 1211-1234.

Welsh, K. A., Breitner, J. C. S., & Magruder-Habib, K. M. (1993). Detection of dementia in the elderly using telephone screening of cognitive status. *Neuropsychiatry, Neuropsychology and Behavioral Neurology*, *6*(2), 103-110.

Wenk-Sormaz, H. (2005). Meditation can reduce habitual responding. *Alternative Therapies in Health and Medicine*, *11*(2), 42–58.

Whitfield, T., Barnhofer, T., Acabchuk, R., Cohen, A., Lee, M., Schlosser, M., Arenaza-Urquijo, E. M., Böttcher, A., Britton, W. B., Coll-Padros, N., Collette, F., Chételat, G., Dautricourt, S., Demnitz-King, H., Dumais, T., Klimecki, O., Meiberth, D., Moulinet, I., Müller, T., . . . Marchant, N. L. (2022). The effect of mindfulness-based programs on cognitive function in adults: A systematic review and meta-analysis. *Neuropsychology Review*, *32*(3), 677–702.

Williams, J. M. G. (2010). Mindfulness and psychological process. *Emotion*, *10*(1), 1-7.

Wilson, B. A., Cockburn, J., & Baddeley, A. (1985). *Rivermead Behavioural Memory Test*. Thames Valley Test Company.

Wolfe, H. E., Livingstone, K. M., & Isaacowitz, D. M. (2022). More positive or less negative? Emotional goals and emotion regulation tactics in adulthood and old age. *The Journals of Gerontology: Series B*, *77*(9), 1603–1614.

Woods, S. P., Morgan, E. E., Loft, S., Matchanova, A., Verduzco, M., & Cushman, C. (2020). Supporting strategic processes can improve time-based prospective memory in the laboratory among older adults with HIV disease. *Neuropsychology, 34*(3), 249-263.

Woods, S. P., Weinborn, M., Li, Y. R., Hodgson, E., Ng, A. R. J., & Bucks, R. S. (2015). Does prospective memory influence quality of life in community-dwelling older adults? *Aging, Neuropsychology, and Cognition*, *22*(6), 679-692.

Woods, S. P., Weinborn, M., Velnoweth, A., Rooney, A., & Bucks, R. S. (2012). Memory for intentions is uniquely associated with instrumental activities of daily living in healthy older adults. *Journal of the International Neuropsychological Society*, *18*(1), 134-138.

Wright, B. C. (2017). What Stroop tasks can tell us about selective attention from childhood to adulthood. *British Journal of Psychology*, *108*, 583-607.

Yang, T., Wang, Y., Lin, H., Zheng, L., & Chan, R. C. K. (2013). Impact of the aging process on event-, time-, and activity-based prospective memory. *PsyCh Journal*, *2*, 63-73.

Yeung, P. Y., Wong, L. L., Chan, C. C., Leung, J. L., & Yung, C. Y. (2014). A validation study of the Hong Kong version of Montreal Cognitive Assessment (HK-MoCA) in Chinese older adults in Hong Kong. *Hong Kong Medical Journal*, *20*(6), 504-510.

Yu, J., Rawtaer, I., Feng, L., Fam, J., Kumar, A. P., Kee-Mun Cheah, I., Honer, W. G., Su, W., Lee, Y. K., Tan, E. C., Kua, E. H., & Mahendran, R. (2021). Mindfulness intervention for mild cognitive impairment led to attention-related improvements and neuroplastic changes: Results from a 9-month randomized control trial. *Journal of Psychiatric Research*, *135*, 203–211.

Zelinski, E. M. (2009). Far transfer in cognitive training of older adults. *Restorative Neurology and Neuroscience*, *27*(5), 455-471.

Zelinski, E. M. (2012). Are strategies necessary to improve memory? *Journal of Applied Research in Memory and Cognition*, *1*(1), 56-57.

Zhang, Y., Li, Y., Shi, Z., & Franz, E. (2022). Does acute exercise benefit emotion regulation? Electrophysiological evidence from affective ratings and implicit emotional effects on cognition. *Biological Psychology*, *172*, 108375.

APPENDICES

Appendix A: Script of Focused Attention

歡迎大家，嚟緊我哋將會開始一個叫靜觀呼吸嘅練習。請稍稍調整好個坐姿，頭頸腰背要自然垂直，膊頭放鬆。雙腳要穩陣咁踩喺地下，雙手放喺大髀上邊或者喺身體嘅兩旁。如果覺得合適，可以闔埋雙眼。或者你都可以微微張開雙眼。望住前方一至兩米嘅一個點。一陣間會聽到一下鐘聲響起，代表練習嘅開始。

Welcome everyone. Today, we are going to practice mindful breathing. You can slightly adjust your posture. Keep you back straight and relax your shoulders. Place your feet firmly on the ground with your hands being put on your thigh or at the side. If appropriate, you can close your eyes. You can also keep your eyes partially closed and gaze toward a point at about one to two meters. You will hear a bell whistle to signal the start of this practice.

「鐘聲響起」

"Bell Whistle"

依家可以慢慢讓注意力放到坐喺度嘅感覺上面，特別喺身體被支持嘅地方。可能喺腳板踩住地下嘅位置，亦都可能喺臀部，背脊掂住座椅嘅地方。去留心呢一份嘅壓力、觸感，呢一份被承托嘅感覺，踏實嘅、穩陣嘅。透過留心呢一啲嘅壓力、觸感，慢慢容讓個心翻返嚟，關注此時此刻。如果合適，可以喺下一下吸氣嘅時候，讓注意力由坐姿轉移到去留心呼吸。容讓注意力放喺腹部，有需要嘅亦都可以將雙手放喺腹部去感受。當吸氣嘅時候，腹部微微膨脹，肚皮有少少拉開嘅感覺。喺呼氣嘅時候，腹部微微收縮，肚皮有少少放鬆嘅感覺。喺呢個練習入面並唔需要去控制呼吸，純粹容讓呼吸自然咁樣去發生。當留意到腹部隨着呼吸變化嘅時候，喜歡嘅亦都可以將雙手放喺大髀或者身體嘅兩旁。個心繼續專注喺腹部。去留意腹部隨着一呼一吸膨

脹收縮。下一下吸氣嘅時候，可以容讓注意力由腹部轉移到去胸口嘅位置。如果需要嘅，可以將雙手或者單手放喺胸前，去讓自己更加留意到心口隨着吸氣時候微微升起，呼氣嘅時候心口微微落下。留心住一吸一呼，心口一升一落。如果已經比較容易留意到心口嘅起伏，都可以將雙手放返喺大髀或身體嘅兩旁。但個心繼續留意住胸口隨着呼吸嘅一升一落。

Now, you can slowly direct your attention to the sensations of sitting, especially on how your body is being supported. It could be the sensation of your feet standing on the ground. It could also be your hip or your back where it touches the chair. Direct your attention to these sensations of pressure. Focus on how your body is firmly supported by the chair. Focusing on these pressure sensations, you can slowly bring your mind to the present moment. If appropriate, you can direct your attention from the sensations of sitting to your breath. Bring your attention toward your stomach. You can also place your hands on it to feel the sensations. You can feel your stomach expands as you inhale. When you exhale, you can feel it contracting and relaxing. Remember that we do not need to control our breath. We simply let it occurs naturally. When you notice the changes in your stomach as you breathe, you can place your hands back on your thigh or at the side. Keep your mind focusing on how your stomach contracts and expands as you inhale and exhale. In your next breath, you can slowly direct your attention from your stomach to your chest. If appropriate, you can also place one or both of your hands at your chest to feel the expansion as you inhale. You may also feel the contraction as you exhale. When you notice the changes in your chest as you breathe, you can place your hands back on your thigh or at the side. But remember to keep your attention toward the expansion and contraction in your chest.

「暫停」

“Pause”

喺下一下吸氣嘅時候，可以容讓注意力由心口轉移到感受鼻孔。留心一下鼻孔喺吸氣時嘅感覺、呼氣時嘅感覺，透過留意氣息一進一出去感受一吸一呼。依家可以選擇將注意力繼續放喺鼻孔，又或者可以讓注意力轉移到去心口或者喺腹部。甚至乎呢三個位置邊一個最讓自己留意到呼吸，就將個心專注喺嗰個位置。透過留意嗰個部份嘅變化，去留意住整個嘅吸入、呼出，甚至乎可以睇吓留唔留意得到吸同呼當中小小嘅情感。

In your next breath, you can direct your attention from your chest to your nostrils. Pay attention to it as you breathe, such as how it feels like when air flow inward and outward of your nostrils. Now, you can either pay attention to your nostrils, chest, or stomach. You can direct your attention toward the part that you found easiest to keep you focus on your breathing. Through these tiny changes in sensations, you can direct your attention toward inhaling and exhaling. At the same time, you may even notice some tiny emotions have emerged as you breathe.

「暫停」

“Pause”

而喺練習嘅過程當中可能察覺到個心游走咗，唔再喺呼吸上面。可能個心走咗去出面聽到嘅聲音，可能去咗計劃一陣間做啲乜嘢，又或者喺回憶返之前發生嘅事，又或者純粹去咗發白日夢。但喺唔緊要喫，其實呢個正正就喺個心嘅常態，個心就好似馬騮仔咁跳嚟跳去。當發現個心游走咗嘅時候，甚至乎可以恭喜一下自己，因為呢一下又返番嚟到當下。當返番嚟到當下嘅時候，只需要穩定而溫柔咁，帶個心返番到嚟呼吸上邊。讓呼吸可以成為關注當下嘅基石，去盡可能留意住整個嘅呼入、呼出。

While you are practicing, you may notice your mind wander and no longer focus on your breathing. Your mind may be attracted to the sounds from outside or your plans after the exercise. It could be memories from the past or you are simply daydreaming. But don’t worry, this is the default state of our mind. Our mind is like a monkey jumping back and forth. When you notice your mind wanders, you can congratulate yourself because you are now at the present moment. Once you are back to the present moment, you can gently direct your focus onto your breathing. Pay close attention to the inhaling and exhaling and let them become an anchor of the present moment.

「暫停」

“Pause”

唔需要追求任何特別嘅境界，亦都唔需要特別去控制個呼吸。睇吓可唔可以藉住呢一個練習，去培養一個容讓嘅心。容讓呼吸自然咁樣一進一出，而個心只需要去觀察，去留心住身體隨住吸氣呼氣嘅變化，同當下嘅呼吸同在。

You do not have to reach a particular state nor control your breathing. The goal of this practice is to cultivate a non-judgmental attitude just as natural as we breathe. We are simply taking an observer role to focus on the changes of sensation as we breathe so we can be present with it.

「暫停」

“Pause”

如果發現自己分咗心嘅話呢，唔緊要嘅，亦都唔需要責怪自己覺得自己做得唔好。分咗心並冇讓我哋錯過任何嘅嘢。只需要發現分咗心時，將個心溫柔、穩定咁帶返嚟。關注返喺呼吸，關注返喺此時此刻。咁樣就已經喺一個好好嘅練習喇。

If you notice your mind wanders, that’s okay. You do not have to blame yourself for not being good enough. Even if our mind wanders, we did not miss out anything from the practice. All you need to do is to gently switch your attention back to breathing at the present moment. This is the only element required to make it a good practice.

「暫停」

"Pause"

而隨着練習嘅時間越嚟越長，可能會發現自己有一啲昏沉，咁可以留心一下自己呢一刻昏沉嘅狀態。可以去審視一下我依家嘅呢一個坐姿喺咪需要稍稍去調整，返番到去一個覺察而穩定嘅姿勢，稍稍提醒自己頭頸腰背坐返直。而另外一個選擇呢，可以微微張開雙眼望住前方一至兩米嘅一個點，亦都喺比較容易保持覺察。咁需要帶住覺察去做一啲坐姿嘅調整。如果可以嘅話，留意一下吸氣呼氣嘅時候，讓個心去觀察住整個嘅吸入、呼出，繼續讓呼吸成為關注當下嘅基石。

As the practice gets longer, you may feel a little drowsiness. You may take a moment to explore the state of drowsiness. You can examine whether you need to slightly adjust your posture. Examine whether your back is straight to keep an alert and stable posture. You can also partially open your eyes to gaze at one to two meters in front of you. It may help to keep you alert. Remain to be alerted as you adjust your posture. If possible, let your mind observe the inhaling and exhaling while letting your breath as an anchor for you to focus on the present moment experience.

「暫停」

"Pause"

而個心游走左一千一萬次都好，都唔緊要。因為正正代表着有一千一萬次嘅機會，去帶返個心返嚟。關注返喺呼吸、關注返去此時此刻。

Even if your mind wanders a thousand times or ten thousand times, that's okay. This means that you have a thousand or ten thousand opportunities to bring your mind back to your breathing at the present moment.

「暫停」

"Pause"

而隨着練習嘅時間越嚟越長，可能身體一啲地方會有比較強烈嘅感覺，而令到我哋嘅注意力被拉扯到去身體嘅呢一啲感覺。咁喺改變坐姿之前，可以藉住呢一個嘅機會俾少少時間去容讓身體去適應一啲強烈嘅感覺。隨着一吸一呼，去留心一下身體呢一啲比較強烈嘅感覺。唔需要急着去改變呢一啲身體嘅感覺。而如果呢一個方法可以嘅話呢，繼續去保持住呢一個坐姿，容讓呼吸去培養自己同身體嘅呢一啲感覺共處。咁如果都喺需要嘅話，可以調整一下坐姿去稍稍舒緩一下呢一啲強烈嘅身體感覺。咁喺改變坐姿之前，可以先喺心中升起呢一個想改變坐姿嘅念頭，然後有意咁樣去留心自己點樣去改變呢一個坐嘅姿勢，對呢一番動作繼續保持住自己嘅覺察。當調整完坐姿之後，就可以容讓注意力再一次放返到去呼吸、繼續留心一吸一呼。

As the practice becomes longer and longer, you may notice some intense bodily sensations. These sensations may drag away our focus. Before adjusting your posture, you can give a moment for your body to adapt these uncomfortable bodily sensations. As you are inhaling and exhaling, you can focus on these bodily sensations. Don’t rush to change these sensations. If possible, you can maintain your current posture. Try to coexist with these bodily sensations as you breathe. If you would like to, you can adjust your posture to reduce these bodily sensations. Before adjusting, you can raise a thought in your mind that you would like to switch your sit position. Then, you can maintain full consciousness in a set of actions on how you adjust your posture. Once you have adjusted your posture, gently bring your attention back to your breath. Keep focusing on the inhaling and exhaling.

「暫停」

“Pause”

呢一個靜觀呼吸嘅練習，就快結束啦。而一陣間你會聽到三下鐘聲，代表練習嘅結束。咁當鐘聲完全消失之後，覺得合適時可以慢慢再一次張開雙眼。

We are almost done here. You will hear three bell whistles to signal the end of our practice. When the bell whistles end, you can slowly open your eyes once you are ready.

「鐘聲響起」

"Bell Whistle"

完成咗呢個練習之後呢，未必需要急於起返身㗎。可以稍稍伸展一下腳、腰部，去聽吓身體嘅聲音，然後先慢慢起翻身。多謝大家同我去做呢一個靜觀呼吸嘅練習。

Don't rush to get up. You can stretch your feet or your back. Try listening to the voices of your body. Then, you can slowly get back up. Thank you everyone for doing this exercise with me.

Appendix B: Script of Open Monitoring

歡迎大家，咁嚟緊會同大家進行一個靜觀練習。咁喺開始做練習之前，可以稍稍調整一下坐嘅姿勢。咁有兩個要點：第一個就喺坐得舒服，第二個就喺坐得醒神嘅、覺醒嘅。普遍我哋可以坐喺張櫈嘅三分一前少少嘅位置，比較容易讓雙腳踩返喺地下。頭頸腰背自然垂直會喺一個比較容易拉直脊骨嘅坐姿，然後可以讓雙手放鬆放喺大髀上面，又或者身體嘅兩旁。可以花少少時間去感覺一下而家呢一個坐姿喺咪舒服，讓自己去做呢一個靜觀嘅練習。而嚟緊我哋會做一個靜觀練習去察覺當下發生嘅所有經歷，呢一個喺一個全然嘅覺察。咁喺一陣間嘅指導入面，我會向大家去介紹點樣去留心自己嘅一啲經驗。但喺做之前呢，可以先介紹一下到底靜觀喺啲乜嘢嚟嘅。靜觀喺講緊練習有意嘅、唔批判咁去留心當下嘅經驗。當中並唔需要特別去要求自己達到某一啲嘅境界，例如要自己放鬆，又或者一定要做到心無雜念。重點在於要盡可能去覺察每一刻所發生嘅事情，咁呢本身就已經喺一個好好嘅練習嚟㗎喇。而喺一陣間嘅練習入面亦都會向大家介紹一個叫做標籤嘅技巧，就好似攞住一張 memo 紙貼上去一啲經驗到。例如我留心到聲音就代表「聽到」，可能我睇到一啲嘢代表「睇到」。咁我哋會去用標籤呢一個方法令到自己覺察當下。一陣間嘅指導入面會更加仔細咁樣去介紹、引導大家去用呢一個方法幫助自己開放留心當下嘅經驗。當預備好嘅時候，喜歡既可以闔埋對眼，又或者微微垂低雙眼去望住前面一至兩米嘅一個點。一陣間會有一下鐘聲，代表練習嘅開始。

Welcome everyone. Today, we are going to do a mindfulness practice. Before that, we can slightly adjust our posture. There are two main points about our posture. First, try to sit in a comfortable position. Second, you should remain alert in your posture. Typically, we sit at about one third of the seat so you can place your feet firmly on the ground. You can also sit with your back straight and put your hands on your thigh or at the side. Take a moment to see if you are in a comfortable posture to do this practice. In this practice, we will try to observe all of our present moment experiences. This is a holistic observation. I will give further instructions on how to do this. But before that, I would like to take a moment to introduce you about mindfulness. It is a non-judgmental awareness of the present moment experience. You do not have to reach a particular state, such as being relaxed or free of any distractions. The main point is to try as much as you could to observe everything within the present moment. This will make it a very good mindfulness practice. Later, I will introduce you to a technique called “labeling”, just as how we take note of our experiences in a memo. For example, it is “hearing” when I notice some sounds. It is “seeing” when I am visually aware of something. We will use “labeling” to help us observe our present moment experience. I will give more detailed instructions to guide your through this technique. Once you are ready, you can close your eyes if you prefer. You can also keep your eyes partially closed and gaze toward a point at one to two meters. There will be a bell whistle to signal the start of our practice.

「鐘聲響起」

“Bell Whistle”

隨著鐘聲響起，可以慢慢容讓注意力放到去而家坐喺度嘅感覺上面，例如腳板踩喺地下嘅感覺，大腿臀部被座椅承托嘅感覺，踏實嘅、穩陣嘅。透過留心呢一啲壓力嘅觸感，讓心慢慢返番嚟，關注返喺此時此刻。當覺得合適，可以讓注意力擴展到去整個身體嘅感覺。靜觀練習入面並唔需要去搵一啲特別嘅感覺，又或者去製造一啲感覺、經驗。只需要保持一個開放唔批判嘅心，喺靜觀練習入面學習純粹讓事物自然嘅呈現，覺察經驗嘅升起、變化、消失，順其自然。而亦都唔需要要求自己去達到某一個特定嘅境界，做到某一個嘅標準。純粹練習去如實地覺察當下升起嘅經驗，咁就已經喺一個好好嘅練習。

As the bell whistle goes off, you can slowly focus on the sensations of sitting on the chair, such as your feet standing on the ground, your hip being firmly supported by the chair. Let your mind slowly back to the present moment by paying attention to these sensations. If appropriate, you can expand this awareness to the sensations of your whole body. In this practice, you do not need to intentionally find or create any sensations or experiences. We simply let it occurs naturally. We observe how these experiences arise and eventually fade away using a non-judgmental attitude. You do not have to reach a particular standard. Simple observing your experiences as they occurred is good enough.

「暫停」

"Pause"

有某啲人會發現用一個叫標籤嘅技巧會比較容易去覺察當下嘅經驗。我哋亦都可以去嘗試去用呢一個標籤嘅技巧，用我哋嘅六感：眼、耳、口、鼻、身體、同埋腦袋，去分類留意到嘅經驗。例如喺眼睛望到嘅嘢、耳朵聽到嘅嘢、鼻聞到嘅嘢、口品嚐到嘅嘢、身體感覺到嘅嘢、同埋腦袋嘅念頭。喜歡既，可以開聲講出留心到當下升起嘅經驗。例如留心自己望到嘅，可以講「望到」。留心到出面嘅車聲，可以講「聽到」。發現自己回憶緊過去嘅一啲事情，或者有一啲批判嘅諗法，可以講「思考」。除咗選擇大聲講出觀察到嘅經驗，亦都可以選擇喺心中默默標籤呢一啲嘅經驗，並唔一定要選擇開口講出嚟。選擇一個自己覺得合適嘅方法去幫助自己覺察當下任何升起嘅經歷。

Some may find it easier to use this "labeling" technique to observe their present moment experiences. We are trying this technique to categorize our experience using our six senses, i.e., eyes, ears, tongue, nose, body, and mind, such as what our eyes have seen, what our ears have heard, smell in our nose, taste in our tongue, feelings in our body and thoughts in our mind. If you wish, you can say it aloud on what you have observed in the moment. For example, you can say "seeing" when you have observed something with your eyes. You may also hear a sound from outside. You can say "hearing". You could think about something in the past or notice yourself having judgmental thoughts. You can say "thinking". If you prefer, you can mentally label these experiences. It is not a must to verbally express these labels. The main point is to choose a way that suits you so you can observe your present moment experiences.

「暫停」

"Pause"

而喺練習嘅過程中，可能會發現自己個心游走咗，唔再喺留心喺當下嘅經驗。但唔緊要，亦都唔需要去責怪自己，覺得自己做唔到，因為分心人之常情。發現到自己分咗心，甚至乎需要恭喜一下自己，因為又再一次返到嚟當下啦。只需要稍稍去標籤一下，自己分咗心去咗邊度。可能喺思考，或者出面嘅聲音，然後溫柔、穩定咁樣去帶返個心返嚟去察覺當下留心到嘅經驗。繼續去嘗試運用呢一個標籤嘅技巧，去幫助自己覺察當下。

While you are practicing, you may find your mind wanders away from the present moment experiences. But that's okay, you don't have to blame yourself for that. It is completely normal for us to wander our mind. When you notice it, you may even congratulate yourself because you are now at the present moment. You can label where your mind wanders. It could be your thoughts or sounds from outside. Then, you can gently bring your focus back to the present moment experiences. You can keep using this technique to observe the present moment.

「暫停」

"Pause"

覺得合適嘅話，可以嘗試更加仔細咁樣標籤經驗。例如可以用更加細緻嘅詞語去形容身體嘅感覺，可能喺凍、暖、濕、乾、痛、痕、放鬆、舒服。甚至乎可以用自己創作嘅詞語，去形容留心到呢一啲身體嘅感覺。重點並在於用啲乜嘢嘅詞語，又或者要好精準咁描述到呢一啲嘅經驗。重點在於嘗試去察覺，留意當下身體嘅感覺喺點樣呈現。當然喜歡嘅話，都可以繼續用返呢一個標籤嘅技巧。選擇一個覺得合適舒服嘅方法，去幫助自己察覺當下就可以啦。除咗身體嘅感覺可以用細緻嘅形容詞之外，可能念頭亦都可以用呢一個方法稍稍為佢哋分類。例如喺計劃、回憶、評論、批判等等。甚至乎可以用自己喜歡嘅詞語，去稍稍為念頭作出一個更加細緻嘅標籤。

If appropriate, we can describe our labels more closely. For example, we can use more delicate words to describe our bodily sensations, such as cold, warm, moist, dry, pain, itchy, relaxed, or comfortable. You can even create your own terms to describe these sensations. The point of this exercise is not about picking words to precisely describe these experiences. It is to observe on how these sensations have emerged. If you wish, you can keep using this technique. It is important to find a comfortable technique to aware of the present moment experiences. Besides these bodily sensations, you can use more delicate words to describe your thoughts, such as plan, memory, comment, critique. You can even create your own terms to further label your thoughts.

「暫停」

“Pause”

每個人嘅狀態喺唔同嘅時候都會有所不同，有時人比較平靜，有陣時會心煩意亂。而隨著心嘅狀態有所不同，用唔同嘅方法或者會比較幫助到自己覺察當下。可能心煩意亂嘅時候可以大聲去講出，標籤當下嘅經驗，會比較幫到自己覺察當下。可以嘗試去留心一下到底自己適合用乜嘢嘅方法，去幫助自己留心此時此刻。

At times, we found ourselves in different mental states. Sometimes, we are calm. Sometimes, we could be upset. Different methods may help us better to observe these mental states. For example, it may be better for you to verbally describe your feelings when you are upset. You can take a moment to feel a better way for you to focus on the present moment.

「暫停」

"Pause"

喺啱啱嘅時間，我哋盡可能去留意當下最明顯嘅經驗，依家我哋會嘗試去練習平衡覺察。嘗試去留心自己較容易忽略嘅經驗，可能喺啱啱嘅練習入面發現到自己比較容易留心到一啲負面嘅思想、負面嘅身體感覺。喺而家呢一刻，嘗試去留心一下一啲比較中性，又或者喺微微愉悅嘅感覺。可能喺身體上面一啲比較放鬆、舒服嘅部分。藉此去平衡自己嘅傾向、習性，去留心一啲比較容易去忽略嘅身體感覺或者經歷，練習一個全然的覺察。

So far in this practice, we have tried our best to observe any distinct experiences. Now, we can balance our observations to those that we are likely to overlook. It could be easier for us to observe negative thoughts or sensations. You can take a moment to explore some neutral or slightly positive feelings. It could be body parts where we feel more comfortable or relaxed. In this way, we can balance our observations to the feelings that are likely to be overlooked.

「暫停」

"Pause"

呢個練習，並唔喺要忽略一啲唔愉悅，或者喺負面嘅事情，而喺嘗試更加整存咁去留心當下所發生嘅事情。當下存在著大大小小中性嘅，又或者愉悅嘅感覺，只喺我哋自然咁樣去忽略咗。而喺呢一個練習入面，嘗試去將注意力放喺呢啲嘅地方，去

平衡自己嘅傾向、習性。去練習全然覺察當下所發生嘅所有事情，用一份開放、唔批判、全然嘅覺察去留心此時此刻。

Remember this practice is not to ignore our negative or unpleasant feelings but to be more holistic in our observations about what happened in the present moment. In the present moment, there are many neutral or pleasant feelings. However, we tend to ignore them. We can take a moment to explore these feelings to balance our observations. It is through this exercise to practice open, non-judgmental observations at the present moment.

「暫停」

"Pause"

當覺得合適，可以喺下一下吸氣，讓注意力放返到去呼吸，留心一吸一呼。一陣間會聽到三下鐘聲響起，代表練習嘅結束。

If appropriate, you can direct your attention back to your breath. There will be three bell whistles to signal the end of this practice.

「鐘聲響起」

"Bell Whistle"

慢慢張開眼睛。而家可以稍稍伸展一下腳、腰部，然後先慢慢起翻身。多謝大家去同我做呢一個靜觀嘅練習。

You can slowly open your eyes. You can stretch a little on your back and feet. Then, you can get back up slowly. Thank you for doing this exercise with me.

Appendix C: Script of Mind Wandering

歡迎大家，嚟緊會同大家進行一個練習。呢個練習喺讓我哋嘅想法呈現。而練習嘅目的喺讓我哋嘅創意、想法，喺腦海嗰度自由地呈現，從而去啟發創意。咁我哋會將個注意力帶到去腦海嗰度，留心我哋腦海嘅想法。個練習並唔需要去控制一啲想法或者喺情緒嘅呈現，而喺純粹去跟隨住呢一啲嘅想法去走。佢哋想走去邊，個心就跟隨佢哋走去邊，去留心住任何喺呢一刻升起嘅諗法就可以㗎啦。喺做呢個練習之前，我哋可以稍稍調整一下我哋坐嘅姿勢。坐返一個頭頸腰背垂直嘅姿勢，想像頭頂好似有條線咁拉直個人。膊頭放鬆嘅、雙腳踩返喺地下、穩陣嘅、踏實嘅。喜歡嘅亦都可以闔上雙眼、又或者垂低雙眼，望住前方一至兩米左右嘅一個點。一陣間會聽到一下鐘聲響起，代表練習嘅開始。

Welcome everyone. We are going to practice on how to let our thoughts emerge. The goal of this practice is to nurture our creativity by allowing our thoughts to freely wander in our mind. We will listen to the thoughts in our mind. In this practice, we do not need to control these thoughts or emotions when they occured. We can simply follow them no matter where these thoughts are leading us into. All we need to do is to listen these thoughts as they occured. Before we start this practice, we can slightly adjust our sit posture and keep your back straight. You can think of an analogy like there is a string pulling from your head. You can relax your shoulders with your feet standing firmly on the ground. If you prefer, you can keep your eyes closed. You can keep it partially close and gaze toward a point at about one to two meters. You will hear a bell whistle to signal the beginning of our practice.

「鐘聲響起」

“Bell Whistle”

可以將個注意力留心喺自己，深呼吸一口、慢慢呼出。當呼出嘅時候，去留心一下而家嘅想法、情緒、升起嘅影像。可以揀其中一個去跟隨住佢，去睇下呢一個嘅

想法、或者喺影像、情緒，會將你帶到去邊度呢？可以將自己完完全全咁樣放喺啲諗法，任何喺腦海而家升起嘅諗法入面。讓呢啲諗法好似成為個心嘅中心點，跟隨住一個又一個嘅諗法。讓自己個心沉入去呢一啲嘅想法上面，讓呢一啲嘅想法一個接一個咁帶住你哋嘅注意力去走。而呢啲嘅諗法可以喺任何嘅嘢，可能喺關於過去、未來，可以關於自己、他人。而呢啲諗法亦都可以升起一個又一個更加多嘅諗法。可能個諗法喺關於食嘢嘅，就回想起之前食嘅食物。可能喺去評價呢一啲食物好唔好食、鍾意又或者唔鍾意，亦都可能喺回憶起幾時會計劃再去食呢啲嘢呢？或者喺再試另外一啲嘢？亦都可能再隨之而來去幻想得到自己去感受嚟緊嘅美食，嗰個感覺會有幾歡樂、有幾享受嘅呢？嗰時可能會同啲咩嘅人喺埋一齊呢？

Now, you can focus on yourself. Take a deep breath and exhale slowly. While you are exhaling, you can take a close look about your thoughts, emotions, or any mental images. You can pick one of them and further explore where it would lead to. You can fully immerse yourself into these thoughts, any thoughts inside your mind. Let your thoughts become the center of your mind and follow them one by one. You can let your mind submerge into these thoughts and let them to take the lead of your attention. These thoughts could be anything. It could be your past or future events. It could be related to yourself or others. It could also lead to multiple thoughts. Perhaps it is about food. It could be the food you had a while ago. You may think about whether the food is good or not, whether you like it or not. You may plan about when to have the food again. It could also be something else. Maybe you think about the emotions associated with the food. Is it enjoyable? Perhaps you may think about the person you are having the food with?

「暫停」

“Pause”

讓一個又一個嘅想法帶住自己去走。或者有啲想法可能同個情緒有關，可能留心到自己一啲開心嘅情緒。可能諗起之前發生一啲開心嘅事，從而會感恩。可能喺某一啲嘅朋友、又或者感恩於自己嘅際遇，同時間亦都可能希望呢一種幸運快樂可以繼續落去。咁我要做啲乜嘢先可以繼續保持住呢一種快樂呢？讓諗法一個又一個咁接住，讓個心跟隨住呢啲諗法一個又一個咁走。無論呢啲諗法喺咩嚟嘅都好，只需要讓注意力盡可能咁樣跟隨住，猶如沉入喺一個「思想嘅洪流」當中。當有新諗法升起嘅時候，隨時都可以放開現有嘅想法，讓新嘅諗法成為新嘅焦點。再一次一個接一個嘅諗法令個心沉入去一啲嘅畫面、一啲嘅橋段、對白。

Let these thoughts, one by one, to take the lead of your mind. Perhaps these thoughts are associated with your emotions. You may notice some of your positive emotions. You could be glad about something positive that happened a while ago. It could be your friends. You may be glad that you have met them. At the same time, you may hope that this happiness can keep on. What could I do to keep it going? While these thoughts are emerging, you can catch it one by one to let your mind follow through. No matter what these thoughts are, you can let your mind follow them like submerging into a “stream of consciousness”. When a new thought arises, you can let go of your existing thoughts and let it become a new focus. Let your mind immerses, one by one, into these mental images, stories, or conversations.

「暫停」

“Pause”

而想法可以喺任何嘅形態、任何嘅內容。佢哋可能喺中性嘅，亦都可能喺充滿著魅力嘅。而有啲諗法呢可能會讓我哋覺得比較負面，可能喺對未來嘅一啲擔心、一啲嘅壓力，可能關於將來遇到嘅一啲障礙、嚟緊嘅死線。讓自己將個注意力呢放喺任

何嘅思想當中。隨著唔同嘅諗法、幻想、概念，帶住自己個心一層一層咁樣走，一個接一個。

Thoughts could take on any form, or any content. They could be neutral. They could be positive. Some of them could be negative, such as pressures or worries about the future. There could also be obstacles that you are going to face, such as deadlines. Let your mind follows, one by one, to these thoughts, ideas, or fantasies.

「暫停」

“Pause”

當有新嘅諗法出現嘅時候，就放開之前嘅想法去跟隨新嘅諗法。繼續讓個心遊走於思緒當中，一個接一個嘅諗法去走。

When a new thought emerges, you can always let go to the old one and follow the new thought. Keep your mind wandering and follow them one by one.

「暫停」

“Pause”

讓個心沉醉於唔同嘅想法、影像，一個又一個嘅故事。嚟緊呢會有幾個心中靜默嘅時間，讓大家繼續去練習讓個心跟隨著思緒、唔同嘅影像、故事遊走。

Let your mind immerses into these thoughts, mental images, and one story after another. There will be a few moments of silence for you to practice on how to let your mind wanders with these thoughts, mental images, and stories.

「暫停」

“Pause”

讓個心隨著一個又一個嘅想法、對白遊走。讓一個接一個嘅思緒自由溜走。

Let your mind follows these thoughts and conversations and freely wanders around.

「暫停」

“Pause”

練習就快結束啦。咁喺結束之前可以花少少時間去感受下自己花咗一啲嘅時間去培養創意。咁一陣間會聽到三下鐘聲，代表練習嘅結束。覺得合適，可以慢慢張開雙眼。

We are almost done here. Before it ends, you take a moment and appreciate the time you have spent to nurture your creativity. You will hear three bell whistles to signal the end of our practice. If appropriate, you can slowly open your eyes.

「鐘聲響起」

“Bell Whistle”

未必需要急住起番身嘅，可以伸展一下個身體，特別喺留意下雙腳有冇麻痺，可以嘅時候先至再一次起番身。多謝大家去同我做呢一個嘅練習。

Don’t rush to get up. You can stretch yourself a bit, especially if there are any numbing sensations in your feet. You can get up once you are ready. Thank you everyone for doing this practice with me.

Appendix D: Descriptions of Mood Induction Materials

No.	Descriptions	
	Neutral Mood Condition	Negative Mood Condition
1	Beekeepers in Hong Kong and how bees have played a vital role within the ecological system.	A son took his mother's wedding ring by force to settle his gambling debt.
2	A bibliography of Yuan Longping, the father of hybrid rice.	A woman confronted her husband about a marital affair.
3	The cultural heritage value of a site in Stanley, Hong Kong.	Soldiers were shooting civilians for trying to escape an isolation camp.
4	The important role of electronic technicians to minimize ecteronic waste.	A woman was hit by a car and eventually declared dead at the emergency room.
5	Cultured meat and how it becomes an alternative way to satisfy the ever-growing human population.	A woman began to mentally break down as the doctor explained about her miscarriage.
6	Challenges in popularizing electric vehicles in Hong Kong.	A young mother was diagnosed from an advanced stage of cancer and eventually passed away.